Critical Success Factors for A Sustainable Interoperable Land Information Management Systems in an Emerging Economy: Evidence from Nigeria

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The study examined the critical success factors for a sustainable interoperable land information management system in Ondo State, Nigeria. The study adopted a survey research design. Respondents were requested to rank twenty-nine (29) Critical Success Factors (CSFs) identified from the literature to be crucial to sustainable interoperable land information management systems according to their level of significance. A cross-sectional survey of four hundred and forty-one (441) respondents comprising ten (10) respondents from holders of land information within the public and four hundred and thirty-one (431) private sector respondents purposively drawn cutting across Estate Surveyors and Valuers (27), Land Surveyors (115), Town Planners (78), Lawyers (183), Geologists (13) and Heads of Indeginous land Owners (15) from the study area. Two hundred and thirty-seven (237) questionnaires were retrieved, representing 53.74% of the respondents sampled. Data obtained from respondents were analysed using weighted mean score, factor analysis and fuzzy synthetic evaluation. Twenty-nine (29) critical success factor variables for sustainable interoperable land information management were clustered within nine (9) components using factor analysis. Furthermore, the fuzzy synthetic evaluation revealed that critical success factor component group 4, which is, “Land information management security and integrity factors” has the highest index of 4.48 and the highest coefficient of 0.1217 among the nine (9) underlying groups. The study therefore recommends an urgent inclusion of relevant critical success factors in the road map or the development of a sustainable interoperable land information management system in developing countries.

Keywords: Critical success factors, Interoperability, Land information, Land information management, Sustainability

Introduction

Critical success factors as observed by Susil, Warnakulasuriya, & Arachchige (2016) highlight progress in specific areas within a system and serve as essential ingredients for achieving objectives and driving organizational improvement. Abidin, Osman, and Hashim (2020) emphasized that organisation’s strategic goals can be assessed and monitored by identifying these success factors, thus ensuring that tasks and projects are logically coordinated across departments. Similarly, Cöster, Engdahl, and Svensson (2014) noted that critical success factors are required factors within an organisation that must be performed so well to ensure success. Their importance extends across virtually all organizational areas, including sustainable interoperable land information management systems, which function efficiently by establishing clear structures that support social, political, economic, and environmental processes for better decision-making (Dawidowicz & Źróbek, 2017).

Adiaba (2014) noted that land information must have desired properties to fulfill users' needs. These qualities include: being comprehensive in terms of spatial coverage and content, being accurate with few or no mistakes, and being exact in terms of the measuring standards necessary. It must be current and free of ambiguity to meet the needs of users; it must be appropriate to relate to potential users' requirements; it must be quantifiable in terms of providing numerical information; it must be verifiable so that users receive the same answer to the same question; it must be accessible in terms of extracting information quickly and easily, and free of bias in which case there is no modification or alteration to influence the receivers. Furthermore, the United Nations Committee of Experts on Global Geospatial Information Management (UNGGIM) (2020) posits that land information is at the heart of land management and cuts across all Sustainable Development Goals in evaluation and progress monitoring. As a result, a long-term land information system must support people's daily activities and interactions with built and natural surroundings. With the expanding usage of ICT and online technologies, this connecting function between people and the earth continues to rise. A sustainable land information system should provide information on the "how," "what," "who," "when," and "where" of land tenure, usage, value, and development. It is anticipated to support the procedures and transactions allowing land tenure, land use, and land valuation changes.

However, Adiaba (2014) and Audu, Ojo & Ige (2024) noted that information asymmetry is a major problem bedevilling land information stakeholders in sub-Saharan countries like Nigeria, and Ghana. Previous efforts to create a hub of interoperable land information across Nigerian states have yielded little or no results. Land information has consistently and continuously remained dispersed and uncoordinated across different government agencies and private organisations (Audu et al., 2024). The inefficient and unreliable access to well-harmonized information on land has further compounded the woes of land sales and transactions through protracted legal disputes, violent altercations, and squabbles over property ownership amongst individuals, families, and communities (Kasanga and Kotey, 2001; Antwi, 2002; Sivam, 2002; Abdulai, 2007; Barry and Danso, 2014; Adiaba, 2014). These significant problems have continually made land transactions and real estate practices suffer huge setbacks and further prevented or, at best, reduced the chances of realising anticipated investment objectives. Furthermore, the monopoly of land information management by various agencies in the public sector has dramatically impaired the performance hoped for in the land market.

The land market in sub-Saharan African countries might have been crippled by diverse problems that have impaired the delivery of a reliable and sustainable land information management system that would satisfy users' needs and deliver clear benefits to the citizens. Conclusively, challenges surrounding the land information management matter in Nigeria might have also inhibited attempts to provide more comprehensive access to land information (Quan, 2006). Hence, owing to the absence of a sustainable interoperable land information management system in a developing country like Nigeria, problems of information disproportionateness in the real estate market, unhealthy land market due to uncertainty, and lack of trust remain major setbacks (Obani & Igwe, 2021; Nwafor, Sado & Johnnie, 2022). It is against this identified backdrop that this research is premised. There is an urgent need to examine the critical success factors for sustainable interoperable land information management systems in Nigeria and other developing countries to ensure that the land market and economic growth are patterned towards global best practices in land management.

Literature Review

Critical success factors in a variety of disciplines have been recognized by many experts. In project construction, Gunasekera (2009) identified thirty (30) critical success factors that influence construction project success in Sri Lanka. Tan and Tan & Ghazali (2011) noted forty (40) critical success factors for contractors and were further classified into seven (7) main categories, which are project manager-related factors, project management factors, client-related factors, procurement-related factors, design team-related factors, contractor-related factors; and business and work environment-related factors. In the area of land information management, McGonigle and Mastrian (2011) posited that accessibility, security, timeliness, correctness, relevancy, completeness, adaptability, dependability, objectivity, usefulness, transparency, verifiability, and reproducibility are all qualities of valuable information. Human mistakes, on the other hand, might jeopardise the validity of such data. The World Health Organization and United Nations Environment Programme (2020) observed that awareness-raising is strategic to raise concerns about sustainable interoperability of land information management systems among various stakeholder groups and to make sure that the issue is brought up in public and by decision-makers. Also, the United Nations Development Programme (1998) noted that capacity building is essential for an interoperable land information management system to be effective, efficient, and sustainable. To achieve effectiveness, efficiency and sustainability of land information management, capacity building should be a continuous process or ongoing activity, not a passive state or short-lived condition (Enemark & Williamson, 2003). In furtherance to these, Haris (2016) noted that capacity building should be regarded as a primary priority in the government's development plan to ascertain performance. Pannell (2004) observed that there are two prerequisites that capacity building in any organization should ideally satisfy. Firstly, to alter practices or actions available and secondly to ascertain that the anticipated changes or activities is sufficient to alter program outcomes significantly. However, to ensure sustainable land information management, the available capacity must have the aptitudes, resources, relationships, and facilitating conditions required to act effectively (Malyan & Jindal, 2013).

