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# Development of an AHP-Based Multi-criteria Decision Model for prioritizing Road-Related Infrastructure in Cameroon: Case Studies of Bogo-Guirvidig and Bingambo-Grandzambi projects

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**ABSTRACT**

Road development projects in Cameroon often fail to address multidimensional poverty and human exclusion, particularly in regions with contrasting socio-economic conditions like the conflict- affected Far North and resource-rich South. This study proposes a systematic approach to prioritize infrastructure investments that reduce exclusion by integrating the Analytic Hierarchic Process (AHP) with multidimensional exclusion indices. The work extends existing AHP applications in Sub-Saharan Africa by incorporating exclusion metrics, offering a replicable framework for inclusive infrastructure planning in developing contexts. The AHP method was applied using expert judgments from local authorities and community representatives to evaluate criteria linked to human exclusion. Case studies from Bogo-Guirvidig (Far North) and Bingambo-Grandzambi (South) provided contrasting regional insights. Sanitation infrastructure, educational infrastructure, rural road development, and water access emerged as top priorities for reducing exclusion. The model demonstrates how targeted investments alongside road projects can significantly improve equity. The study provides actionable insights for policymakers to allocate resources effectively, emphasizing the need for context-sensitive infrastructure planning to combat multidimensional poverty.



## 1. INTRODUCTION

### 1.1. Context and issues

In Cameroon, road infrastructure accounts for nearly 85% of the total transport infrastructure [60]. This is what leads [7] to say that it ensures nearly 90% of domestic demand for passenger transport and almost 75% of demand for freight transport.

[60] projects an annual growth rate of 7,9% for this branch of transport infrastructure, based on the completion of structural road projects. This growth trajectory, however, could be compromised by Chad's and the Central African Republic's stated intentions to reduce their reliance on Cameroonian ports by developing alternative maritime routes [64].

However, over the past two decades, a considerable number of road projects have been matured and implemented, along with related infrastructure, for the benefit of local populations. Poverty indicators are not improving sufficiently, as shown by the multidimensional poverty index in Cameroon, estimated at 45.3% in 2014 [56], as well as the Human Development Index (HDI), estimated at 0.563 in 2019, lower than the average for countries in the medium human development group, established at 0.631 [56]. These deficits illustrate that the exclusion of many people from the development process remains a development challenge for Cameroon today and tomorrow.

The primary causes of these shortcomings lie in Cameroon's strategic direction for economic growth, namely, combating monetary poverty by increasing Gross Domestic Product (GDP). This, therefore, urgently requires a

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new approach to road projects that will be the crucible of inclusive economic growth, given that inclusiveness is based on the need for a fair distribution of growth benefits within the population. The benefits are not limited solely to income and wealth, that is, to the fight against monetary poverty. This approach includes non-monetary factors such as access to socio-economic infrastructure and amenities [28]. Despite this lack of inclusiveness, which is also due to Cameroon's spatially concentrated development model that reinforces urban-rural divides, where peripheral populations remain underserved despite national growth trends, Cameroon has continued to build related infrastructure through road projects without truly relying on a rational, inclusive approach. Existing methods fail to systematically integrate local needs or balance conflicting criteria, perpetuating exclusion. This research aims to fill this gap. It aims to i) develop and validate a participatory Multi-Criteria Decision Making (MCDM) model that integrates both quantitative indicators and qualitative stakeholder inputs, ii) prioritize related infrastructure projects in two contrasting regions of Cameroon, and iii) validate a replicable framework for Sub-Saharan Africa, bridging top-down planning and local needs. This article is applied to the Bogo-Guirvidig and Bingambo-Grandzambi road projects.

The first road project traverses' conflict-affected zones in the Far North Region, while the second connects rural communities with limited access to basic services in the South Region.

### 1.2. Literature review

The core of every human's activity involves decisions. In everyday life and at the family level, these decisions are made based on socio-cultural factors, intuition, and feedback from life experiences.

However, at the level of Public Administration, which is a complex system reflecting the aspirations of the population, decision-making becomes much more difficult. In [13], indicates that, for complex systems, the decision-making approach pursued is incremental. It consists of considering a limited number of alternatives that aim to modify the status quo gradually [13].

The decision is therefore carried out through a process that presents itself as a set of successive actions and dynamic factors undertaken by a limited number of individual or organizational actors [44]. Multi-criteria approaches provide an analytical support adapted to the complexity of such decisions.They help facilitate the decision-making process by making it more explicit, rational, and efficient [18].

The uses and applications of Multi-Criteria Decision Making (MCDM) approaches have been proven over time in allowing:
(a) prioritize interventions in rural water supply in Senegal based on six (06) quantitative and qualitative criteria [18], b) select health infrastructure projects [4], c) prioritize buildings for renovation [32], d) evaluate, prioritize and select public investment projects [59], e) propose a model for selecting road transport projects [23], f) allocate financial resources in the health sector [60], g) plan energy sustainably [25], (h) prioritize public investments in infrastructure [8].

[31] categorizes multi-criteria decision problems into four types: (1) choice (selecting the best alternative), (2) sorting (allocating alternatives to predefined categories), (3) ranking (ordering alternatives), and (4) description (profiling alternatives based on criteria) [37]. This typology aligns with Ben Mena's partial/total aggregation framework [11].

The work of [31] presents a comparison of multi-criteria decision support methods to better match the chosen method to the problem posed.

The ELECTRE, TOPSIS, and PROMETHEE methods are called partial-aggregation methods, while the MAUT and AHP methods are called total-aggregation methods.

Of all these methods, AHP is the oldest and most widely used decision-making technique [24]. It has been applied for a) select health infrastructure projects [4], b) assess the performance of commercial banks [20], c) select appropriate handling equipment in an industrial company [30], d) evaluate educational infrastructure projects [55], e) model the dysfunction of a sanitation network in the city of JIJEL [29].

[40] introduced a systematic framework to evaluate projects through two integrated indices: the Social-Environmental Index (SEI) and the Financial-Economic Index (FEI). By applying the Analytic Hierarchy Process (AHP), this method weights and combines financial, economic, social, and environmental criteria into actionable metrics, with budget constraints embedded as a key decision boundary. This model has been applied to prioritize many projects in countries such as Panama [41] and Chile [39].

Based on a review of existing literature regarding infrastructure prioritization, where the AHP method has been widely applied to transport and energy projects [23][25] few studies

This study has focused on road-related/socio-economic infrastructure in Cameroon using the AHP method, suggesting a significant research gap that this study aims to address.

Moreover, the use of Multi-Criteria Decision Making (MCDM) methods, such as AHP or TOPSIS, has proven effective for prioritizing public infrastructure investments that involve multiple, often conflicting, criteria [55].

For this article, the AHP methodology is employed to (i) weight criteria via pairwise comparisons from thirty (30) decision-makers, (ii) synthesize primary (questionnaires) and secondary (national data) inputs, and

(iii) rank infrastructure alternatives using consistency ratios (CR<0.1) to ensure reliability.

### 1.3. Value of research

In continuity with the elements presented previously, this study delivers three groundbreaking contributions to socio-economic infrastructure planning in Cameroon. First, it provides Cameroon's National Development Strategy [60] with a tool to operationalize inclusive infrastructure planning. Second, this study bridges MCDM literature with participatory design by incorporating local exclusion metrics to quantify the importance of different factors [51]. Third, it offers a transferable model for Sub-Saharan Africa, demonstrated through region-specific case studies. This builds on previous applications of MCDM in infrastructure planning in Nigeria [1] and extends the framework by incorporating local perceptions of exclusion.

## 2. METHODOLOGY

### 2.1. Conceptual approach

The problem of prioritizing related infrastructure associated with structuring road projects in Cameroon consists of establishing the priorities of the alternatives $F_i$ by considering certain criteria from a family
$F_i = \{F_1, F_2, \dots \dots, F_n\}$ representing the types of related infrastructure.

Since the problem involves multiple alternatives [53] and evaluation criteria, it is recognized as a multicriteria decision-making issue. It corresponds to a ranking problem (P3) because the alternatives can be differentiated by their relative importance and thus ordered from most to least preferable [54]. It therefore aligns with the total aggregation operational approach.

AHP is widely used to simplify complex decision-making by structuring alternatives and helping decision-makers identify priorities for optimal outcomes [38].

In its implementation, the AHP considers evaluation criteria (quantitative and qualitative) and alternatives. It allows the problem under study to be fragmented into hierarchical secondary issues that are easily understandable and self-evaluatable. These self-evaluations are converted into numerical values, allowing the ordering of alternatives and the calculation of the effectiveness of the alternative or the criterion $A_i$ with respect to the property $X_j$. This method uses the matrix of pairwise comparisons structured in the form:

$$A = (\alpha_{ij})_{n*n} = \begin{pmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \cdots & \alpha_{1n-1} & \alpha_{1n} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \cdots & \alpha_{2n-1} & \alpha_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ \alpha_{n1} & \alpha_{n2} & \alpha_{n3} & \cdots & \alpha_{nn-1} & \alpha_{nn} \end{pmatrix} \quad (1)$$

where

$$a_{ij} \geq 0 \quad (2)$$

Indicating how much option $\mathcal{X}_i$ is preterred over option $\mathcal{X}_i$ [4].

This method, which enables the consistency of the judgments used to determine priorities to be measured, can be synthesized into several stages [20].

Step 1: The decision problem is divided into its main components according to a hierarchy, including: the objective, primary criteria, secondary criteria (if any), and alternatives Figures 1 and 3, representing the The most critical and creative part of the decision-making process.

Step 2: The data are compiled by experts and decision-makers in accordance with the hierarchical structure. Pairwise comparisons are represented qualitatively according to the Saaty scale Table 1. Experts may assess these comparisons on a qualitative scale, ranging from equal importance to absolute dominance [50].

Step 3: Comparisons between criteria are arranged in a square matrix, with the diagonal elements set to 1 by convention. Criterion $i$ is preferred over criterion $j$ when the corresponding matrix value $a_{ij}$ exceeds 1; otherwise, criterion $j$ is favored [48]. Unlike traditional AHP applications, our model incorporates human exclusion criteria calibrated on Cameroonian data.

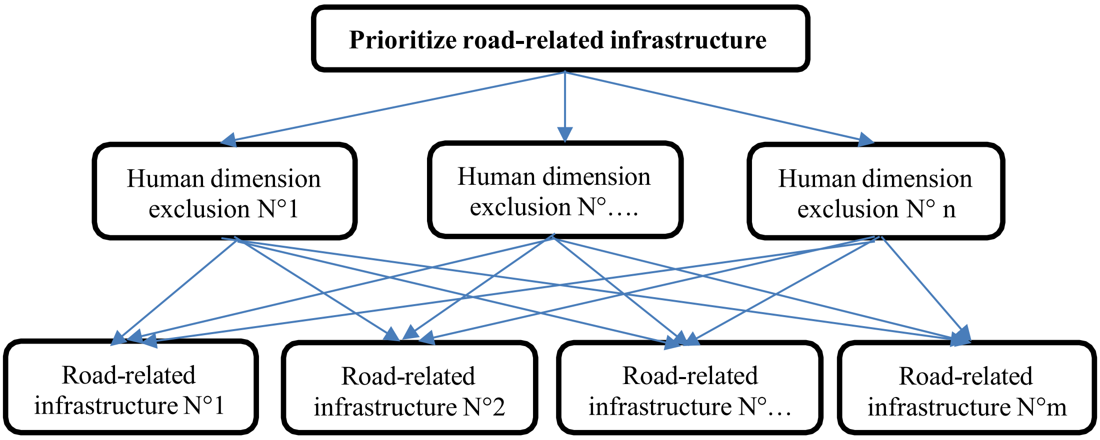


Figure 1. Customized hierarchical structure for prioritizing road-related infrastructure using AHP [20].

