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Research Article

Assessment of Causes of Delays in the Road Construction Projects in the Benin Republic Using Fuzzy PIPRECIA Method

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Purpose. The purpose of this study is to examine the causes of delays in road construction projects in the Benin Republic from the consultant, client, and contractor perspectives. *Design/Methodology/Approach*. Through construction project reports, 20 factors that could cause delays in road construction projects were identified. The factors were arranged into a questionnaire, which was distributed to three separate experts. The fuzzy PIPRECIA (PIvot Pairwise RElative Criteria Relevance Assessment) method was used to calculate the independent importance of each delay factor. The Spearman and Pearson correlation coefficients were used to test the method's consistency. *Findings*. The top five road construction project delays in the Benin Republic, according to the analysis of the 20 factors considered, are project funding, slowness during the client-endorsed payment process, scarcity of professional personnel, delay in indemnifying reimbursement (land-owners), and price escalation. This shows that of the various types of delays, the financial delay group is the most crucial. Originality/value. This study evaluates the causes of delays in road construction projects in the Benin Republic for the first time in literature. This study also examined the top 5 delay factors in road construction projects. This study is based on reports from road construction projects and a performed questionnaire survey. Based on the findings, measures have been formulated to aid project managers to alleviate the road construction delays in the Benin Republic. In addition, this study is practical for both scholars and road construction parties and provides a complete and verifiable analysis of the progress of a road construction project to make it easier and attain a competitive level of time, cost, and quality for successful road construction.

1. Introduction

Delays during the construction of infrastructure projects are universally considered to be perpetual. Numerous documents have noted the substantial delays in road construction in less developed countries. For instance, Kaliba et al. [1] noted delays in road construction in Zambia of around 227 percent of the initial timeline while in Ghana delays had climbed to 240 percent [2]. Considering road projects, especially mainly new ones can comprise a major portion of national investment budgets; considerable delays may result in serious political and economic implications. Although Benin Republic committed more of its gross domestic product (GDP) to public investment in comparison to other countries of the West African Economic and Monetary Union (WAEMU) from 1990 to 2015, its public investment is more unstable (https://www.elibrary.imf.org/view/journals/002/2020/028/article-A001-en.xml). Political leaders, on the other hand, have decided to reveal the country through a large-scale transformational investment. Eight large-scale projects worth a total of € 2,802 billion were initiated as part of the government's action plan 2016–2021, including an approximately 1,300-kilometer road network extension (https://beninrevele.bj/en/programme-dactions/programme/infrastructure/).

Despite their severity, the fundamental delay parameters for road construction persist, mostly resulting in economic losses and costly litigation plans of action between contractors and customers [3]. The first step in avoiding litigation is to identify potential delays as early as possible throughout the project and then to address them. According to Derakhshanfar et al. [4] and Xenidis and Stavrakas [5], improper risk management is the primary cause of budget and time overruns. As a result, clients' and contractors' reputations are universally worsening. These negative consequences persist in the absence of effective risk management.

According to Derakhshanfar et al. [4], the investigation into construction delay factors began in 1985, with 1 to 3 publications published annually until 2006, and 4 to 7 after that, with roughly 18 published in 2017. Three similar types of research released in 2020 did a meta-analytical review, claiming to discover a comprehensive reason for the delay in the construction industry [6–8]. Through 47 study articles, Viles et al. [6] identified 1057 different reasons for delays. The major steps provided in each publication were systematized, and a new significant measure was created, which was then statistically researched to generate a list of 35 delay factors, which were then categorized. Durdyev and Hosseini [8] looked at a list of 123 research publications published in over 25 scholarly journals. Since 1985, a list of 149 delay variables has been examined based on 97 research papers that met their study criteria.

Although Sanni-Anibire et al. [7] identified 93 research papers, only 11 matched their study requirements and were included in their meta-analysis. In total, 36 universal delay reasons were identified, and their relative importance indices (RIIs) were used to compare them. Furthermore, they analyzed research based on geographical zones as well as construction project types as part of their analysis. Only five studies were found working on determining delay factors in Oceania, Europe, and North and South America, whereas 9 articles dealt with the subject in Africa and 25 in Asia. These findings follow those of Viles et al. [6], who discovered that over 80% of all research was conducted in Africa and Asia, as well as Durdyev and Hosseini [8] findings that scientists from less developed countries have spent the most time researching the causes of construction delays. This could indicate that answers to planning and delay issues have been established to a satisfactory degree in advanced countries and are no longer worthy of further investigation. Nonetheless, as Sanni-Anibire, Mohamad et al. [7] have demonstrated the causes of delay could be project-specific and location/country-specific, thus explaining country-specific study investigations.

The majority of the publications discovered in Africa were about the investigation of delay factors (see Table 1). Other studies on the duration of road construction projects were conducted, but they focused on risk assessment [11], cost escalation analysis [14], and cost overrun analysis [17, 18]. Most scholars have approved the formulation of a category of probable fundamental construction delay parameters and their subsequent classification according to the recognized project influence and several occurrences as a viable methodology to identify expected delays and provide alleviation instruction, as discovered by previous studies [1–3, 9–18]. As a result, all thirteen papers take into account the conclusions of essential road project delay reasons based on questionnaire surveys. Accordingly, their conclusions are based on expert judgment rather than the current examination of established delay reasons that occur in real projects and are unrelated to the project's characteristics.

As a result, the following question arises: do the plethora of key parameters that cause project delays as determined by expert judgment occur frequently in real projects? The word "regularly" is crucial. All parameters estimated in the literature occurred at some point because they were linked to the expert's own experience. The effects of established road construction delay parameters were examined using a variety of quantitative methodologies to help professionals make better decisions about how to deal with the risks. These comprise the RII [1–3, 9, 13]; the statistical model [10, 16, 18]; and the regression [11].

Other studies that addressed the delay factor analysis using the RII with either statistical model or Spearman's rank correlation comprise Kassa [14] who conducted the causes of infrastructure project delays and cost escalation in the federal road construction in Ethiopia, Kamanga and Steyn [12] who identified the causes of delay in completing a road construction project in Malawi, and Atibu [15] who investigated the factors producing a delay in road projects in Kenya. On the other hand, to enhance the managing system in the construction sector, Alinaitwe et al. [17] applied frequency, severity, and importance indexes values to evaluate and classify the reasons of delays and overruns in construction projects in Uganda.

Surprisingly, none of the studies cited above recommended the application of multicriteria decision-making (MCDM), that is, the fuzzy PIPRECIA created by Stević et al. [19]. One of the most difficult challenges in construction is the process to make an objective choice [20]. Due to the complexity of the projects, the decision-making process can be time-consuming and difficult. Difficulties often happen at the stage of the criteria set criterion. As a result, Książek et al. [21] provided a set of relevant norms and mathematical methods that can significantly improve an impartially made judgment. These mathematical tools can be used to aid in the presentation of procedures, such as governmental megaprojects [22].

MCDM techniques are increasingly being used in the transportation industry in conjunction with decision-making, resulting in several benefits [23–30]. The majority of the peer-reviewed research relates to the application of decision-making based on the road transportation, with the remainder covering intermodal, air, and rail transportation. In general, two types of decision-making approaches are used to address transportation difficulties [31]: determining issues with a discrete set of options or selecting from a continuous range of possibilities. Saaty [32] established the analytical hierarchy process (AHP), which is the most commonly utilized decision-making approach in the transportation sector [33]. In a paper by Razi et al. [34], the AHP technique was used to conduct a practical study of risk

TABLE 1: Literature review related to the delays of road construction projects.