A critical success factor of sustainable land information is the partnership between public and private sector participants. OECD LEED Forum (2006) noted that countless collaborations had been created worldwide in the past two decades to support the course and implementation of programs at diverse levels. Abdul Quium (2003) posited that, governments across the globe are increasingly partnering with the private sector for extra funding, improved productivity, and sustainable development. In many nations in the Asia-Pacific region, private sector participation and involvement in various industries have grown relatively prevalent. Extending this idea to land information management may not be a terrible idea since working out a partnership with the business sector may be preferable to improve land information management's efficiency and make it sustainable. UNGGIM (2020) pointed out that integrated land information may not be available shortly but will require ongoing investment. Hence, land data may be acquired from various reliable sources to consistently identify the spatial extent, period, and persons subject to the right, limitation, or duty. The necessity for acceptable geographical precision, the demand to be temporally up-to-date, and the requirement to be backed up, assured, and potentially insured by an authority are all defining requirements of land data. Without these components, the data's societal use and significance are swiftly eroded. Land data availability, accessibility, and interoperability are requirements for efficient land administration.

In another perspective, Aromolaran (2009), posited that information preservation must be implemented for information to be correct. Kurwakumire (2014) asserted that active government support through technology changes is essential for enhancing both access to cadastral information, which is public knowledge, and land governance. The government must take the initiative to make sure that the necessary efficiencies are realized through a reliable and useful information system to achieve sustainable land information management, which will also benefit other government sectors like the health, security, statistical, agricultural, tourism, and transportation agencies. According to Ngerem (2015), one of the most important success factors in the development of a system is the user. A crucial factor in the success of human and computer-based systems has been the participation of users in the development of an information system. This will enhance the operation of the system and further aid to better understand the end-user's daily activities in general and their preferences in particular. In light of this, these user engagement principles in the context of sustainable land information management may be a crucial success factor for achieving the SDGs in developing nations like Nigeria.

Wamukoya and Mutula (2005) claimed that in order to function successfully in an environment where e-records capacity is being built sustainably, individuals should acquire new skills and competencies through training or reskilling. Sustainable development goals (SDGs) are intricate, interconnected objectives that call for a shift in how business is done. For development professionals to achieve the challenging SDGs, skill-up is crucial. This will provide concerned parties with the chance to learn the skills needed to engage fully in the workplace of the future, and build more inclusive, sustainable economies and societies where no one gets left behind. Reskilling might be a good alternative to firing current employees and hiring new ones with different skill sets. It is also a good way to move a person who fits better for another role, but for some reason ended up working in a totally different one. Ziemba & Oblak (2015) maintained that in the current, fiercely competitive, and constantly changing environment, change is necessary to offer the public adequate services. Moreover, a change management (CM) procedure needs to be implemented when firms are faced with changes. One of the most important success factors for change management in information system projects is the requirement to notice a change within an information system. Personnel preparation for the change is crucial to the success of sustainable land information management. This variable capture how willing a business is to adapt in order to enhance performance as perceived by its workforce (Weber & Weber, 2001). Employees are more able to understand upcoming adjustments after dealing with a change.

Huge data projects should receive special consideration because they are innovation projects (Gao, Koronios, & Selle, 2015). Therefore, in order to address this problem, proper technology is required (Bhashyam, 2011). A major success element for big data initiatives like sustainable land information management is the availability of data processing resources. Sustainable land information management also requires investments in infrastructure such as GIS based land information management, document management system, trained experts, data management equipment, ICT tools, laboratories and softwares. Furthermore, data collection processes require storage systems. It is necessary to have a flexible IT infrastructure that can quickly adapt to different problem scenarios. The most crucial characteristic of analytical systems is scalability. The system must be able to scale quickly in response to the incoming data's changing velocity considering that the business value of the projects is a significant insight to be gained from the data gathered.

In a study to investigate the connections between quality management practices and performance outcomes, Utami & Harahap (2018) posited that leadership is a crucial factor that can drive performance improvement in any organization. The implementation of good leadership will have a significant impact on overall performance and especially the service quality of projects such as the sustainable interoperable land information management system (SILIMS) development. Dwivedi and Dwivedi (2021) posited that stakeholders can either directly or indirectly impact and influence the proceedings and success of the project. Hence the interest of stakeholders is vital to the success or otherwise of any project (Kamassi, Abd Manaf, & Omar, 2020). Stakeholders are needed in the mobilization of institutional mechanisms, the legal and regulatory framework governing the processes involved in the development of a land information infrastructure. Therefore, availability of stakeholders' support is germane towards the realization of a sustainable land information management. A strong commitment from all major partners and stakeholders involved in land administration is required to achieve a sustainable land information management (UN-GGIM, 2020).

