Vendor Selection by Analytic Hierarchy Process (AHP) in Livestock Trading Ecosystem

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ABSTRACT

As livestock plays a very crucial role in Indian economy. Livestock trading in India is very unstructured. The Buyer can be farmer or Diary farm owner who wants to procure a livestock. In this research the Livestock which is considered is the Murrah buffalo belong to water buffalo (Bubalus bubalis) breed which are mainly kept for milk production. The buyer is available with 8 suppliers which are fulfilling the same criteria of the breed. The Suppliers are divided into two segments, large scale supplier and small scale supplier. The supplier having more than 10 livestock of same breed has been considered large scale supplier, and the supplier having less than or equal to 10 has been considered small scale supplier. As competition is increasing every day the procurement activities are highly important. So, Multi criteria decision making approach has been used. Specifically, Analytic Hierarchy Process has been used for the selection of vendor among the alternatives available. In this research three criteria, seven sub criteria and eight alternatives has been evaluated. All vendors are ranked according to the result obtained from the AHP to aid the decision making. By implementation of AHP we were able to obtain the best fit vendor. AHP is a practical tool used for aiding the decision making when there are too many parameters. In Livestock trading ecosystem this tool will help in decision making.

Keywords:

Vendor Selection, Analytic Hierarchy Process, Multi Criteria Decision Making

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Introduction

In Indian Economy Livestock plays a very crucial role. It approximately contributes 16% to the small farmers and an average of 14% for all rural household. For livelihood around 205 lakh people are depending on the livestock. Two-Third of rural community in India depends on livestock(Dr. Rajesh Singh, 2020).

Livestock trading in India currently operates via 4 channels. Animal fares, Local marketplace, Brokers & E-commerce platform. All the channels have their own Pros & Cons. Traditionally a Buyer would reach out to one of the above mentioned channel and try to procure the Livestock (Peeyusha R, 2016).

Traditionally a buyer would procure a Livestock either on appearance basis or by listening to word of mouth. So in this traditional method buyer perception which is how he obtains, interprets and analyse information of the product & service (Peeyusha R, 2016). It plays a major role and vendor selection is done not on quantitative basis. So to counter this problem AHP approach is selected. As Analytic Hierarchy Process (AHP) is able to structure the information available to the buyer and combine both quantitative and qualitative attributes and deliver the most optimum decision which best suits the final objective of the buyer.

The paper is has following sections: Section one provides the introduction to impact of Livestock trading on Indian economy and Importance of implementation of AHP in the Livestock trading environment. Section two gives details on the literature review. Section three consist of methodology and data analysis which were conducted to obtain the results. Section four includes the steps to obtain the objective. Section five discusses on the finding and suggestions

Literature Review

“Due to pressure of growing demand for food and economic gain, livestock production has been developing rapidly” (Qiu et al., 2017). The same goes for milk production so the Diary business are also in demand. As stated by many researchers that Livestock based industry are the most productive sector from investment point of view(Hossain et al., 2012). As stated by many researchers that health of livestock is very

important for any decision making before procuring any livestock. Which is an influential factor in AHP model, we have considered Health & fitness of livestock as sub criteria under quality criteria as it contains some risk factor (Mohan et al., 2012).

Vendor selection as a process is very tiring & complex task as it has many variables which are taken into consideration for the selection of vendor (KAMATH et al., 2016). Supplier selection starts with criteria selection that should be used for the selection of supplier. "According to (Astanti et al., 2020) this step is called pre-qualification stage in supplier process." In order to sustain in this market which is vey competitive the buyer must be provided with adequate cost, quality standard must be met & satisfying service which meets the goal (KAMATH et al., 2016) (Carolina, 1996). Vendor selection becomes a problem when it involves multiple criteria both tangible & intangible (KAMATH et al., 2016). "For supplier selection problem are better dealt with multiple criteria decision making because it enables to overcome the contradicting criteria affecting most in the selection procedure. The selection of a convenient vendor is very essential but it contains a high degree of complexity due to inclusion of numerous new factors" (Unal & Temur, 2020).

