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# USING AN ANALYTIC HIERARCHY PROCESS APPROACH IN DISTRIBUTION DECISION LOCATION

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***Abstract:*** **This paper aids in making distribution location decisions, making the use of decision factor analysis and the analytic hierarchy process. The location decision model includes a criterion factors such as government policy, labour, transportation, future development, population. For this study, a questionnaire was developed and given to 36 companies in transportation, warehousing, distribution sector, and manufacturing industry to choose between four (4) major cities in Ghana asking their opinions about the locations of a distribution facility. Using Delaw Logistics as a case study. The survey results were analysed based on the location selection criteria. This application of the location decision model to real-world case. Since the consistency is satisfactory, AHP suggest that Delaw logistics should select Accra as its distribution center.**

***Keywords*****: facility location, decision factor analysis, analytic hierarchy process, transportation.**

## 1. INTRODUCTION

Distribution location is one of the most important supply chain activities. The selection of the most effective distribution centre has become a strategic study. Placing a distribution centre at a strategic place helps a company to reduce it inventory cost.Distribution of products to customers is one of the most crucial activities of a manufacturing company. Facilities location and the distribution process are two key components of a distribution system

The design of a warehouse and distribution centres requires attention to detail and the collection and compilation of large quantities of relevant data. This study proposes the use of decision factor analysis and the analytic hierarchy process (AHP) as aids in making distribution location decisions and using Delaw Logistics as a case study. The AHP enables the decision maker to structure intricate problems as a simple hierarchy and to evaluate a large number of often contradictory quantitative and qualitative factors in a systematic way. Our location decision model includes 5 criterion factors. For this study, a questionnaire was developed and given to 36 companies in transportation, warehousing, distribution sector, and manufacturing industry asking their opinions about the locations of the distribution facilities. The results were analyzed on grounds of the criteria of selecting locations.

The goal of this research is to provide decision-makers with a more effective and efficient model for making facility location decisions. In this paper, we show how an integrated decision model can aid location decisions by generating a solution that recognizes the practical considerations while adopting AHP weightings for the decision factors of a qualitative nature. Our integrated decision model is illustrated with a real-world case involving a distribution industry.

The remainder of this paper is structured as follows. In section 2, related literature is reviewed. Section 3 describes a brief overview of the solution methodology, Based on the AHP and decision modeling approach, the integrated decision model for distribution facility location is presented. And finally in section 4 conclusions are included.

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## 2. LITERATURE REVIEW

Facility position in a supply chain is one of the common research topics in decision-making undertakings. These problems have received much attention over the years and numerous approaches, both qualitative and quantitative, have been suggested. Facility location has a well-developed theoretical background [1], [2]. Generally, research in this area has been focused on optimizing methodology [3] [4] [5] [6]. Widespread effort has been devoted to solving location problems employing a wide range of objective criterion and methodology used in the decision analysis. Other researchers stress the importance of several measures that must be included in the decision analysis [4]. Many methodologies have been utilized to solve the facility location problem. [1] Have solved the location problem for minimum total delivery cost with nonlinear programming. Others have incorporated stochastic functions to account for demand and/or supply [5] [7]. Other approaches that have been employed include dynamic programming [8] [9]; [10], multivariate statistics using multidimensional scaling [11] and empirical and search procedures [12]. In many location problems, cost minimization may not be the most important factor. The use of multiple criteria has been thoroughly discussed in the literature [13] [14]. Researchers have suggested numerous criteria for the facility location problem. These decision factors include labour cost, future Development, population, government policies, availability of transportation facilities, cost of transportation, availability of labor, cost of living, availability and nearness to raw materials, proximity to markets, size of markets, attainment of favorable competitive position, anticipated growth of markets, income and population trends, cost and availability of industrial lands, proximity to other industries, cost and availability of utilities, government attitudes, tax structure, community related factors, environmental considerations, assessment of risk and return on assets ,distribution of sales location ,natural environmental policy environment.

Qualitative factors are crucial but often cumbersome and usually treated as part of management's responsibility in analyzing results rather than quantified and included in a model formulation of the facility location problem [16]. Qualitative decision factors can be integrated into facility location problems if the analytic hierarchical process is employed. Relating decision factor analysis and AHP, this study will analyze the evaluation of location decisions involving distribution facility location factors. Specifically, this research concerns the stage in the decision-making process when the weighted score of potential distribution sites has been ranked to choose an optimal candidate.