Thomas, Reed, Clifton, Appadurai, Mill, Zucca, Kodsi, Sircely, Haddad, von Hagen, Mapedza, Woldearegay, Shalander, Bellon, Le, Mabikke, Alexander, Leu, Schlingloff, LalaPritchard, Mares and Quiroz (2017) observed that effective financial management at the macro and micro-levels within public government budgets, local organizations, and individuals is a crucial success factor for sustainable land management improvement. In addition, Bitondo and Bakoumé (2021) made the case that sustainable land management needed to be scaled up through the availability and proper management of financial resources for the incorporation of sustainable land management into a nation's development policies and strategies frameworks. This will assist in mobilizing specific indicators for monitoring and evaluating land management sustainability, prevent the marginalization of some crucial aspects of land management such as land information management and help in determining the commitment to achieving sustainable development goals. Furthermore, a favorable investment environment has been identified one of the critical success factors for projects (Nguyen, Likhitruangsilp, & Onishi, 2020). A favourable investment climate for land information management will encourage productivity and spur the growth of land information databases. It will also create opportunities and jobs for people and professionals alike. Ismail (2013); Babatunde, Opawole and Akinsiku (2012); Mladenovic, Vajdic, Wündsch, and Temeljotov-Salaj (2013); and Nguyen, Likhitruangsilp, and Onishi, (2020) have identified favourable legal framework as a critical success factor in varieties of fields. This may be due to the observation of Scott and Gong (2021) that information within government agencies is contained in silos that are bedevilled with retrieval bottlenecks. Hence, providing a legal framework for land information management that is favourable will help in timely information sharing which can go a long way towards combating fraud from all sectors.

For sustainable interoperable land information management system development to be successful, it must be able to function and thrive at the level necessary for it to survive and prosper. Katwalo (2010) opined that competency is an assemblage of information, abilities, and personality traits that are connected to effective and successful behaviour in a particular field. This, however, will be supported by the skills and resources available to provide a competitive edge, improved performance, and improved market position. In a study by Nguyen, Likhitruangsilp, and Onishi, (2020), realistic assessment of cost and benefits was identified as a critical success element in the accomplishment of public-private partnership projects. Realistic assessment of the cost and benefits of sustainable land information management system development is extremely important in the overall risk management of the project and the achievement of peculiar goals and objectives. A critical measurement of the cost and benefit of provision of infrastructure for land information management is essential to the success of its sustainability. Yang, Ho, Shen and Drew (2009) posited that identifying stakeholders, understanding the area of stakeholders' interests, exploring stakeholders' needs and constraints in projects, assessing attributes of stakeholders, predicting the influence of stakeholders, assessing stakeholders' behavior are crucial to the success of a project. Land Information management stakeholder's management is important as it influence the relationships that are the backbone of successful projects. Stakeholder management in sustainable land information management would require building trusting relationships and comprehending how their efforts are influencing the success of the project. Therefore, the successful implementation of the advantages of sustainable land information management is dependent on the land market stakeholder management.

Ennsfellner, (2018) posited governance as the foundation of any business and affects operational business through initiatives, programs, and portfolios as well as organizational strategies. Good governance requires the active stewardship of all of an organisation's investments. The establishment of proper frameworks through principles, policies, and culture to assist assure an organization and/or region will accomplish its aims and standards is the duty of the organization's top management as well as governments and relevant authorities. According to Nguyen et al. (2020), outstanding governance is one of the crucial success criteria for public private partnership infrastructure projects in Vietnam. Using good governance in sustainable land information management would help all parties create synergies.

Social and community support programs are intended to help people, organizations, or communities reach satisfying standards of living through initiatives that strengthen interpersonal and collective links. In varieties of disciplines, success has been hinged on social and community support. For instance, Zhao, Jin, and Hu (2022) found that social support within the community helps to reduce psychological discomfort. In addition to allaying land market stakeholders worry about lack of information, social and community support for sustainable land information management will also encourage relationships and interactions among market participants, which will have a positive impact on the market's overall health.

However, some of the critical success factors for land information management identified were tested in a developed country while other critical success factor discussed in the other studies has not been tested for land information. Thus, the critical success criteria are expected to provide a shared point of reference to guarantee that interoperable land information management systems and projects are coordinated across concerned stakeholders and that everyone in the land market is well informed.

Methodology

The study adopted a survey research design. A cross-sectional survey of four hundred and forty-one (441) respondents comprising ten (10) respondents from holders of land information within the public sector and four hundred and thirty-one (431) private sectors respondents purposively drawn from the study area. The study used descriptive statistical tools to analyse the data collected from the respondents. Four hundred and forty-one (441) questionnaires were distributed across the public and private sectors generating and holding land information in Ondo state. The distribution of the questionnaire retrieved cut across the public sector land information holders. Two hundred and thirty-seven (237) questionnaires in total were retrieved, and this represents 53.74% of the respondents sampled. This, however, implied that opinions and inferences for this study were drawn from a sizeable percentage. Data obtained from respondents were analysed using fuzzy synthetic evaluation. The fuzzy synthetic evaluation model adopted for analysing the critical success factors, requires six steps. The first step is to establish the set of basic critical success factors for sustainable interoperable land information management as represented in eq1.

$CSF = \{ f_1, f_2, \cdots f_n\}$ ------------- (eq 1)

where CSF = critical success factor,

f_1, f_2 = identified factors,

n is the number of critical success

factors.

The next step involves establishing the grade alternatives with the set of grade categories as the scale measurement. A 7-point Likert scale was used as the set of grade alternatives. Joshi et.al. (2015) posited that a seven point likert scale performs better than a 5-point likert scale as it affords the respondents wider varieties of options, which in turn increases the probability of meeting the reality of their opinion. The grade alternatives range between extremely highly insignificant (L_1), highly insignificant (L_2), insignificant (L_3), mildly significant (L_4), significant (L_5), highly significant (L_6) and extremely highly significant (L_7). In furtherance of this, weightings are awarded to the grade categories to aid in analysing the mean score of a particular factor criterion. The weights of each factor are calculated from the indices obtained. Step 3 involves the grouping of the identified critical success factor variables into components (i.e. critical success factor groupings CSFGs) to reduce the number of variables and to identify patterns of relationships among variables using factor analysis as represented in eq 2.

$$F_k = W_1kX_1 + W_2kX_2 + W_3kX_3 + - - - - - W_nkX_n - - - - - (eq2)$$

Where F_k = factor K

WkX = weight of variable

Thereafter, an evaluation matrix $R_i = (r_{ij})_{m\times n}$ is generated in Step 4 by fuzzy statistics method to denote the degree to which the grade alternative L_j satisfies the criterion F_k. The evaluation matrix is represented in eq 3.