As competition is increasing every day, the procurement activities is highly important which ensure profitability. "However, it cannot always be determined by quantitative qualities, some qualitatively best sought"(Demir & Koca, 2020). Recently, MCDM techniques play a major strategic key responsibility in consideration of criteria and capitulate the most sustainable option among others (Otay & Y\ild\iz, 2020). Multi Criteria Decision making most common practice is AHP basically it is a structured approach for modelling & solving complex decision problems. By using this method, we can construct the criteria which influence criteria in a hierarchy, calculate the weights of each criteria and alternative we can compare the alternative which will aids in decision making (Oztaysi et al., 2021). "In solving a multi criteria decision making problems the decision environment affects the decision outcome in which the criteria knowledge is known or uncertain. So the decision making environment are classified into three types: certain, uncertain and risk" (Prasad et al., 2020). "AHP is a practical tool that incorporate both qualitative and quantitative factors into decision making process. It bifurcates any complex problem into several sub problems" (Abraham et al., 2015). "MCDM methods have been applied by different researchers and applied in many different areas" (Goswami & Mitra, 2020). Recently it has find its application in Livestock. Many survey and research has stated which types of criteria are considered while selection of a particular kind of breed of livestock (Paakala et al., 2020). As suggested by Kamath(2016) for selection of vendor from group of criteria, the criteria which are important like low price, delivery time & quality are considered by many researchers (KAMATH et al., 2016). Under the Economy criteria net price, transportation cost and payment terms are the sub-criteria. Under the Quality Criteria Health and fitness are the sub-criteria. Under the Service Criteria Veterinary Service and Insurance are the sub-criteria. A pairwise comparison between each criteria in achieving the objective and pair wise comparison between the alternatives is done to implement AHP (Noradachanon & Senivongse, 2017). "It also determines the relative importance of each alternative with respect to each criterion. In addition, consistency ratio is computed to check whether pair-wise comparisons are consistent" (Noradachanon & Senivongse, 2017). The studies relating to vendor selection by analytic hierarchy process in livestock trading ecosystem is scanty.

Methodology/Data Analysis

In this research the observation is for the supplier selection for the procurement of the Livestock, here we have considered the evaluator who can be any Farmer or Diary Farm owner. We have considered 8 suppliers which are further classified as small scale supplier & Large scale supplier. The classification of the class of supplier is solely on the basis of Livestock owned by the Supplier. We have considered that any supplier having more than 10 Livestock has been considered Large scale supplier and any supplier having less than or equal to 10 Livestock has been considered Small scale supplier.

Objective Function: - Vendor Selection

Input Parameters: - Ratings from Buyer

Variables Used: -
"CR: - Consistency Ratio
CI: - Consistency Index
RI: - Random Index
$\lambda_{max.}$: - eigenvalue maximum
n: - matrix order"

So for the implementation of AHP into Vendor Selection we need to bifurcate the process into below mentioned steps.

Step 1: Defining the Criteria for Vendor Selection

Stating the criteria is the foremost important step for the selection of Vendor. The criteria for the Selection depends on the parameters on which Buyer would like to evaluate the vendor & establish relation for further engagement for business.

Step 2: State the Sub-Criteria for Vendor Selection

This step is crucial for the further analysis of the parameters. It gives us the greater clarity on the Vendor Selection. The sub criteria are basically selected based on the literature review & the parameters which are currently being followed for the vendor selection in Livestock ecosystem. A total of seven sub criteria are considered. These sub criteria majorly affect the result of vendor selection and holds top most priority among rest of sub criteria which haven't been selected. These sub criteria are essential from the buyer perspective.