Table 1. AHP Pairwise Comparison Scale [4].

| Intensity of importance | Definition | Explanation | Practical example |
|---|---|---|---|
| 1 | Equal importance | Two elements contribute equally to the objective. | Choosing between two equally reliable suppliers. |
| 3 | Moderate importance | Slight preference for one element over another. | Supplier A is marginally preferred due to better customer service. |
| 5 | Strong importance | Clear dominance based | Material X is significantly more durable than Material Y (proven by tests). |
| 7 | Very Strong importance | One element is strongly favored and validated in practice. | Technology A outperforms B in 90% of benchmark studies. |
| 9 | Absolute importance | Maximum evidence supports one element's dominance. | Safety protocol C is legally mandated vs. optional protocol D. |
| 2, 4, 6, 8 | Intermediate values | Used to express nuanced compromises. | A score 4 indicates a balance between moderate (3) and strong (5). |
| Reciprocals (e.g.:1/3, 1/5) | Inverse importance | If element $i$ is rated 3 vs element $j$, then element $j$ is 1/3 vs element $i$. | If the cost is 5xmore important than delivery time, delivery time is 1/5x vs. cost. |

Step 4: The eigenvalue (λ) and corresponding eigenvector, derived from the pairwise comparison matrix, quantify the relative importance of criteria/sub-criteria. Specifically, i) eigenvector components provide normalized weights (summing to 1) for each criterion, (ii) the principal eigenvalue ($\lambda_{\max}$) reflects the matrix's consistency level. Example: for eigenvector (0.7, 0.20, 0.1), criterion 1 holds 70% of the total weight. Step 5: To ensure the reliability of pairwise comparisons, the AHP method assesses the judgment matrix's consistency by analyzing its eigenvalue. The degree of inconsistency Index (CI), which measures how far the matrix deviates from perfect coherence. This index is derived from the principal eigenvalue ($\lambda_{max}$) of the matrix, normalized by the number of criteria ($n$). The resulting CI value is then compared to a Random Index (RI) Table 2 benchmark to determine the Consistency Ratio (CR). If the ratio exceeds 0.1, it indicates significant inconsistencies, prompting a review of the original judgments. The CI and CR are calculated as follows [4]:

$$CI = \frac{(\lambda_{max} - n)}{n-1} \tag{3}$$

$$CR = \frac{CI}{RI} \tag{4}$$

.

CR quantifies the reliability of the decision-maker's judgements by measuring the degree of logical inconsistency in the pairwise comparisons [2]. Example: for $n = 3$, $\lambda_{max} = 3.2$, $CI = \frac{3.2-3}{2} = 0.1, CR = \frac{0.1}{0.58} = 0.17, CR > 0.1$ revise judgements.

The Random Index (RI) value depends on the matrix order ($n$), corresponding to the number of comparison criteria, and is obtained from standardized reference values Table 2.

Table 2. Random Consistency Index (RI) [20].

| $n$ | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|
| $RI$ | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

Step 6: The evaluation process systematically aggregates weighted scores across all decision levels: each alternative's performance is first multiplied by relevant sub-criterion weights (where applicable) to generate local evaluations, which are then combined with main criterion weights through matrix-based pairwise comparison.

For each decision maker ($d_k$), and for all criteria ($c_i$) the alternatives are compared in pairs and generating $m$ matrix ($1 \le m \le i$) $A_m$ :

$$A = (\alpha_{ij})_{/ci} = \begin{pmatrix} 1 & \alpha_{12/ci} & \alpha_{13/ci} & \cdots & \alpha_{1n-1/ci} & \alpha_{1n/ci} \\ \alpha_{12/ci} & 1 & \alpha_{13/ci} & \cdots & \alpha_{2n-1/ci} & \alpha_{2n/ci} \\ \vdots & \vdots & 1 & \cdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \cdots & 1 & \vdots \\ \alpha_{n1/ci} & \alpha_{n2/ci} & \alpha_{n3/ci} & \cdots & \alpha_{nn-1/ci} & 1 \end{pmatrix} \quad (5)$$

The elements of the matrix $A_m$ are each time normalized to give a new matrix $[A_m]^N$ whose elements have the expression:

$$(a_{ij})^N_{/ci} = {(a_{ij})_{/ci}} \Big/ {S_{j/ci}} \quad (6)$$

with

$$S_j/_{ci} = \sum_i a_{ij}{}_{/ci} \quad (7)$$

From each matrix $[A_m]^N$ the weight of each alternative $l$ relative to the criterion ($c_i$) is calculated by the expression:

$$W^l_{/ci} = {\sum_j (a_{ij})^N_{/ci}} \Big/ {Size\ of\ matrix\ A_m} \quad (8)$$

For each decision maker ($d_k$), there ultimately corresponds a matrix of intermediate priorities of the alternatives that look like [52]:

$$\text{Alternatives } (A_i) \quad \begin{matrix} & \text{Criteria } (c_i) \\ \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_t \end{matrix} & \begin{pmatrix} c_1 & c_2 & \cdots & c_n \\ W_{11} & W_{12} & \cdots & W_{1n} \\ W_{21} & W_{22} & \cdots & W_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ W_{t1} & W_{t2} & \cdots & W_{tn} \end{pmatrix} \end{matrix} \quad (9)$$

The Analytic Hierarchy Process generates quantified priority weights for alternatives through its structured evaluation framework. These weights are derived by i) conducting pairwise comparisons between other options relative to each criterion, (ii) processing these judgements through eigenvector calculations to produce alternative-specific priority weights (W) and criterion importance weights (vector $\varphi$) [65], and (iii) synthesizing results via matrix multiplication between the alternative priority matrix (W) and the criterion weight matrix ($\varphi$).

The AHP synthesis process combines alternative weights ($w_j$ ) and criterion ($\varphi_i$) priorities through the Global Priority Matrix (GPM) and the Global Priority Vector (GPV) [52].

Each element $gpm_{ij}$ of (GPM) represents the weighted priority of alternative $j$ under criterion $i$:

$$gpm_{ij} = w_j \times \varphi_i \tag{10}$$

With $i = 1 \ldots\ldots n$ criteria and $j = 1 \ldots\ldots m$ alternatives [21]. The overall priority $gpv_j$ for each alternative is obtained by:

$$gpv_j = \sum_{i=1}^{n} gpm_{ij} = \sum_{i=1}^{n}(w_j \times \varphi_i) \tag{11}$$

In a space ($m$: alternatives, $n$: criteria), the weights of the alternatives are therefore expresse as:

$$\begin{aligned} gpv_1 &= w_{11} \times \varphi_1 + w_{12} \times \varphi_2 + w_{13} \times \varphi_3 + \cdots + w_{1n} \times \varphi \\ gpv_3 &= w_{31} \times \varphi_1 + w_{32} \times \varphi_2 + w_{33} \times \varphi_3 + \cdots + w_{3n} \times \varphi_n \\ gpv_3 &= w_{31} \times \varphi_1 + w_{32} \times \varphi_2 + w_{33} \times \varphi_3 + \cdots + w_{3n} \times \varphi_n \\ \vdots &= \vdots \\ gpv_m &= w_{m1} \times \varphi_1 + w_{m2} \times \varphi_2 + w_{m3} \times \varphi_3 + \cdots + w_{mn} \times \varphi_n \end{aligned} \tag{12}$$

The general prioritization equation can therefore be written:

$$GPV = [w] \times [\varphi] \tag{13}$$

where:

- $[w]$ is the pairwise comparison matrix of alternatives made by thirty (30) decision-makers through questionnaires [51], i.e, $[w]$ contains primary data.
- $[\varphi]$ represents the column matrix of criteria weights [51], i.e $[\varphi]$contains secondary data (national data).

### 2.2. Application of the AHP to the prioritization of road-related infrastructure in Cameroon

The AHP method in this article is based on three levels. Level 1 represents the objective, the level 2 includes seven human exclusion criteria, and level 3 consists of eight alternatives (i.e., eight road-related infrastructures).

#### 2.2.1.Objective

The aim is to establish intervention priorities for a set of road-related infrastructure using several human-exclusion criteria.

#### 2.2.2.Formulation of criteria

Considering that, for each stage of life, a key dimension of well-being is thus identified, in which people in the age group concerned are likely to be excluded, and therefore to participate less and contribute less to development [16][35], the seven criteria retained Table 3 are the human dimensions for better consideration of inclusiveness in traditional economic growth.

Table 3. The different criteria based on the dimensions of human exclusion

| No | Criteria | Exclusion index calculation formula | Observation |
|---|---|---|---|
| 1 | Infant/neonatal mortality<br>(It measures deaths occurring within the first 28 days per 1000 live births, serving as a critical indicator of both survivals rates and access to healthcare. Research confirms these mortality patterns often reflect systemic exclusions from health services or deficiencies in care quality) [16][35]. | $[IEx^{Nm}] = \frac{Nm^{n}_{0-28} - Nm^{r}_{0-28}}{Nm^{n}_{0-28}}$ (14) | $[IEx^{Nm}]$ : index of exclusion from basic health services<br>$Nm^{n}$ : local estimate of infant mortality<br>0−28<br>$Nm^{r}$ : reference value for neonatal mortality<br>0−28<br>(benchmark average from middle-income countries), used<br>for comparative analysis of healthcare system performance [16][35]. |

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| | | | |
|---|---|---|---|
| 2 | Prevalence of child undernutrition (Child undernutrition, measured by stunting (height-for-age > 2 Standards Deviations below the international reference for ages 1 – 59 months), reflects exclusion from basic nutritional needs. Chronic undernutrition impairs physical and cognitive development irreversibly, highlighting systemic failures in public health infrastructure) [16][35]. | $[IEx^{ChM}] = \frac{ChM^{n}_{28d-259m}}{1-ChM^{n}_{28d-259m}}$ (15) | $[IEx^{ChM}]$ : index of exclusion from an appropriate level of nutrition<br>$ChM^{n}_{28d-59m}$ : rate of chronic undernutrition among children between 28 days and 59 months of age, observed at either the community or national level [16][35]. |
| 3 | Youth literacy Metric (ages 15 – 24) (It represents the proportion of this demographic cohort demonstrating functional reading and writing competencies, establishing it as a critical benchmark for evaluating educational system performance [16][35]. | $[IEx^{Lr}] = \frac{1-Lr^{\theta}_{15-24}}{Lr^{\theta}_{15-24}}$ (16) | $[IEx^{Lr}]$ : exclusion index measures disparities in access to quality education, calculated as the inverse ratio of literacy rates among youth aged 15-24 [16][35].<br>$Lr^{\theta}_{15-24}$: variable quantifies reading and writing proficiency levels among adolescents and young adults (15-24 age cohort), establishing a baseline for educational outcome evaluation [46]. |
| 4 | Youth Unemployment (ages 15 - 24) (It measures the percentage of economically active individuals aged 15 – 24 who are jobless despite seeking employment, reflecting systemic labor market barriers) [62]. | $[IEx^{Yu}] = \frac{Yu^{n}_{15-24}}{1-Yu^{n}_{15-24}}$ (17) | $[IEx^{Yu}]$: exclusion index quantifies labor market disparities, calculated from $Yu^{n}_{15-24}$ (local/ national youth unemployment rates), where higher values indicate [34]. |
| 5 | National poverty line (Poverty incidence tracks the share of the population unable to meet basic subsistence needs, serving as a key indicator of socioeconomic exclusion)[56]. | $[IEx^{Np}] = \frac{Np^{n}_{h}}{1-Np^{n}_{h}}$ (18) | $[IEx^{Np}]$ : exclusion index assesses deprivation severity, derived from $Np^{n}_{h}$ (poverty rate relative to national thresholds), with elevated values signaling acute livelihood insecurity [47]. |
| 6 | Life expectancy at age 60 (It quantifies the projected remaining lifespan for individuals reaching six decades, calculated using current mortality patterns [63]. This metric also reflects systemic age-based exclusion, where socioeconomic barriers limit elderly populations' capacity to maintain social participation and quality living standards) [57]. | $[IEx^{Lef}] = \frac{Le^{abRif}-Le^{abD}}{Le^{abRif}}$ (19) | $[IEx^{Lef}]$ : exclusion index measures disparities in longevity attainment, computed as the normalized difference between regional ($Le^{abD}$) and benchmark ($Le^{abRif}$) survival rates at 60 [22]. Here:<br>$-Le^{abRif}$ : represents aspirational longevity standards from high-performance health systems.<br>$-Le^{abD}$: captures observed lifespan outcomes at subnational/national levels. |
| 7 | Rural accessibility | $[RAI] = \frac{P_{avec\ acces}}{P_{Totale}}$ (20) | $[RAI]$ : index of rural access<br>$P_{avec\ accès}$ : residents within a 2 km radius of primary roads<br>$P_{Totale}$ : sum of population in countryside area |

The weights of the criteria are therefore obtained from these exclusion indices Table 4.