$$R = \begin{bmatrix} MF_{ui1} \\ MF_{ui2} \\ --- \\ MF_{uim} \end{bmatrix} \text{--------------(eq3)}$$

$$\text{Where } MF_{ui1} = \left(\frac{N_{i1}}{N}, \frac{N_{i2}}{N}, \frac{N_{i3}}{N}, - - \frac{N_{i7}}{N}\right) \text{(eq4)}$$

Where MF is the membership function; and N_{i1} is the number of critical success factors f_i from the questionnaires. The data for the weights and evaluation results is calculated in step 5 and the final fuzzy synthetic evaluation results is generated for the evaluation by considering the weighting vector and the fuzzy evaluation matrix in step 6, using the following eq5.

$$T = WxR = (w_1, w_2, - - - - w_n) \text{ x } \begin{bmatrix} r_{11}, r_{12}, - - - - - r_{1m} \\ r_{21}, r_{22}, - - - - - r_{2m} \\ - - - - - - - - - - - - \\ r_{n1}, r_{n2}, - - - - - r_{nm} \end{bmatrix} \text{----(eq5)}$$

Following the computation of the fuzzy evaluation matrix, a Sustainable Interoperable land information management system success index is calculated (SI) for each of the factor component using the following equation:

$$SI = \sum_{i=1}^{7} T\ X\ L \quad \dots\dots\dots\dots\dots\dots\dots. eq(6)$$

Data Analysis

This section details the critical success factors for a sustainable interoperable land information management system in Ondo State. Twenty-nine critical success factors were identified from the literature and respondents were required to rank them according to their level of significance ranging from extremely highly significant (7), highly significant (6), significant (5) mildly significant (4), insignificant (3) highly insignificant (2) to extremely highly insignificant (1). The results are detailed in tables 1, 2, 3, 4, 5, 6, and 7 respectively.

Table 1 details the mean score ranking of the critical success factors for sustainable interoperable land information management in Ondo state. Respondents were requested to rank twenty-nine (29) variables according to their significance level. Land information must be accurate with little or no mistakes ranked 1st with a mean value of 5.42. This is followed by land information must be verifiable so that users receive the same answer to the same question which ranked 2nd with a mean value of 4.71. Good governance ranked 3rd with a mean value of 4.70, land information must be current and free of ambiguity to meet the needs of users raanked 4th with a mean value of 4.63. Sustainable land information management advocacy and awareness ranked 5th with a mean value of 4.48. The least five variables as indicated Table 1 include Training and re-skilling (25th rank) with mean value of 3.67, End User Involvement (26th rank) with mean value of 3.65, Land information dependability (27th rank) with mean value of

3.62, Quality work environment (28th rank) with mean value of 3.60; and Comprehensiveness in terms of spatial coverage and content. (29th rank) with a mean value of 3.35. The result in Table 1 however, indicated the respondents perceive the twenty-nine (29) factors are crucial to the success of a sustainable interoperable land information management system in Ondo State. The high-ranking factors, such as accuracy, verifiability, good governance, currency, and awareness, show that these elements are vital for achieving a sustainable interoperable land information management system. Prioritizing and addressing these factors can significantly enhance system reliability and user trust.

Table 1: Descriptive statistics for Critical Success Factors for a Sustainable Interoperable Land Information Management System

Code	Critical Success Factors	Mean	Std. Deviation	Rank
CSF 26	Land information must be accurate with little or no mistakes.	5.42	1.662	1st
CSF 28	Users must receive the same answer to the same question.	4.71	1.791	2nd
CSF 24	Good governance.	4.70	1.550	3rd
CSF 27	It must be current and free of ambiguity to meet the needs of users.	4.63	1.913	4th
CSF 11	Sustainable land information management advocacy and awareness	4.48	1.463	5th
CSF 1	Land information accessibility	4.40	2.043	6th
CSF 4	Information relevancy	4.38	1.768	7th
CSF 22	Staff Competence	4.37	1.775	8th
CSF 29	Free of bias in which case there is no modification or alteration to influence the receivers.	4.36	1.945	9th
CSF 23	Realistic assessment of costs and benefits of land information management	4.33	1.634	10th
CSF 3	Correctness of other associated information	4.31	1.883	11th
CSF 5	Land information completeness	4.24	1.797	12th
CSF 9	information process transparency	4.14	2.099	13th
CSF 12	Partnerships amongst stakeholders	4.13	1.708	14th
CSF 2	Information Security	4.13	1.814	14th
CSF 16	Data processing resources, technological improvement and advancement	4.06	1.647	16th
CSF 7	Land information objectivity	4.05	1.742	17th
CSF 13	Information Standardisation	4.00	1.762	18th
CSF 18	Stakeholders' support for sustainable land information management	3.95	1.683	19th
CSF8	Land information usefulness	3.92	1.683	20th
CSF 21	Favourable legal framework for land information management	3.88	1.844	21st
CSF 10	Information Availability	3.86	1.767	222nd
CSF 19	Financial management	3.72	1.766	23rd
CSF 20	Favourable investment environment for land information management	3.70	1.825	24th
CSF 15	Training and re-skilling	3.67	1.474	25th
CSF 14	End User Involvement	3.65	1.735	26th
CSF 6	Land information dependability	3.62	1.907	27th
CSF 17	Quality work environment	3.60	1.740	28th
CSF 25	Comprehensiveness in terms of spatial coverage and content.	3.35	1.496	29th

** Extremely highly significant (7), Highly significant (6), Significant (5), Mildly significant (4), Insignificant (3), Highly insignificant (2), Extremely highly insignificant (1).*

Source: Analysis of field survey 2024

This however, implied that the critical success factor are key to the development of a sustainable interoperable land information management system. In furtherance of this, Factor analysis was further used to compress the twenty-nine (29) variables identified to be critical success factors essential to the development of a sustainable interoperable land information management system in Ondo state. Table 2 shows the KMO and Bartlett's Test of the CSFs for sustainable interoperable land information management system.

