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Development of Analytic Hierarchy Process for Improving Information Management in Project Execution and Control in NDDC

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ABSTRACT

Efficiency in project execution and control depends upon many factors with effective information management in the various stages in project execution and control key for a successful project execution. The purpose of this study is to investigate the critical factors in improving information management in project execution using NDDC as a hub example. The study employed a Survey approach, with questionnaires designed to gather data about information systems usage and the attendant effects. Analytic Hierarchy Process (AHP) was applied on identified criteria. The Analytical Hierarchy Process (AHP) was used to identify which criteria are most relevant to improvement of information management in executing projects. A canonical correlation analysis was carry out to estimate the relationship of information systems usage to projects performance. The AHP gave a resulting weight of the criteria with Site Meetings having a priority value of 29.13% and emerged first among the criteria evaluated with a consistency ratio of 6.69% which is within the acceptable limit. The study showed that relationships exist between information systems usage and the perceived poor service delivery of projects.

1. Introduction

Information management means deploying new technology solutions, such as content or document management systems, data warehousing or portal applications. Improving information management is a key focus for most organizations across all sectors in both the public and private. Information is being driven by a range of factors, including a need to improve the efficiency of business processes, the demands of compliance regulations and the desire to deliver new services. Efficiency in project execution and control depends upon the quality of relationship between the clients, professionals, contractors, and sub-contractors [1-2]. The various stages in project execution and control rely on professionals transferring appropriate and relevant information to develop a design that meets the clients requirements [3]. In Nigeria, the construction professionals who are regularly engaged in the industry are Architects, Quantity Surveyors (QS), Geodetic Engineers (GE), Structural Engineers (STE), Electrical Engineers (EE) and Services Engineers (SE). These entire professionals are regulated by their professional institution. Information sharing among the project participants is vital for realizing the project objectives. Construction project management requires effective communication among project stakeholders for successful project delivery [4-7]. One of the most serious barriers that any company faces is to resolve the problem of information flow – upwards, downwards, and sideways which is often generally termed communication. According to BRE [8], most defects in project executions are as the result of poor communication. For example, a poorly detailed drawing, operatives being given incorrect instructions or technical information not being available. However, what is not known is how project professionals collect and disseminate timely information when working on a project in NDDC. It is this noticeable gap in information management in project execution which is lacking in literature in NDDC that this research seeks to fill. As projects are being done regularly in the commission, it is therefore vital to identify factors that contribute to the successful implementation of project. Gorse et.al [9] investigated interpersonal communication behavior between designers and contractors during the construction phase of projects. Their findings reveal that informal approaches such as face-to-face are perceived to be the most effective medium of communication within the industry. Their results are also supported by Carlsson et.al [10] who conducted communication research within the Swedish construction industry. Carlsson et.al [10] argue that barriers to effective communication are likely to be broken down by more integrated project delivery systems. This work aimed at developing a multi-criteria decision making model for identifying the critical factors contributing to the successful implementation of project in NDDC.

2. Methodology

The goal of decision making is considered first, the other associated decision criteria of then identified as shown in Figure 1. The hierarchy is established, a questionnaire with a Nine-point Saaty scale was designed and distributed among the respondents (managers, experts, and workers) in NDDC to abstract the needed information and their judgment. Significantly, decision-makers selected their favourite values as presented in the nine points scale for each criterion and their responses converted into a pairwise comparison matrix.
CRITERIA-: Nine (9') criteria were chosen for this survey because the AHP make use of Nine-point Saaty scale for criteria decision as presented in Table 1.

Table 1: Criteria used for AHP

CRITERIA INDEX	CRITERIA DESCRIPTION	NOTATION
C1	Site meeting	SM
C2	Feedback system	FS
C3	Project communication management	PCM
C4	Planning and Control	PC
C5	Staff trainings	ST
C6	Information Security	IS
C7	Communication strategy	CS
C8	Cost of Information Technology	CI
C9	Local culture	LC