## 3. A CASE STUDY

Delaw Logistics in Ghana, has manage to have a strategic position in the supply chain of various in reputable companies such Uniliver Ghana Limited, Coca Cola bottling Company Ghana Company Limited ,Accra Brewery Limited and just to mention a few. It offers various logistics services to these companies especially transportation services.

Recently the company has decided to offer warehousing services in order to reduce its transportation cost especially to the hinterlands. This will also help reduce inventory cost of it partner companies. The company is ready to invest hugely into a 500 square foot distribution centre. Delaw logistics has decided to make a decision between the three (3) major cities in the Country. Accra, Takoradi and Kumasi.

This paper seek to make use of the analytic hierarchy process (model) to show how Delaw Logistics can select a suitable city for their distribution centre and also some factors that will influence the decision process.

## 4. THE SOLUTION APPROACH

In today's vibrant and volatile global economy, many researchers underline the importance of facility location factors. Issues associated with distribution facility location include political, economic, legal, social and cultural environments. Facility location decisions involve a substantial capital investment and result in long-term constraints on distribution of goods. These problems are complex and, like most real-world problems, depend upon a number of tangible and intangible factors that are unique to the problem. The complexity stems from a multitude of qualitative and quantitative factors influencing location decisions as well as the core difficulty of making trade-offs among those factors. One analytical approach often suggested for solving such a complex problem is the AHP, first introduced by [9]. It is a highly flexible decision methodology that can be applied in a wide variety of situations [5]. It is typically used in a decision-making situation involving selecting one or more alternatives from several candidate locations on the basis of multiple decision criteria of a competing or conflicting nature. Particularly important, the decision criteria may hold a different degree of adequacy or level of importance in the eyes of the decision-makers. In this paper, the decision factor analysis is performed first. Then a combined AHP and decision factor model is presented to evaluate collectively the location criteria in the decision-making process.

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**STEP 1**

In using the AHP in Helping the Delaw Logistics locates its distribution center in one of these countries, the following objectives or criterions are selected.

Analysis of factors in distribution center selectin

- Factor 1; Labour cost (LC)
- Factor 2; Future Development (FD)
- Factor 3; Population (PO)
- Factor 4; Government Policies (GP)
- Factor 5; Transportation (TR)

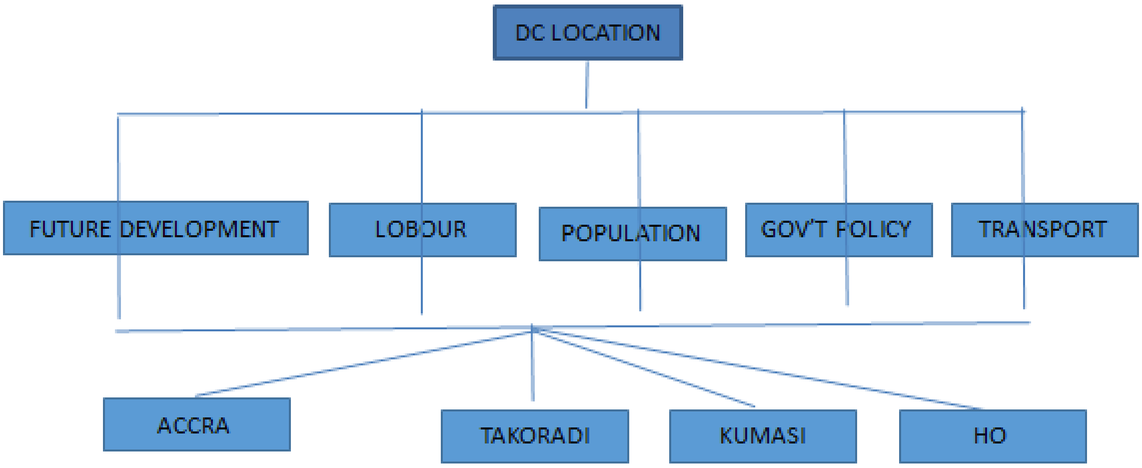


**Figure 4.1: AHP Model Design**

**STEP 2**

Create Pairwise matrix. By ranking the factors against each other.