Table 1: Criteria & Sub Criteria used for Vendor Selection (Source: Author's compilation)

Criteria	Description
Price(Astanti et al., 2020; Goswami & Mitra, 2020)	In the competitive market of Livestock, the price is very influential factor for decision making. The price here is referred as the price of Livestock.
Transportation Cost(Astanti et al., 2020)	The Transportation cost is paid by the buyer and sometimes it can be 60% of the price of livestock. The transportation cost here is referred as the cost of transportation from the seller location to the buyer location. So it is the second most important factor which is influential in decision making
Payment Terms(Astanti et al., 2020)	Payment terms are referred as the method of payment whether it is cash or online mode. The payment breakup like how much of amount to be paid in advance and how much after delivery
Health(Diti Bajpai, 2018)	Health is referred here as Health of the Livestock. The parameters which are considered under this criterion is Age, Milk Yield, Breed, Physical appearance etc.
Fitness(Diti Bajpai, 2018)	Fitness here is referred as fitness to travel. The buyer is responsible to select only fit animal for transportation and those who can cope with the distance and the nature of Journey. There are many points which are taken into account like Stage of pregnancy, Age, Injury (if any), Body condition & clinical evidence of disease(if any)
Veterinary Service (Source: Author's compilation)	Veterinary Service is included or not
Insurance (Source: Author's compilation)	Insurance of the livestock is done or not

Step 3: Hierarchy model structuring

Criteria and Sub criteria are assigned weight. Weight allocation for each criteria and sub criteria are done by pair wise comparison between the criteria and sub criteria using AHP technique. By doing so we can obtain the priority matrix according their importance. "A 9 point scale is

used for the purpose which is stated in Saaty(1980). The nine-point scale basically signifies on a scale levels as equal, moderate, strong, very strong and extreme represented by 1, 3, 5, 7 and respectively. Intermediate values between the two adjacent judgments like 2, 4, 6, 8 are used where compromise is needed. So the nine-point scale depicted by Saaty is very strongly preferred for comparison of two alternate criteria (Saaty, 1980). In AHP technique, the main assumption for the comparisons of the criteria is that Criteria 1. is strongly preferred over other Criterias."(Astanti et al., 2020; Goswami & Mitra, 2020; Saaty, 2003; Saaty & Saaty, 2013; Saaty & Shang, 2011)

