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Analysis of operational efficiency of a meat processing supply chain: A case study from the UAE

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Abstract

The purpose of this paper is to analyse the factors affecting operational efficiency for a meat processing supply chain. The paper focuses on the operations that take place in a slaughterhouse. The results obtained by testing a simulation model and the related factors mentioned are used to analyse the operational efficiency. The study takes place in the Middle East and North African (MENA) region, particularly the United Arab Emirates (UAE). The Arena Simulation software which is a discrete event simulation and automation tool developed by System Modelling has been used to develop a process simulation model of a real time slaughterhouse processes scenario along with factors such as waste disposal, and government regulation procedures that are also taken into account. The simulation model analysis shows that the current operational efficiency of the slaughterhouse processes is too low, as compared to the standard industrial operational efficiency. In the Arena based process simulation, the parameters were varied and new resource utilization was obtained. By testing the new values into the relationship it was found that the operational efficiency has improved to the initial results from 0.2193 to 0.2612. This study implies that there is room for improvement in the slaughterhouse facilities to achieve sustainability, and eco-friendliness by increasing the operational efficiency. Even though there is enough literature on operational efficiency of meat supply chain (Fattahi et al., 2013), very few researchers have focused on the slaughterhouse operations and the relevant supporting processes. Further refinement based on the factors that can affect the slaughterhouse operations needs to be studied. The data collected reflect the general aspects of the operations that are easily accessible; a study on the complete process carried out in the slaughterhouse supply chain would possibly support a better understanding of the factors and thus develop a better view of the operational efficiency of the slaughterhouse. The analysis of the operational efficiency of the slaughterhouse may improve the slaughterhouse management practices to increase the performance. The managers and strategic decision makers need to decide on the appropriate mix of factors that would contribute to the improvement of slaughterhouse's operational performance. This study brings to light the improvement needs of the slaughterhouse facilities operate in this region in order to meet the food requirements of the consumers with utmost quality and by reducing the impact on environment which is a growing concern at present.Although few researches have studied the aspects of waste disposal, government regulation, and resource utilization of a slaughterhouse facility, this paper investigates the operational efficiency of a slaughterhouse by considering all the aforementioned aspects by creating a relationship among them which makes it a unique contribution to the meat

industry. This study provides an insight on the operation aspects of the slaughterhouse and the common practices carried out in this industry thereby considering the dimensions and factors that can improve the targeted operational efficiency.
Keywords: slaughterhouse, meat supply chain, operational efficiency, Arena simulation.

1. Introduction

Supply chain is a very broad term in the business world. It is generally defined as a network of facilities that deal with the supply and demand of the product and services. The network consists of people, activities, goods or services from one end to the other to meet the demand of the customer. The food industry over the past few years has been struggling to meet the expectancy in quality due to various reasons (Bogataj et al. 2005). With the increase in population, the need to meet the requirement for the large mass increased. This has had a very bad impact to keep the market responsive to the demands. There are various inhibitors that contribute to this decline in the food industry, such as government regulation on quality, processing inefficiency, infrastructures, distribution channels, poor handling, and customer practices (Trienekens et al 2012). In such crucial time where the industry finds difficulties to meet the demand, cope up losses and reduction in wastages are affecting the world economy, overall environment and hunger levels (Folinas et al. (2006)). Thus attention to the shelf life of these perishable units play a very important role in the meeting the industry requirement. Food loss and wastage occurs at the pre-consumption and consumption stages. Hence, the need to improve to operating model is essential to have a good business model that can help to survive the current drop in the industry. Figure 1 illustrated a three stage comprehensive meat supply chain, which starts from farming and ends at the consumption.