Authors	Year	Scope	Source of data	Sample	Method	Country	Area	No DF/IV
Rachid et al. [9]	2019	DFA	Data collection, questionnaire	16 owners, 16 contractors, and 20 consultants	RII	Algeria	Africa	59
Aziz and Abdel-Hakam [3]	2016	DFA	Questionnaire	500 construction participants	RII	Egypt	Africa	293
Amoatey and Ankrah [2]	2017	DFA	Data collection, questionnaire	48 road projects and 123 questionnaires	RII	Ghana	Africa	23
Alfakhri et al. [10]	2017	DFA	Data collection, questionnaire	31 engineers (owners, contractors, and consultants)	Statistical model	Libya	Africa	59
Leo-Olagbaye and Odeyinka [11]	2020	RA	Questionnaire	146 stakeholders, 40 road projects	Regression	Nigeria	Africa	
Kamanga and Steyn [12]	2013	DFA	Questionnaire	Client, contractor, and consultant	RII, Spearman's rank correlation	Malawi	Africa	72
Khair et al. [13]	2018	DFA	Questionnaire	Group of experts and professionals	RII	Sudan	Africa	66
Kaliba et al. [1]	2009	DFA	Questionnaire	26 questionnaires	RII	Zambia	Africa	14
Kassa [14]	2020	DFA, CEA	Questionnaire, data collection	65 client agencies, 23 contractors, and 10 consultants	RII, statistical model, Excel	Ethiopia	Africa	-
Atibu [15]	2015	DFA	Questionnaire	15 consultants and 16 contractors	RII, Spearman's rank correlation	Kenya	Africa	141
Ezeldin and Abdel-Ghany [16]	2013	DFA	Questionnaire	10 practitioners, 35 professional experts (contractor, employer, and consultant)	Statistical analysis	Egypt	Africa	31
Alinaitwe et al. [17]	2013	DFA, COA	Questionnaire	Civil Aviation authority	FI, SI, and IMPI	Uganda	Africa	22
Chileshe et al. [18]	2010	COA (cost overrun analysis)	51 questionnaires	4 consultants, 23 clients, and 7 contractors	Statistical analysis	Ghana	Africa	14
This study		DFA	Questionnaire report	One contractor, one consultant, one client	Fuzzy PIPRECIA (proposed method)	Benin Republic	Africa	20

Note. CEA = cost escalation analysis, COA = cost overrun analysis, DFA = delay factor analysis, FI = frequency index, IMPI = importance index, RA = risk assessment, RII = relative importance index, and SI = severity index.

evaluation for an ordinary road construction project in Malaysia. Table 2 depicts the application of MCDM techniques in road construction.

The National Government of Benin (NGB) has worked tirelessly to provide a reliable transportation infrastructure. This can be seen in various programmes started by political leaders, as noted by Boko-haya et al. [54], as well as in the priority of additional money for the road sector over the railway sector [55–58]. Nonetheless, the quality of roads varies from province to province, which is insufficient to meet the 2025 Agenda targets for sustainable development. President Patrice Talon's administration launched a five-year Government Action Programme (2016–2021) in 2016 to improve Benin's infrastructure, logistics, and trade. This scheme was revised and reapproved in 2021, during his second term. The programme planned to update the road network around Cotonou's port, build a bypass in the north of Cotonou, develop the Route des Pêches (Phase 2), construct a highway between Sèmè-Kpodji and Porto-Novo, develop the Djougou-Pehunco-Kerou-Banikoara route, and extend the road network by 1, 236 km. As a result of this government effort, every region of the country is being built, at an increasing rate (https://www.24haubenin.info/?Les-chantiers-reprennent-sous-Talon-2).

However, a recent assessment on the completion of these projects revealed a significant delay, which impedes the country's road infrastructure development and, as a result, economic growth. While there is substantial literature on the diagnosis of road construction delay factors in many African countries, the same cannot be stated for the Benin Republic. As a result, using Scopus, Web of Science (WoS), and Google Scholar, keywords such as "delay factors in construction" or "construction delays" or "causes of delays" and "roads" or "highways" and "Benin" or "Benin Republic" and "Benin" or "Benin Republic" and "Benin" or "Benin Republic" were searched from 1990 to 2020, and not a single article precisely associated with the delay factor examination. As a result, the study's objectives were to examine the causes of delays in road construction projects in the Benin Republic and to propose applicable recommendations for considerably alleviating these issues.

The study's objectives are to document (i) the various groups of delay cause in executing road construction projects in the Benin Republic, (ii) the most significant delay group as well as the most significant causes of delay in road construction projects in the Benin Republic, and (iii) design and distribute a questionnaire survey to construction professionals to obtain their perceptions on the main causes of delay. As a result, the following three questions are addressed in this study: (*) what are the various types of delays in the execution of road construction projects in the Benin Republic? (**) What is the most significant group causing delays in the execution of road development projects in the Benin Republic? (***) What are the primary causes of road construction project delays in the Benin Republic? (***) What are construction professionals' assessments of the causes of delays in completing these projects on time?

The fuzzy PIPRECIA approach was employed in this investigation. It is a well-known method for determining the weights of criteria (factors) in MCDM situations. The benefits of the proposed approach are numerous: (i) it allows the evaluation of criteria without first sorting them by significance, (ii) group decision-making is also another advantage of this method, and (iii) it enables the reduction of uncertainty and subjectivity in a decision-making process. According to Stanković et al. [59] and Memiş et al. [60], the only applications of the fuzzy PIPRECIA for decision-making issues in the road sector were related to traffic risk analysis and road transport risk factors prioritization, respectively, and none referred to its use in the evaluation of delay causes in the road construction project. Subsequently, the method has been extensively used in different research areas such as green supplier selection [61], selection of the reach stackers [62], the business of passenger rail operators [63], railway traffic safety evaluation [64], evaluation of rapeseed varieties [65], the application of high-performance computing (HPC) analysis [66], safety degree assessment around the crossings of the railway [67], achievement of the business quality and durability [68], upgrade of the performance of logistics [69], and the strategic decision evaluation of the transportation corporation [70].

The application of the fuzzy PIPRECIA in the assessment of the causes of delays in road project construction is innovative in this work since it is the first time in the literature. Furthermore, this is the first study to look at the impact of delays in the country. This paper's contribution can be explained in a variety of ways. It initially proposes and uses a new way to evaluate the causes of delays in road construction projects rather than existing ones (RII, FI, SI, IMPI, statistical model, and regression). Furthermore, the weighting mechanism improves the process's reliability and consistency while reducing the ambiguity and subjectivity of human perception.

The study includes six components, in addition to the introduction. Section 2 describes the technique used in this study. The presentation of fuzzy scales for criterion evaluation as well as the various steps of the fuzzy PIPRECIA has been presented. The case study is covered in Section 3. Section 4 presents the findings and discussion of the examination of the causes of delays in the country's road development project. A sensitivity analysis, as reported in section 5, was used to validate the results. Section 6 depicts the plan formulation for mitigating delays in road construction projects. The seventh section contains the conclusions as well as some recommendations for future works.

2. Methodology

Figure 1 depicts the entire course of the investigation, which includes examining the causes of delays in the road construction project using a fuzzy PIPRECIA approach. The first stage of the initial phase was to recognize the need for research, followed by the identification of research challenges and objectives in the second step. The first phase of the study concludes with the development of a set of criteria for assessing delay causes in the road construction project. The formation of a decision-making group comprised a consultant, a client, and a contractor that is the first stage in the

Table 2: The studies related to the application of MCDM techniques on road transport.

