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Multi-Criterion Decision-Making Approach to Prioritize Strategies for Combating Smuggling and Border Control Along the North-East Borders of Nigeria

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ABSTRACT

Smuggling is a worldwide issue that leads to serious problem of insecurity, health risks, money laundering, the extinction of endangered species, and the premature collapse of local industries due to illegal trade. North-East region of Nigeria, is significantly affected by these smuggling challenges. Despite various efforts by stakeholders over time, to find a lasting solution has been difficult. This research aims to identify a more effective approach to address the problem of combating smuggling and border control. The study utilizes the Analytic Hierarchy Process approach with multiple respondents to assess different strategies to reducing problem of smuggling and border control along North-East borders of Nigeria. The strategies considered include; Physical Patrol (PP), Border Closure (BC), Perimeter Fencing (PF), Electronic/Digital Camera Surveillance (ED), and Mechanical/Drone Surveillance (MD). These strategies were assessed with the following criteria; Cost Efficiency (CES), Efficiency in Trade Facilitation (ETF), Efficiency in Revenue Generation (ERG), and Efficiency in Combating Smuggling (ECS). Data were collected from four experts respondents (senior customs officers in the north-east geopolitical zone of Nigeria), using a structured Saaty 9-point scale questionnaire. Purposive sampling was employed for respondents' selection. The experts' judgments were aggregated using the geometric mean. Pairwise comparison matrices were created, and the consistency of each aggregated pairwise comparison judgments were tested. The consistency ratio of pairwise comparison judgements of the criteria by the respondents is 0.0500 and, that of the alternatives with respect to each criterion; The consistency ratios of CES, ETF, ERG, and ECS were 0.07148, 0.0373, 0.0393, and 0.0239, respectively. The values were less than 0.1 indicates, the judgments were consistent. The findings shows that ED ranked first as the most effective strategy, followed by PP ranked second, PF and BC were closely ranked third and fourth, and MD ranked fifth. The study recommended that Electronic/Digital Camera Surveillance and Physical Patrol should be considered for effective combating smuggling and border control along the north-east borders of Nigeria.

1. Introduction

Smuggling is a global Phenomenon- a worldwide activity which cuts across all the nations of the world. Omale (2017) defined smuggling as any illegal economic activities, importing into or exporting outside the country in defiance or violation of the law or prohibition, restriction, or control, and to

evade or attempt to evade payment of taxes and other levies. It usually occurs between countries with disparities in fiscal policies on importation and exportation. Smuggling is one of the oldest crimes in history. Smuggling activities constitute a threat to global and national security as they affect the socio-economic and political development of a country and tarnish its image as a corporate and independent entity with the attendant effects of youth restiveness, terrorism, ethnic militias, and other related trans-border crimes. It often flourishes in regions where legal trade is hindered by bureaucratic red tape, high tariffs, or political instability (Mark and Iwebi, 2019).

Smuggling is one of the organized crimes, perpetrated clandestinely. It is a crime that, when perpetrated in a particular country, has a linkage or formidable network of syndicates in a chain from the country of origin of the goods to the country or countries of destination. In the case of Nigeria, cars, rice, vegetable oil, Petroleum, arms/ammunition, frozen chickens/turkey, etc. (which are either banned, restricted, or prohibited) are smuggled into the country from the neighboring countries, often had already-made buyers. This is what makes smuggling very difficult to combat, especially in Nigeria, where the agencies saddled with the responsibility of combating it are still using crude methods (Mobolaji & Alabi, 2017). Smuggling from customs parlance is not limited to non-declaration on imported or exported goods. It included Falsification of Customs documents, overvaluation (for capital flight), undervaluation, and concealment of any form (including ingestion in humans), etc., constituted smuggling (Omale, 2017).

It has been established that in today's modern world, no nation can exist in isolation due to differences in both natural endowments and technological advancement (comparative advantage). The interdependence created by both natural and artificial factors necessitated global, intracontinental, regional (multi-lateral and bilateral economic), trade/commerce, and security treaties among nations. Unfortunately, these legitimate treaties are now used to perpetrate clandestine heinous crimes (Opanke, 2015). The regular reviewing of government fiscal policies, all in an attempt to deplete the activities of the smugglers, is not yielding the desired results, as the monsters called smugglers would always have already-made plans to defy whatever policy that works against them (Olapegba & Idemudia, 2012).

Border points in Nigeria have, over the years, been characterized by their porous nature, weak control, and a dearth of security personnel. Consequently, the development has led to the influx of smuggled arms and ammunition, drugs and other related items on a daily basis into the country (Mark & Iwebi, 2019). Smuggling across the borders of Nigeria, particularly in the North-East region, has become a significant challenge impacting economic stability, security, and governance. The porous nature of these borders, coupled with socio-economic factors, has facilitated the illicit movement of goods, arms, and even people. Factors that influence smuggling along this region include: porous borders; state actors colluding with smugglers; impunity; economic factors; disparity in tariff and trade regimes among neighboring countries (Imogbighe, 2009; Babalola, 2018; Preregrino, 2014; Ucwumba, 2019). Smuggling also has devastating consequences, among which include: revenue leakage; suffocation of local industries; security challenges; social vices; the extinction of endangered species of fauna/flora; money laundering; public health risks from trade of counterfeit goods and medications, (Okeke and Oji, 2014; Omale, 2017; Nwannennaya & Abiodun, 2017; Tonya, 2020).