**Table 4.1: Pairwise matrix**

| | **TR** | **LC** | **FD** | **PO** | **GP** |
|---|---|---|---|---|---|
| **TR** | 1 | 5 | 2 | 4 | 3 |
| **LC** | 1/5 | 1 | 1/2 | 1/2 | 1/3 |
| **FD** | 1/2 | 2 | 1 | 2 | 2 |
| **PO** | 1/4 | 2 | 1/2 | 1 | 1/2 |
| **GP** | 1/3 | 3 | 1/2 | 2 | 1 |
| | | | | | |

Below are the reasons of the ranking based on survey

- **TR-LC 5** Transportation is strongly more important than Labor cost. It is transportation facilities that link the various distribution centers together. In other words with good transportation distribution centers cannot be link be effectively to customers, labor cost less important to transportation- LC-TR 1/5.
- **TR-FD 2** Transportation is somewhere between equally and slightly more important than future development. Future development in this situation, we are talking about the selecting from an economic development zone and also based on the planning of these centers or zone but all these zones or should be connected with a good transportation facility hence transportation ranking slightly higher than land. Which means future development is somewhere between less equally and slightly more important than transportation FD-TR 1/2.

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- **TR-PO 4** Transportation is somewhere between slightly and strongly more important than population. By population we are talking about the your customer base in a particular geographical area .Even though it is good to have knowledge about your customers the impact that transportation would have on the business or cost outweighs population as a reason because the backbone or every logistics or distribution activity is transportation. Hence population is somewhere between slightly and strongly less important than transportation PO-TR 1/4.
- **TR-GP 3** Transportation is slightly more important than policy government policy. Government policy is important because some countries give incentives to importers which encourages foreign investment but policy by t8he government help to enhance transportation that mean transportation is important than government policy. Likewise policy by government being slightly less important than transportation 7GP-TR 1/3.
- **FD-LC 2** Future development is somewhere between equally important and slightly more important Labor cost. Future development is slightly important Labor cost because locating the Labor cost in a good land (economic development zone) is going to have a good distribution sales location LC-FD 1/2.
- **PO-LC 2** Population is somewhere equally important and slightly more important than distribution sales location. A favorable customer population is always conducive for good business, therefore population being somewhere equally important and slightly important than labor cost LC-PO 1/2
- **GP-LC 3** Government policy is slightly more important than labor cost. Government policy is important because a reduction in taxes and tariffs help increases sales. Labor cost location would strive on good policies LC-GP 1/3.
- **FD-PO 2** Future development is somewhere between equally important and slightly more important than population. If there is plan for Future development in a municipality then that means population in terms of customer base would not be a problem PO-FD 1/2
- **FD-GP 2** Future development is somewhere between is equally important and slightly more important than Government policy. In finding a good Future development to build your distribution center Government policy becomes less of problem because economic development zones have already good regulations of rules set by the government there considering Government policy less important GP-FD 1/2
- **GP-PO 3** Government policy is somewhere between equally important and slightly more than Population. Supporting policies in an industry help bring foreign in investors which means the environment would conducive for business so natural becomes less important to policy environment PO-GP 1/3.
- **TR-TR 1** Any decision factor compared against itself is equally important

**STEP 3**

Determining the pairwise weight for the factors.

In determining the weight, we use the formula

$$a_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

$$a_{11} = \frac{1}{1+\frac{1}{5}+\frac{1}{2}+\frac{1}{4}+\frac{1}{4}} = 0.4380$$

$$a_{22} = \frac{1}{5+1+2+2+3} = 0.0754$$

$$a_{33} = \frac{1}{2+\frac{1}{2}+1+\frac{1}{2}+\frac{1}{2}} = 0.2222$$

$$a_{44} = \frac{1}{4 + \frac{1}{2} + 2 + 1 + 2} = 0.1053$$

$$a_{55} = \frac{1}{3 + \frac{1}{3} + 2 + \frac{1}{2} + \frac{1}{2}} = 0.1463$$

**STEP 4**

To determine the $A_{norm}$ where each of the columns of A, divide each entries in the column by the sum of the entries in the column. This yields a new matrix call $A_{norm}$ below;

$$A_{norm} = \begin{pmatrix} 0.4380 & 0.3846 & 0.4444 & 0.4211 & 0.4392 \\ 0.0875 & 0.0769 & 0.1111 & 0.0526 & 0.0488 \\ 0.2190 & 0.1538 & 0.2222 & 0.2105 & 0.2927 \\ 0.1096 & 0.1538 & 0.1111 & 0.1053 & 0.0732 \\ 0.1459 & 0.2307 & 0.1110 & 0.2105 & 0.1463 \end{pmatrix}$$