Table 4. Weight of Criteria

| No | Criteria | Weight of the criterion |
|---|---|---|
| 1 | Infant/neonatal mortality | $\varphi^{Nm} = \frac{[IEx^{Nm}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (21) |
| 2 | Prevalence of child undernutrition | $\varphi^{ChM} = \frac{[IEx^{ChM}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (22) |
| 3 | Youth literacy Metric (ages 15 – 24) | $\varphi^{Lr} = \frac{[IEx^{Lr}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (23) |
| 4 | Youth Unemployment (ages 15 – 24) | $\varphi^{Yu} = \frac{[IEx^{Yu}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (24) |
| 5 | National poverty line | $\varphi^{Np} = \frac{[IEx^{Np}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (25) |
| 6 | Life expectancy at age 60 | $\varphi^{Lef} = \frac{[IEx^{Lef}]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (26) |
| 7 | Rural accessibility | $\varphi^{rai} = \frac{[RAI]}{[IEx^{Nm}]+[IEx^{ChM}]+[IEx^{Lr}]+[IEx^{Yu}]+[IEx^{Np}]+[IEx^{Lef}]+[RAI]}$ (27) |

### 2.2.3.Alternatives

In this study, the alternatives represent the various road infrastructure types in Cameroon. It is a question of prioritizing the intervention on the eight related infrastructures selected, namely Alternative 1 (Alt 1): Borehole/Well; Alternative 2 (Alt 2): Classroom block; Alternative 3 (Alt 3): Latrines; Alternative 4 (Alt 4): Storage shed; Alternative 5 (Alt 5): Fence for securing schools; Alternative 6 (Alt 6): Health center; Alternative 7 (Alt 7): Municipal Road; Alternative 8 (Alt 8): Urban roads.

### 2.2.4.Model automation flowchart

The prioritization model, as described in this paper, is automatable via a MATLAB-based numerical code, with implementation details provided in Table 5.

Table 5. Model automation flowchart

| Component | Description |
|---|---|
| Supporting Dataset | ▪ Alternative options (Alt1 - Alt8): A prioritized set of 8 potential solutions or scenarios for analysis<br>▪ Evaluation criteria (C1 - C7): key metrics used to assess alternatives<br>▪ Priority weighting matrix: A comparative table ranking alternatives (Alt1-Alt8) against criteria (C1-C7) to determine interim preferences. |
| Input parameters | ▪ $Nm^{n}_{0-28}$ : local estimate of infant mortality [16][35].<br>▪ $Nm^{r}_{0-28}$ : reference value for neonatal mortality (average value for middle-income countries)<br>▪ $ChM^{n}$ : prevalence of chronic undernutrition among children aged 1 month to 5 years at the local or national level [16][35].<br>▪ $Lr^{\theta}_{15-24}$ : Youth literacy Metric (ages 15 – 24)<br>▪ $Yu^{n}_{15-24}$ : unemployment rate among youth aged 15 to 24, assessed locally or nationally [16][35].<br>▪ $Np^{n}_{h}$: percentage of the population living under the poverty threshold (local or national) [16][35].<br>▪ $Le^{n}_{60}$ : average remaining life expectancy at age 60, measured at the local or national level [16][35].<br>▪ $Le^{Réf}$: benchmark life expectancy at 60 years [16][35]. |
| Output 1 | ▪ $[IEx^{Nm}]$ : basic healthcare deprivation index [16][35] (Nota Benne: if $Nm^{n}_{0-28} < Nm^{r}_{0-28}$ then $[IEx^{Nm}] = 0$)<br>▪ $[IEx^{ChM}]$ : index of exclusion from appropriate level of nutrition [16][35]<br>▪ $[IEx^{Lr}]$ : educational access deprivation index (measuring exlusion from quality schooling) [16][35] (Nota Benne: if $Lr^{\theta}_{15-24} < 50\%$ then $[IEx^{Lr}] = 1$)<br>▪ $[IEx^{Yu}]$ : labor market exclusion index (measured barriers to employment opportunities) [16][35] (Nota Benne: if $50\% < Yu^{n}_{15-24}$ then $[IEx^{Yu}] = 1$)<br>▪ $[IEx^{Np}]$ : livelihood deprivation index (assessing lack of access to essential resources for survival) [16][35] (Nota Benne: if $50\% < Np^{n}$ then $[IEx^{Np}] = 1$)<br>▪ $[IEx^{Lef}]$: longevity exclusion index [16][35] (Nota Benne: if $Le^{Réf} < Le^{n}$ then $[IEx^{Lef}] = 0$) |

| | |
|---|---|
| | 60 60<br>▪ [RAI]: index of rural access |
| Output 2 | ▪ Weight of criteria: $\varphi^{Nm}$, $\varphi^{ChM}$, $\varphi^{Lr}$, $\varphi^{Yu}$, $\varphi^{Np}$, $\varphi^{Lef}$, $\varphi^{rai}$<br>▪ Weight of the overall priority of each alternative<br>▪ vector of global priorities<br>▪ ranking of alternatives in decreasing order of weight of overall priorities |

## 3. RESULTS AND DISCUSSION

### 3.1. Hierarchical structure for prioritizing road-related infrastructure

For this study, the hierarchical structure includes three levels Figure 2. Level one represents the objective; level two represents the criteria, and level three represents the alternatives.

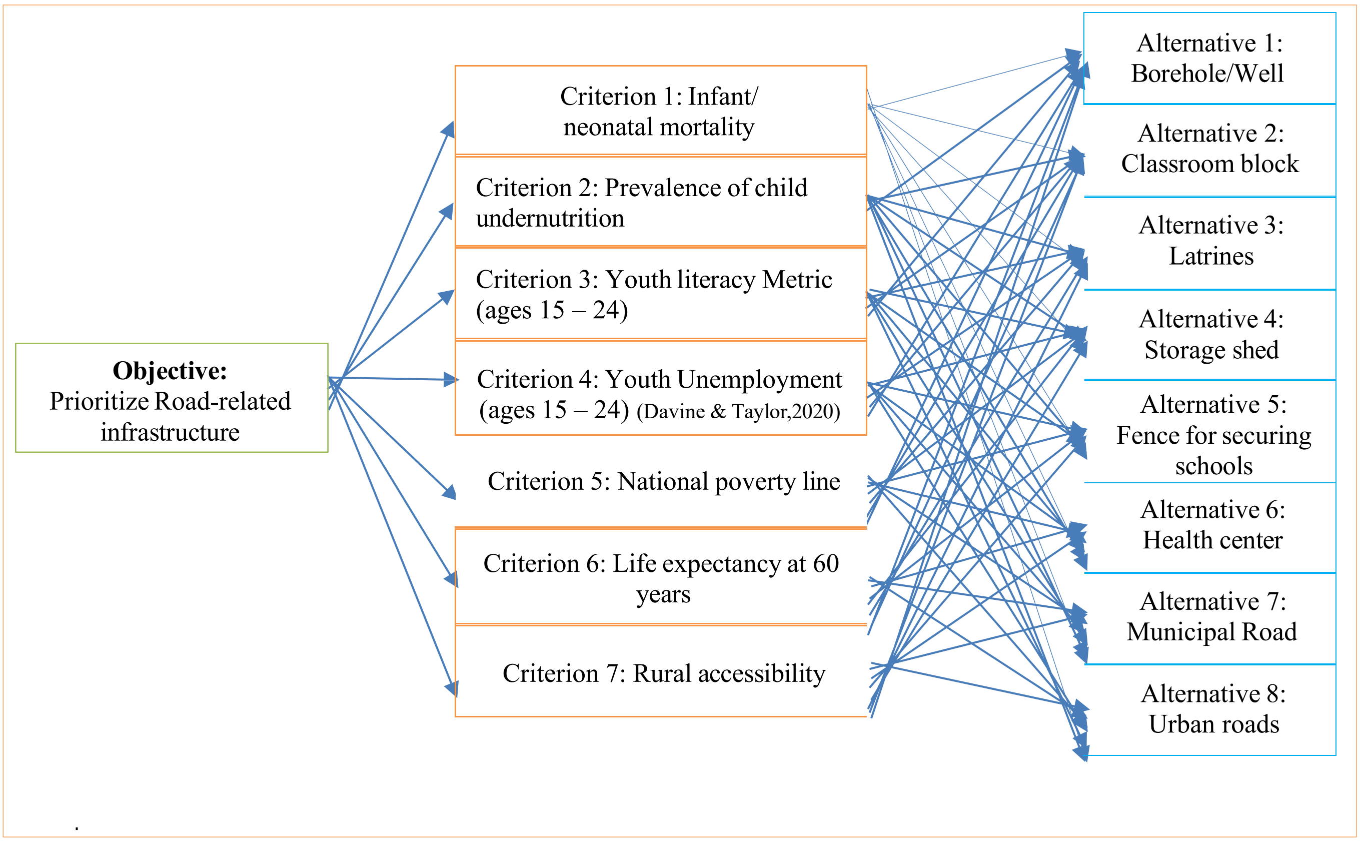


Figure 2. Hierarchical Structure for Prioritizing Road-Related Infrastructure

### 1.1. Pairwise comparison matrix of alternatives

This involves establishing intermediate priorities for alternatives for each criterion. From a sample of thirty (30) people (decision-makers) surveyed, thirty (30) matrices per criterion were obtained, making a total of two hundred and ten (210) pairwise comparison matrices. To evaluate the reliability of participants' judgements, consistency ratios (CR) were computed across all matrices. As shown in Table 5, all CR values fell below the 10% acceptability threshold, confirming statistically consistent responses.