Border enforcement is a highly politicized topic in the twenty-first century. However, official attempts to control the movement of goods and people across borders have prevailed throughout history (Daina & Yuhki, 2022). There are many strategies/methods of preventing/combating smuggling and border control worldwide. However, some methods are peculiar to some countries due to their terrains, the dimension of the smuggling, technological advancement, etc. These methods are further categorized into two: that is, methods of preventing smuggling through the approved routes (in borders, seaports, and airports) and methods of combating or suppressing smuggling through unapproved routes. Methods of preventing smuggling through the approved routes include: Destination Inspection, Manifest, Pre-Arrival Assessment Report (PAAR), Automated System for Custom Data (ASYCUDA), Scanning, Post Clearance Audit (Omale, 2017, ASYCUDA online, 2017, COTECNA online, 2015, CEMA,

2004). However, this study is more interested in the methods applicable to the unapproved routes. Globally, there are five major strategies/methods of combating/suppressing smuggling at the international borders. These include: Physical Patrol, Border Closure, Perimeter Fencing, Electronic/Digital Cameras Surveillance, and Mechanical/Drone Surveillance. Physical Patrol (Land Patrol, Water/Marine Patrol, Aerial Patrol) is the most conventional strategy and is very effective where the borders are short and characterized with difficult terrains such as swampy, hilly gully erosion-affected areas, etc. It is equally an integral part of any other strategy. Only that the quantity and quality of personnel needed by any other strategy differ. International diplomacy is another means of suppressing smuggling, e.g., dialogue, offering of appoin tments, security treaty, etc. (United Nations (UN), 2017). The most used method in Nigeria, in general, and in the North-East in particular, is Physical Patrol. Border Closure has always been a temporary alternative when the need arises.

The Nigeria Customs Service has had a series of unending seminars and meetings to bring experts in the border control mechanism, also trained high-ranking officers on the modalities of putting up a formidable border control strategy in order to reduce or eliminate smuggling. Despite the heavy presence of cross-border security agencies (such as Nigeria Customs Service, Nigeria Immigration Service, Nigerian Police Force, etc.), illegal importation of prohibited, restricted, or banned goods is on the increase, due to the porous nature of our land/maritime borders, alleged collusion with state actors, archaic security apparatus/logistics, etc. (Olapegba & Idemudia, 2012; Ugwuja A A & Chukwukere C, 2021).

Goal programming, Multi-attribute Utility Theory, Analytic Network Process (ANP), Analytical Hierarchy Process (AHP), are the Multi-Criteria Decision Making (MCDM) techniques that are widely used. The MCDA techniques are based on the evaluation of numerical comparison of alternatives within the framework of the defined criterion (Joel *et al*., 2019; Timuçin, 2018). Most of the study carried out using MCDAM techniques include, study of the risk involve in various stages of the customs supply chain (Hammadi *et al*., 2016), frameworks to allocate resources such as vehicles to disaster scene to evacuate victims and allocation of resources to customs personnel (Jose, 2015), application of MCDM in surveillance and logistics application (Omale, 2017), appraisal of the crime of smuggling in Nigeria and combating smuggling and strengthening border control (Ogui *et al*., 2020, Hoekman & Shepherd, 2023; Ogutu, 2025) among others.

None of these studies consider prioritizing the strategies of combating smuggling and border control, in North-east geopolitical region of Nigeria. This study, however, focuses on assessing and prioritizing the strategy of combating smuggling and border control in the North-East, Nigeria using AHP. The study will assist stakeholders in area of effective decision making, identify the most effective alternative strategy to reduce problem of international cross-border security of combating smuggling and border control.

2. Methodology

The approved international borders stations with their coordinates in the North-East are: Nguru 12.867925°N, 10.437868°E, Machina 12.885662°N, 10.761438°E, Telotuloa 12.898258°N, 11.112150°E, Geidam 12.896895°N, 00.924093°E, Gashagar 13.374412°N, 12.789960°E, Mallam Fatori 13.673809°N, 13.1334268°E, Doro Baga 13.123811°N, 13.859069°E, Damasak 13.099115°N, 12.512967°E, Wulgo 12.378742°N, 14.238186°E, Gamboru Ngala 12.370206°N, 14.220378°E, Sigal 12.308880°N, 14.513353°E, Jilbe 11.916094°N, 14.615137°E, Kumshe 11.3568851°N, 14.208965°E, Banki 11.254937°N, 14.152075°E and Kirawa 11.193108°N, 13.906257°E in BON/YOB Command. Madagali 10.883239°N, 13.635936°E, Sahuda 10.141214°N, 13.416469°E, Belel 9.624012°N, 13.231120°E, Wuro Bokki 9.38005°N, 12.793974°E, Gurin 9.112105°N, 12.885478°E, Mayo Balwa 9.080727°N, 12.064968°E, Kajoli 8.573185°N, 12.377834°E, Tipsan

8.568642°N, 12.365538°E, Takum 7.252991°E, 9.985784°E and Gembu 6.723151°N, 11.256769°E in ADW/TRB Command (Google Maps app. retrieved online 15 Feburary, 2021).

Most of the inhabitants of these borders have blood relations across the neighboring borders. For example, the Borgu ethnic nationality cuts across Borno State in Nigeria and Chad; the Ketu Kingdom in Nigeria and the Benin Republic, the Amazonia in Nigeria and Cameroon, the Togolese and the Yoruba of Nigeria. The impact of these dynamic heritages is that the people see themselves as kin and kith and as such do not see the reason for there to be any impediment to the movement of goods and services. Furthermore, most of the border communities lacked government presence in terms of socioeconomic infrastructures. As such, they are loyal to smugglers who provide employment to them rather than the government agencies. Additionally, smuggling is seen or valued as a legitimate trade by the inhabitants of our border community because they are used to it from time immemorial. Tariff disparities and differential customs duties between jurisdictions or close neighboring countries across different periods in time can influence the likelihood of smuggling (Ships and Ports, 2014).

North-East comprises the following state: Adamawa, Borno, Bauchi, Gombe, Taraba, and Yobe. The Nigeria Customs Service structures the country into four zones (A, B, C, and D) for administrative convenience. North-East borders is under Zone 'D' (North-east and part of North-central). Zone 'D' is comprised of five Customs Area Commands: Plateau/Benue/Nasarawa (PL/BN/ NS), Bauchi/Gombe (BAU/GOM), Adamawa/Taraba (ADM/TRB), Borno/Yobe (BON/YOB), and North-East Marine Customs Area Commands. The Federal Operation Unit (FOU), which is an enforcement/patrol unit, operates in every nook and cranny of the zone; it has its administrative base at the zonal headquarters in Bauchi. Each Command is headed by a Controller of Customs, while the zonal Headquarters (located in Bauchi) is headed by Assistant Controller General of Customs (ACGC). Only BON/YOB and ADM/TRB Area Commands have borders with the Republics of Chad and Cameroon, respectively (Okeke & Oji, 2014).