Authors	Year	Country	Methods	Research topic
Wagale and Singh [35]	2019	India	ANFIS, FDM	Assessing socio-economic impacts of construction of rural roads
Phogat and Singh [36]	2013	India	AHP, SAW, DBM, PROMETHEE, ELECTRE	Selecting adequate equipment for construction of a hilly road
Hasnain et al. [37]	2018	Pakistan	ANP	Selecting contractor in road construction project
Yucelgazi and Yitmen [38]	2019	Europe, Middle East	ANP	Risk evaluation in transport infrastructure projects
Yücelgazi and Yitmen [39]	2020	Europe, Middle East	ANP	Prioritizing risk response on bridge projects
Mosalman et al. [40]	2019	Iran	Fuzzy logic	Determining time delay in road construction project
Badalpur and Nurbakhsh [41]	2019	Iran	WASPAS	Assessing negative influences of risks on the project
Zavadskas et al. [42]	2008	Worldwide	MADM	Evaluation of quality in bridge and road construction management
Khorasani et al. [43]	2012	Europe	Fuzzy TOPSIS, TOPSIS	Assessing road safety management
Kishore et al. [44]	2020	Iran	AHP, SAW	Selecting subcontractor in construction project
Paredes and Herrera [45]	2020	Worldwide	WRC, CBA, AHP	Teaching MCDM techniques applied in the road infrastructure projects
Antoniou [46]	2021	Greece	TOPSIS	Assessing delay risk in road projects
Sandra et al. [47]	2007	India	FMCDM	Prioritizing the pavement stretches
Talebi et al. [48]	2019	Iran	MCDM, AHP	Evaluating road network for tourism purposes
Nenadić [49]	2019	Bosnia and Herzegovina	FUCOM, WASPAS	Classifying dangerous sections of road
Taş and Çakır [50]	2021	Turkey	Fuzzy MARCOS	Analyzing road risk
Vrtagić et al. [51]	2021	Republic of Srpska	IMF SWARA	Classifying road sections
Liachovičius et al. [52]	2020	World	SAW, COPRAS, TOPSIS, EDAS, PROMETHEE	Evaluating asset-based road freight transport
Malik et al. [53]	2021	Malaysia	AHP, ENTROPY, VIKOR	Proposing a new roadside unit positioning framework

Note. AHP: analytical hierarchy process, ANFIS: adaptive neuro-fuzzy inference system, ANP: analytical network process, CBA: choosing by advantage, COPRAS: COmplex PRoportional Assessment, DBM: distance-based method, EDAS: evaluation based on Distance from Average Solution, ELECTRE: Elimination Et Choice Translating Reality, FDM: fuzzy Delphi method, FMCDM: fuzzy multicriteria decision-making, FUCOM: Full Consistency Method, MADM: multiattribute decision-making, MARCOS: Measurement Alternatives and Ranking according to the COmpromise Solution, PROMETHEE: preference ranking organization method, SAW: simple additive weights method, SWARA: stepwise weight assessment ratio analysis, WRC: weighting rating and calculating, TOPSIS: Technique for Order Preference by Similarity to Ideal Situation, and VIKOR: Vlsekriterijumska Optimizacija I Kompromisno Resenje.

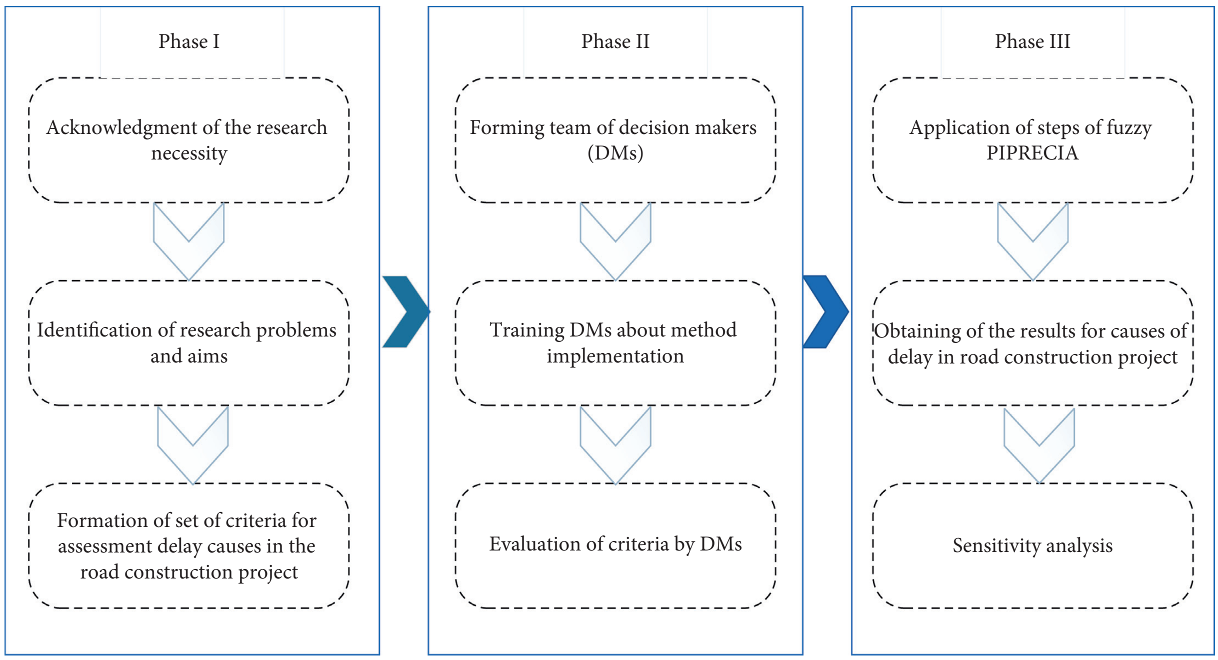

FIGURE 1: Proposed methodology of the research.

second phase. The second part of the second phase entails describing to the decision-makers how they used the method. The final step in this phase is to allow the decision-makers (DMs) to evaluate depending on their experience and preferences. The third phase begins with an analytical part that includes data processing and result calculations. Finally, the correlation coefficients were computed to do a sensitivity analysis.

The fuzzy PIPRECIA method comprises eleven steps as can be seen below:

Step 1. Establishing category criteria and classifying the criteria based on marks from the initial to the final, which suggests that they require to be sorted unspecified.

Step 2. Each decider separately assesses preclassified criteria by beginning from the second criterion, as can be shown in equation.

$$\overline{s_j^r} = \begin{cases} > \overline{1} & \text{if} \quad C_j > C_{j-1}, \\ = \overline{1} & \text{if} \quad C_j = C_{j-1}, \\ < \overline{1} & \text{if} \quad C_j < C_{j-1}, \end{cases} \tag{1}$$

$\overline{s_j^r}$ represents the evaluation of criteria by a decider r.

To get $\overline{S_j}$, the integration of the matrix $\overline{S_j^r}$ is important to be examined through the usage of the geometric mean. The criteria are assessed by the deciders through the application of scales explained in Tables 3 and 4.

When the criterion is of considerable significance concerning the preceding one, evaluation is made using Table 3 for scaling. To make easier the evaluation of the criteria by the decision-makers, the defuzzified value (DFV) for each comparison is shown in Table 3.

TABLE 3: Scale 1–2 for the assessment of criteria.

Linguistic scale		Fuzzy number				
			l	m	u	DFV
Almost equal value	Scales 1-2	1	1.000	1.000	1.050	1.008
Slightly more significant		2	1.100	1.150	1.200	1.150
Moderately more significant		3	1.200	1.300	1.350	1.292
More significant		4	1.300	1.450	1.500	1.433
Much more significant		5	1.400	1.600	1.650	1.575
Dominantly more significant		6	1.500	1.750	1.800	1.717
Absolutely more significant		7	1.600	1.900	1.950	1.858

When the criterion is of less significance in comparison to the preceding one, the evaluation is done using the scale in Table 4.