Table 6. Decision consistency assessment results across evaluators and criteria

| Decision-Marker | Criterion 1 (C1) | Criterion 2 (C2) | Criterion 3 (C3) | Criterion 4 (C4) | Criterion 5 (C5) | Criterion 6 (C6) | Criterion 7 (C7) |
|---|---|---|---|---|---|---|---|
| DM1 | 9,29% | 8,82% | 2,53% | 3,25% | 6,82% | 8,35% | 0,00% |
| DM2 | 8,07% | 8,81% | 4,41% | 7,58% | 7,62% | 9,85% | 9,82% |
| DM3 | 8,59% | 8,25% | 3,96% | 6,66% | 9,69% | 7,74% | 4,59% |
| DM4 | 9,06% | 8,14% | 9,31% | 9,61% | 9,78% | 9,97% | 6,08% |
| DM5 | 9,70% | 9,71% | 9,89% | 9,79% | 9,33% | 9,76% | 8,65% |
| DM6 | 9,77% | 9,75% | 9,06% | 8,10% | 9,50% | 9,90% | 9,93% |
| DM7 | 6,28% | 9,79% | 9,97% | 8,73% | 9,78% | 9,31% | 3,34% |
| DM8 | 8,85% | 9,89% | 9,63% | 8,89% | 9,93% | 9,75% | 6,72% |
| DM9 | 9,34% | 8,26% | 8,14% | 9,20% | 9,88% | 9,08% | 9,98% |
| DM10 | 9,83% | 9,00% | 9,90% | 9,45% | 9,67% | 9,39% | 9,19% |
| DM11 | 8,03% | 5,41% | 8,98% | 9,95% | 6,97% | 8,66% | 9,81% |
| DM12 | 9,33% | 8,48% | 9,09% | 8,56% | 9,40% | 9,76% | 9,56% |
| DM13 | 8,57% | 9,79% | 9,34% | 8,86% | 9,68% | 9,21% | 9,86% |
| DM14 | 9,88% | 9,97% | 9,81% | 7,05% | 8,88% | 6,05% | 8,86% |
| DM15 | 8,94% | 7,50% | 9,74% | 9,30% | 7,79% | 9,41% | 4,08% |
| DM16 | 9,58% | 9,20% | 2,81% | 9,86% | 9,20% | 9,82% | 9,40% |
| DM17 | 6,89% | 9,54% | 9,90% | 9,88% | 9,72% | 8,73% | 9,83% |
| DM18 | 8,54% | 5,19% | 8,75% | 9,74% | 0,00% | 9,65% | 9,92% |
| DM19 | 6,86% | 9,95% | 9,11% | 7,52% | 9,09% | 7,83% | 9,34% |
| DM20 | 1,36% | 4,27% | 9,86% | 3,57% | 7,08% | 7,28% | 2,86% |
| DM21 | 9,84% | 8,48% | 9,84% | 8,76% | 0,88% | 5,08% | 3,40% |
| DM22 | 6,10% | 9,59% | 5,55% | 9,17% | 0,98% | 7,30% | 9,18% |
| DM23 | 7,83% | 5,70% | 8,49% | 0,51% | 5,91% | 2,71% | 5,09% |
| DM24 | 3,33% | 1,19% | 0,00% | 0,77% | 8,72% | 0,06% | 0,06% |
| DM25 | 6,32% | 5,68% | 0,36% | 0,10% | 4,71% | 6,73% | 3,05% |
| DM26 | 1,35% | 0,07% | 5,18% | 0,92% | 0,94% | 3,45% | 0,47% |
| DM27 | 0,49% | 0,20% | 9,95% | 1,70% | 9,81% | 1,25% | 4,62% |
| DM28 | 1,11% | 3,44% | 1,28% | 4,84% | 2,57% | 0,99% | 0,65% |
| DM29 | 9,01% | 6,26% | 9,35% | 0,46% | 7,32% | 5,77% | 4,31% |
| DM30 | 6,93% | 5,04% | 1,09% | 2,21% | 2,37% | 2,54% | 9,59% |

Thirty (30) local priority matrices of alternatives Table 6 to 35 were deduced from these two one hundred and ten (210) pairwise comparison matrices.

Table 7. Local priority matrix of decision maker No. 1

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1278 | 0,0906 | 0,0833 | 0,0702 | 0,0715 | 0,1897 | 0,0714 |
| 0,0908 | 0,1049 | 0,2875 | 0,2274 | 0,2487 | 0,0827 | 0,0714 |
| 0,0908 | 0,0994 | 0,0833 | 0,0702 | 0,0715 | 0,1350 | 0,0714 |
| 0,0972 | 0,0840 | 0,0833 | 0,1929 | 0,1625 | 0,0702 | 0,0714 |
| 0,0756 | 0,1103 | 0,0958 | 0,0702 | 0,0611 | 0,0702 | 0,0714 |
| 0,2958 | 0,3126 | 0,2000 | 0,0702 | 0,1580 | 0,2730 | 0,0714 |
| 0,1024 | 0,1139 | 0,0833 | 0,2107 | 0,1551 | 0,0696 | 0,5000 |
| 0,1196 | 0,0843 | 0,0833 | 0,0881 | 0,0715 | 0,1097 | 0,0714 |

Table 8. Local priority matrix of decision maker No. 2

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0647 | 0,1549 | 0,0578 | 0,1046 | 0,1027 | 0,1747 | 0,0820 |
| 0,0456 | 0,0709 | 0,3824 | 0,1637 | 0,1528 | 0,0585 | 0,0794 |
| 0,0572 | 0,0709 | 0,0578 | 0,0703 | 0,0777 | 0,1400 | 0,0820 |
| 0,0468 | 0,0709 | 0,0578 | 0,0994 | 0,1831 | 0,1286 | 0,0820 |
| 0,0736 | 0,0709 | 0,0786 | 0,0703 | 0,0902 | 0,0592 | 0,1830 |
| 0,3859 | 0,2300 | 0,1483 | 0,2108 | 0,1498 | 0,2564 | 0,0820 |
| 0,1700 | 0,2127 | 0,1275 | 0,2108 | 0,1660 | 0,1078 | 0,2138 |
| 0,1562 | 0,1187 | 0,0900 | 0,0703 | 0,0777 | 0,0747 | 0,1959 |

Table 9. Local priority matrix of decision maker No. 3

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1582 | 0,2233 | 0,072 | 0,1028 | 0,0868 | 0,1170 | 0,0694 |
| 0,0820 | 0,0867 | 0,3406 | 0,1886 | 0,0991 | 0,0747 | 0,0704 |
| 0,0820 | 0,0721 | 0,0744 | 0,1167 | 0,0997 | 0,1551 | 0,0722 |
| 0,1122 | 0,0903 | 0,0674 | 0,0863 | 0,1594 | 0,0853 | 0,0764 |
| 0,1032 | 0,0941 | 0,0822 | 0,1038 | 0,0799 | 0,0799 | 0,0722 |
| 0,2398 | 0,1498 | 0,1626 | 0,1823 | 0,1728 | 0,2161 | 0,0973 |
| 0,1268 | 0,1703 | 0,1208 | 0,1167 | 0,2012 | 0,1695 | 0,3128 |
| 0,0957 | 0,1134 | 0,0802 | 0,1028 | 0,1011 | 0,1023 | 0,2292 |

Table 10. Local priority matrix of decision maker No. 4

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1530 | 0,1061 | 0,0939 | 0,0728 | 0,0891 | 0,1345 | 0,0822 |
| 0,0800 | 0,0769 | 0,1846 | 0,1814 | 0,1028 | 0,0399 | 0,0636 |
| 0,0751 | 0,1206 | 0,0511 | 0,0485 | 0,0659 | 0,1074 | 0,0670 |
| 0,0800 | 0,1140 | 0,1121 | 0,0983 | 0,1505 | 0,0912 | 0,0845 |
| 0,0950 | 0,0956 | 0,0563 | 0,0603 | 0,1184 | 0,0853 | 0,0897 |
| 0,2882 | 0,2498 | 0,2673 | 0,2582 | 0,2473 | 0,3176 | 0,0699 |
| 0,1068 | 0,1319 | 0,1407 | 0,1825 | 0,1334 | 0,1083 | 0,3531 |
| 0,1217 | 0,1051 | 0,0939 | 0,0980 | 0,0927 | 0,1158 | 0,1900 |

Table 11. Local priority matrix of decision maker No. 5

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0940 | 0,1405 | 0,1088 | 0,1475 | 0,0680 | 0,2069 | 0,0680 |
| 0,0560 | 0,0742 | 0,3529 | 0,1521 | 0,0960 | 0,0586 | 0,0739 |
| 0,0498 | 0,1043 | 0,0506 | 0,0796 | 0,0489 | 0,1381 | 0,0680 |
| 0,0601 | 0,1208 | 0,0392 | 0,1183 | 0,0783 | 0,1375 | 0,0796 |
| 0,0505 | 0,0661 | 0,0446 | 0,066 | 0,0825 | 0,0430 | 0,0600 |
| 0,4311 | 0,3049 | 0,1634 | 0,2763 | 0,3699 | 0,2007 | 0,1585 |
| 0,1613 | 0,0822 | 0,175 | 0,0864 | 0,1588 | 0,1225 | 0,3175 |
| 0,0971 | 0,1070 | 0,0655 | 0,0739 | 0,0976 | 0,0927 | 0,1744 |

Table 12. Local priority matrix of decision maker No. 6

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0703 | 0,1640 | 0,1434 | 0,1549 | 0,0758 | 0,1278 | 0,0617 |
| 0,0654 | 0,0608 | 0,3273 | 0,1039 | 0,1325 | 0,0573 | 0,0531 |
| 0,0547 | 0,053 | 0,0942 | 0,1164 | 0,1367 | 0,1323 | 0,0716 |
| 0,1095 | 0,1469 | 0,0251 | 0,0993 | 0,1242 | 0,1233 | 0,1105 |
| 0,1908 | 0,0609 | 0,0538 | 0,0558 | 0,0833 | 0,0410 | 0,0991 |
| 0,1915 | 0,2283 | 0,1903 | 0,1924 | 0,0893 | 0,2184 | 0,0644 |
| 0,2028 | 0,1552 | 0,0941 | 0,1386 | 0,2539 | 0,1968 | 0,3656 |
| 0,1150 | 0,1309 | 0,0717 | 0,1385 | 0,1042 | 0,1030 | 0,1738 |

Table 13. Local priority matrix of decision maker No. 7

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0280 | 0,0947 | 0,0410 | 0,1448 | 0,2338 | 0,1033 | 0,0410 |
| 0,0923 | 0,0331 | 0,0634 | 0,1041 | 0,1378 | 0,0813 | 0,0410 |
| 0,0854 | 0,0494 | 0,0683 | 0,1130 | 0,0903 | 0,0971 | 0,0410 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0982 | 0,0997 | 0,0732 | 0,1274 | 0,1173 | 0,0747 | 0,1114 |
| 0,0679 | 0,1043 | 0,1116 | 0,1024 | 0,0425 | 0,0904 | 0,0410 |
| 0,3460 | 0,2741 | 0,1087 | 0,1003 | 0,1528 | 0,1500 | 0,0489 |
| 0,1648 | 0,2380 | 0,2491 | 0,1130 | 0,1715 | 0,2750 | 0,3576 |
| 0,1174 | 0,1066 | 0,2847 | 0,1951 | 0,0539 | 0,1283 | 0,3179 |

Table 14. Local priority matrix of decision maker No. 8

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1382 | 0,0725 | 0,1518 | 0,1135 | 0,1291 | 0,1101 | 0,0658 |
| 0,1042 | 0,0554 | 0,0825 | 0,1062 | 0,0800 | 0,0766 | 0,0564 |
| 0,0774 | 0,0874 | 0,1058 | 0,1356 | 0,0673 | 0,0558 | 0,0954 |
| 0,0790 | 0,1594 | 0,1361 | 0,1130 | 0,1069 | 0,0997 | 0,0630 |
| 0,1201 | 0,1480 | 0,0918 | 0,0993 | 0,0757 | 0,1646 | 0,0979 |
| 0,1714 | 0,1594 | 0,1141 | 0,1215 | 0,2470 | 0,1412 | 0,1560 |
| 0,1159 | 0,1729 | 0,1537 | 0,1062 | 0,1308 | 0,0919 | 0,3029 |
| 0,1937 | 0,1450 | 0,1642 | 0,2047 | 0,1632 | 0,2602 | 0,1625 |

Table 15. Local priority matrix of decision maker No. 9

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1114 | 0,1045 | 0,0758 | 0,0855 | 0,0432 | 0,0953 | 0,0691 |
| 0,1218 | 0,0420 | 0,0496 | 0,0709 | 0,1151 | 0,0459 | 0,0837 |
| 0,0783 | 0,0659 | 0,0725 | 0,0779 | 0,2534 | 0,0953 | 0,1229 |
| 0,0601 | 0,1284 | 0,1471 | 0,0577 | 0,1343 | 0,0701 | 0,1169 |
| 0,1231 | 0,1976 | 0,0647 | 0,1422 | 0,0945 | 0,1786 | 0,1406 |
| 0,1917 | 0,1284 | 0,2543 | 0,1078 | 0,1222 | 0,2103 | 0,1788 |
| 0,2167 | 0,2094 | 0,2417 | 0,2477 | 0,1890 | 0,1662 | 0,1418 |
| 0,0968 | 0,1237 | 0,0942 | 0,2102 | 0,0482 | 0,1383 | 0,1464 |