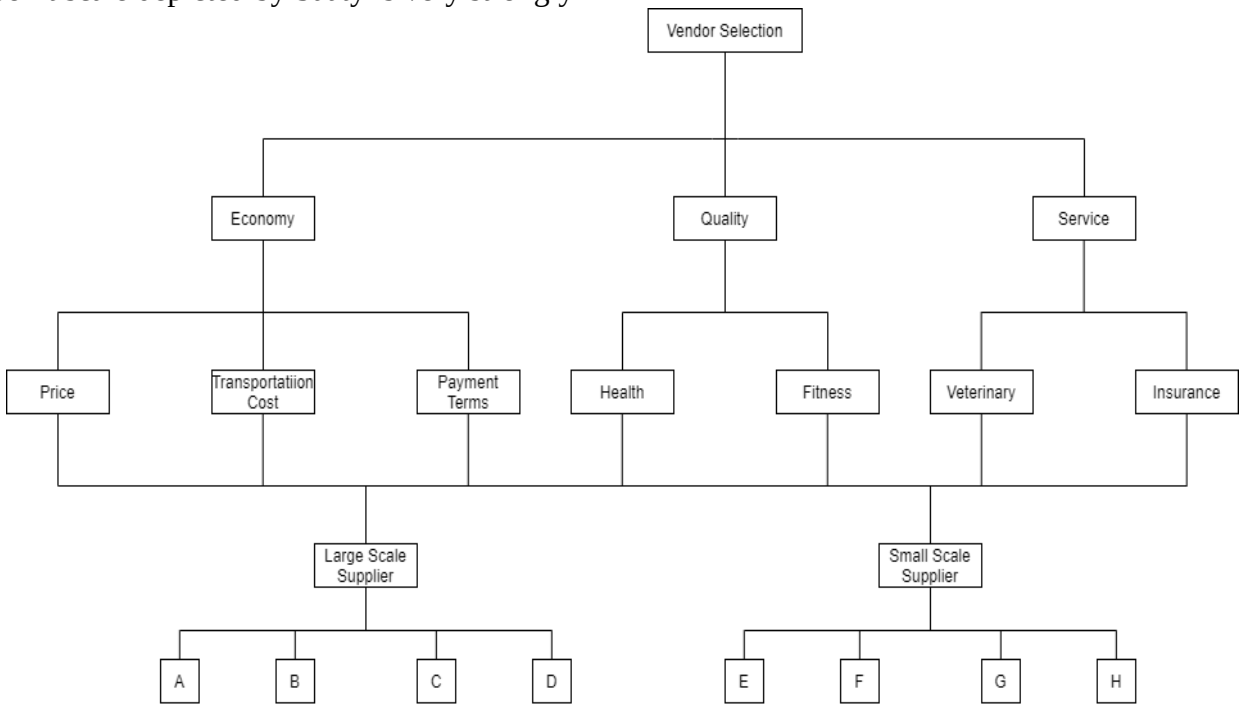

Figure 1: AHP Hierarchy model

Step 4: Pairwise Comparison among Criteria & Sub Criteria

Basically in this at every tier of Hierarchy model a pair wise comparison is done among every criterion with respect to a preceding level is carried out. In this rating is given by the Buyer according to his own perception. The preference is expressed using Saaty's 1-9 scale.

Table 2: Saaty Comparison Scale (Goswami & Mitra, 2020) (Saaty & Saaty, 2013)

"Saaty's pair wise comparison scale"	**"Compare factor of i & j"**
1	Equal Importance
3	"Moderate Importance"
5	Strong Importance
7	"Very Strong or Demonstrated Importance"
9	Extreme Importance
2,4,6,8	"Intermediate Values when compromise is needed"

Step 5: Normalization of Matrix

Normalization of the data is done by doing the following steps:

- Finding the sum of the rating assigned in every column of the pair wise comparison matrix
- Dividing every values in the column by the respective column sum.
- The final output is the Normalized Matrix.
- The average of each row, gives the respective weightage or local priority of the Criteria or Sub Criteria.

Step 6: Checking of Consistency of Matrix

Consistency check is done to validate that model is reliable or not. The decision made by the evaluator is consistent or not on the basis of Consistency Ration(CR). "The CR value is acceptable if the value ranges from 0 to 0.1. A CR

value above 0.1 is unacceptable, and the result are considered inconsistent" (Astanti et al., 2020; Goswami & Mitra, 2020). And the judgment from the evaluator need to be evaluated again.
How to calculate CR is mentioned below:

- To obtain λ_{max} we need to first calculate a matrix by matrix multiplication of the Pairwise comparison matrix & Local priority matrix, then we need to divide the obtained matrix with the local priority of the respective criteria. The obtained values are the λ for each criterion, by taking the average of λ we will get $\lambda_{max.}$
- Then we will calculate Consistency Index

"$CI = \frac{\lambda_{max.} - n}{n-1}$

Where:

CI = Consistency Index
$\lambda_{max.}$= eigenvalue maximum
n = matrix order"

- "The average value of Random Index(RI) can be seen in Table. It is noted that if the order of the matrix is 2, the matrix is always consistent" (Astanti et al., 2020; Goswami & Mitra, 2020)

Table 3: Random Consistent Index (RI) (Astanti et al., 2020) (Saaty, 2003)

Matrix Order (n)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random Index(RI)	0	0	0.52	.90	1.11	1.25	1.35	1.40	1.45	1.49

- Then calculate Consistence Ratio (CR)

"CR = CI/RI
Where:

CR = Consistency Ratio
CI = Consistency Index
RI = Random Index"

Post-study of literature and by capturing buyer's perception for the choice of product, an AHP model was created.

Pairwise comparison matrix was created for every level of the model. Below shown process is for only one tier. In rest tiers the same process will be followed.

Table 4: Pairwise Comparison (Source: Author's compilation)

Criteria	**Economy**	**Quality**	**Service**
Economic	1	0.2	3
Quality	5	1	7
Service	0.333333333	0.142857143	1
Sum	6.333333333	1.342857143	11

In the above matrix, there are three criteria- Economy, Quality & Service. The ratings of the criteria are based on Saaty Scale. The above rating depicts that Quality is more important than Economy & Service. And Economy is more important than Service.

Normalized matrix for the pairwise comparison among criteria can be seen in Table 5.