The expected respondents (key stakeholders) in this study include officers of the Nigeria Customs Service (NCS) in the zone. These include: Assistant Controllers, Deputy Controllers, and Controllers of Customs and other officers of the Nigeria Customs Service Zone 'D' (North-east zone of Nigeria). The choice of the mentioned officers above as respondents was informed due to their wealth of experience in both operations and administration in the Nigeria Customs Service. They are expected to be aware of activities of simulating. Since the respondents are from the same agency (NCS), homogeneous purposive sampling (Ashley, 2020) was used to select four respondents. Which include: two controllers of customs, three Deputy Controllers of Customs, and two Assistant Controllers of Customs a total of seven (7) respondents.

Interviews were also conducted with stakeholders to identify alternative strategies feasible for combating smuggling along the north-east borders. Contributing parameters (criteria) to assess these strategies. A questionnaire was designed and administered to the respondents to obtain the pairwise relative importance of the criteria and the alternative strategies with respect to each of the criteria. Saaty(2008) used a nine-point scale structured questionnaire through direct personal contact in their respective offices. Out of the senve (7) questionnaire administered, four of the officers perfectly responded to the questionnaire, and their responses were used for the analysis. The geometric mean was used to aggregate the individual pair-wise relative comparison judgments of the criteria and the alternative strategies with respect to each of the criteria.

2.1 Multi-criteria Decision-Making

Multiple criteria decision-making (MCDM) techniques are major parts of decision theory and analysis. They seek to take explicit account of multiple criteria in supporting the decision process (Sujit *et al.,* 2011). Multiple Criteria Decision Analysis (MCDA) is useful in situations that necessitate the consideration of different courses of action, which can not be evaluated by the measurement of a single dimension. MCDM techniques seek to take explicit account of more than one criterion in supporting

the decision process (Sujit *et al.*, 2011). The AHP, ANP, Simple Additive Weighting (SAW), Weighted Product Method (WPM), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and dominance, max-max, max-min, are the most used MCDM techniques. For example, while AHP focuses on deriving priority weights through pairwise comparisons, TOPSIS emphasizes ranking alternatives based on distance from the ideal solution; however, both methods are powerful tools in multi-criteria decision making, and sometimes the two are combined to produce more reliable decision outcomes. AHP is the most commonly used and has widespread application among MCDM techniques, due to its plain and simple mathematical system based on pairwise comparison which includes tangible and intangible criteria for numerical evaluation. (Timuçin, 2018).

2.2 Analytic Hierarchy Process (AHP)

The AHP is one of the MCDM techniques for dealing with multiple goals and multiple criteria in complex decision settings, developed by Saaty (1980). The technique tends to formulate problems as hierarchical and believes in a mixture of quantitative and qualitative criteria as well. AHP is based on three principles: decomposition, comparative judgments, and synthesis of priorities (Wolfgang *et al.*, 2015). The AHP according Barma *et al.* (2025) includes the following steps:

i. Define the problem and determine its Goal. Set up a decision hierarchy by breaking down the problem into a hierarchy of interrelated decision elements. The structure of the hierarchy comprises of the goal or focus at the topmost level, criteria (and sub-criteria if any) (C_1, C_2,... C_n) at the intermediate levels, while the lowest level contains the options or alternatives (A_1, A_2, ... A_n). This is shown in Figure 1.

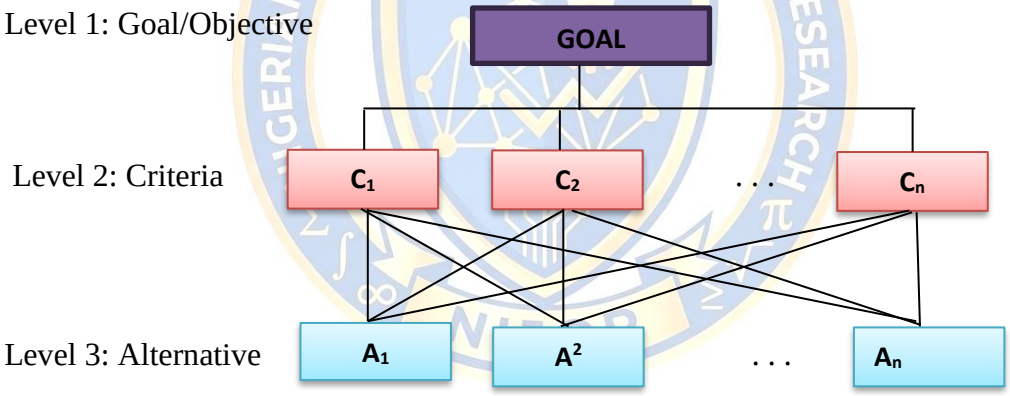

Figure 1: Decision hierarchy of the AHP Problem

ii. Questionnaire should be designed and distributed among the respondents (can be managers, experts, users, etc.) to collect their opinion (input data) by pair-wise comparisons judgment of the decision elements. Every attribute on each level is compared with adjacent attributes with respect to their importance to the parent.

iii. Extracted from the data collected from the interviews and construct a set of pair-wise comparison matrices A (size n x n) for each of the lower-level attributes, with one matrix for each element in the level immediately above, by using the relative scale measurement shown in Table 1. The pair-wise comparisons are done in terms of which element dominates the other. That is, the pair-wise comparison matrices A should be constructed for the criteria and the alternatives with respect to each criterion. In each case, reciprocals are automatically assigned in each pair-wise comparison to have the complete entries of matrices A as in Eqn. (1).