The result of the Kaiser-Meyer Olkin and Barlett's test of sampling adequacy is detailed in Table 2. The Kaiser-MeyerOlkin Measure of Sampling Adequacy (KMO) value in Table 2 revealed a value of 0.773 (exceeding the recommended value of 0.6) while the Bartlett's Test of Sphericity value (which indicate the strength of the relationships among variables) revealed a p value of 0.000. This however implied that the sample used is adequate (p value ≤ 0.005), therefore supporting the factorability of the critical success factors for sustainable interoperable land information management system. The communalities of the critical success factor for interoperable land information management system is revealed in Table 3.

Table 3 shows the communalities of the variables which indicate the proportion of the variance explained by the common factors. The result of the communalities showed that about 56% of the variation in Land information accessibility is explained by the factor model. For information security, the extraction value indicated that about 58.8% of the variation in this factor is explained by the factor model. All of the the variables in table 3 are well and completely fitted except for comprehensiveness in terms of spatial coverage and content with a weak extraction value of 0.276. however, this variable was not considered for deletion because the extraction value is above the minimum 0.2. All of the twenty-nine (29) variables were included for factor analysis.

Table 4 details the factor analysis of the critical success factors for sustainable interoperable land information management system in ondo state. Twenty-nine (29) variables were analysed and the results loaded the factors into nine (9) principal components after suppressing factors with loadings less than 0.4 to ensure easy and quality of result interpretation. The eigen values associated with each group after extraction further revealed the variance in the dataset within a particular direction. The principal components analysis revealed the presence of nine components with eigenvalues exceeding 1, explaining 17.9%, 14%, 6.8%,4.9%, 4.7%, 4.6%, 3.9%, 3.7% and 3.6% of the variance respectively. From Table 4, twenty-nine (29) critical success factor variables for sustainable interoperable land information management clustered within nine (9) components and generated normalized cumulative sums of squared loading of 64.401% which however implied that 64.401% of the total variation in the critical success factors for sustainable interoperable land information management is explained by cumulative effect of the nine (9) components extracted. Thus, efforts to identify the critical success factors for sustainable interoperable land information management are targeted at the nine (9) major groups.

Table 2: KMO and Bartlett's Test of the Critical Success Factors for a Sustainable Interoperable Land Information Management System

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.773
Bartlett's Test of Sphericity	Approx. Chi-Square	2425.259
	df	406
	Sig.	.000

Source: Analysis of field survey 2024

Table 3: Communalities of the Critical Success Factors for a Sustainable Interoperable Land Information Management System

	Initial	Extraction
Land information accessibility	1.000	.564
Information Security	1.000	.588
Correctness of information	1.000	.602
Information relevancy	1.000	.583
Land information completeness	1.000	.577
Land information dependability	1.000	.713
Land information objectivity	1.000	.532
Land information usefulness	1.000	.735
information process transparency	1.000	.507
Information verifiability	1.000	.452
Sustainable land information management advocacy and awareness	1.000	.604
Partnerships amongst stakeholders	1.000	.709
Information Standardisation	1.000	.546
End User Involvement	1.000	.629
Training and re-skilling	1.000	.751
Data processing resources, technological improvement and advancement	1.000	.699
Quality work environment	1.000	.681
Stakeholders' support for sustainable land information management	1.000	.738
Financial management	1.000	.734
Favourable investment environment for land information management	1.000	.691
Favourable legal framework for land information management	1.000	.685
Staff Competence	1.000	.789
Realistic assessment of cost and benefits of land information management	1.000	.827
Good governance.	1.000	.805
Comprehensiveness in terms of spatial coverage and content.	1.000	.276
Land information must be accurate with little or no mistakes.	1.000	.707
It must be current and free of ambiguity to meet the needs of users.	1.000	.761
Land information must be verifiable so that users receive the same answer to the same question.	1.000	.569
Free of bias in which case there is no modification or alteration to influence the receivers.	1.000	.624

* Extraction Method: Principal Component Analysis.
Source: Analysis of field survey 2024

Table 4: Factor Analysis of the Critical Success Factors for a Sustainable Interoperable Land Information Management System

CSF Code	Factor Grouping	Factor Label	Factor loading	Eigen value	Variance explained	
					%	Cumulative %
CSF 4	1. Land information management performance driver factors	Information relevancy	.409	5.215	17.981	17.981
CSF 21		Favourable legal framework for land information management	.640			
CSF 22		Staff Competence	.864			
CSF 23		Realistic assessment of costs and benefits of land information management	.885			
CSF 24		Good governance.	.871			
CSF 1	2. Land information management quality assurance factors	Land information accessibility	.490	4.061	14.005	31.986
CSF 3		Correctness of associated information	.619			
CSF 5		Land information completeness	.630			
CSF 6		Land information dependability	.789			
CSF 7		Land information objectivity	.440			
CSF 9		information process transparency	.530			
CSF 10		Information availability	.417			
CSF 11	3. Land information management community engagement and sustainability factors	Sustainable land information management advocacy and awareness	.751	1.980	6.828	38.814
CSF 12		Partnership amongst stakeholders	.709			
CSF 16		Data processing resources, technological improvement and advancement	.536			
CSF 18		Stakeholders' support for sustainable land information management	.526			
CSF 2	4. Land Information management security and integrity factors	Information security	.731	1.409	4.859	43.673
CSF 25		Comprehensiveness in terms of spatial coverage and content.	.408			
CSF 26		Land information must be accurate with little or no mistakes.	-.791			
CSF 19	5. Land information management transparent and fiscal factors	Financial management	.770	1.370	4.724	48.397
CSF 20		Favourable investment environment	.618			
CSF 29		Free of bias in which case there is no modification or alteration to influence the receivers.	-.492			
CSF 8	6. Land information management productive ambiance factors	Land information usefulness	.816	1.352	4.663	53.060
CSF 17		Quality work environment	.483			
CSF 15	7. Land information management learning development factors	Training and reskilling	.804	1.149	3.963	57.023

CSF Code	Factor Grouping	Factor Label	Factor loading	Eigen value	Variance explained	
CSF 13	8. Land information management uniformity implementation factors	Information Standardisation	.561	1.087	3.749	60.772
CSF 14	9. Land information management relevancy factor	End User Involvement	.715	1.053	3.630	64.401
CSF 27		It must be current and free of ambiguity to meet the needs of users.	.780			
CSF 28		Users must receive the same answer to the same question.	.485			

* Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 19 iterations.
Source: Analysis of field survey 2024

From Table 4, five (5) factors which are "Information relevancy", "Favourable legal framework for land information management", "Staff competence", "Realistic assessment of costs and benefits of land information management" and "Good governance", exhibit significant correlation loading on Component 1. The factors constituting Component 1 are synonymous with *"Land information management performance driver factors"* which is adopted as the component name. The factor loading figures in the table revealed the correlation between each variable and its respective component. The higher the loading of a variable, the more correlated the variable to the component. While a positive value indicates direct relationship, negative value represents inverse relationship. For instance, there is a moderate positive correlation between Information relevancy and Performance driver factors (component 1) with a value of 0.409, a strong positive correlation exists between favourable legal framework for land information management and component 1 with a correlation value of 0.64 while a very strong correlation exists between staff competence and component 1. Furthermore, seven (7) factors which include "Land information accessibility", "Correctness of associated information", "Land information completeness", "Land information dependability", "Land information objectivity", "information process transparency", and "Information availability" displayed significant correlation loading on Component 2 and *"Land information management quality assurance factors"* is adopted as the component name. Four (4) factors displayed significant correlation loading on component 3 i.e. "sustainable land information management advocacy and awareness", "Partnership amongst stakeholders", "Data processing resources, technological improvement and advancement" and "stakeholders support for sustainable land information management. The adopted name for component 3 is *"Land information management community engagement and sustainability factors"*. Three (3) factors exhibited significant correlation loading on component 4 and are "Information security", "Comprehensiveness in terms of spatial coverage and content", and "Land information must be accurate with little or no mistakes". the adopted name of component 4 is *"Land information management security and integrity factors"*. Component 5 also has three (3) factor which possess significant correlation loading and they are "financial management", "favourable investment environment" and "Free of bias in which case there is no modification or alteration to influence the receivers". the adopted component name is *"Land information management transparent and fiscal factors"*. component 6 has two factors namely "Land information usefulness" and "Quality work environment". The adopted name is *"Land information management productive ambiance factors"*. Component 7 and component 8 has one factor each as detailed in Table 4 and their adopted names are "*Land information management learning development factors"* and "*Land information management uniformity implementation factors*". component 9 which has *"Land information management relevancy factors"* as its adopted name has three (3) factor that showed significant correlation loading. The factors include "End User Involvement", "It must be current and free of ambiguity to meet the needs of users" and "users must receive the same answer to the same question". Each of the components represents an area of focus to achieve a sustainable interoperable land information management system in the study area. Together, the components form a comprehensive blueprint for achieving a sustainable interoperable land information management system. By addressing these components, stakeholders can ensure the system meets current demands while remaining adaptable to future challenges. The membership function of the critical success factor for sustainable interoperable land information management system is presented in Table 5.

Table 5 details the membership function of critical success factors for a sustainable interoperable land information management system. Twenty nine (29) critical success factor variables for sustainable interoperable land information management were clustered within nine (9) components namely: Land information management performance driver factors (component 1), Land information management quality assurance factors (component 2), Land information management community engagement and sustainability factors (component 3), Land information management security and integrity factors (component 4), Land information management transparent and fiscal factors component (5), Land information management productive ambiance factors (component 6), Land information management learning development factors (component 7), Land information management uniformity implementation factors (component 8); and Land information management relevancy factors (component 9). The cumulative mean score of each component group revealed that component 1 has a cumulative mean score of 21.66. The weight of each of all five (5) factor variables within component 1 revealed that CSF 4 weighs 0.20, CSF 21 weighs 0.18, CSF 22 and CSF 23 weigh 0.20 each and CSF 24 has a weight of 0.22 across group 1. Furthermore, Component 1 has a group weight of 0.18056 across the nine component groupings. Component 2 has seven (7) factor variables and a cumulative mean score of 28.62 and the weight of each factor variable in component 2 revealed that CSF 1, CSF 3 and CSF 5 weigh 0.15 each, CSF 6 weighs 0.13, CSF 7 and CSF 9 weigh 0.14 each and CSF 10 weighs 0.13. Component 2 has a group weight of 0.23858. Component 3 has four (4) factor variables and a cumulative mean score of 16.62. The weight of each factor in component 3 as detailed in Table 26 revealed that CSF 11 weighs 0.27, CSF 12 weighs 0.25, CSF 16 and CSF 18 weigh 0.24 each respectively. Component 3 has a group weight of 0.13855. Component 4 has three (3) factor variables and a cumulative mean score of 13.10. CSF 2 weighs 0.32, CSF 25 weighs 0.27, and CSF 26 weighs 0.41. The group weight of component 4 is 0.10920. The group weights of Components 5,6,7,8 and 9 are 0.09820, 0.06269, 0.03059, 0.03334 and 0.10829 respectively. The fuzzy relational matrix data indicators and CSF grouping index order for critical success factors for sustainable interoperable land information management systems in Ondo state are detailed in Tables 6 and 7 respectively.

Table 5: Membership Function of Critical Success Factors for a Sustainable Interoperable Land Information Management System