Table 15. Local priority matrix of decision maker No. 10

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0663 | 0,0974 | 0,1240 | 0,0999 | 0,1036 | 0,1044 | 0,0616 |
| 0,0697 | 0,0683 | 0,0412 | 0,0767 | 0,1058 | 0,0942 | 0,1148 |
| 0,0904 | 0,0986 | 0,1166 | 0,0738 | 0,0758 | 0,1056 | 0,1038 |
| 0,0920 | 0,0942 | 0,1006 | 0,1176 | 0,1143 | 0,1259 | 0,1131 |
| 0,1145 | 0,0777 | 0,1318 | 0,1124 | 0,1411 | 0,1353 | 0,1318 |
| 0,2340 | 0,2096 | 0,1288 | 0,1570 | 0,1353 | 0,1342 | 0,1273 |
| 0,1635 | 0,1290 | 0,1778 | 0,1523 | 0,1733 | 0,1368 | 0,1954 |
| 0,1697 | 0,2252 | 0,1792 | 0,2103 | 0,1509 | 0,1636 | 0,1523 |

Table 16. Local priority matrix of decision maker No. 11

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1042 | 0,1589 | 0,0454 | 0,0257 | 0,2671 | 0,1308 | 0,1134 |
| 0,0706 | 0,0436 | 0,4415 | 0,1033 | 0,1989 | 0,0710 | 0,1225 |
| 0,1042 | 0,0538 | 0,0382 | 0,0383 | 0,0373 | 0,0617 | 0,0955 |
| 0,1042 | 0,4216 | 0,0382 | 0,0884 | 0,0977 | 0,1061 | 0,1518 |
| 0,0886 | 0,0392 | 0,1729 | 0,0847 | 0,0352 | 0,0474 | 0,0893 |
| 0,3025 | 0,1204 | 0,0380 | 0,1258 | 0,1453 | 0,3128 | 0,0955 |
| 0,1128 | 0,0864 | 0,1346 | 0,2703 | 0,1292 | 0,1351 | 0,2366 |
| 0,1128 | 0,0760 | 0,0911 | 0,2634 | 0,0894 | 0,1351 | 0,0955 |

Table 17. Local priority matrix of decision maker No. 12

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0616 | 0,0822 | 0,0824 | 0,1034 | 0,0931 | 0,0803 | 0,0973 |
| 0,1013 | 0,1845 | 0,1174 | 0,1726 | 0,1487 | 0,1161 | 0,1271 |
| 0,0409 | 0,0337 | 0,0381 | 0,0415 | 0,0445 | 0,0483 | 0,0455 |
| 0,0292 | 0,0479 | 0,0330 | 0,0415 | 0,0389 | 0,0579 | 0,0407 |
| 0,0508 | 0,0429 | 0,0497 | 0,0415 | 0,0432 | 0,0477 | 0,0602 |
| 0,2219 | 0,2509 | 0,2219 | 0,1626 | 0,2670 | 0,2282 | 0,2555 |
| 0,2228 | 0,2086 | 0,2926 | 0,2273 | 0,2468 | 0,2310 | 0,2646 |
| 0,2715 | 0,1493 | 0,1649 | 0,2094 | 0,1178 | 0,1904 | 0,1092 |

Table 18. Local priority matrix of decision maker No. 13

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1582 | 0,1130 | 0,0981 | 0,0849 | 0,0953 | 0,0934 | 0,1035 |
| 0,1293 | 0,1130 | 0,0249 | 0,0919 | 0,1457 | 0,1048 | 0,1572 |
| 0,0551 | 0,1559 | 0,0464 | 0,0777 | 0,1083 | 0,1317 | 0,0727 |
| 0,0566 | 0,1345 | 0,1073 | 0,0705 | 0,0415 | 0,0574 | 0,0466 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1024 | 0,1195 | 0,1594 | 0,1298 | 0,0961 | 0,1234 | 0,1440 |
| 0,1160 | 0,1255 | 0,2019 | 0,0932 | 0,2260 | 0,2076 | 0,2065 |
| 0,1850 | 0,1034 | 0,2502 | 0,2156 | 0,1415 | 0,1317 | 0,1295 |
| 0,1975 | 0,1351 | 0,1119 | 0,2364 | 0,1457 | 0,1499 | 0,1399 |

Table 19. Local priority matrix of decision maker No. 14

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,2376 | 0,1878 | 0,1573 | 0,1151 | 0,2062 | 0,1786 | 0,0882 |
| 0,1123 | 0,1310 | 0,1766 | 0,0734 | 0,1111 | 0,1675 | 0,0809 |
| 0,1589 | 0,1037 | 0,0832 | 0,0493 | 0,1573 | 0,0487 | 0,0975 |
| 0,1058 | 0,0603 | 0,0646 | 0,0937 | 0,1389 | 0,0923 | 0,0725 |
| 0,0500 | 0,0477 | 0,0724 | 0,1172 | 0,0529 | 0,2554 | 0,1383 |
| 0,0795 | 0,1336 | 0,1649 | 0,1051 | 0,0614 | 0,0694 | 0,2176 |
| 0,1025 | 0,1978 | 0,2217 | 0,2778 | 0,1494 | 0,1403 | 0,1968 |
| 0,1533 | 0,1381 | 0,0593 | 0,1684 | 0,1228 | 0,0478 | 0,1081 |

Table 20. Local priority matrix of decision maker No. 15

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0772 | 0,2756 | 0,2456 | 0,2020 | 0,1702 | 0,1032 | 0,1445 |
| 0,1308 | 0,1452 | 0,1720 | 0,1735 | 0,1714 | 0,1657 | 0,1195 |
| 0,0692 | 0,1584 | 0,1388 | 0,0613 | 0,0473 | 0,1877 | 0,1195 |
| 0,1305 | 0,1288 | 0,1535 | 0,0478 | 0,1217 | 0,1298 | 0,0956 |
| 0,1424 | 0,1202 | 0,0644 | 0,0832 | 0,0623 | 0,1205 | 0,1403 |
| 0,1291 | 0,0674 | 0,0418 | 0,1578 | 0,0730 | 0,0626 | 0,1070 |
| 0,1892 | 0,0571 | 0,0286 | 0,1926 | 0,1096 | 0,1782 | 0,1653 |
| 0,1316 | 0,0472 | 0,1552 | 0,0817 | 0,2445 | 0,0524 | 0,1081 |

Table 21. Local priority matrix of decision maker No. 16

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0525 | 0,0657 | 0,0580 | 0,0535 | 0,0477 | 0,0719 | 0,0399 |
| 0,0514 | 0,1073 | 0,3289 | 0,0731 | 0,0477 | 0,0652 | 0,0787 |
| 0,2221 | 0,0835 | 0,0713 | 0,0816 | 0,0946 | 0,0517 | 0,0709 |
| 0,0639 | 0,1124 | 0,0626 | 0,1188 | 0,1143 | 0,1395 | 0,1070 |
| 0,0569 | 0,1146 | 0,2949 | 0,1635 | 0,1140 | 0,1445 | 0,1129 |
| 0,2050 | 0,2256 | 0,0613 | 0,2154 | 0,1224 | 0,1697 | 0,1691 |
| 0,1714 | 0,1009 | 0,0592 | 0,1494 | 0,2296 | 0,1712 | 0,2102 |
| 0,1767 | 0,1899 | 0,0638 | 0,1449 | 0,2296 | 0,1863 | 0,2114 |

Table 22. Local priority matrix of decision maker No. 17

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1631 | 0,0787 | 0,0342 | 0,0515 | 0,0726 | 0,0537 | 0,0750 |
| 0,1262 | 0,0628 | 0,2421 | 0,1739 | 0,0581 | 0,0302 | 0,0599 |
| 0,1378 | 0,0459 | 0,0323 | 0,0409 | 0,0594 | 0,0461 | 0,0519 |
| 0,0333 | 0,1284 | 0,0259 | 0,0418 | 0,1113 | 0,0713 | 0,0439 |
| 0,0742 | 0,0340 | 0,2184 | 0,0782 | 0,0546 | 0,0402 | 0,0392 |
| 0,2933 | 0,2816 | 0,0936 | 0,1367 | 0,1364 | 0,3489 | 0,1017 |
| 0,1155 | 0,1923 | 0,1754 | 0,3053 | 0,2346 | 0,2673 | 0,3999 |
| 0,0566 | 0,1764 | 0,1782 | 0,1718 | 0,2729 | 0,1423 | 0,2286 |

Table 23. Local priority matrix of decision maker No. 18

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1390 | 0,1782 | 0,2089 | 0,0472 | 0,1250 | 0,1275 | 0,0582 |
| 0,1276 | 0,1699 | 0,1246 | 0,0891 | 0,1250 | 0,1006 | 0,0395 |
| 0,1261 | 0,1494 | 0,1265 | 0,0472 | 0,1250 | 0,0801 | 0,0508 |
| 0,0420 | 0,0587 | 0,1002 | 0,0591 | 0,1250 | 0,0801 | 0,0361 |
| 0,0675 | 0,0377 | 0,2131 | 0,1244 | 0,1250 | 0,0711 | 0,0496 |
| 0,1760 | 0,1521 | 0,1045 | 0,1504 | 0,1250 | 0,2566 | 0,1564 |
| 0,1968 | 0,1271 | 0,0795 | 0,2692 | 0,1250 | 0,1884 | 0,3249 |
| 0,1250 | 0,1268 | 0,0426 | 0,2134 | 0,1250 | 0,0957 | 0,2844 |

Table 24. Local priority matrix of decision maker No. 19

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1030 | 0,2085 | 0,0986 | 0,1338 | 0,0644 | 0,2023 | 0,0733 |
| 0,0981 | 0,1567 | 0,0653 | 0,0903 | 0,0740 | 0,0821 | 0,0895 |
| 0,1201 | 0,0518 | 0,1062 | 0,0742 | 0,1153 | 0,0965 | 0,1414 |
| 0,0605 | 0,2635 | 0,1489 | 0,1517 | 0,1492 | 0,0773 | 0,1243 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1119 | 0,1056 | 0,0885 | 0,1279 | 0,0730 | 0,0696 | 0,1503 |
| 0,1020 | 0,0557 | 0,0948 | 0,1215 | 0,1370 | 0,0775 | 0,0954 |
| 0,1769 | 0,1042 | 0,1510 | 0,2227 | 0,1390 | 0,1479 | 0,0908 |
| 0,2275 | 0,0539 | 0,2468 | 0,0778 | 0,2480 | 0,2469 | 0,2349 |

Table 25. Local priority matrix of decision maker No. 20

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1024 | 0,1181 | 0,0945 | 0,1152 | 0,0927 | 0,1207 | 0,0958 |
| 0,0765 | 0,1008 | 0,1311 | 0,1051 | 0,1658 | 0,1544 | 0,1736 |
| 0,1509 | 0,1765 | 0,1403 | 0,1468 | 0,1259 | 0,1364 | 0,1411 |
| 0,1656 | 0,1626 | 0,1049 | 0,1414 | 0,1499 | 0,1045 | 0,1186 |
| 0,1239 | 0,1418 | 0,1075 | 0,1838 | 0,1305 | 0,0989 | 0,1254 |
| 0,0980 | 0,0660 | 0,1940 | 0,0891 | 0,1207 | 0,1216 | 0,1072 |
| 0,1122 | 0,0661 | 0,0945 | 0,1472 | 0,0833 | 0,1555 | 0,1415 |
| 0,1706 | 0,1680 | 0,1331 | 0,0714 | 0,1311 | 0,1080 | 0,0968 |