Table 1: AHP Pair-Wise Comparison Scale of Preferences

Numerical Scale of Importance	Definition of the Importance of Numerical Scale (Verbal Judgement)
1	Equally Important Preferred
2	Equally to Moderately Important Preferred
3	Moderately Important Preferred
4	Moderately to Strongly Important Preferred
5	Strongly Important Preferred
6	Strongly to Very Strongly Important Preferred
7	Very Strongly Important Preferred
8	Very Strongly to Extremely Important Preferred
9	Extremely Important Preferred

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{21}} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \quad (1)$$

a_{ij}: numerical comparison between criterion i and j or alternative i and j with respect to a particular criterion.

iv. There are n (n -1) judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.

v. Computing the relative weights from the pair-wise matrix. This step is to find the relative priorities of criteria or alternatives implied by these comparisons. The relative priorities will be worked out using the theory of eigenvectors. The consistency check will be carried out at each stage of the selection process. To evaluate the consistency of the results, three components will be considered as benchmarks, namely Consistency Index (CI), Random Consistency Index (RI), and Consistency Ratio (CR). The value of CR obtained will also be compared with a benchmark value of 0.10.

vi. Consistency evaluation will be performed to examine the extent of consistency of the judgments once the priorities were determined. Saaty (1980) recommended using the CI and the CR to check for the consistency associated with the pair-wise comparison matrix. The final step in the consistency evaluation was to examine the ratio of the calculated CI and the RI derived from the number of matrix activities. A CI, which measures the inconsistencies of pair wise comparison, is gven in Eqn. (2) as:

$$CI = \frac{(\lambda_{max} - n)}{n - 1} \quad (2)$$

Where $\lambda \max = \frac{\sum ajwj - n}{w1}$ is the average to the sum of the ratio of weighted sum by its corresponding weight. The CR is the basis by which an analyst can conclude that the pair-wise comparisons matrix evaluations are sufficiently consistent. The CR is determined by taking ratio of the CI and the RI and is given in Eqn. (3) as:

$$CR = \frac{CI}{RI} \quad (3)$$

The value of RI is related to the dimension of the matrix (n x n) and will be extracted from the Table 2. If CI is sufficiently small, the decision-makers' comparisons are probably consistent enough to give useful estimates of the weights for the objective function.

That is If CR = $\frac{CI}{RI} \leq 0.10$, the degree of consistency is satisfactory, but if CR = $\frac{CI}{RI} > 0.10$, inconsistencies may exist, and the AHP may not yield meaningful results. The evaluation procedure has to be repeated to improve the consistency. The measurement of consistency can be used to evaluate the consistency of decision maker's opinion as well as the consistency of all the hierarchy.

Table 2: Average Random Consistency Index (RI)

Size of matrix	1	2	3	4	5	6	7	8	9	10	11
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.52

vii. In a final step, the options/alternatives priority vectors are combined with the criteria weights to produce an overall priority score for the options/alternatives.

2.3 Decision Makers Consensus

The AHP is often used in group settings where group members either engage in discussion to achieve a consensus or express their own preferences. Individual judgments can be aggregated in different ways. Two fundamentally accepted aggregation methods that have been found to be most useful in the application of AHP are the Aggregation of Individual Judgments (AIJ) and the Aggregation of Individual Priorities (AIP) using the arithmetic mean and geometric mean, respectively. In case the group structure is homogenous and decision makers are willing to act like one single individual, a synergistic AIJ is possible. Each decision maker conducts the pairwise comparisons by himself. Afterwards, the (weighted) geometric mean method (GMM) could be used to obtain the group judgment for each entry of the comparison matrices (Wolfgang *et al.*, 2015). In this study, the geometric mean method was adopted due to the homogeneous nature of the respondents (experts) considered for the data collected.

3. Structure of the Decision Problem Under Consideration

The decision structure required for the problem under study is illustrated in Figure 2. The overall goal of the problem, which is level 1, and the contributing parameters (criterion) are shown in level 2. The alternatives to be assessed are shown in level 3. Table 3 shows the strategies (alternatives) for combating smuggling and the criteria for assessing the strategy with respect to the goal/objective (Prioritization of the effective strategy for combating smuggling in the North-East border of Nigeria).

Cost-efficiency is a critical criterion in evaluating policies and strategies used to combat smuggling. Border security operations require significant investments in personnel, infrastructure, technology, and logistics. By applying cost-efficiency as a criterion, governments ensure that resources are allocated to strategies that deliver the highest impact relative to their cost. Efficient revenue generation is significantly strengthened through effective combating of smuggling and strict border control measures. Smuggling undermines government revenue by allowing goods to enter or leave the country without proper declaration, taxation, or compliance with customs regulations. Therefore, effective anti-smuggling operations and robust border control mechanisms directly contribute to greater efficiency in revenue generation by ensuring that all liable goods are properly assessed and taxed (Evans, 2025).

Trade facilitation aims to make legitimate trade faster, safer, and more efficient while maintaining effective regulatory control. In this context, combating smuggling and strengthening border control are essential criteria for achieving both secure borders and efficient revenue generation. Effective anti-smuggling measures ensure that all goods entering or leaving a country pass through official channels where they can be properly inspected, documented, and assessed for duties and taxes.

Smuggling undermines trade facilitation by creating unfair competition, distorting markets, and causing significant revenue losses to governments. Combating smuggling and strengthening border control are essential trade facilitation criteria (Hoekman & Shepherd, 2023; Ogutu, 2025).

Matrix C in Eqn. (4) is the structure of the aggregate pairwise comparison matrix of the criteria from the four respondents, and matrix G_j (for j = 1, 2, 3, 4) in Eqn. (5) is the structure of the aggregate pairwise comparison matrix of the alternatives with respect to the four different criteria from the four respondents.