Step 3. Finding out the coefficient $\overline{k_j}$:

$$\overline{k_j} = \begin{cases} = \overline{1} & \text{if} \quad j = 1, \\ 2 - \overline{s_j} & \text{if} \quad j > 1. \end{cases} \tag{2}$$

Step 4. Finding out the fuzzy weight $\overline{q_j}$:

$$\overline{q_j} = \begin{cases} = \overline{1} & \text{if} \quad j = 1, \\ \dfrac{\overline{q_{j-1}}}{\overline{k_j}} & \text{if} \quad j > 1. \end{cases} \tag{3}$$

Table 4: Scale 0-1 for the assessment of criteria.

	Fuzzy number				Linguistic scale
	l	m	u	DFV	
Scale 0-1	0.667	1.000	1.000	0.944	Weakly less significant
	0.500	0.667	1.000	0.694	Moderately less significant
	0.400	0.500	0.667	0.511	Less significant
	0.333	0.400	0.500	0.406	Really less significant
	0.286	0.333	0.400	0.337	Much less significant
	0.250	0.286	0.333	0.288	Dominantly less significant
	0.222	0.250	0.286	0.251	Absolutely less significant

Step 5. Finding out the corresponding weight of the criterion $\overline{w_j}$:

$$\overline{w_j} = \frac{\overline{q_j}}{\sum_{j=1}^{n} \overline{q_j}}. \tag{4}$$

In the subsequent steps, the inverted methodology of the fuzzy PIPRECIA method requires to be implemented.

Step 6. Carrying out the evaluation but this time beginning from a final criterion.

$$\overline{s_j^r}' = \begin{cases} > \overline{1} & \text{if} \quad C_j > C_{j+1}, \\ = \overline{1} & \text{if} \quad C_j = C_{j+1}, \\ < \overline{1} & \text{if} \quad C_j < C_{j+1}. \end{cases} \tag{5}$$

Step 7. Finding out the coefficient $\overline{k_j}'$:

$$\overline{k_j}' = \begin{cases} = \overline{1} & \text{if} \quad j = n, \\ 2 - \overline{s_j}' & \text{if} \quad j > n. \end{cases} \tag{6}$$

Step 8. Finding out the fuzzy weight $\overline{q_j}'$:

$$\overline{q_j}' = \begin{cases} = \overline{1} & \text{if} \quad j = n, \\ \dfrac{\overline{q_{j+1}}'}{\overline{k_j}'} & \text{if} \quad j > n. \end{cases} \tag{7}$$

Step 9. Finding out the relative weight of the criterion $\overline{w_j}'$:

$$\overline{w_j}' = \frac{\overline{q_j}'}{\sum_{j=1}^{n} \overline{q_j}'}. \tag{8}$$

Step 10. To find out the final weights of criteria, it is essentially required to carry out the defuzzification of the fuzzy values $\overline{w_j}$ and $\overline{w_j}'$:

$$\overline{w_j}' = \frac{1}{2}\left(w_j + w_j{}'\right). \tag{9}$$

Step 11. Examining the results acquired by using the Spearman and Pearson correlation coefficients.

3. Case Study

3.1. The Road Transport System in the Benin Republic. The Republic of Benin has a relatively well-developed network with a total length of 15,500 km, of which 8,300 km are classified, and 2,100 km are paved [71]. Figure 2 shows Benin's Republic classified road density of 75 km/100 km^2 of the land area as it is the highest in the subregion and comparable to the average of 88 km/100 km^2 for low-income countries. The road development index (RDI), which indicates how well the population is served, is 0.26 for the classified network. Its classified network comprises four main corridors (Figure 2), as can be seen below.

(i) A coastal highway from Lagos to Lomé via Cotonou;

(ii) two north-south corridors from Burkina-Faso border to Cotonou via Porga-Djougou-Savalou and from Niger border to Cotonou via Malanville-Parakou; and

(iii) a transverse road from Nigerian border to Togo border via Chicandou, Nikki, and Djougou.

3.2. Data Collection Methodology. The questionnaire created for use in the survey included 20 delay causes identified in road construction project reports and classified into four categories (see Table 5). A questionnaire survey was prepared for data collection and distributed to three decision-makers representing the engineer working at the Benin Republic's road transport general directorate (client institution), a consultant who has been inspecting road works, and a contractor who has been engaged in road projects under the road transport general directorate. Because of their professional experience, all three individuals have higher positions (at least over ten years).

3.3. Defining Delays Groups and Causes. Construction plays a critical role in economic growth in West Africa in general and in the Benin Republic in particular. However, due to some delays, infrastructure projects, particularly highways, cannot be completed on time. As shown in Table 5, there are four types of delays: construction-related, managerial-related, financial-related, and technical-related, each with five different types of delays.

The process of constructing something is known as construction. There are three types of construction requirements: prescriptive, performance, and proprietary. The

Figure 2: Road network in the Benin Republic.

construction group consists of five subcriteria, of which low labor and equipment productivity (C1) and insufficient equipment (C2) are of the beneficial type (B), whereas delays in relocating utilities (C3), varying or unexpected geotechnical conditions during construction (C4), and the effect of rain on construction activities (C5) are of the cost type (C).

The managerial group or management directs or supervises an organization or a group of people. It is the plan and execution of tasks to achieve a goal. This group contains five subcriteria, the work license (M4) being of the cost type, while the other subcriteria are of the advantageous type. Financial management is the process of managing money and accumulating necessary savings. It has five subcriteria, which are all of the cost types. Technical is the quality of acquiring extraordinary and broadly applicable knowledge, particularly in scientific and mechanical fields. It has five subcriteria, of which the cost type is the persistent design changes requested by the client during construction (T1), misreading of drawings (T2), and reworks due to construction faults (T3). In contrast, a lack of technical personnel (T4) and the consultant's supervisory staff's unfamiliarity with or lack of information about new construction methods, materials, and procedures (T5) are of a beneficial type.

4. Assessment of Causes of Delay in the Road Construction Project in the Benin Republic by Using a Fuzzy PIPRECIA Method

A category of 20 subcriteria was formed in the first step, and fuzzy PIPRECIA is used to determine their weights. The main criteria, including construction (C), managerial (M), financial (F), and technical (T), are classified as in the CMFT matrix, not considering their importance. Additionally, in

Table 5: Main group of delays and their causes.

Main criteria	Subcriteria	Mark
Construction (C)	Low productivity of labor and equipment	C1
	Insufficient equipment	C2
	Delay in relocating utilities	C3
	Unpredicted geotechnical situation through the construction	C4
	Effect of rain on construction activities	C5
Managerial (M)	Shortage in the construction supervision and coordination	M1
	Inadequacy in planning and scheduling	M2
	Slowness in making the decision	M3
	Work license	M4
	Poor conversation and cooperation by the client and other parties	M5
Financial (F)	Price escalation	F1
	Challenges related to the funds of the projects	F2
	Slowness during the payment process endorsed by the client	F3
	Retard in indemnifying reimbursement (land-owners)	F4
	No financial motivation for contractors to complete the work before the due date	F5
Technical (T)	Persistent variation in design demanded by the client through the construction	T1
	Misconception of designs	T2
	Redraft due to mistake during the construction	T3
	Scarcity of professional personnel	T4
	Shortage of knowledge by the consultant's guidance staff related to new techniques, materials, and construction procedures	T5

this step, a group of three deciders was formed for the evaluation. In the second step, each decider separately evaluates the criteria, which characterizes the establishment of the four main criteria analyses.

4.1. Assessment of the Main Criteria. Tables 6 and 7 indicate the evaluation of the main criteria CMFT matrix for the method used and its inverse by three deciders and an average value (AV), which value is employed to assess additional computation.