Table 26. Local priority matrix of decision maker No. 21

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1417 | 0,1781 | 0,1530 | 0,0699 | 0,1894 | 0,2273 | 0,0795 |
| 0,1540 | 0,0474 | 0,2447 | 0,1546 | 0,1923 | 0,0387 | 0,0784 |
| 0,0348 | 0,1198 | 0,1260 | 0,1620 | 0,0496 | 0,0902 | 0,0784 |
| 0,0804 | 0,1122 | 0,0722 | 0,2188 | 0,0821 | 0,1108 | 0,0784 |
| 0,1280 | 0,1334 | 0,0793 | 0,0655 | 0,0666 | 0,0480 | 0,0784 |
| 0,1298 | 0,1588 | 0,1196 | 0,1171 | 0,1669 | 0,2092 | 0,0969 |
| 0,1395 | 0,1409 | 0,1173 | 0,1328 | 0,1663 | 0,1554 | 0,2819 |
| 0,1918 | 0,1094 | 0,0879 | 0,0792 | 0,0868 | 0,1204 | 0,2283 |

Table 27. Local priority matrix of decision maker No. 22

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1720 | 0,1322 | 0,1109 | 0,1545 | 0,0947 | 0,1994 | 0,0964 |
| 0,1508 | 0,0719 | 0,1297 | 0,1947 | 0,1562 | 0,1465 | 0,2012 |
| 0,0844 | 0,1748 | 0,1350 | 0,1966 | 0,1898 | 0,1568 | 0,1306 |
| 0,0526 | 0,0483 | 0,1030 | 0,0695 | 0,0919 | 0,0792 | 0,1942 |
| 0,0622 | 0,0811 | 0,1391 | 0,0858 | 0,0992 | 0,0459 | 0,1000 |
| 0,1723 | 0,1934 | 0,1788 | 0,0907 | 0,1592 | 0,1651 | 0,0605 |
| 0,1621 | 0,1454 | 0,1314 | 0,1175 | 0,1000 | 0,1304 | 0,0883 |
| 0,1436 | 0,1529 | 0,0722 | 0,0907 | 0,1090 | 0,0768 | 0,1289 |

Table 28. Local priority matrix of decision maker No. 23

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1683 | 0,1580 | 0,0653 | 0,1309 | 0,1211 | 0,1402 | 0,1335 |
| 0,1186 | 0,0806 | 0,1704 | 0,1750 | 0,1439 | 0,1055 | 0,3014 |
| 0,1449 | 0,0724 | 0,0662 | 0,0417 | 0,0882 | 0,1750 | 0,0839 |
| 0,1031 | 0,1906 | 0,1348 | 0,1687 | 0,1515 | 0,1154 | 0,1078 |
| 0,0846 | 0,0881 | 0,2065 | 0,1081 | 0,1079 | 0,1132 | 0,0375 |
| 0,1426 | 0,1589 | 0,1362 | 0,0919 | 0,1857 | 0,1572 | 0,0638 |
| 0,0887 | 0,1256 | 0,1279 | 0,1627 | 0,0977 | 0,0825 | 0,1472 |
| 0,1491 | 0,1256 | 0,0927 | 0,1210 | 0,1039 | 0,1109 | 0,1249 |

Table 29. Local priority matrix of decision maker No. 24

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1727 | 0,1567 | 0,0838 | 0,0492 | 0,1515 | 0,1615 | 0,1042 |
| 0,0639 | 0,0917 | 0,2032 | 0,1590 | 0,0855 | 0,0595 | 0,1699 |
| 0,1339 | 0,1191 | 0,0865 | 0,0529 | 0,0968 | 0,1062 | 0,1015 |
| 0,1350 | 0,1105 | 0,0783 | 0,2110 | 0,1464 | 0,0669 | 0,0891 |
| 0,1118 | 0,0935 | 0,1996 | 0,1074 | 0,1183 | 0,1912 | 0,1632 |
| 0,1475 | 0,1840 | 0,1066 | 0,0880 | 0,1615 | 0,1820 | 0,1405 |
| 0,1011 | 0,1144 | 0,0953 | 0,1662 | 0,0726 | 0,1252 | 0,0847 |
| 0,1339 | 0,1300 | 0,1467 | 0,1662 | 0,1673 | 0,1074 | 0,1468 |

Table 30. Local priority matrix of decision maker No. 25

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1763 | 0,1442 | 0,0832 | 0,1192 | 0,1378 | 0,1155 | 0,1273 |
| 0,1289 | 0,1592 | 0,1775 | 0,1700 | 0,1121 | 0,0690 | 0,1866 |
| 0,0939 | 0,1295 | 0,1058 | 0,1327 | 0,0890 | 0,1551 | 0,1177 |
| 0,0820 | 0,0634 | 0,0997 | 0,1919 | 0,1403 | 0,1471 | 0,0636 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0960 | 0,0966 | 0,1345 | 0,0747 | 0,1648 | 0,1629 | 0,1192 |
| 0,1222 | 0,1017 | 0,1375 | 0,1011 | 0,1252 | 0,1114 | 0,1136 |
| 0,1719 | 0,1719 | 0,1553 | 0,1244 | 0,1012 | 0,1276 | 0,1529 |
| 0,1289 | 0,1337 | 0,1065 | 0,0860 | 0,1296 | 0,1114 | 0,1191 |

Table 31. Local priority matrix of decision maker No. 26

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0657 | 0,1012 | 0,1429 | 0,1940 | 0,1326 | 0,1544 | 0,1010 |
| 0,1422 | 0,1361 | 0,1640 | 0,1798 | 0,0813 | 0,1669 | 0,1654 |
| 0,1653 | 0,0959 | 0,1307 | 0,0714 | 0,1199 | 0,1207 | 0,1269 |
| 0,0709 | 0,0990 | 0,0703 | 0,0986 | 0,1039 | 0,0790 | 0,0890 |
| 0,0698 | 0,0996 | 0,0987 | 0,1043 | 0,1920 | 0,0937 | 0,1039 |
| 0,1664 | 0,1225 | 0,1334 | 0,1215 | 0,1555 | 0,0872 | 0,1059 |
| 0,1767 | 0,2149 | 0,1590 | 0,1215 | 0,1212 | 0,1912 | 0,1490 |
| 0,1429 | 0,1308 | 0,1011 | 0,1090 | 0,0937 | 0,1071 | 0,1589 |

Table 32. Local priority matrix of decision maker No. 27

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1583 | 0,1100 | 0,0715 | 0,1310 | 0,2558 | 0,1807 | 0,1366 |
| 0,1074 | 0,1135 | 0,3490 | 0,1569 | 0,1103 | 0,1114 | 0,1269 |
| 0,1473 | 0,1029 | 0,0637 | 0,0956 | 0,1019 | 0,1253 | 0,1129 |
| 0,1014 | 0,2119 | 0,0628 | 0,1268 | 0,1186 | 0,1126 | 0,1247 |
| 0,1083 | 0,1029 | 0,1531 | 0,1132 | 0,1228 | 0,0733 | 0,1240 |
| 0,1669 | 0,1112 | 0,1291 | 0,1498 | 0,1311 | 0,1676 | 0,0799 |
| 0,0853 | 0,1239 | 0,0852 | 0,1373 | 0,0798 | 0,1114 | 0,1535 |
| 0,1252 | 0,1239 | 0,0856 | 0,0893 | 0,0798 | 0,1175 | 0,1414 |

Table 33. Local priority matrix of decision maker No. 28

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1041 | 0,2321 | 0,0878 | 0,0422 | 0,1085 | 0,1603 | 0,1337 |
| 0,0725 | 0,0481 | 0,3579 | 0,0880 | 0,0999 | 0,2216 | 0,1259 |
| 0,1054 | 0,0352 | 0,0788 | 0,1601 | 0,0427 | 0,0955 | 0,1080 |
| 0,1976 | 0,2481 | 0,1374 | 0,2112 | 0,1881 | 0,0463 | 0,1002 |
| 0,0779 | 0,0696 | 0,0701 | 0,1160 | 0,1210 | 0,0766 | 0,1571 |
| 0,1415 | 0,1153 | 0,0889 | 0,1340 | 0,1369 | 0,1030 | 0,1055 |
| 0,1504 | 0,1258 | 0,0828 | 0,1682 | 0,1948 | 0,1796 | 0,1445 |
| 0,1506 | 0,1258 | 0,0963 | 0,0804 | 0,1082 | 0,1170 | 0,1252 |

Table 34. Local priority matrix of decision maker No. 29

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1333 | 0,1731 | 0,1359 | 0,1397 | 0,1314 | 0,1237 | 0,1310 |
| 0,1145 | 0,0756 | 0,1558 | 0,1801 | 0,1098 | 0,1228 | 0,1310 |
| 0,1707 | 0,1464 | 0,1333 | 0,1233 | 0,1300 | 0,1280 | 0,0972 |
| 0,1415 | 0,1253 | 0,0931 | 0,1041 | 0,2047 | 0,0955 | 0,1117 |
| 0,0805 | 0,0959 | 0,1163 | 0,0910 | 0,1031 | 0,1338 | 0,2184 |
| 0,1036 | 0,1098 | 0,1171 | 0,1340 | 0,1155 | 0,1508 | 0,1358 |
| 0,1413 | 0,1464 | 0,1437 | 0,1371 | 0,0971 | 0,1383 | 0,0486 |
| 0,1145 | 0,1276 | 0,1047 | 0,0906 | 0,1084 | 0,1071 | 0,1262 |

Table 35. Local priority matrix of decision maker No. 30

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,1226 | 0,1451 | 0,0940 | 0,1397 | 0,1421 | 0,1714 | 0,1252 |
| 0,1507 | 0,1070 | 0,1315 | 0,1275 | 0,1758 | 0,0789 | 0,1449 |
| 0,1820 | 0,1924 | 0,1466 | 0,1623 | 0,1589 | 0,1786 | 0,1541 |
| 0,0865 | 0,0881 | 0,0819 | 0,0717 | 0,0758 | 0,0811 | 0,0802 |
| 0,1160 | 0,0922 | 0,1775 | 0,1543 | 0,0820 | 0,0811 | 0,1557 |
| 0,1226 | 0,1473 | 0,1175 | 0,1275 | 0,1265 | 0,1653 | 0,1607 |
| 0,0972 | 0,1070 | 0,1466 | 0,1150 | 0,1306 | 0,1358 | 0,0626 |
| 0,1226 | 0,1209 | 0,1044 | 0,1020 | 0,1083 | 0,1078 | 0,1167 |

These matrices illustrate that the weight of the alternative is a bivariate function that varies with the decision maker and the criterion. The average weight of each alternative per criterion leads to an intermediate priority matrix Table 36.

Table 36. Intermediate Priority Matrix of Alternatives

$[W] =$

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,12086 | 0,14153 | 0,10344 | 0,10665 | 0,12343 | 0,13868 | 0,09099 |
| 0,10118 | 0,09397 | 0,20067 | 0,13689 | 0,12614 | 0,09494 | 0,11292 |
| 0,10630 | 0,10076 | 0,08895 | 0,09199 | 0,09896 | 0,11273 | 0,09310 |
| 0,08925 | 0,13083 | 0,08715 | 0,11457 | 0,12408 | 0,09522 | 0,09282 |
| 0,09394 | 0,09273 | 0,12091 | 0,10124 | 0,09446 | 0,09953 | 0,10980 |
| 0,19714 | 0,17096 | 0,14064 | 0,13967 | 0,15742 | 0,18239 | 0,12098 |
| 0,15781 | 0,15491 | 0,17239 | 0,17523 | 0,17311 | 0,14941 | 0,28394 |
| 0,14364 | 0,12671 | 0,11507 | 0,13483 | 0,12609 | 0,12423 | 0,16157 |

## 1.2. Quantification of criteria weights

The seven retained criteria are the dimensions of human exclusion, and the weights are calculated based on the exclusion indices. The column matrix of the criteria the expression gives weights:

$$[\varphi] = \begin{pmatrix} \varphi^{Nm} \\ \varphi^{ChM} \\ \varphi^{Lr} \\ \varphi^{Yu} \\ \varphi^{Np} \\ \varphi^{Le} \\ \varphi^{rai} \end{pmatrix} \quad (28)$$

## 1.3. Application to the Bogo-Pouss Road project: Bogo-Guirvidig section (32.86 km)

The Bogo-Pouss Road project's Bogo-Guirvidig segment, spanning 32.86 km, serves as a critical transportation link connecting Cameroon's Diamaré and Mayo Danay departments. As noted by Andrea et al. (2025), this infrastructure initiative in the Far North region represents a collaborative funding model, with 85% financing from the African Development Bank (85%) and 15 % from the Cameroonian government.