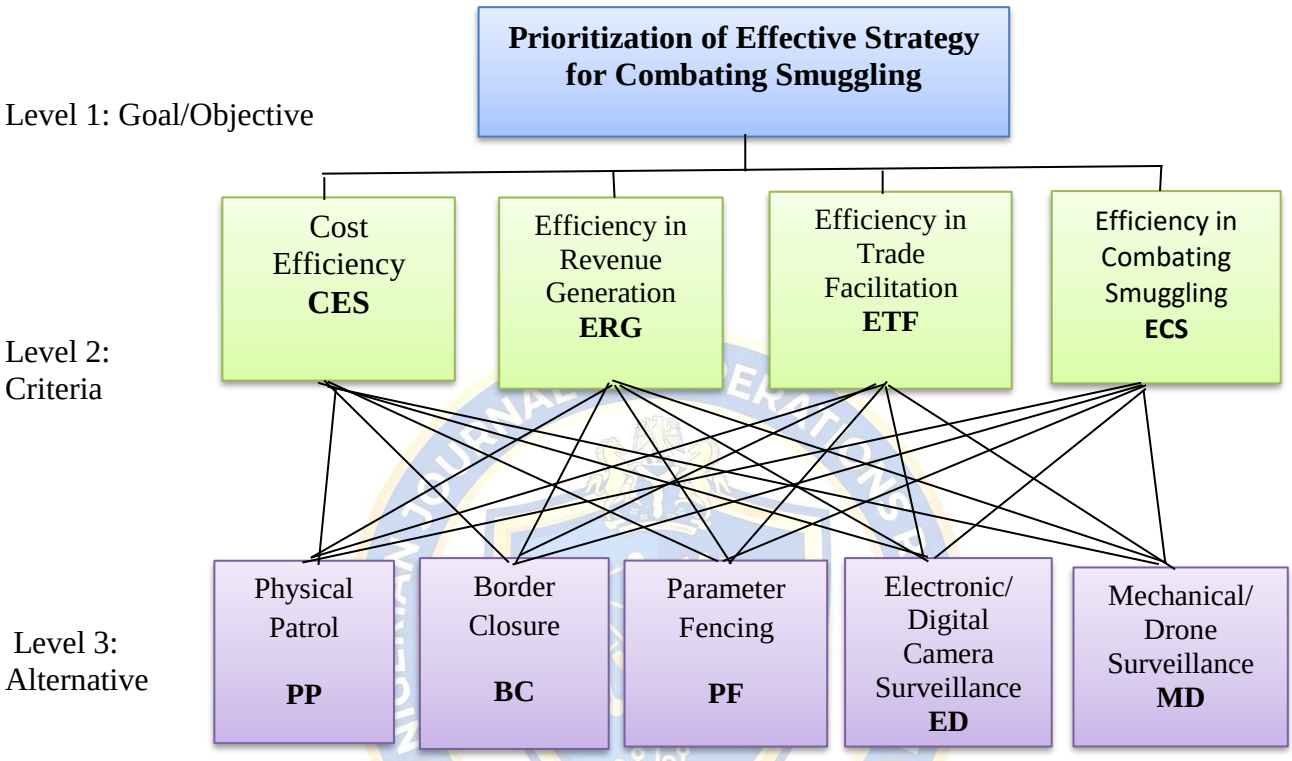

Figure 2: Hierarchical Structure of Combating Smuggling and Border Control Strategies

Table 3: Strategy for Combating Smuggling and Criteria for Assessment

S/N	Strategy (Alternative)	S/N	Criteria for Assessment
i.	Physical Patrol= **PP**	**i.**	Cost Efficiency= **CES**
ii.	Border Closure = **BC**	**ii.**	Efficiency in Revenue Generation = **ERG**
iii.	Parameter Fencing =**PF**	**iii.**	Efficiency in Trade Facilitation = **EFT**
iv.	Electronic/ Digital Camera Surveillance =**ED**	**iv.**	Efficiency in Combating Smuggling = **ECS**
v.	Mechanical/ Drone Surveillance = **MD**		

$$C = \begin{array}{c} \\ \textbf{CES} \\ \textbf{ERG} \\ \textbf{ETF} \\ \textbf{ECS} \end{array} \begin{array}{c} \begin{array}{cccc} \textbf{CES} & \textbf{ERG} & \textbf{ETF} & \textbf{ECS} \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} \\ - & 1 & a_{23} & a_{24} \\ - & - & 1 & a_{34} \\ - & - & - & 1 \end{bmatrix} \end{array} \quad (4)$$

$$G_j = \begin{array}{c} \\ \mathbf{PP} \\ \mathbf{BC} \\ \mathbf{PF} \\ \mathbf{ED} \\ \mathbf{MD} \end{array} \begin{array}{c} \begin{array}{ccccc} \mathbf{PP} & \mathbf{BC} & \mathbf{PF} & \mathbf{ED} & \mathbf{MD} \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} \\ - & 1 & a_{23} & a_{24} & a_{25} \\ - & - & 1 & a_{34} & a_{35} \\ - & - & - & 1 & a_{34} \\ - & - & - & - & 1 \end{bmatrix} \end{array}, \quad J = 1,2,3,4 \qquad (5)$$

4. Result and Discussion

Saaty's (2008) nine-point scale structured questionnaire was administered to executive-level management officers of the customs in the Zone, through direct personal contact in their respective offices, who served as expert respondents. They include: two controllers of customs (33 years of working experience), three Deputy Controllers of Customs (31 years of working experience), and two Assistant Controllers of Customs (30 years of working experience), a total of seven (7) respondents.

Out of the seven (7) questionnaires administered, four (4) officers perfectly responded to the questionnaire and the responses of the four executive level management officers were used for the analysis. First the subjective judgement on pair-wise comparison of the criteria were collected from the expert respondents. Then subjective judgements of pair-wise comparison of the strategies (alternatives) with respect to each criterion were collected from each respondent.