CSF Code	Factor Group	Factor Label	Mean Scores		Weighting	
			CSF	CSF Group cumulative	CSF	CSF Group
CSF 4	1. Land information management performance driver factors	Information relevancy	4.38	21.66	0.20	0.18056
CSF 21		Favourable legal framework for land information management	3.88		0.18	
CSF 22		Staff Competence	4.37		0.20	
CSF 23		Realistic assessment of cost and benefits of land information management	4.33		0.20	
CSF 24		Good governance.	4.70		0.22	
CSF 1	2. Land information management quality assurance factors	Land information accessibility	4.40	28.62	0.15	0.23858
CSF 3		Correctness of associated information	4.31		0.15	
CSF 5		Land information completeness	4.24		0.15	
CSF 6		Land information dependability	3.62		0.13	
CSF 7		Land information objectivity	4.05		0.14	
CSF 9		information process transparency	4.14		0.14	
CSF 10		Information availability	3.86		0.13	
CSF 11	3. Land information management community engagement and sustainability factors	Sustainable land information management advocacy and awareness	4.48	16.62	0.27	0.13855
CSF 12		Partnership amongst stakeholders	4.13		0.25	
CSF 16		Data processing resources, technological improvement and advancement	4.06		0.24	
CSF 18		Stakeholders' support for sustainable land information management	3.95		0.24	
CSF 2	4. Land information management security and integrity factors	Information security	4.13	13.10	0.32	0.10920
CSF 25		Comprehensiveness in terms of spatial coverage and content.	3.55		0.27	
CSF 26		Land information must be accurate with little or no mistakes.	5.42		0.41	
CSF 19	5. Land information management transparent and fiscal factors	Financial management	3.72	11.78	0.32	0.09820
CSF 20		Favourable investment environment	3.70		0.31	
CSF 29		Free of bias in which case there is no modification or alteration to influence the receivers.	4.36		0.37	
CSF 8	6. Land information management productive ambiance factors	Land information usefulness	3.92	7.52	0.52	0.06269
CSF 17		Quality work environment	3.60		0.48	
CSF 15	7. Land information management learning development factors	Training and reskilling	3.67	3.67	1.00	0.03059

CSF Code	Factor Group	Factor Label	Mean Scores		Weighting	
			CSF	**CSF Group cumulative**	**CSF**	**CSF Group**
CSF 13	8. Land information management uniformity implementation factors	Information Standardisation	4.00	4.00	1.00	0.03334
CSF 14	9. Land information management relevancy factors	End User Involvement	3.65	12.99	0.28	0.10829
CSF 27		It must be current and free of ambiguity to meet the needs of users.	4.63		0.36	
CSF 28		Users must receive the same answer to the same question.	4.71		0.36	
		Total		119.96		

Source: Analysis of field survey 2024

Table 6. Fuzzy Relational Matrix data indicators for Critical Success Factors.

CSF Code	Factor Group	Factor Label	Weighting	CSF Membership functions Level 2	Level 1
CSF 4	1. Land information management performance driver factors	Information relevancy	0.20	(0.07, 0.10, 0.13, 0.22, 0.20, 0.12, 0.16)	(0.08, 0.10, 0.10, 0.26, 0.15, 0.21, 0.10)
CSF 21		Favourable legal framework for land information management	0.18	(0.17, 0.12, 0.10, 0.17, 0.23, 0.17, 0.05)	
				(0.07, 0.14, 0.06, 0.29, 0.09, 0.26, 0.10)	
CSF 22		Staff Competence	0.20	(0.05, 0.10, 0.12, 0.35, 0.06, 0.23, 0.09)	
CSF 23		Realistic assessment of costs and benefits of land information management	0.20	(0.05, 0.05, 0.07, 0.28, 0.18, 0.28, 0.10)	
CSF 24		Good governance.	0.22		
CSF 1	2. Land information management quality assurance factors	Land information accessibility	0.15	(0.11, 0.10, 0.11, 0.22, 0.12, 0.08, 0.26)	(0.10, 0.14, 0.13, 0.21, 0.13, 0.12, 0.16)
CSF 3		Correctness of associated information	0.15	(0.12, 0.10, 0.07, 0.20, 0.17, 0.23, 0.11)	
CSF 5		Land information completeness	0.15	(0.07, 0.14, 0.13, 0.20, 0.21, 0.10, 0.15)	
CSF 6		Land information dependability	0.13	(0.13, 0.22, 0.17, 0.18, 0.10, 0.07, 0.13)	
CSF 7		Land information objectivity	0.14	(0.05, 0.15, 0.22, 0.25, 0.08, 0.11, 0.14)	
CSF 9		Information process transparency	0.14	(0.13, 0.17, 0.11, 0.13, 0.14, 0.13, 0.20)	
CSF 10		Information availability	0.13	(0.11, 0.14, 0.15, 0.30, 0.10, 0.09, 0.11)	
CSF 11	3. Land information management community engagement and sustainability factors	Sustainable land information management advocacy and awareness	0.27	(0.03, 0.04, 0.18, 0.22, 0.31, 0.10, 0.11)	(0.08, 0.07, 0.20, 0.22, 0.22, 0.11, 0.10)
				(0.10, 0.06, 0.21, 0.20, 0.19, 0.15, 0.09)	
CSF 12		Partnership amongst stakeholders	0.25	(0.08, 0.10, 0.20, 0.19, 0.27, 0.07, 0.10)	
CSF 16		Data processing resources, technological improvement and advancement	0.24	(0.10, 0.08, 0.22, 0.26, 0.12, 0.13, 0.08)	
CSF 18		Stakeholders' support for sustainable land information management	0.24		
CSF 2	4. Land information management security and integrity factors	Information security	0.32	(0.10, 0.13, 0.12, 0.22, 0.13, 0.21, 0.09)	(0.07, 0.13, 0.14, 0.16, 0.13, 0.22, 0.16
CSF 25		Comprehensiveness in terms of spatial coverage and content.	0.27	(0.05, 0.30, 0.24, 0.25, 0.06, 0.06, 0.06)	
				(0.05, 0.03, 0.08, 0.05, 0.17, 0.33, 0.29)	
CSF 26		Land information must be accurate with little or no mistakes.	0.41		
CSF 19	5. Land information	Financial management	0.32	(0.09, 0.20, 0.19, 0.21, 0.11, 0.09, 0.10)	(0.13,0.14,0.14, 0.19, 0.13, 0.18, 0.09)
CSF 20		Favourable investment environment	0.31	(0.16, 0.14, 0.13, 0.26, 0.14, 0.09, 0.09)	