Table 5: Normalized Matrix (Source: Author's compilation)

"Criteria"	**"Economy"**	**"Quality"**	**"Service"**	**"Local Priority"**
Economic	0.157894737	0.14893617	0.272727273	0.193186
Quality	0.789473684	0.744680851	0.636363636	0.723506
Service	0.052631579	0.106382979	0.090909091	0.083308

After Normalization we have calculated Local priority of the criteria. The above matrix after

normalization states that Quality criteria is having the most weightage of around 72.35%, then Economy criteria is having the weightage of around 19.31% and at least priority is given to Service which is equal to 8.33%. All the weightages are in accordance with the rating assigned to the respective criteria by Buyer.

$$\begin{pmatrix} 1 & 0.2 & 3 \\ 5 & 1 & 7 \\ 0.333 & 0.1428 & 1 \end{pmatrix} \times \begin{pmatrix} 0.1931 \\ 0.7235 \\ 0.0833 \end{pmatrix} = \begin{pmatrix} 0.5878 \\ 2.2725 \\ 0.2510 \end{pmatrix} = \begin{pmatrix} 0.5878/0.1931 \\ 2.2725/0.7235 \\ 0.2510/0.0833 \end{pmatrix} = \begin{pmatrix} 3.042719 \\ 3.141082 \\ 3.013655 \end{pmatrix}$$

$\lambda_{max.}$ = (3.042719 + 3.141082 + 3.013655)/3 = 3.065819
CI = 0.032909
CR = CI/RI = 0.05674
As CR is less than 0.1 than it is clearly evident that Matrix is consistent.
Using the same process, we will calculate the local priority and checking the consistency for respective Sub criteria, alternative and sub alternative.

Table 6: Local Priority of each criterion (Source: Author's compilation)

"Economic Criteria"	***"Local Priority"***
Price	0.4761
"Transportation Cost"	0.4523
Payment Terms	0.0717
"Quality Criteria"	***"Local Priority"***
Health	0.8333
Fitness	0.1667
Service Criteria	***Local Priority***
Veterinary Service	0.1429
Insurance	0.8571
"Price Sub Criteria"	***"Local Priority"***
Large Scale Supplier	0.125
"Small Scale Supplier"	0.875
Transportation Cost Sub Criteria	***Local Priority***
"Large Scale Supplier"	0.8571
Small Scale Supplier	0.1429
"Payment Term Sub Criteria"	***"Local Priority"***
Large Scale Supplier	0.8889
"Small Scale Supplier"	0.1111
Health Sub Criteria	***Local Priority***
"Large Scale Supplier"	0.75
Small Scale Supplier	0.25
"Fitness Sub Criteria"	***"Local Priority"***
Large Scale Supplier	0.6667
"Small Scale Supplier"	0.3333
Veterinary Serivce Sub Criteria	***Local Priority***
"Large Scale Supplier"	0.8571
Small Scale Supplier	0.1429
"Insurance Sub Criteria"	***"Local Priority"***
Large Scale Supplier	0.6667
"Small Scale Supplier"	0.3333
Large Scale Supplier Sub Alternative	***Local Priority***
A	0.6034
B	0.1364
C	0.1957

D	0.0646
"Small Scale Supplier Sub Alternative"	***"Local Priority"***
E	0.6941
F	0.1062
G	0.2
H	0.0739

Below table consists the Consistency results.

Table 7: Consistency Checking Result (Source: Author's compilation)

	λ_{max}	n	CI	RI	CR	Conclusion
Criteria respect to Goal	3.0658	3	0.0329	0.58	0.0567	Consistent
Sub Criteria respect to Economy	3.0026	3	0.0013	0.58	0.0023	Consistent
Sub Alternative respect to Large scale supplier alternative	4.1007	4	0.0336	0.9	0.0373	Consistent
Sub Alternative respect to Small scale supplier alternative	4.1477	4	0.0492	0.9	0.0547	Consistent

As per the result the value of CR of all the matrix is less than 0.1 therefore all the matrix is consistent. The consistency table has been shown only for matrix order more than 2, as All the matric of order 2 are always consistent.