Table 4 presents the pairwise comparison of criteria by the four respondents. The geometric mean was used to aggregate the four respondents' judgments. The aggregated pairwise comparison matrix of the criteria from the four expected respondents is shown in Table 5. The synthesized matrix and priority vector of the criteria is shown in Table 6. The judgments of the respondents were consistent (since the value of $CR_{Criteria} = 0.0500 < 0.1$)

Table 4: Pair-wise Comparison Judgement of Criteria by the Four Respondents

	1	2	3	4	5	6
Respondent (Expert)	**CES vs ERG**	**CES vs ETF**	**CES vs ECS**	**ERG vs ETF**	**ERG vs ECS**	**ETF vs ECS**
i	3	2	9	2	0.5	5
ii	5	3	4	0.3333	1	0.3333
iii	2	2	5	3	5	3
iv	2	5	3	7	0.5	0.5
Geomean	**2.7832**	**2.7832**	**4.8206**	**1.9343**	**1.0574**	**1.2574**

Table 5: Aggregated Pair-wise Comparison Matrix of the Criteria

Criteria	CES	ERG	ETF	ECS
CES	1	2.7832	2.7832	4.8206
ERG	-	1	1.9343	1.0574
ETF	-	-	1	1.2574
ECS	-	-	-	1

Table 6: Synthesized Matrix and Priority Vector of the Criteria

Pairwise Comparison Matrix of the Criteria						**Synthesized matrix of the Criteria**				
Criteria	**CES**	**ERG**	**ETF**	**ECS**		**CES**	**ERG**	**ETF**	**ECS**	**Priority Vector**
CES	1	2.7832	2.7832	4.8206		0.5192	0.5195	0.4273	0.5925	**0.5146**
ERG	0.3593	1	1.9343	1.0574		0.1865	0.1867	0.2970	0.1300	**0.2000**
ETF	0.3593	0.5170	1	1.2574		0.1865	0.0965	0.1535	0.1546	**0.1478**
ECS	0.2074	1.0574	0.7953	1		0.1077	0.1974	0.1229	0.1229	**0.1377**
Total	**1.9261**	**5.3575**	**6.5127**	**8.1353**					**Total**	**1.0000**

λ_{max} = 4.1349, CI = 0.0450, RI = 0.9, **$CR_{Criteria}$ = 0.0500 < 0.1 the judgement is ok.**

Table 7 shows the pairwise comparison judgement of the alternatives with respect to the Cost Efficiency (CES) criterion by the four respondents. The judgments of the four individual respondents were then aggregated using the geometric mean. Table 8 shows the aggregated pair-wise comparison metric of the strategies with respect to the cost efficiency criterion. The synthesized matrix and priority vector of the strategies with respect to the cost efficiency criterion are shown in Table 9 below. The judgments of the expert respondents were consistent (since veleu of CR_{CES} = 0.07148 < 0.1).

Table 7: Pairwise Comparison Judgement of the Strategies with Respect to Cost Efficiency (CES) Criterion by the Four Respondents

	1	2	3	4	5	6	7	8	9	10
Respondent (Expert)	**PP vs BC**	**PP vs PF**	**PP vs ED**	**PP vs MD**	**BC vs PF**	**BC vs ED**	**BC vs MD**	**PF vs ED**	**PF vs MD**	**ED vs MD**
I	5	2	3	3	0.2	0.3333	2	2	3	2
Ii	3	0.5	3	3	0.5	3	5	1	2	3
Iii	0.2	1	0.5	0.5	2	3	3	0.25	0.3333	2
Iv	0.5	3	3	5	3	3	3	0.3333	3	2
Geomean	**1.1067**	**1.3161**	**1.9168**	**2.1779**	**0.8801**	**1.7320**	**3.0801**	**0.6389**	**1.5650**	**2.2134**

Table 8:Aggregated Pair-wise Comparison Matrix of the Altenative with Respect to Cost Efficiency Criterion

Criteria	**PP**	**BC**	**PF**	**EDS**	**MDS**
PP	1	1.1067	1.3161	1.9168	2.1779
BC	-	1	0.8801	1.7320	3.0801
PF	-	-	1	0.6389	1.5650
EDS	-	-	-	1	2.2134
MDS	-	-	-	-	1

Table 9: Synthesized Matrix and Priority Vector of the Alternatives with Respect to Cost Efficiency (CES)Criterion

Aggregated Pairwise Comparison Matrix of the Alternative With Respect to Cost Efficiency Criterion (CES) Criteria							**Synthesized matrix of the Criteria**					
Criteria	**PP**	**BC**	**PF**	**ED**	**MD**		**PP**	**BC**	**PF**	**ED**	**MD**	**Priority Vector**
PP	1	1.1067	1.3161	1.9168	2.1779		0.2744	0.2670	0.2437	0.3340	0.2170	**0.2672**
BC	0.9036	1	0.8801	1.7320	3.0801		0.2480	0.2413	0.1630	0.3018	0.3069	**0.2522**
PF	0.7598	1.1362	1	0.6389	1.5650		0.2085	0.2741	0.1852	0.1113	0.1559	**0.1870**
ED	0.5217	0.5774	1.5651	1	2.2134		0.1432	0.1393	0.2898	0.1742	0.2205	**0.1934**
MD	0.4591	0.3247	0.6390	0.4518	1		0.1260	0.0783	0.1183	0.0787	0.0996	**0.1002**
Total	**3.6443**	**4.1449**	**5.4003**	**5.7396**	**10.0364**						**Total**	**1.0000**

λ_{max} = 5.0661, CI = 0.0165, RI = 1.12, **CR_{CES} = 0.07148 < 0.1 the judgement is ok.**

Similarly, the judgments of the four respondents on the pairwise comparisons of the alternatives with respect to the efficiency criteria for revenue generation (ERG), trade facilitation (ETF), and combating smuggling (ECS) are shown in Tables 10, 13, and 16, respectively. The aggregated pairwise comparison matrices for the strategies with respect to the criteria are shown in Tables 11, 14, and 17, respectively. Also, the synthesized matrices and priority vectors for the strategies with respect to the corresponding strategies are shown in Tables 12, 15, and 18, respectively. Equally, the corresponding judgements of the respondents of the pair-wise comparisons of the alternatives with respect to efficiency in revenue generation (ERG), efficiency in trade facilitation (ETF), and efficiency in combating smuggling (ECS) are consistent (with respective values of CR_{ERG} = 0.0393, CR_{ETF} = 0.0373, and CR_{ECS} = 0.0239, all < 0.1)

Table 19 presents the overall priority matrix for assessing alternative strategies for combating smuggling and Border Control across four criteria. The overall priority vector of the alternatives with respect to the criteria shows that Electronic/Digital Camera Surveillance (ED) has the highest priority, followed by Physical Patrol (PP), Parameter Fencing (PF), Border Closure (BC), and Mechanical/Drone Surveillance (MD).