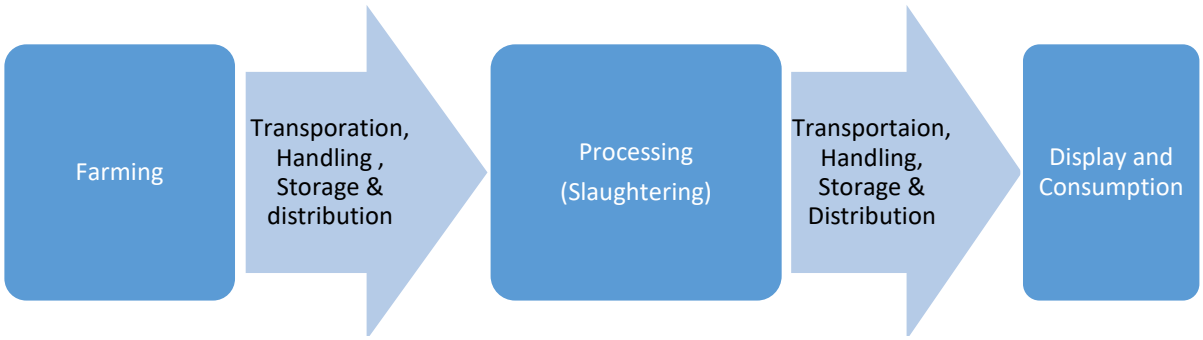

Fig. 1. *-Three stage meat Supply Chain*

In the case of meat supply chain, livestock production and processing is the least efficient process with losses of more than 40% of food loses in the post-harvest and processing phase while in industrialized countries more than 40% of the loses and wastage are seen at the retail and consumer level, according to Gustavsson et al. (2011). With the increase in population, meeting demands could affect the environment by causing loss of diversity. To achieve efficiency, the need for control system is required in the food industry. To gain maximum profitability, technology needs to be utilized efficiently in the food supply chain to stay aligned with the business expectation (Tamimi et al., 2010). Concentrating into the production section, which has the most implications in the supply chain, De Burgos et al. (2001) discussed the effect of operation objectives linking with environmental performance and supply chain issues. For example, in the food industry, customers are very keen on purchasing high quality products due to the potential health implications, apart from the

government regulations, quality can also be taken into consideration during the production time as this is the key area where the chances of quality degradation are found to be high. As estimated, in an average wastage of food accounts to 35% of the total output (Prafitt et al. 2010).

All these have led the focus of this study on the management of a slaughterhouse. This study takes place in the UAE thus takes into account the Halal approach for meat processing. Halal is a credence quality attribute, an intangible feature of the food product that cannot be assessed by the consumer, even at a pre or post consumption phase (Grunert, 2005). Halal certification addresses the nature, origin, and processing methods of meat, applying similar approaches for sustainability and animal welfare as organic food production methods (Bonne et al., 2008). The study is based on the details obtained from site visits of a functioning slaughterhouse and by calculating the impact of government regulation, waste management and resource utilization (57.4%, 38.75% and 10%). Only limited literature has been identified that has a specific focus on the slaughterhouse operation related issues (Al Halaseh and Sundarakani, 2012; Moschini, 1989; Gemma et al., 2002) Thus, the paper is looking forward to analyse the operational efficiency of a slaughterhouse. For testing the efficiency, a model is created that describes the real time slaughterhouse facility using Arena simulation. The model is tested using original data collected from the site as well as with a scenario to test the scope of improvement. In this study the efficiency of the resource utilization changed from 38.39% to 48.79%. Furthermore, a list of other factors have been considered on their relativity factor and a formulation of the obtained values to find the efficiency has assessed the operational efficiency (0.0216) and thereby focusing onto the operational aspect with the analysis of relative factors contributing to the operations. The paper would definitely be helpful for managers and decision makers, as it would help them to run the operations more efficiently. In the further sections a better understanding of the reasons and the circumstances that lead to the selection of these factors and the model that was used to reach to the conclusion would become evident.

2. Literature Review

As per the international consumer research on meat-related requirements the quality related attributes be categorized into three areas; a) the meat quality as perceived by consumers b) meat safety as per the consumer attitude and c) mandatory quality and safety certification schemes of the meat supply chain (Krystallis et al. 2006).

Other important crucial factors to be considered in addition to the above mentioned three factors in food consumption are the religion and culture. Research has shown clear evidence in the past that religion as well affects the consumers' choices and eating habits (Delener, 1994). Some religions have direct clear instructions on how and what food can be consumed for example some pork meat is forbidden in Islam and Judaism or pork and beef in Hinduism and Buddhism except for Christianity that has no restriction on food (Sack, 2001).