According to the estimation of criteria and using equation (1), a matrix is established. Using (2), the subtraction of those values is done from number 2. Based on the rules of effectiveness on fuzzy numbers, the k_j matrix is gained in the following way:

$\overline{k_1} = (1.000,\ 1.000,\ 1.000)$

$\overline{k_2} = (2–1.350,\ 2–1.300,\ 2–1.200) = (0.650,\ 0.700,\ 0.800)$

$\overline{k_3} = (2–1.650,\ 2–1.600,\ 2–1.400) = (0.350,\ 0.400,\ 0.600)$

$\overline{k_4} = (2–0.800,\ 2–0.556,\ 2–0.429) = (1.200,\ 1.444,\ 1.571)$

Based on (3), the values of q_j are obtained as follows:

$\overline{q_1} = (1.000,\ 1.000,\ 1.000)$

$\overline{q_2} = (1.000/0.800,\quad 1.000/0.700,\quad 1.000/0.650) = (1.250,\ 1.429,\ 1.538)$

$\overline{q_3} = (1.250/0.600,\quad 1.429/0.400,\quad 1.538/0.350) = (2.083,\ 3.573,\ 4.394)$

$\overline{q_4} = (2.083/1.571,\quad 3.571/1.444,\quad 4.396/1.200) = (1.326,\ 2.473,\ 3.663)$

Using (4), the corresponding weights are computed as follows:

$\overline{w_1} = (1.000/10.597,\ 1.000/8.473,\ 1.000/5.659) = (0.094,\ 0.118,\ 0.117)$

$\overline{w_2} = (1.250/10.597,\ 1.429/8.473,\ 1.538/5.659) = (0.118,\ 0.169,\ 0.272)$

$\overline{w_3} = (2.083/10.597,\ 3.571/8.473,\ 4.396/5.659) = (0.197,\ 0.422,\ 0.777)$

$\overline{w_4} = (1.326/10.597,\ 2.473/8.473,\ 3.663/5.659) = (0.125,\ 0.292,\ 0.647)$

Table 8 indicates the finalized antecedent calculation, and the defuzzified values of corresponding weights of criteria are shown in the last column.

To obtain the final weights of criteria, it is essential to use equations (5-9), particularly the inverse fuzzy PIPRECIA method. According to the evaluation conducted by the deciders and using an average value (AV), the obtainment of $s_{j'}$ is done:

$s_{1'} = (0.411,\ 0.522,\ 0.722)$

$s_{2'} = (0.290,\ 0.340,\ 0.411)$

$s_{3'} = (1.200,\ 1.300,\ 1.350)$

The coming values are got through the usage of (7):

$q_{4'} = (1.000,\ 1.000,\ 1.000)$

$q_{3'} = (1.000/0.800, 1.000/0.700, 1.000/0.650) = (1.250,\ 1.429,\ 1.538)$

$q_{2'} = (1.250/1.710, 1.429/1.660, 1.538/1.589) = (0.731,\ 0.860,\ 0.968)$

$q_{1'} = (0.731/1.589, 0.860/1.478, 0.968/1.278) = (0.460,\ 0.582,\ 0.758)$

Next, it is indispensable to use equation (8) to get the corresponding weights for the fuzzy inverse PIPRECIA approach:

Table 6: Assessment of the main criteria by three deciders for the fuzzy PIPRECIA method.

PIPR.	C	M			F			T		
DM1		1.100	1.150	1.200	1.300	1.450	1.500	0.500	0.667	1.000
DM2		1.200	1.300	1.350	1.400	1.600	1.650	0.500	0.667	1.000
DM3		1.300	1.450	1.500	1.500	1.750	1.800	0.286	0.333	0.400
AV		1.200	1.300	1.350	1.400	1.600	1.650	0.429	0.556	0.800

Table 7: Assessment of the main criteria by three deciders for the inverse fuzzy PIPRECIA method.

PIPR.	T	F			M			C		
DM1		1.100	1.150	1.200	0.333	0.400	0.500	0.500	0.667	1.000
DM2		1.100	1.150	1.200	0.286	0.333	0.400	0.400	0.500	0.667
DM3		1.400	1.600	1.650	0.250	0.286	0.333	0.333	0.400	0.500
AV		1.200	1.300	1. 350	0.290	0.340	0.411	0.411	0.522	0.722

Table 8: Computation and results of fuzzy PIPRECIA for the main criteria.

P.	s_j			k_j			q_j			w_j			Df
C				1.000	1.000	1.000	1.000	1.000	1.000	0.094,	0.118	0.117	0.124
M	1.200	1.300	1.350	0.650,	0.700	0.800	1.250	1.429	1.538	0.118	0.169	0.272	0.177
F	1.400	1.600	1.650	0.350,	0.400	0.600	2.083	3.573	4.394	0.197	0.422	0.777	0.443
T	0.429	0.556	0.800	1.200	1.444	1.571	1.326	2.473	3.663	0.125	0.292	0.647	0.323
SU							5.659	8.473	10.597				

Note. P stands for PIPRECIA; SU stands for SUM.

$w_{4'} = (1.000/4.264, 1.000/3.871, 1.000/3.441) = (0.234, 0.258, 0.291)$

$w_{3'} = (1.250/4.264, 1.429/3.871, 1.538/3.441) = (0.293, 0.369, 0.447)$

$w_{2'} = (0.731/4.264, 0.860/3.871, 0.968/3.441) = (0.171, 0.222, 0.281)$

$w_{1'} = (0.460/4.264, 0.582/3.871, 0.758/3.441) = (0.108, 0.150, 0.220)$

Using (9), the final weights of the criteria are done. Before the application of this equation, it is of great importance to carry out the defuzzification of the values of criteria got through equations (1)–(9):

$$w_{1''} = 0.124 + 0.155/2 = 0.139$$

$$w_{2''} = 0.177 + 0.224/2 = 0.201$$

$$w_{3''} = 0.443 + 0.369/2 = 0.406$$

$$w_{4''} = 0.323 + 0.260/2 = 0.292$$

4.2. Assessment of the Causes of Delay Related to the Four Groups of Delays. The computation of components of all CMFT matrix categories was carried out identically. Tables 9–16 indicate computations and outcomes for all elements of the CMFT matrix. The weights of the construction criteria elements are as follows: $w_{1''} = 0.190$, $w_{2''} = 0.256$, $w_{3''} = 0.236$, $w_{4''} = 0.165$, and $w_{5''} = 0.181$.

The weights of the managerial criteria elements are as follows: $w_{1''} = 0.221$, $w_{2''} = 0.253$, $w_{3''} = 0.202$, $w_{4''} = 0.179$, and $w_{5''} = 0.166$.

The weights of the financial criteria elements are as follows: $w_{1''} = 0.186$, $w_{2''} = 0.266$, $w_{3''} = 0.218$, $w_{4''} = 0.198$, and $w_{5''} = 0.159$.

The weights of the technical criteria elements are as follows: $w_{1''} = 0.170$, $w_{2''} = 0.178$, $w_{3''} = 0.193$, $w_{4''} = 0.292$, and $w_{5''} = 0.195$.

5. Sensitivity Analysis and Discussion of Results

The estimation of Spearman coefficient correlation for the classification obtained by the fuzzy PIPRECIA method and its inverse fuzzy variant was used in the sensitivity analysis. A Pearson correlation coefficient was also determined for the derived weights of CMFT matrix components from both variants of the developed approach. Tables 17 to 21 show the classification as well as the correlation coefficients.

As shown in Table 17, the most significant group of delays is related to the financial aspect, with a value of 0.406. Five subcriteria linked with the financial delay group have been identified and can be resolved by allocating sufficient funds to the project, controlling price escalation, accelerating indemnity of reimbursement, and making the payment procedure supported by the client very quickly. The construction category is the least important source of delay. Furthermore, Table 17 shows the classifications that are identical when applying the fuzzy PIPRECIA and inverse fuzzy PIPRECIA techniques, indicating that the classifications have a complete correlation (SCC = 1.000). The Pearson correlation coefficient of 0.967 validated the higher reliability of the data obtained.