Now estimate the weight for criterion by using the formula below to obtain the *wi* values

$$W_i = \frac{\sum_{j=1}^{n} a_{ij}}{n}$$

$$W_1 = \frac{0.4380 + 0.3846 + 0.4444 + 0.4211 + 0.4380}{5} = 0.4255$$

$$W_2 = \frac{0.0876 + 0.0754 + 0.1111 + 0.0526 + 0.0488}{5} = 0.0754$$

$$W_2 = \frac{0.2190 + 0.2190 + 0.2222 + 0.2105 + 0.2927}{5} = 0.2196$$

$$W_2 = \frac{0.1096 + 0.1538 + 0.1111 + 0.1053 + 0.1463}{5} = 0.1106$$

$$W_2 = \frac{0.1459 + 0.2307 + 0.1111 + 0.2105 + 0.1463}{5} = 0.1689$$

**STEP 5**

The pairwise can suffer from inconsistencies, so to check for consistency.

The first step is to compute for *AW*

$$AW = \begin{pmatrix} 1 & 5 & 2 & 4 & 3 \\ 1/5 & 1 & 1/2 & 1/2 & 1/3 \\ 1/2 & 2 & 1 & 2 & 2 \\ 1/4 & 2 & 1/3 & 1 & 1/2 \\ 1/3 & 3 & 1/2 & 2 & 1 \end{pmatrix} \times \begin{pmatrix} 0.4255 \\ 0.0754 \\ 0.2196 \\ 0.1106 \\ 0.1689 \end{pmatrix} = \begin{pmatrix} 2.14908 \\ 0.3819 \\ 1.1415 \\ 0.5620 \\ 0.8679 \end{pmatrix}$$

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} =$$

$$\frac{2.14908}{5 \times 0.4255} + \frac{0.3819}{5 \times 0.0754} + \frac{1.1415}{5 \times 0.2196} + \frac{0.5620}{5 \times 0.1106} + \frac{0.8679}{5 \times 0.1689} = 5.1267$$

**Step 6**

Is to compute for consistency index (CI)

Where n is the number factors

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{5.1267 - 5}{5 - 1} = \frac{0.1267}{4} = 0.0317$$

**Step 7**

Is to compare CI to Random Index (RI) for the appropriate value of n.

RI=1.12

**Table 4.2: Source: Saaty**

| Matrix Size | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.91 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.140 |

$$CR = \frac{CI}{RI} = \frac{0.0317}{1.12} = 0.028$$

Saaty suggests that if the result thud CR is <0.10, the degree of consistency is satisfactory. And based on this result, the consistency is satisfactory

Now that the weight of each objective is known, the next step is to determine the score of each decision alternatives on each objective. The scores are listed in the following table below

**Table 4.3: Score, city against criteria**

| | TRANSPORTATION | LABOR COST | FUTURE DEVELOPMENT | POPULATION | GOV'T POLICY |
|---|---|---|---|---|---|
| **ACCRA** | 4 | 4 | 3 | 2 | 4 |
| **TAKORADI** | 3 | 3 | 2 | 2 | 4 |
| **KUMASI** | 3 | 3 | 3 | 2 | 3 |
| **HO** | 2 | 3 | 1 | 2 | 1 |

The various scores obtained from the table above are as a result of findings from careful research of the decision factors against each city. For example under Transportation, Accra registers the highest scores the city has a very good transportation system and policy and also the logistics industry is of the highest quality, then followed by Takoradi, Kumasi and Ho scoring the same.

For Calculation of scores

Accra;

(4*0.4255) + (4*0.0754) + (3*0.2196) + (2*0.1106) + (4*0.1689) = 3.5592

Takoradi;

(3*0.4255) + (3*0.0754) + (2*0.2196) + (2*0.1106) + (3*0.1689) = 2.6698

Kumasi;

(3*0.4255) + (3*0.0754) + (3*0.2196) + (2*0.1106) + (3*0.1689) =2.8894

Ho;

(2*0.4255) + (3*0.0754) + (1*0.2196) + (2*0.1106) + (2*0.1689) = 1.6869

From the calculations above for the various cities, the overall score for Accra is the largest. Hence Accra is the best place for the location of the distribution center

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## 5. CONCLUSION

This paper deals with an integrated decision model for determining the location of distribution facilities.

Distribution facility location decision is a more complex problem due to the uncertainty and volatility of distribution environments. The location decision process involves qualitative as well as quantitative factors. Decision makers can no longer ignore the influence of sensitive factors such as the population status of a candidate region, transportation conditions, market surroundings, location properties and cost factors related the alternative location.

Since the consistency is satisfactory, AHP suggest that Delaw logistics should select Accra as its distribution center.

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