"To select the final Vendor, we need to calculate the Overall priority of the Sub-Alternative. The overall priority of each sub-alternative can be obtained by summation of the products of the local priority of the criterion priority times the local priority of sub-criteria times the local priority of alternatives times the local priority of sub alternative with respect to that alternative, sub criterion and criterion" (Astanti et al., 2020). The results of overall priority are shown below in Table

Table 8: Overall Priority of each alternative (Source: Author's compilation)

"Supplier"	**Overall Priority"**	**"Supplier"**	**Overall Priority"**
A (Large)	0.4158	**E (Small)**	0.215808
B (Large)	0.094	**F (Small)**	0.033007
C (Large)	0.1348	**G (Small)**	0.062172
D (Large)	0.0445	**H (Small)**	0.022979

Then the above table is rearranged in descending order as per weightages, and Ranked accordingly. The results of Ranked of alternatives is shown below in Table.

Table 9: Rank of each alternative (Source: Author's compilation)

"Supplier"	**Overall Priority**	**"Rank"**	**"Supplier"**	**Overall Priority**	**"Rank"**
A (Large)	0.415776	1	**G (Small)**	0.062172	5
E (Small)	0.215808	2	**D (Large)**	0.04449	6
C (Large)	0.134829	3	**F (Small)**	0.033007	7
B (Large)	0.093983	4	**H (Small)**	0.022979	8

Below shown image represents the breakup of weightage of Alternatives of Vendors.

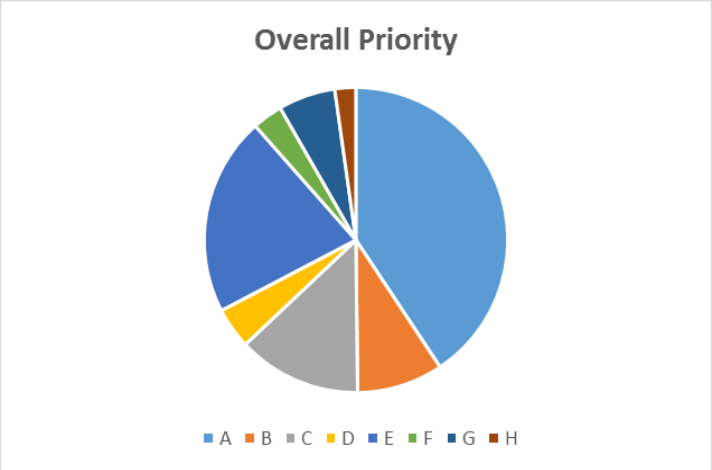

Figure 2: Weightage breakup according to Priority

Discussion

In India Livestock trading market is very much unstructured. We did our research in this particular domain to fill some gaps in Vendor Selection, which are there in in current practices. Traditionally a buyer would procure a Livestock either on appearance basis or by listening to word of mouth. So in this traditional method buyer perception which is how he obtains, interprets and analyse information of the product & service (Peeyusha R, 2016). To counter this particular problem AHP is used for selection of Vendor according to the Criteria which are the influential for the fulfilment of the objective. After the finalization of the parameters which were used for the vendor selection. The comparative rating was given by the buyer for the parameters. After that a Normalized matrix was found to calculate the priority of the respective parameters. A check of the consistency was done on the matrix. Similarly, for every tier priority was calculated. At last overall priority was calculated and Vendors were ranked according to the overall priority.

Conclusion

As per the result we can decipher that Vendor A has the highest weightage of around 41.57% so buyer can select the Vendor A for the procurement purpose, as it fits according to all criterion and Sub criterion. And best suits as per the Buyer requirements. The Least Favoured Vendor is Vendor H. "AHP is a practical tool that incorporate both qualitative and quantitative factors into decision making process. It bifurcates any complex problem into several sub problems. But it is criticized by the use of discrete scale which cannot handle the uncertainty and ambiguity present in different attributes" (Abraham et al., 2015). To overcome traditional analytical hierarchy process certain limitations we can implement fuzzy AHP (Kumar et al., 2019) . "In Fuzzy AHP uses triangular fuzzy number from fuzzy set theory are basically used for the pair wise comparison, as in traditional AHP the relative importance is given by the decision maker and are based on individual judgement".(Noradachanon & Senivongse, 2017). All these problems are stated in Fuzzy AHP to improve the precision of the model. We can implement this also for Vendor Selection.

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