The social profile of the area is characterized by the elements of Tables 37 and 38.

Table 37. Social profile of the Bogo-Pouss project area: Bogo-Guirvidig section

- $Nm^{n}{}_{0-28}$ : local estimate of infant mortality [16][35] 10.2% [33]
- $Nm^{r}{}_{0-28}$ : reference value for neonatal mortality (average value for middle-income countries) =2,39% (UNICEF)
- $ChM^{n}{}_{28d-59m}$ : prevalence of chronic undernutrition among children aged 1 month to 5 years at the local or national level [16][35] =37% [33]
- $Lr^{\theta}{}_{15-24}$ : Youth literacy Metric (ages 15 – 24) =40% [17]
- $Yu^{n}{}_{15-24}$ : unemployment rate among youth aged 15 to 24, assessed locally or nationally (Bolduc & Urbaine, 2010; Iris Macculi & Carlos Acosta Bermůdez, 2015) =20,7% [18]
- $Np^{n}{}_{h}$ percentage of the population living under the poverty threshold (local or national) (Bolduc & Urbaine, 2010; Iris Macculi & Carlos Acosta Bermůdez, 2015) =74,3% [60]
- $Le^{n}{}_{60}$ : average remaining life expectancy at age 60, measured at the local or national level (Bolduc & Urbaine, 2010; Iris Macculi & Carlos Acosta Bermůdez, 2015) =67,9 [17]
- $Le^{Réf}_{60}$: benchmark life expectancy at 60 years [16][35] =69,3 [56]

Table 38. Human exclusion indices of the Bogo-Pouss project area: Bogo-Guirvidig section

- $[IEx^{Nm}]$ = 0,7657
- $[IEx^{ChM}]$ = 0,5873
- $[IEx^{Lr}]$ = 1
- $[IEx^{Yu}]$ = 0,2610
- $[IEx^{Np}]$ = 1
- $[IEx^{Le}]$= 0,0202
- $[RAI]$ = 0,2000

The weights of the criteria resulting from these exclusion indices are recorded in Table 39.

.

Table 39. Weight of the different criteria

- $[\varphi^{Nm}] = 0{,}1997$
- $[\varphi^{ChM}] = 0{,}1582$
- $[\varphi^{Lr}] = 0{,}2608$
- $[\varphi^{Yu}] = 0{,}0681$
- $[\varphi^{Np}] = 0{,}2608$
- $[\varphi^{Lef}] = 0{,}0053$
- $[\varphi^{rai}] = 0{,}0522$

The aggregated priority rankings for related infrastructure alternatives for the Bogo-Guirvidig roadway segment were derived from a synthesis of primary data Table 36 and secondary data Table 39. As shown in Table 40 and Figure 3, the analysis reveals the relative weights and ordinal rankings of each alternative. For instance, Alternative 2 achieved a higher priority score (0.1355, ranked 2nd) compared to Alternative 1 (0.1177, ranked 4th), reflecting differentiated project requirements.

Table 40. Overall priorities of related infrastructure associated with the Bogo-Pouss project: section Bogo-Guirvidig

| Alternatives | Relative Weighting | Ranking |
|---|---|---|
| Alternative 1: Borehole/Well | 0.1177 | 4th |
| Alternative 2: Classroom block | 0.1355 | 2nd |
| Alternative 3: Latrines | 0.0974 | 7th |
| Alternative 4: Storage shed | 0.1061 | 5th |
| Alternative 5: Fence for securing schools | 0.1023 | 6th |
| Alternative 6: Health center | 0.1601 | 1st |
| Alternative 7: Municipal Road | 0.1210 | 3rd |
| Alternative 8: Urban roads | 0.0646 | 8th |

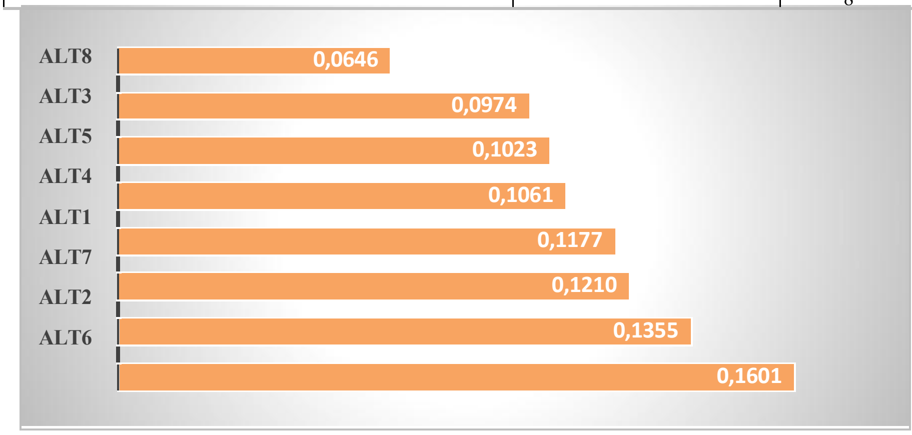


Figure 3. Overall priorities of related infrastructure associated with the Bogo-Pouss project: Bogo-Guirvidig section

The results show that alternatives 6 (health center), 2 (classroom block), 7 (communal roads) and 1 (boreholes/wells) form the quartet of related infrastructure to be carried out within the framework of the Bogo-Pouss Road construction project: Bogo -Guirvidis section, with respective overall priorities of 16.01%, 13.55%, 12.10%, 11.77%. They contribute 53.43% to the overall objective.

The preeminence of health and school infrastructure in the result ranking reflects the dimensions of wellbeing (health and quality education) from which the area's populations are excluded. This confirms that the priorities are not just technical or economic but are centered on improving human well-being. Table 38 presents the exclusion index from access to quality education $[IEx^{Lr}] = 1$ (indicating total exclusion in this dimension) and the exclusion index from basic health services $[IEx^{Nm}] = 0{,}7657$ (reflecting a very high level of exclusion). These figures clearly show that the Bogo-Guirvidig area is severely underserved in essential social services. To address critical gaps, the Government of Cameroon must prioritize investments in key infrastructures. This will:

- ✓ Reduce exclusion indices and advance progress toward the following Sustainable Development Goals (SDGs): i) SDG 3 (Good health and well-being), (ii) SDG 4 (Quality education), (iii) SDG 9 (industry, innovation, and infrastructure), and (iv) SDG 11 (Sustainable cities and communities).
- ✓ Align with pillar 2 (Human Capital Development and Well-being) and pillar 3 (Employment Promotion and Economic Integration) of Cameroon's National Development Strategy [60].

- **Sensitivity Analysis**

In any decision-making process, we would like to know more about the parameters that most influence the results as well as the stability of said results. This is why it is helpful to carry out a "what if… and if…" analysis to examine how varying the weights assigned to the criteria might have influenced the final results: this involves carrying out the sensitivity analysis with Excel software, also called 'If analysis' [4].

Based on the basic scenario, four scenarios were selected by adjusting the importance assigned to each criterion [36]:

– Scenario 1: investigating the influence [36] of the 15-24 age group literacy rate on the sensitivity of the results;
– Scenario 2: assessment of the impact of changes in the poverty line criterion [9] on the overall analysis;
– Scenario 3: evaluation of how changes in the criterion of child undernutrition prevalence [36] affect analysis;
– Scenario 4: sensitivity analysis in relation to the youth unemployment criterion (15 to 24 years old).

Table 41 summarizes the different weights obtained.

Table 41. Sensitivity analysis scenarios

| | | initial Scenario | scenario 1 | scenario 2 | scenario 3 | scenario 4 |
|---|---|---|---|---|---|---|
| CRITERIA | Infant/neonatal mortality | 0.1997 | 0.2347 | 0.2270 | 0.2218 | 0.1863 |
| | Prevalence of child undernutrition | 0.1532 | 0.1800 | 0.1741 | 0.0593 | 0.1429 |
| | Youth literacy metric (ages15-24) | 0.2608 | 0.1314 | 0.2965 | 0.2897 | 0.2434 |
| | Youth unemployment (ages15-24) | 0.0681 | 0.0800 | 0.0774 | 0.0756 | 0.1305 |
| | National poverty line | 0.2608 | 0.3065 | 0.1596 | 0.2897 | 0.2434 |
| | Life expectancy at age 60 | 0.0053 | 0.0062 | 0.0060 | 0.0059 | 0.0049 |
| | Rural accessibility | 0.0522 | 0.0613 | 0.0593 | 0.0579 | 0.0487 |
| Sum of normalized weights (per scenario) | | 1 | 1 | 1 | 1 | 1 |
| Outcomes of the alternative weighting analysis | | | | | | |
| ALTERNATIVES | Alt1: Drilling/Wells | 0,1117 | 0,1202 | 0,1169 | 0,1151 | 0,1170 |
| | Alt2: Classroom block | 0,1355 | 0,1242 | 0,1368 | 0,1401 | 0,1357 |
| | Alt3: Latrines | 0,0974 | 0,0989 | 0,0972 | 0,0970 | 0,0970 |
| | Alt4: Storage Shed/Shop | 0,1061 | 0,1094 | 0,1036 | 0,1033 | 0,1067 |
| | Alt5: Security fencing for educational establishments | 0,1023 | 0,0990 | 0,1033 | 0,1033 | 0,1022 |
| | Alt6: Health Center | 0,1601 | 0,1635 | 0,1604 | 0,1589 | 0,1587 |
| | Alt7: Rural road | 0,1210 | 0,1211 | 0,1210 | 0,1224 | 0,1211 |
| | Alt8: Urban roads | 0,0646 | 0,0659 | 0,0648 | 0,0648 | 0,0648 |

Table 42 shows the range of variation of the different parameters of the model in which the ranking of proposed priorities remains stable.

Table 42. Analysis of the robustness of priorities

| | |
|---|---|
| Scenario 1: Stable ranking of alternatives if: | $Lr^{\theta}_{15-24} \in [40\% ;\ 70\%]\ i.e{:} [IEx^{Lr}] \in [0{,}4286 ;\ 1]$ |
| Scenario 2 Stable ranking of alternatives if: | $Np^{n}_{h} \in [35\% ;\ 74{,}3\%]\ i.e{:}\ [IEx^{Np}] \in [0{,}5384 ;\ 1]$ |
| Scenario 3: Stable ranking of alternatives if: | $ChM^{n}_{28d-59m} \in [17\% ;\ 37\%]\ i.e{:}\ [IEx^{ChM}] \in [0{,}2048 ;\ 0{,}5873]$ |
| Scenario 4: Stable ranking of alternatives if: | $Yu^{n}_{15-24} \leq 34{,}9\%\ i.e{:}\ [IEx^{Yu}] \leq\ 0{,}5361$ |

These results show that, if the Government invests in accordance with these priorities, the social profile of the area will improve according to three main determinants:

- the 15-24 age group literacy metric will increase from 40% to 70%, an increase of 30%;
- the percentage of individuals below the poverty line will fall from 74.3% to 35%, a decrease of 39.3%;
- the prevalence of child malnutrition will drop from 37% to 17%, a decrease of 20%.

The improvements will remain in force even if the unemployment rate of young people aged 15 to 24 increases from 20.4% to 34.9%, an increase of 14.5%.

## 1.4. Application to the Bingambo-Grandzambi Road Project (43 km)

The Bingambo-Grandzambi road project is in Cameroon's Southern region. It is financed by BADEA (10.42%), FKDEA (22%), FSD (21.85%), FADD (17.96%), OFID (17.89%), and the State of Cameroon (9.88%), and constitutes a link between the political capital of Cameroon (Yaoundé) and the Port of Kribi.