The study looked at five subfactors in the construction delay category, with the second being the most important, which is insufficient equipment (Table 18). Our findings are consistent with previous studies by Al-Najjar [72] and Mahamid, Bruland, and Dmaidi [73], which conclude that a lack of equipment is one of the most significant factors

Table 9: Assessment of construction delay causes by three deciders for the fuzzy PIPRECIA and inverse fuzzy PIPRECIA.

PIPR.	C1		C2			C3			C4			C5	
DM1		1.300	1.450	1.500	0.667	1.000	1.000	0.333	0.400	0.500	1.000	1.000	1.050
DM2		1.100	1.150	1.200	0.667	1.000	1.000	0.500	0.667	1.000	0.500	0.667	1.000
DM3		1.100	1.150	1.200	0.500	0.667	1.000	0.400	0.500	0.667	1.300	1.450	1.500
AV		1.167	1.250	1.300	0.611	0.889	1.000	0.411	0.522	0.722	0.933	1.039	1.183
PIPR-I	C5		C4			C3			C2			C1	
DM1		0.667	1.000	1.000	1.300	1.450	1.500	1.000	1.000	1.050	0.333	0.400	0.500
DM2		1.200	1.300	1.350	1.100	1.150	1.200	1.000	1.000	1.050	0.500	0.667	1.000
DM3		0.333	0.400	0.500	1.200	1.300	1.350	1.100	1.150	1.200	0.500	0.667	1.000
AV		0.733	0.900	0.950	1.200	1.300	1.350	1.033	1.050	1.100	0.444	0.578	0.833

Table 10: Computation and results of the utilization of fuzzy PIPRECIA and inverse fuzzy PIPRECIA for construction delay causes.

PIPRECIA		s_j			k_j			q_j			w_j		Df
C1	1.167	1.250	1.300	1.000	1.000	1.000	1.000	1.000	1.000	0.158	0.193	0.243	0.195
C2	0.611	0.889	1.000	0.700	0.750	0.833	1.200	1.333	1.429	0.189	0.257	0.347	0.261
C3	0.411	0.522	0.722	1.000	1.111	1.389	0.864	1.200	1.429	0.136	0.231	0.347	0.235
C4	0.933	1.039	1.183	1.278	1.478	1.589	0.544	0.812	1.118	0.086	0.156	0.272	0.164
C5				0.817	0.961	1.067	0.510	0.845	1.369	0.080	0.163	0.332	0.177
SUM							4.118	5.190	6.344				
PIPRECI-I		$s_{j'}$			$k_{j'}$			$q_{j'}$			$w_{j'}$		DF
C1	0.444	0.578	0.833	1.167	1.422	1.556	0.656	0.961	1.395	0.102	0.174	0.313	0.185
C2	1.033	1.050	1.100	0.900	0.950	0.967	1.021	1.367	1.628	0.158	0.247	0.366	0.252
C3	1.200	1.300	1.350	0.650	0.700	0.800	0.987	1.299	1.465	0.153	0.235	0.329	0.237
C4	0.733	0.900	0.950	1.050	1.100	1.267	0.789	0.909	0.952	0.123	0.164	0.214	0.166
C5				1.000	1.000	1.000	1.000	1.000	1.000	0.155	0.181	0.225	0.184
SUM							4.453	5.536	6.441				

Table 11: Assessment of managerial delay causes by three deciders for the fuzzy PIPRECIA and inverse fuzzy PIPRECIA.

PIPR.	M1		M 2			M 3			M 4			M 5	
DM1		1.100	1.150	1.200	0.400	0.500	0.667	0.400	0.500	0.667	0.667	1.000	1.000
DM2		1.100	1.150	1.200	0.400	0.500	0.667	1.100	1.150	1.200	0.500	0.667	1.000
DM3		1.000	1.000	1.050	1.100	1.150	1.200	0.500	0.667	1.000	0.667	1.000	1.000
AV		1.067	1.100	1.150	0.633	0.717	0.844	0.667	0.772	0.956	0.611	0.889	1.000
PIPR-I	M 5		M 4			M 3			M 2			M 1	
DM1		1.000	1.000	1.050	1.200	1.300	1.350	1.200	1.300	1.350	0.500	0.667	1.000
DM2		1.100	1.150	1.200	0.500	0.667	1.000	1.200	1.300	1.350	0.500	0.667	1.000
DM3		1.000	1.000	1.050	1.100	1.150	1.200	0.667	1.000	1.000	0.667	1.000	1.000
AV		1.033	1.050	1.100	0.933	1.039	1.183	1.022	1.200	1.233	0.556	0.778	1.000

Table 12: Computation and results of the utilization of fuzzy PIPRECIA and inverse fuzzy PIPRECIA for managerial delay causes.

PIPRECIA		s_j			k_j			q_j			w_j		Df
M1				1.000	1.000	1.000	1.000	1.000	1.000	0.194	0.232	0.259	0.230
M 2	1.067	1.100	1.150	0.850	0.900	0.933	1.071	1.111	1.176	0.208	0.257	0.304	0.257
M 3	0.633	0.717	0.844	1.156	1.283	1.367	0.784	0.866	1.018	0.152	0.201	0.263	0.203
M 4	0.667	0.772	0.956	1.044	1.228	1.333	0.588	0.705	0.975	0.114	0.163	0.252	0.170
M 5	0.611	0.889	1.000	1.000	1.111	1.389	0.423	0.635	0.975	0.082	0.147	0.252	0.154
SUM							3.867	4.317	5.144				
PIPRECI-I		$s_{j'}$			$k_{j'}$			$q_{j'}$			$w_{j'}$		DF
M1	0.556	0.778	1.000	1.000	1.222	1.444	0.687	1.120	1.775	0.098	0.199	0.379	0.212
M 2	1.022	1.200	1.233	0.767	0.800	0.978	0.992	1.369	1.775	0.147	0.243	0.379	0.249
M 3	0.933	1.039	1.183	0.817	0.961	1.067	0.970	1.095	1.361	0.138	0.194	0.291	0.201
M 4	1.033	1.050	1.100	0.900	0.950	0.967	1.034	1.053	1.111	0.147	0.187	0.237	0.189
M 5				1.000	1.000	1.000	1.000	1.000	1.000	0.142	0.177	0.214	0.178
SUM							4.684	5.637	7.021				

Table 13: Assessment of financial delay causes by three deciders for the fuzzy PIPRECIA and inverse fuzzy PIPRECIA.

PIPR.	F1		F 2			F 3			F 4			F 5	
DM1		1.300	1.450	1.500	0.400	0.500	0.667	1.200	1.300	1.350	0.286	0.333	0.400
DM2		1.200	1.300	1.350	0.500	0.667	1.000	0.500	0.667	1.000	0.667	1.000	1.000
DM3		1.100	1.150	1.200	0.667	1.000	1.000	0.400	0.500	0.667	0.667	1.000	1.000
AV		1.200	1.300	1.350	0.522	0.722	0.889	0.700	0.822	1.006	0.540	0.778	0.800
PIPR-I	F 5		F 4			F 3			F 2			F 1	
DM1		1.400	1.600	1.650	0.500	0.667	1.000	1.200	1.300	1.350	0.333	0.400	0.500
DM2		1.000	1.000	1.050	1.100	1.150	1.200	1.100	1.150	1.200	0.400	0.500	0.667
DM3		1.000	1.000	1.050	1.200	1.300	1.350	1.000	1.000	1.050	0.500	0.667	1.000
AV		1.133	1.200	1.250	0.933	1.039	1.183	1.100	1.150	1.200	0.411	0.522	0.722

Table 14: Computation and results of the utilization of fuzzy PIPRECIA and inverse fuzzy PIPRECIA for financial delay causes.