Table 10: Pairwise Comparison Judgement of the Alternatives with Respect to Efficiency in Revenue Generation (ERG) Criterion by four Respondents

	1	2	3	4	5	6	7	8	9	10
Respondent (Expert)	**PP vs BC**	**PP vs PF**	**PP vs ED**	**PP vs MD**	**BC vs PF**	**BC vs ED**	**BC vs MD**	**PF vs ED**	**PF vs MD**	**ED vs MD**
I	3	1	0.3333	0.25	0.3333	0.125	0.2	0.3333	0.2	5
Ii	5	1	3	3	0.3333	0.3333	5	1	3	0.2
Iii	3	0.5	0.2	0.2	0.3333	0.2	5	0.2	0.3333	6
Iv	5	3	3	3	0.1429	0.25	0.25	4	4	1
Geomean	**3.8730**	**1.1067**	**0.8801**	**0.8190**	**0.2697**	**0.2136**	**1.0574**	**0.7186**	**0.9457**	**1.5651**

Table 11: Aggregated Pair-wise Comparison Matrix of the Alternatives with Respect to Efficiency in Revenue Generation (ERG) Criterion

Criteria	**PP**	**BC**	**PF**	**EDS**	**MDS**
PP	1	3.8730	1.1067	0.8801	0.8190
BC	-	1	0.2697	0.2136	1.0574
PF	-	-	1	0.7186	0.9457
EDS	-	-	-	1	1.5651
MDS	-	-	-	-	1

Table 12: Pairwise Comparison Matrix, Synthesized Matrix, and Priority Vector of the Alternatives with Respect to Efficiency in Revenue Generation (ERG) Criterion

Aggregate Pairwise Comparison Matrix of the Alternative With Reapec to Efficiency in Revenue Generation (ERG) Criterion							**Synthesized matrix of the Criteria**					
Criteria	**PP**	**BC**	**PF**	**ED**	**MD**		**PP**	**BC**	**PF**	**ED**	**MD**	**Priority Vector**
PP	1	3.8730	1.1067	0.8801	0.8190		0.2213	0.2726	0.2293	0.2550	0.1520	**0.2261**
BC	0.2582	1	0.2697	0.2136	1.0574		0.0571	0.0704	0.0559	0.0619	0.1963	**0.0883**
PF	0.9036	3.7078	1	0.7186	0.9457		0.2000	0.2610	0.2072	0.2082	0.1755	**0.2104**
ED	1.1362	4.6808	1.3916	1	1.5651		0.2514	0.3295	0.2884	0.2897	0.2905	**0.2899**
MD	1.2209	0.9457	1.0574	0.6389	1		0.2702	0.0666	0.2191	0.1851	0.1856	**0.1853**
Total	**4.5190**	**14.2073**	**4.8254**	**3.4513**	**5.3872**						**Total**	**1.0000**

λ_{max} = 5.1759, CI = 0.0440, RI = 1,12, **CR_{ERG} = 0.0393 < 0.1 the judgement is ok.**

Table 13: Pairwise Comparison Judgement of the Alternatives with Respect to Efficiency in Trade Facilitation (ETF) Criterion by four Respondents

	1	2	3	4	5	6	7	8	9	10
Respondent (Expert)	**PP vs BC**	**PP vs PF**	**PP vs ED**	**PP vs MD**	**BC vs PF**	**BC vs ED**	**BC vs MD**	**PF vs ED**	**PF vs MD**	**ED vs MD**
I	3	2	1	1	0.2	0.5	0.2	5	0.5	1
Ii	5	4	3	3	0.2	0.3333	6	0.5	0.5	7
Iii	4	0.5	0.5	0.5	0.3333	0.3333	7	0.3333	4	2
Iv	5	6	0.3333	0.2	7	0.2	0.2	0.3333	2	1
Geomean	**4.1618**	**2.2134**	**0.8409**	**0.7401**	**0.5527**	**0.3247**	**1.1385**	**0.7259**	**1.1892**	**1.9343**

Table 14: Aggregated Pair-wise Comparison Matrix of the Alternatives with Respect for Efficiency in Trade Facilitation (ETF) Criterion

Criteria	**PP**	**BC**	**PF**	**EDS**	**MDS**
PP	1	4.1618	2.2134	0.8409	0.7401
BC	-	1	0.5527	0.3247	1.1385
PF	-	-	1	0.7259	1.1892
EDS	-	-	-	1	1.9343
MDS	-	-	-	-	1

Table 15: Synthesized Matrix and Priority Vector of the Alternatives with Respect to Efficiency in Trade Facilitation (ETF) Criterion

Pairwise Comparison Matrix of the Alternative With Respect to Efficiency in Trade Facilitation (ETF) Criterion							Synthesized matrix of the Criteria					
Criteria	**PP**	**BC**	**PF**	**EDS**	**MD**		**PP**	**BC**	**PF**	**ED**	**MD**	**Priority Vector**
PP	1	4.1618	2.2134	0.8409	0.7401		0.2363	0.3808	0.3699	0.2467	0.1233	**0.2714**
BC	0.2403	1	0.5527	0.3247	1.1385		0.0568	0.0915	0.0924	0.0952	0.1897	**0.1051**
PF	0.4518	1.8093	1	0.7259	1.1892		0.1067	0.1655	0.1671	0.2130	0.1981	**0.1701**
ED	1.1892	3.0802	1.3775	1	1.9343		0.2810	0.2818	0.2302	0.2934	0.3223	**0.2817**
MD	1.3512	0.8784	0.8409	0.5170	1		0.3192	0.0804	0.1405	0.1517	0.1666	**0.1717**
Total	**4.2325**	**10.9296**	**5.9845**	**3.4084**	**6.0021**						**Total**	**1.0000**