The social profile of the area is characterized by the elements of Table 43 and 44.

Table 43. Social profile of the Bingambo-Grandzambi project area

- $Nm^{n}_{0-28}$ : local estimate of infant mortality [16][35] = 9% [33]
- $Nm^{r}_{0-2}$ : reference value for neonatal mortality (average value for middle-income countries) =2,39% (UNICEF)
- $ChM^{n}_{28d-59m}$ : prevalence of chronic undernutrition among children aged 1 month to 5 years at the local or national level [16][35]=26% [33]
- $Lr^{\theta}_{15-24}$ : Youth literacy Metric (ages 15 – 24) =90%[17]
- $Yu^{n}_{15-24}$ : unemployment rate among youth aged 15 to 24, assessed locally or nationally [16][35] =38,5% [18]
- $Np^{n}_{h}$ percentage of the population living under the poverty threshold (local or national) [16][35] =34,1% [60]
- $Le^{n}_{60}$ average remaining life expectancy at age 60, measured at the local or national level [16][35] =45,1 [17]
- $Le^{Réf}_{60}$ benchmark life expectancy at 60 years [16][35] =69,3 [56]

Table 44. Human exclusion indices of the Bingambo-Grandzambi project area

- $[IEx^{Nm}]$ = 0,7344
- $[IEx^{ChM}]$ = 0,3514
- $[IEx^{Lr}]$ = 0,1111
- $[IEx^{Yu}]$ = 0,6260
- $[IEx^{Np}]$ = 0,5175
- $[IEx^{Le}]$ = 0,3492
- $[RAI]$ = 0,3000

The weights of the criteria resulting from these exclusion indices are recorded in Table 45.

Table 45. Weight of the different criteria

- $[\varphi^{Nm}]$ = 0,2457
- $[\varphi^{ChM}]$ = 0,1175
- $[\varphi^{Lr}]$ = 0,0372
- $[\varphi^{Yu}]$ = 0,2094
- $[\varphi^{Np}]$ = 0,1731
- $[\varphi^{Le}]$ = 0,1168
- $[\varphi^{rai}]$ = 0,1003

The aggregated priority rankings for related infrastructure alternatives tied to the Bingambo Grandzambi road project were derived through a synthesis of primary data Table 43 and secondary data Table 45. As shown in Table 46 and Figure 4, the analysis reveals the relative weights and ordinal rankings of each alternative. For instance, Alternative 1 achieved a higher priority score (0.1192, ranked 3rd) compared to Alternative 2 (0.1163, ranked 4th), reflecting differentiated project requirements.

Table 46. Overall priorities for related infrastructure associated with the Bingambo-Grandzambi project

| Alternatives | Relative Weighting | Ranking |
|---|---|---|
| Alternative 1: Borehole/Well | 0,1192 | 3rd |
| Alternative 2: Classroom block | 0,1163 | 4th |
| Alternative 3: Latrines | 0,1002 | 6th |
| Alternative 4: Storage shed | 0,1064 | 5th |
| Alternative 5: Fence for securing schools | 0,0987 | 7th |
| Alternative 6: Health center | 0,1637 | 1st |
| Alternative 7: Municipal Road | 0,1232 | 2nd |
| Alternative 8: Urban roads | 0,0676 | 8th |

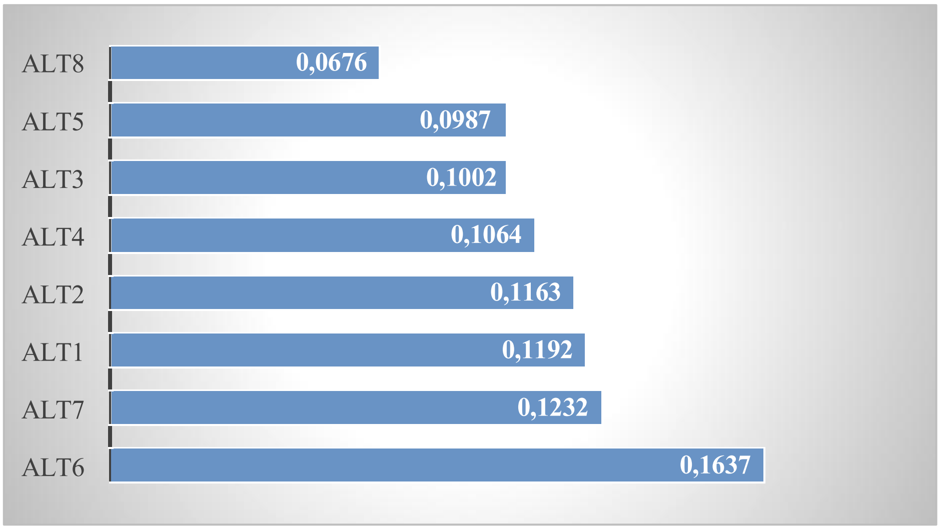


Figure 4. Overall priorities for related infrastructure associated with the Bingambo-Grandzambi project

The results show that alternatives 6 (health center), 7 (communal roads), 1 (boreholes/wells) and 2 (classroom block) form the quartet of related infrastructure to be carried out within the framework of the Bingambo-Grandzambi Road construction project, with respective overall priorities of 16.37%, 12.32%, 11.92%, and 11.63%. They contribute 52.24% to the overall objective.

The preeminence of these road-related infrastructures in the ranking of the result effectively reflects the dimensions of well-being (health, decent life, productive employment, means of subsistence) for which the area's populations are excluded. Table 44 gives the values of the exclusion index from basic health services $[IEx^{Nm}] = 0{,}7344$ (reflects a very high level of exclusion) of the exclusion index from labor market access $[IEx^{Yu}] = 0{,}6260$ (reflects a high level of exclusion), and the basic livelihood exclusion index $[IEx^{Np}] = 0{,}5175$ (reflects a significant level of exclusion). It is therefore up to the State to invest more in these priority infrastructures. This will:

- ✓ Reduce the level of exclusion and advance progress toward the following Sustainable Development Goals (SDGs): i) SDG 1 (No poverty), ii) SDG 3 (Good health and well-being), and iii) SDG 8 (Decent Work and Economic Growth).
- ✓ Align with pillar 2 (Human Capital Development and Well-being) and pillar 3 (Employment Promotion and Economic Integration) of Cameroon's National Development Strategy [60].

- **Sensitivity Analysis**

In any decision-making process, we would like to know more about the parameters that most influence the results as well as the stability of said results. This is why it is helpful to carry out a "what if… and if…" analysis to examine how varying the weights assigned to the criteria might have influenced the results: this involves carrying out the sensitivity analysis with Excel software, also called 'If analysis' [4].

Based on the basic scenario, three scenarios were selected by adjusting the importance assigned to each criterion [36]:

- Scenario 1: The weight assigned to the youth unemployment rate (ages 15-24) was systematically altered to observe it's on the final ranking [36];
- Scenario 2: the weight of the child undernutrition prevalence criterion was modified to analyse its effect on the overall results [9];
- Scenario 3: The influence of life expectancy at age 60 was tested by adjusting its weight in the evaluation framework [9].

Table 47 summarizes the different weights obtained.

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Table 47. Sensitivity analysis scenarios

| | | Initial Scenario | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| CRITERIA | Infant/neonatal mortality | 0,2457 | 0,2237 | 0,2618 | 0,2633 |
| | Prevalence of child undernutrition | 0,1175 | 0,1070 | 0,0595 | 0,1260 |
| | Youth literacy rate (15-24 years) | 0,0372 | 0,0338 | 0,0396 | 0,0398 |
| | Youth unemployment (15-24 years old) | 0,2094 | 0,2800 | 0,2232 | 0,2245 |
| | Individual below the poverty line | 0,1731 | 0,1576 | 0,1845 | 0,1855 |
| | Life expectancy at age 60 | 0,1168 | 0,1064 | 0,1245 | 0,0533 |
| | Rural accessibility | 0,1003 | 0,0914 | 0,1069 | 0,1076 |
| Sum of normalized weights (per scenario) | | 1 | 1 | 1 | 1 |
| Outcomes of the alternative weighting analysis | | | | | |
| ALTERNATIVES | Alt1: Drilling/Wells | 0,1192 | 0,1181 | 0,1117 | 0,1178 |
| | Alt2: Classroom block | 0,1163 | 0,1181 | 0,1117 | 0,1178 |
| | Alt3: Latrines | 0,1002 | 0,0994 | 0,1001 | 0,0993 |
| | Alt4: Storage Shed/Shop | 0,1064 | 0,1072 | 0,1048 | 0,1073 |
| | Alt5: Security fencing for educational establishments | 0,0987 | 0,0989 | 0,0991 | 0,0986 |
| | Alt6: Health Center | 0,1637 | 0,1615 | 0,1632 | 0,1623 |
| | Alt7: Rural road | 0,1232 | 0,1231 | 0,1242 | 0,1245 |
| | Alt8: Urban roads | 0,0676 | 0,0676 | 0,0679 | 0,0680 |

Table 48 shows the range of variation for the different model parameters, with the ranking of the proposed priorities remaining stable.

Table 48. Analysis of the robustness of priorities

| | |
|---|---|
| Scenario 1: Stable ranking of alternatives if: | $Yu^{n}_{15-24} \in [38{,}5\% \; ; \; 47{,}9\%]$ $i.e$: $[IEx^{Yu}] \in [0{,}6260 \; ; \; 0{,}9194]$ |
| Scenario 2 Stable ranking of alternatives if: | $ChM^{\theta}_{28d-59m} \in [14{,}3\% \; ; \; 26\%]$ $i.e$: $[IEx^{ChM}] \in [0{,}1668 \; ; \; 0{,}3514]$ |
| Scenario 3: Stable ranking of alternatives if: | $Le^{n}_{60} \in [45{,}1 \; ; \; 59]$ $i.e$: $[IEx^{Le}] \in [0{,}1486 \; ; \; 0{,}3492]$ |

These results show that, if the Government invests in accordance with these priorities, the social profile of the area will improve according to two main determinants:

- The prevalence of child undernutrition will fall from 26% to 14.3%, a decrease of 11.7%.
- life expectancy at 60 years will increase from 45.1 years to 59 years, an increase of 13.9 years.

The improvements will remain in force even if the unemployment rate for young people aged 15 to 24 increases from 38.5% to 47.9%, a 9.4% increase.

## 2. CONCLUSION AND LIMITS

The study highlights the importance of integrating related infrastructure into road corridor development plans in Cameroon to promote inclusive economic growth. Access to Sanitation infrastructure, educational infrastructure, and rural road development were identified as critical priorities in the Bogo-Guirvidig corridor, while Sanitation infrastructure, rural road development and water access were prioritized in Bingambo-Grandzambi.

The study builds on previous applications of AHP (Analytic Hierarchy Process) in infrastructure prioritization in Nigeria [1] and extends the approach by incorporating multidimensional exclusion indices. This study contributes a novel integration of exclusion indices with AHP-based multi-criteria decision-making, offering a replicable framework for inclusive infrastructure planning in developing countries. The model combines expert judgment (primary data) with local socio-economic data (secondary data) to produce weighted scores that guide investment decisions where exclusion is most severe.

The government should institutionalize the prioritization model within regional development plans. Local councils should be involved in monitoring progress toward reducing exclusion indices. The model can help allocate limited resources effectively to benefit marginalized communities.

The model's application is constrained by the availability and accuracy of local-level social data, which needs improvement for broader implementation.

Integrating human exclusion indices into infrastructure planning can significantly enhance the inclusiveness of road development projects in Cameroon.

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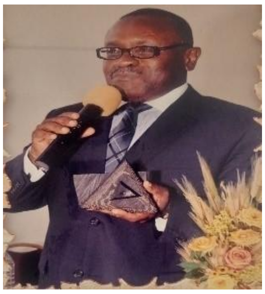

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