PIPRECIA		s_j			k_j			q_j			w_j		Df
F1				1.000	1.000	1.000	1.000	1.000	1.000	0.154	0.190	0.239	0.192
F2	1.200	1.300	1.350	0.650	0.700	0.800	1.250	1.429	1.538	0.193	0.271	0.367	0.274
F3	0.522	0.722	0.889	1.111	1.278	1.478	0.846	1.118	1.385	0.131	0.212	0.330	0.218
F4	0.700	0.822	1.006	0.994	1.178	1.300	0.651	0.949	1.392	0.100	0.180	0.332	0.192
F5	0.540	0.778	0.800	1.200	1.222	1.460	0.446	0.777	1.160	0.069	0.147	0.277	0.156
SUM							4.192	5.273	6.476				
PIPRECI-I		$s_{j'}$			$k_{j'}$			$q_{j'}$			$w_{j'}$		DF
F1	0.411	0.522	0.722	1.278	1.478	1.589	0.756	1.035	1.597	0.999	0.169	0.308	0.181
F2	1.100	1.150	1.200	0.800	0.850	0.900	1.200	1.530	2.041	0.158	0.250	0.393	0.274
F3	0.933	1.039	1.183	0.817	0.961	1.067	1.082	1.301	1.633	0.142	0.213	0.314	0.218
F4	1.133	1.200	1.250	0.750	0.800	0.867	1.154	1.250	1.333	0.152	0.204	0.257	0.204
F5				1.000	1.000	1.000	1.000	1.000	1.000	0.132	0.164	0.193	0.163
SUM							5.194	6.116	7.064				

Table 15: Assessment of technical delay causes by three deciders for the fuzzy PIPRECIA and inverse fuzzy PIPRECIA.

PIPR.	T1		T2			T3			T4			T5	
DM1		1.100	1.150	1.200	1.000	1.000	1.050	1.300	1.450	1.500	0.286	0.333	0.400
DM2		0.667	1.000	1.000	1.100	1.150	1.200	1.100	1.150	1.200	0.400	0.500	0.667
DM3		0.667	1.000	1.000	1.000	1.000	1.050	1.300	1.450	1.500	0.500	0.667	1.000
AV		0.811	1.050	1.067	1.033	1.050	1.100	1.233	1.350	1.400	0.395	0.500	0.689
PIPR-I	T5		T4			T3			T2			T1	
DM1		1.400	1.600	1.650	0.333	0.400	0.500	0.667	1.000	1.000	0.500	0.667	1.000
DM2		1.200	1.300	1.350	0.500	0.667	1.000	0.500	0.667	1.000	1.000	1.000	1.050
DM3		1.100	1.150	1.200	0.333	0.400	0.500	0.667	1.000	1.000	1.000	1.000	1.050
AV		1.233	1.350	1.400	0.389	0.489	0.667	0.611	0.889	1.000	0.833	0.889	1.033

Table 16: Computation and results of the utilization of fuzzy PIPRECIA and inverse fuzzy PIPRECIA for technical delay causes.

PIPRECIA		s_j			k_j			q_j			w_j		Df
T1				1.000	1.000	1.000	1.000	1.000	1.000	0.148	0.167	0.220	0.172
T2	0.811	1.050	1.067	0.933	0.950	1.189	0.841	1.053	1.071	0.124	0.175	0.235	0.177
T3	1.033	1.050	1.100	0.900	0.950	0.967	0.870	1.108	1.190	0.129	0.185	0.261	0.188
T4	1.233	1.350	1.400	0.600	0.650	0.767	1.135	1.705	1.984	0.168	0.284	0.436	0.290
T5	0.395	0.500	0.689	1.311	1.500	1.605	0.707	1.136	1.513	0.105	0.189	0.332	0.199
SUM							4.553	6.002	6.759				
PIPRECI-I		$s_{j'}$			$k_{j'}$			$q_{j'}$			$w_{j'}$		DF
T1	0.833	0.889	1.033	0.967	1.111	1.167	0.500	0.825	1.293	0.077	0.156	0.308	0.168
T2	0.611	0.889	1.000	1.000	1.111	1.389	0.583	0.916	1.250	0.090	0.173	0.298	0.180
T3	0.389	0.489	0.667	1.333	1.511	1.611	0.810	1.018	1.250	0.125	0.192	0.298	0.199
T4	1.233	1.350	1.400	0.600	0.650	0.767	1.304	1.538	1.667	0.202	0.290	0.397	0.293
T5				1.000	1.000	1.000	1.000	1.000	1.000	0.155	0.189	0.238	0.191
SUM							4.196	5.298	6.460				

Table 17: Classification and weight values of the principal delay groups of CMFT matrix.

	Rank	Rank	d	d_2	I	II	w_j	
C	4	4	0	0	0.124	0.155	0.139	4
M	3	3	0	0	0.177	0.224	0.201	3
F	1	1	0	0	0.443	0.369	0.406	1
T	2	2	0	0	0.323	0.260	0.292	2
							SCC	1.000
							PCC	0.967

Table 18: Classification and weight values of construction delay group.

	Rank	Rank	d	d_2	I	II	w_j	
C1	3	3	0	0	0.195	0.185	0.190	3
C2	1	1	0	0	0.261	0.252	0.256	1
C3	2	2	0	0	0.235	0.237	0.236	2
C4	5	5	0	0	0.164	0.166	0.165	5
C5	4	4	0	0	0.177	0.184	0.181	4
							SCC	1.000
							PCC	0.985

Table 19: Classification and weight values of the managerial delay group.

	Rank	Rank	d	d_2	I	II	w_j	
M1	2	2	0	0	0.230	0.212	0.221	2
M2	1	1	0	0	0.257	0.249	0.253	1
M3	3	3	0	0	0.203	0.201	0.202	3
M4	4	4	0	0	0.170	0.189	0.179	4
M5	5	5	0	0	0.154	0.178	0.166	5
							SCC	1.000
							PCC	0.959

Table 20: Classification and weight values of the financial delay group.

	Rank	Rank	d	d_2	I	II	w_j	
F1	4	4	0	0	0.192	0.181	0.186	4
F2	1	1	0	0	0.274	0.259	0.266	1
F3	2	2	0	0	0.218	0.218	0.218	2
F4	3	3	0	0	0.192	0.204	0.198	3
F5	5	5	0	0	0.156	0.163	0.159	5
							SCC	1.000
							PCC	0.973

Table 21: Classification and weight values of the technical delay group.

	Rank	Rank	d	d_2	I	II	w_j	
T1	5	5	0	0	0.172	0.168	0.170	5
T2	4	4	0	0	0.177	0.180	0.178	4
T3	3	2	0	0	0.188	0.199	0.193	3
T4	1	1	0	0	0.290	0.293	0.292	1
T5	2	3	0	0	0.199	0.191	0.195	2
							SCC	0.900
							PCC	0.990

causing time delays in building construction projects in the Gaza Strip and road construction projects in the West Bank of Palestine, respectively. The unpredicted geotechnical situation during construction is the least prominent subcriteria in the construction delay category. A perfect correlation has been observed for the correlation coefficients relating to classifications, whereas a nearly complete correlation has been recorded for the weight elements.

Five subcriteria relating to the managerial group of delays were investigated. The most significant managerial delay factor is insufficiency in planning and scheduling (Table 19). Our findings are consistent with prior studies of Sambasivan and Soon [74] and Khalid [75], which identified improper scheduling/planning as one of the most major delay factors. The least significant managerial delay factor is poor communication and cooperation by the client and other partners. The correlation coefficients show a perfect correlation for the classification and a near-complete connection for the weight elements.