2.1Comparism

A pair-wise comparison matrix is formed by ranking the response of each criteria element against the other since there are nine decision elements the number of comparison equals n(n1)/2, hence thirty-six comparisons were obtained, when $a_{ij} = K, a_{ij} = 1/k$. All the diagonal values are one when ranking against itself. This is normalized by dividing each decision element by its column sum to obtain its relative weight (eigenvector). The Principal Eigenvalue λmax is used to ascertain the validity of the judges' decisions. The original comparison matrix A is shown in Equation (1)

$$E_1 \quad E_2 \quad \cdots \quad E_n$$

$$A = \begin{matrix} E_1 \\ E_2 \\ \vdots \\ E_n \end{matrix} \begin{pmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \vdots & \ddots \\ d_{n1} & d_{n2} & \cdots & d_{nn} \end{pmatrix} \quad (1)$$

Normalizing pair-wise comparison matrix, by dividing each element by column sum as shown in Equation (2)

$$A = \begin{pmatrix} 1 & \frac{c_1}{c_2} & \cdots & \frac{c_1}{c_n} \\ \frac{c_2}{c_1} & 1 & \cdots & \frac{c_2}{c_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{c_n}{c_1} & \frac{c_n}{c_2} & \cdots & 1 \end{pmatrix} \quad (2)$$

N is a normalized Eigenvector as shown in Equation (3)

$$N = \begin{pmatrix} w_1 & w_1 & \cdots & w_1 \\ w_2 & w_2 & \cdots & w_2 \\ \vdots & \vdots & \vdots & \vdots \\ w_n & w_n & \cdots & w_n \end{pmatrix} \quad (3)$$

The Eigenvalue is obtained from the expression as shown in Equation (4)

$$\begin{pmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \quad (4)$$

Principal Eigenvalue is obtained from the expression as shown in Equation (5)

$$\lambda_{max} = \frac{\sum a_{jw_{j-n}}}{n} \quad (5)$$

Consistency Index is obtained in Equation (6)

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (6)$$

Table 2: The value of Random Consistency Index, source: Golden and Wang (1990)

Dimension	1	2	3	4	5	6	7	8	9
RI	0	0	0.5799	0.8921	1.1159	1.2358	1.3322	1.3952	1.4882

The AHP encompasses six basic stages Saaty and Vargas [11] as highlighted below:

1. Develop a model for the comparison matrix, goal and criteria should be connected Lee et al (2012). Bring together the judgment hierarchy
2. Collate responses into (m*m) matrix.

3. Allocate the inverted value in the equivalent location of the matrix, (where the entire amount of comparisons is n (n—1)/2 (Lee et al 2012).
4. Compute the priority value (λ) and eigenvector (priorities (weights) for the criteria.
5. Check for consistency using the expression in equation (6)
6. Rank the priority weights and select the vector with the highest value.

3. Model Development and Application

The decision matrix for each decision maker is constructed and then the mean average weight is computed from equation (1) and equation (2)

For DM_1.

Criteria Comparison Matrix

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	2	1	2	4	1	2	1	3
$C2$	0.5	1	3	2	4	2	2	2	3
$C3$	1	0.33	1	1	1	1	1	1	1
$C4$	0.5	0.5	1	1	2	2	1	1	3
$C5$	0.25	0.25	1	0.5	1	0.33	1	1	1
$C6$	1	0.5	1	0.5	3	1	3	1	2
$C7$	0.5	0.5	1	1	1	0.33	1	1	1
$C8$	1	0.5	1	1	1	1	1	1	5
$C9$	0.33	0.33	1	0.33	1	0.5	1	0.2	1

For DM_2.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	1	1	2	3	0.33	2	1	2
$C2$	1	1	2	2	2	2	2	0.25	1
$C3$	1	0.5	1	1	1	1	1	1	1
$C4$	0.5	0.5	1	1	2	2	1	0.5	3
$C5$	0.33	0.5	1	0.5	1	0.33	0.5	0.5	0.5
$C6$	3	0.5	1	0.5	3	1	3	0.5	2
$C7$	0.5	0.5	1	1	2	0.33	1	0.5	1
$C8$	1	4	1	2	2	2	2	1	3
$C9$	0.5	1	1	0.33	2	0.5	1	0.33	1