λ_{max} = 5.1672, CI = 0.0418, RI = 1.12, **CR_{ETF} = 0.0373 < 0.1 the judgement is ok.**

Table 16: Pairwise Comparison Judgement of the Alternatives with Respect to Efficiency in Combating Smuggling (ECS) Criterion by four Respondents

	1	2	3	4	5	6	7	8	9	10
Respondent (Expert)	**PP vs BC**	**PP vs PF**	**PP vs ED**	**PP vs MD**	**BC vs PF**	**BC vs ED**	**BC vs MD**	**PF vs ED**	**PF vs MD**	**ED vs MD**
i	0.25	0.1667	0.1428	0.125	0.3333	0.25	0.2	0.3333	0.1667	6
ii	1	0.3333	0.3333	0.3333	1	0.5	0.3333	3	0.5	1
iii	0.5	2	0.3333	7	2	2	2	0.3333	0.3333	0.5
iv	0.3333	0.25	0.2	0.2	0.3333	0.5	0.3333	1	3	0.5
Geomean	**0.4518**	**0.4083**	**0.2373**	**0.4914**	**0.6866**	**0.5946**	**0.4591**	**0.7598**	**0.5373**	**1.1067**

Table 17: Aggregated Pair-wise Comparison Matrix of the Alternatives with Respect to Combating Smuggling (ECS)Criterion

Criteria	**PP**	**BC**	**PF**	**EDS**	**MDS**
PP	1	0.4518	0.4083	0.2373	0.4914
BC	-	1	0.6866	0.5946	0.4591
PF	-	-	1	0.7598	0.5373
EDS	-	-	-	1	1.1067
MDS	-	-	-	-	1

Table 18: Synthesized Matrix and Priority Vector of the Alternatives with Respect to Efficiency in Combating Smuggling (ECS) Criterion

Pairwise Comparison Matrix of the Alternative With Reapect to Efficiency in Revenue Generation (ECS) Criterion							**Synthesized matrix of the Criteria**					
Criteria	**PP**	**BC**	**PF**	**ED**	**MD**		**PP**	**BC**	**PF**	**ED**	**MD**	**Priority Vector**
PP	1	0.4518	0.4083	0.2373	0.4914		0.0840	0.0668	0.0774	0.0679	0.1367	**0.0866**
BC	2.2134	1	0.6866	0.5946	0.4591		0.1858	0.1478	0.1302	0.1701	0.1277	**0.1523**
PF	2.4494	1.4565	1	0.7598	0.5373		0.2056	0.2152	0.1897	0.2174	0.1495	**0.1955**
ED	4.2135	1.6818	1.3161	1	1.1067		0.3537	0.2485	0.2496	0.2861	0.3079	**0.2892**
MD	2.0348	2.1780	1.8612	0.9036	1		0.1708	0.3218	0.3530	0.2585	0.2782	**0.2765**
Total	**11.9112**	**6.7682**	**5.2721**	**3.4953**	**3.5945**						**Total**	**1.0000**

λ_{max} = 5.1075, CI = 0.0268, RI = 1.12, **CR_{ECS} = 0.0239 < 0.1 the Judgement is ok.**

Table 19: Overall Priority Matrix for Assessing the Alternative Strategy of Combating Smuggling /Boader Control.

	CES (0.5146)	**ERG (0.2)**	**ETF (0.1478)**	**ECS (0.1377)**	**Overall Priority**	**Priority Ranking**
PP	0.2672	0.2261	0.2714	0.0866	0.0587	**2nd**
BC	0.2522	0.0883	0.1051	0.1523	0.0460	**4th**
PF	0.187	0.2104	0.1701	0.1955	0.0476	**3rd**
ED	0.1934	0.2899	0.2817	0.2892	0.0597	**1st**
MD	0.1002	0.1853	0.1717	0.2765	0.0380	**5th**

5. Conclusion

In this study, five alternative strategies for combating smuggling and strengthening border control along Nigeria's north-eastern borders were assessed. The criteria considered for the assessment were; Cost Efficiency, Efficiency in Revenue Generation, Efficiency in Trade Facilitation, Efficiency in Combating Smuggling, The pairwise comparison judgments obtained from the expert respondents were found to be consistent, as indicated by the value of the consistency ratios (CI < 0.1) for both the criteria and the alternative strategies. The Multi-Criteria Decision Method (AHP) analysis revealed a slight shift from a traditional/ conventional strategy that relies heavily on physical patrols toward a modern, technology-based approach. The results show that Electronic/Digital Camera Surveillance was the most effective strategy, ranking first with a priority value of 0.0597. This was closely followed by the conventional strategy, Physical Patrol, with a value of 0.0587, which was ranked second. Perimeter Fencing and Border Closure were ranked third and fourth with a priority value of 0.0476 and 0.0460, respectively. Mechanical/Drone Surveillance was ranked fifth with a value of 0.0380. The findings of this work align with the study by Godarzi and Alireza (2023), which indicates modern technology, such as night vision cameras, drones, and thermal cameras, has the highest functionality in terms of controlling and monitoring borders and preventing smuggling in the border strip of Kurdistan province. These technologies, with high accuracy and efficiency, can minimize human error and damage, playing an effective role in preventing, identifying, and addressing smuggling at the entry and exit points of borders.

Author Contributions

Conceptualization, M. B., and J .J. E; methodology, M. B; software, M. B; validation, M. B; J. J. E.; formal analysis, M. B.; investigation, A. H. B.; resources, A. H. B.; writing—original draft preparation, M. B.; writing—review and editing, A. H. B.; visualization, J. J. E.; supervision, M. B.; All authors have read and agreed to the published version of the manuscript.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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