CSF Code	Factor Group	Factor Label	Weighting	CSF Membership functions Level 2	Level 1
CSF 29	management transparent and fiscal factors	Free of bias in which case there is no modification or alteration to influence the receivers.	0.37	(0.14, 0.09, 0.10, 0.11, 0.15, 0.33, 0.08)	
CSF 8	6. Land information management productive ambiance factors	Land information usefulness	0.52	(0.11, 0.11, 0.12, 0.35, 0.13, 0.10, 0.08)	(0.11,0.17,0.15, 0.27, 0.13, 0.08, 0.08)
CSF 17		Quality work environment	0.48	(0.10, 0.23, 0.18, 0.19, 0.14, 0.06, 0.09)	
CSF 15	7. Land information management learning development factors	Training and reskilling	1.00	(0.12, 0.05, 0.25, 0.33, 0.15, 0.07, 0.03)	(0.12, 0.05, 0.25, 0.33, 0.15, 0.07, 0.03)
CSF 13	8. Land information management uniformity implementation factors	Information Standardisation	1.00	(0.11, 0.12, 0.17, 0.16, 0.28, 0.06, 0.11)	(0.11, 0.12, 0.17, 0.16, 0.28, 0.06, 0.11)
CSF 14	9. Land information management relevancy factors	End User Involvement	0.28	(0.09, 0.20, 0.19, 0.28, 0.06, 0.08, 0.10)	(0.08,0.14,0.10, 0.18, 0.12, 0.28, 0.11)
CSF 27		It must be current and free of ambiguity to meet the needs of users.	0.36	(0.09, 0.13, 0.05, 0.14, 0.13, 0.34, 0.13)	
CSF 28		Users must receive the same answer to the same question.	0.36	(0.07, 0.11, 0.07, 0.13, 0.15, 0.38, 0.10)	

Source: Analysis of field survey 2024

Table 7 details the critical success factor grouping index for the sustainable interoperable land information management system in Ondo state. The fuzzy synthetic evaluation revealed that Critical success factor component group 4 which is “Land information management security and integrity factors” has the highest index of 4.48 and the highest coefficient of 0.1217 among the nine (9) underlying groups. This is closely followed by Land information management relevancy factors (component 9) with an index of 4.43 and a coefficient of 0.1203. Land information management performance driver factors (component 1) ranked 3rd with an index of 4.33 and a coefficient of 0.1176. Land information management community engagement and sustainability factors (component 3) ranked 4th with an index value of 4.16 and a coefficient of 0.1130. Land information management quality assurance factors (component 2) ranked 5th with an index value of 4.10 and a coefficient of 0.1114. Land information management uniformity implementation factors (component 8) ranked 6th with an index value of 4.03 and a coefficient of 0.1095. Land information management transparent and fiscal factors (component 5) ranked 7th with an index value of 3.95 and a coefficient of 0.1073. Two component groups namely Land information management productive ambiance factors (component 6) and Land information management learning development factors (component 8) ranked least with an index value of 3.67 each and a coefficient of 0.0997 accordingly.

The findings indicate that land information management security and integrity factors are the most critical determinants of a sustainable interoperable land information management system, emphasizing the foundational role of data security, integrity, confidentiality, and protection against unauthorized access. Stakeholders perceive these safeguards as prerequisites for system interoperability and long-term sustainability. Land information management relevancy factors ranked second, underscoring the importance of contextually relevant, up-to-date, and user-oriented information that supports policy formulation, planning, and decision-making. This highlights stakeholders’ preference for functional usefulness over mere technological sophistication. The ranking of performance driver factors in third position reflects concerns about operational efficiency, system responsiveness, institutional capacity, and service delivery improvements. Community engagement and sustainability factors, ranked fourth, demonstrate recognition of stakeholder participation and institutional support as important, albeit secondary, to technical and functional priorities. The fifth-ranked quality assurance factors highlight the role of standards, validation, and data consistency in supporting trust and interoperability, though their lower ranking suggests an assumption that quality improves once core security and performance mechanisms are established. Moderate emphasis was placed on uniformity implementation factors, indicating that harmonization of standards and procedures is important but often subordinated to practical system performance in contexts characterized by institutional diversity and legacy systems. Transparency and fiscal factors, ranked seventh, were perceived as less immediate drivers of success, possibly reflecting contextual priorities where operational effectiveness outweighs financial and transparency considerations. Finally, productive ambiance and learning development factors ranked lowest, suggesting that organizational culture, training, and continuous learning are viewed as supportive rather than core success drivers, despite their relevance for long-term system adaptability and capacity building.

The success index for a sustainable interoperable land information management system in Ondo state is therefore expressed using the following equation:

CSF for SILIMS = 0.1217 (Land information management security and integrity factors) + 0.1203 (Land information management relevancy factors)

+ 0.1176 (Land information management performance driver factors) + 0.1130 (Land information management community engagement and sustainability factors) + 0.1114 (Land information management quality assurance factors) + 0.1095 (Land information management uniformity implementation factors) + 0.1073 (Land information management transparent and fiscal factors) + 0.0997 (Land information management productive ambiance factors) + 0.0997 (Land information management learning development factors).

Conclusion and Recommendation

Land information to a very large extent, is integral to real estate investment decisions. Its availability or otherwise has continually bothered all stakeholders of the land market. A large emphasis should be placed on making land information sustainable and interoperable. Decision making in land, urban or built-up areas management and planning policies requires a sustainable and interoperable land information. Therefore, a deep understanding of the critical success factors is crucial to the success of a sustainable interoperable land information management systems in developing countries such as Nigeria. Owing to the varieties of information scattered among the stakeholders of the land market, there is a need for the players of the land market to harmonise all land information to create an encompassing and robust land information management system that is sustainable and interoperable. In view of this, the land market stakeholders should ensure that the critical success factors for sustainable interoperable and information management systems be included in the road map for the development of a sustainable interoperable land information management systems.

Table 7: CSF grouping index order for SILIMS in Ondo State

CSF grouping	Group Name	Index	Coefficient	Rank
4	Land information management security and integrity factors	4.48	0.1217	1
9	Land information management relevancy factors	4.43	0.1203	2
1	Land information management performance driver factors	4.33	0.1176	3
3	Land information management community engagement and sustainability factors	4.16	0.1130	4
2	Land information management quality assurance factors	4.10	0.1114	5
8	Land information management uniformity implementation factors	4.03	0.1095	6
5	Land information management transparent and fiscal factors	3.95	0.1073	7
6	Land information management productive ambiance factors	3.67	0.0997	8
7	Land information management learning development factors	3.67	0.0997	8
			1.000	

**coefficient= (criterion index/sum of indices of all criteria)*
Source: Analysis of field survey 2024

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