For DM_3.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	1	1	2	3	3	3	1	2
$C2$	1	1	2	2	2	2	2	0.5	1
$C3$	1	0.5	1	1	1	1	1	1	1
$C4$	0.5	0.5	1	1	2	2	1	0.5	3
$C5$	0.33	0.5	1	0.5	1	0.33	0.5	0.33	0.5
$C6$	0.33	0.5	1	0.5	3	1	3	0.5	2
$C7$	0.33	0.5	1	1	2	0.33	1	0.5	1
$C8$	1	2	1	2	3	2	2	1	2
$C9$	0.5	1	1	0.33	2	0.5	1	0.5	1

For DM_4.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	0.5	1	2	4	3	3	1	1
$C2$	2	1	2	2	2	1	2	0.5	1
$C3$	1	0.5	1	1	1	1	1	1	1
$C4$	0.5	0.5	1	1	2	2	1	0.5	2
$C5$	0.25	0.5	1	0.5	1	0.33	0.5	0.2	0.5
$C6$	0.33	1	1	0.5	3	1	4	0.5	2
$C7$	0.33	0.5	1	1	2	0.25	1	0.25	1
$C8$	1	2	1	2	5	2	4	1	4
$C9$	1	1	1	0.5	2	0.5	1	0.25	1

For DM_5.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	0.5	1	2	4	3	3	1	1
$C2$	2	1	2	2	2	1	2	0.5	1
$C3$	1	0.5	1	1	1	1	1	1	1
$C4$	0.5	0.5	1	1	4	2	2	0.5	2
$C5$	0.25	0.5	1	0.25	1	0.33	0.5	0.25	0.5
$C6$	0.33	1	1	0.5	3	1	3	0.5	2
$C7$	0.33	0.5	1	0.5	2	0.33	1	0.33	1
$C8$	1	2	1	2	4	2	3	1	5
$C9$	1	1	1	0.5	2	0.5	1	0.2	1

For DM_6.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	0.5	1	2	4	4	4	1	3
$C2$	2	1	2	2	2	1	2	0.5	1
$C3$	1	0.5	1	1	3	1	2	1	1
$C4$	0.5	0.5	1	1	4	2	2	0.5	2
$C5$	0.25	0.5	0.33	0.25	1	0.25	0.25	0.25	0.25
$C6$	0.25	1	1	0.5	4	1	3	0.25	2
$C7$	0.25	0.5	0.5	0.5	4	0.33	1	0.25	1
$C8$	1	2	1	2	4	4	4	1	4
$C9$	0.33	1	1	0.5	4	0.5	1	0.25	1

For DM_7.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	1	1	2	9	2	2	1	3
$C2$	1	1	2	2	9	1	2	0.5	1
$C3$	1	0.5	1	1	3	1	2	1	1
$C4$	0.5	0.5	1	1	4	2	2	0.5	2
$C5$	0.11	0.11	0.33	0.25	1	0.25	0.25	0.11	0.25
$C6$	0.5	1	1	0.5	4	1	3	0.25	2
$C7$	0.5	0.5	0.5	0.5	4	0.33	1	0.14	1
$C8$	1	2	1	2	9	4	7	1	7
$C9$	0.33	1	1	0.5	4	0.5	1	0.14	1

For DM_8.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$
$C1$	1	1	1	2	9	2	2	1	3
$C2$	1	1	2	2	9	1	2	0.5	1
$C3$	1	0.5	1	1	3	3	2	1	1
$C4$	0.5	0.5	1	1	4	3	4	0.33	1
$C5$	0.11	0.11	0.33	0.25	1	0.25	0.25	0.25	0.25
$C6$	0.5	1	0.33	0.33	4	1	3	0.33	2
$C7$	0.5	0.5	0.5	0.25	4	0.33	1	0.16	1
$C8$	1	2	1	3	4	3	6	1	5
$C9$	0.33	1	1	1	4	0.5	1	0.2	1

For DM_9.