The financial category of delay includes five subcriteria, of which the problems associated with funding projects are the most significant (Table 20). Our findings are in agreement with previous studies by Bounthipphasert et al. [76] and Soliman [77] which put the financial concerns among the main factors driving road construction delays in Laos and Kuwait, respectively. The least dominant subcriteria remain a no financial motivation for contractors to complete the work. The correlation of classifications in the financial delay group is full with a value of 0.973 for the Pearson correlation coefficient.

The technical delay group comprises five elements of which the scarcity of professional personnel is the most significant delay subcriteria (Table 21). Our findings are in agreement with the study of Al-Kharashi and Skitmore [78], which showed that the most affecting delay causes remain the scarcity of experienced and qualified personnel regarding a significant quantity of immense, innovating construction projects and related present deficiencies of personnel in the industry in Saudi Arabia. The following two subcriteria comprising the shortage of knowledge by the consultant's guidance staff and the redraft due to mistakes during the construction are relatively close based on their weight calculation results. The same remark is observed with the last two subcriteria: the misconception of designs and the persistent variation in design demanded by the client. Concerning the classification correlations, it is not complete (SCC = 0.900) due to the variation in the classification of the third and the fifth elements that shift their places by employing fuzzy PIPRECIA and inverse fuzzy PIPRECIA approaches. Concerning weight correlation, it is higher than the correlation of classifications, and it is PCC = 0.990.

When considering full sensitivity analysis, the results acquired through the established model are assumed to be steady. The classifications within the established method and the values of weights elements are disposed to correspond completely. Table 22 indicates the accomplished integrated results of the fuzzy PIPRECIA method that describe the local and global importance of elements of each aspect separately and the global classifications of elements.

Table 22: Final results of the fuzzy PIPRECIA approach.

Category	Local value	Global value	Rank
Construction			
C1	0.190	0.028	18
C2	0.256	0.037	14
C3	0.236	0.034	17
C4	0.165	0.024	20
C5	0.181	0.027	19
Managerial			
M1	0.221	0.046	12
M2	0.253	0.053	11
M3	0.202	0.042	13
M4	0.179	0.037	15
M5	0.166	0.035	16
Financial			
F1	0.186	0.080	5
F2	0.266	0.115	1
F3	0.218	0.094	2
F4	0.198	0.086	4
F5	0.159	0.069	6
Technical			
T1	0.170	0.054	10
T2	0.178	0.056	9
T3	0.193	0.060	8
T4	0.292	0.091	3
T5	0.195	0.061	7

As previously stated, the study looked at 20 delay variables that were divided into four categories, with the financial delay category having the most important subfactors. The five most major causes of delays, according to Table 20, are the projects' financial issues, slowness during the client-endorsed payment procedure, scarcity of professional people, delay in indemnifying reimbursement (land-owners), and price escalation. As a result, the formulation of strategies to mitigate delays in road construction projects in the Benin Republic is necessary.

6. Strategy Formulation to Mitigate Delay in Road Construction Projects

Based on the findings, this study showed the saying, "More wisdom exists in an older person than in an intelligent one," implying that using construction professionals is a step that the construction industry could take to avoid the most common causes of delays in road construction projects. Their knowledge and understanding of the building sector, as well as their competence, will help them achieve their goals quickly. Following an examination of the study's findings, the following solutions have been developed to alleviate the causes of delays in road construction in the Benin Republic.

The lack of equipment is the biggest difficulty in road projects in African countries since contractors do not sufficiently analyze equipment for the construction during the procurement stage. Further investigations are also not performed to discover whether the equipment is dedicated to other contractor projects. Consequently, it is proposed that the inspectors or controllers monitor an appropriate examination of the undertaking equipment during the achievement time of the procurement phase.

Inadequate planning and operation during the construction project could lead to a variety of adverse project results. Due to scheduling constraints and construction delays, a successful adventure is turning into a defeat. As a result, effective project management and thorough pre-project planning should be performed to reduce or eliminate these delays as they are critical success factors for completing the construction project.

A project's proper guidance and work are based on a schedule, which is an important aspect of primarily employing available resources and labor. Extensive technical knowledge, the sequential order of building works, and an accurate rational relationship between the works and assets required for each activity are all essential in scheduling. Due to an ineffective project timetable, important project assets will be diverted to nonessential operations. As a result, key activities will be hampered, and delays will occur during the construction phase. To lessen or avoid scheduling challenges, the scheduler must have a strong technical understanding background that applies to the project. The scheduler should also be able to grasp the job's dimensions correctly.

According to the results of our research, the major financial-related causes of project delays are issues linked to project funding and delays during the payment procedure endorsed by the client. To reduce cash flow concerns for project clients, banks should provide end-financing. Banks should also speed up the delivery of loans to customers once all conditions have been met. In terms of payment, the client should make a timely payment to the main contractor. In terms of legislation, it should be updated to provide a clear understanding of the refund and payment processes for both clients and contractors.

Highly skilled resource persons are vital for the socioeconomic growth of a country, to which education is one of the primary elements. The shortage of professionals is identified to be the major technical-related cause leading to road project delays. Consequent supply of suitable education and professional training is important to enhance national capability and assist high-quality human resources with technical skills.

7. Conclusions

The fuzzy PIPRECIA approach is used in this study to examine the causes of delays in road construction projects in the Benin Republic. A total of 20 causes for delays were investigated, and they were divided into four categories: construction, managerial, financial, and technical. Three decision-makers are included in the survey. The findings revealed the top five reasons for road construction project delays in the Benin Republic, four of which are financial and one being technical. The most significant causes of delays in the construction, managerial, financial, and technical groups, respectively, are a lack of equipment, improper scheduling/planning, finding challenges, and a lack of experienced and competent staff.

The financial aspect is the most significant delay group, with a weight value of 0.406, followed by the technical aspect ($w = 0.292$), and the management aspect ($w = 0.201$), according to the classification and weight values of delay groups. With a score of 0.139, the construction category is the least significant among the delay groups. A sensitivity analysis based on the estimate of Spearman and Pearson coefficients was used to confirm the findings of this study. Given the detrimental consequences of delays in specific road construction projects, it is recommended that strategies based on the study's findings be developed to control and mitigate delays during the road construction project. These strategies can assist project managers in the Benin Republic in reducing road construction delays. Furthermore, this research is useful for both academic institutions and road construction practitioners since it enables efficient and detailed analysis of a road construction project's progress to facilitate and achieve a competitive level of time, cost, and quality for successful road construction.

This is the first study of its kind in the Benin Republic, involving the use of multicriteria decision-making to examine the causes of the delay. The implemented methodology demonstrated how the criteria were examined without first classifying them in order of critical importance and how subjectivity and uncertainty can be reduced in the decision-making process. As a result, the applied methodology may be useful in different decision-making scenarios. The method's greatest shortcoming is that researchers can only utilize the scales provided for the assessment and no others. In addition, for the entire procedure, including the steps of the fuzzy PIPRECIA and the inverse fuzzy PIPRECIA, fuzzy PIPRECIA necessitates a very exact assessment of decision-makers. In future studies, the adopted method can be applied to objective data to demonstrate and prove all of the approach's benefits. The study's shortcoming is that it only considers four types of delays and the perspectives of only three decision-makers: one consultant, one contractor, and one client. Other types, such as personnel and equipment, materials, projects, and externally connected delays, may be considered in future studies. In addition, the number of decision-makers needs to be increased. In terms of the methodology to be implemented, certain classic methodologies [79–85] or new newly established methods [86–97] can be used to assess the causes of the delay.

Data Availability

The data used to support the findings of this study are included within this article. However, more details on the data can be made available upon request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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