$$
\begin{bmatrix}
 & C1 & C2 & C3 & C4 & C5 & C6 & C7 & C8 & C9 \\
C1 & 1 & 3 & 1 & 2 & 5 & 4 & 2 & 1 & 1 \\
C2 & 0.33 & 1 & 0.5 & 3 & 4 & 3 & 3 & 0.5 & 1 \\
C3 & 1 & 2 & 1 & 1 & 2 & 3 & 2 & 1 & 1 \\
C4 & 0.5 & 0.33 & 1 & 1 & 4 & 3 & 4 & 0.33 & 1 \\
C5 & 0.2 & 0.25 & 0.5 & 0.25 & 1 & 0.25 & 0.33 & 0.2 & 0.25 \\
C6 & 0.25 & 0.33 & 0.33 & 0.33 & 4 & 1 & 3 & 0.25 & 2 \\
C7 & 0.5 & 0.33 & 0.5 & 0.25 & 3 & 0.33 & 1 & 0.167 & 1 \\
C8 & 1 & 2 & 1 & 3 & 5 & 4 & 6 & 1 & 5 \\
C9 & 1 & 1 & 1 & 1 & 4 & 0.5 & 1 & 0.2 & 1
\end{bmatrix}
$$

Table 3: Eigen vector for CDM and Ranking order of Criteria

CRITERIA	WEIGHT	λ	RANK
C1	0.2913	2.7007	1
C2	0.1994	1.8347	2
C3	0.1155	1.0438	4
C4	0.1290	1.1815	3
C5	0.0488	0.4391	7
C6	0.0733	0.6631	5
C7	0.0681	0.6144	6
C8	0.0473	0.4244	8
C9	0.0272	0.2469	9

The sum of all elements in the priority vector is I showing normalization. The priority vector shows relative weights. In the analysis above, the Site Meeting (SM) is 29.13%, is Feedback system (FS) is 19.94% and Planning and control (PC) is 12.3%.etc. It, therefore, means that the site meeting is the most important criteria to be considered in project execution and control in NDDC. Local culture ranked the least with a criterion weight of 2.72%.

Table 4: Eigenvalue and principal Eigenvalue computed

DM	Principal Eigenvalue λ(max)
DM1	9.5449
DM2	9.5607
DM3	9.8002
DM4	9.8710
DM5	9.8218
DM6	9.8337
DM7	9.8712
DM8	9.8316
DM9	9.8465
Mean Decision	9.1486
Total λ(max)	87.9820

3.1 Consistency Analysis

Consistency analysis computed from equation (6).The final consistency ratio (CR), on the basis of which one can conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the consistency index (CI) and the random consistency index (RI). The number 0.1 is the accepted upper limit for CR. If the final consistency ratio exceeds the number, the evaluation procedure has to be repeated to improve consistency. The measurement of consistency can be used to evaluate the consistency of decision makers as well as the consistency of all the hierarchy.

From Table 4, $\lambda_{(max)}$= **87.9820**

But, $CR = \left(\frac{CI}{RI}\right)$

$$CI = \frac{\frac{\lambda max}{n} - n}{n-1}$$

$$CI = \frac{\frac{87.9820}{9} - 9}{9-1} = 0.0968084$$

From, $CR = \left(\frac{CI}{RI}\right)$

$$CR = \frac{0.0968084}{1.4882} * 100\% = 6.69\%$$

Since the consistency is approximately 7% <than 10%. It is acceptable. Consistency, ratio value of 0.07 obtained was less than 0.1 implies than the responses were consistent and reliable. From Results, site meeting ranked first with 29.13% in the decision thereby indicating that the issue of improving information management in project execution and control is depended on the site meeting in NDDC. The priority vector displays relative weights amongst the items that were compared. In the above analysis, Feedback system is 19.94%, Planning and control is 12.9%, project communication management Identification is 11.55%, Information security is 7.33%, Communication strategy is 6.81%, staff trainings is 4.88%, Cost of information technology is 4.73% and Local culture is 2.72%. The results show the level of preference as shown above.

4. Conclusion

Arising from the foregoing results and discussion, it is evident that information management in an organization depends on the prevailing Site Meeting. The model developed in this study can be used by the practitioners to identify factors and attributes. It can help the practitioners to make a better decisions and obtain better results on managing information systems in the NDDC. Indeed, this approach using of group decision-making, takes into account multiple involvements, multiple criteria. Another characteristic of the approach is that the approach allows incorporating experts' judgments and practices. It is obvious that without using knowledge and experience of experts, evaluation process cannot be done completely and NDDC may not have assessed the real case project which should be evaluated under a real case business context with uncertainty and ambiguity environment in order to improve their information management for a successful project.

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