The number of people requiring such credence quality attributes to be followed in food processing affects the consumption and requirements that shall be adhered to in the globalization Arena which puts no limits or borders on the movements of food, goods, services labour or capital (Opara, (2003).

Livestock products contribute to 33% of the protein consumption worldwide, and is globally forecasted that by 2025 demand for meat products is likely to increase rapidly (Rosegrant et al 2009). With the aspects of hygiene taken into consideration, the functioning of slaughterhouses became vivid. The slaughterhouse function is meant for the production of edible portion of slaughtered animals to meet the meat protein demand for human consumption. Despite form other production unit, the level of hygiene is of prior importance.

Such complexity would always lead to production inefficiencies according to WHO (2002) and (2007). Therefore, understanding the process model and thereby measuring the efficiency of the processing unit of various operational processes seems to be imperative in the modern meat supply chain, especially places like the UAE where extreme temperature prevails during summer.

3. Research methodology

Phase 1:

Data collection from slaughterhouse operations:

In this step the slaughterhouse is visited and the procedures and process carried out and the data's regarding the time taken for the entity to pass from one process to another, the tine taken for an entity in a single process and human resource allocation for each process and the time over all time taken were observed in Appendix 1.

Modelling and detailing of the process in simulation Arena software.

The data's collected and the framework of the process carried out in the slaughterhouse facility are used as the input to the model created in the Arena simulation software. The analysis of the operations and the flow of products are modelled and then the data fed into the model and run over the replication of 10 times from a span of 12 hours a day.

Obtaining the report from the model and analysing the result.

The model is then tested and the output is obtained from the report generated by the software. The report would assist in assessing the factors that hinders the best performance of the overall process mentioned in the model. Also the alternatives that are required to make improvements in the operation cycle are analysed.

Phase 2:

Searching the literatures for factors affecting operational efficiency

An extensive search through the literature review is carried out to see other core factors that may impact the operations of the slaughter house are listed for further analysis.

Selection of key factors affecting slaughterhouse process

For a system, there are macro and micro environment factors that affect its operations, from the literatures the most critical and important factors are selected.

Calculation of contribution based on the secondary data

From the secondary data available from the literatures and online-published sources, the proportion of selected factors affecting the operations are calculated. Further, by the impact of the selected factors and their interdependencies the efficiency is found which the sole purpose of this study is.

Simulation methods have always been used by managers as a management tool for production and processing environments to implement changes at strategic and operational levels. In this study, the simulation of the model represented in the below section is based on Arena simulation software developed by Rockwell Inc. Discreet event simulation helps to understand the process with unique, specific events in time. These are mostly activity based modelling methods that are capable to accommodate flexibility in processes and simulate almost any processes in the industry. It provides a range of implications of the decisional changes before its practical application in the unit, thus reducing the uncertainties that would impact as a consequence on the operation dues to new changes implemented.

This would also help managers in the industry to combine the layout, utilization of resources and space orientation to facilities in the production floor. The software allows users to enter data and design the features of the process intuitively with the following:

1. Real time decision making.

2. Addressing bottlenecks.
3. Increased reliability.

4. Data collection

In this study, data were collected from field measurement and observation of activities during the animal slaughter operation at a slaughterhouse located in Al Qusais was considered for the analysis. The research takes into account the whole process and activities occurring in the slaughterhouse facility. For understanding the various processes in the slaughterhouse operations, an exploratory visit to the slaughterhouse was made and the measurement of time and the number of employees required for the different process in the slaughterhouse was observed. The model was created based on the field operation in the simulation software with the parameters and input variables observed from the field. The parameters include the time taken by an entity (cattle) to be processed through the various processing units across the production centre, time taken by employees to perform their function, the number of employees at each work stations; the resources employed for the business operations were gathered.

The second part of the analysis calculates the effect of the parameters selected based on the secondary data available and correlating it to the relation and there by formulating a formula based on the relationship and calculating the efficiency of the operations.

The literature review depicts the various factors that would determine the efficiency of the operations in a slaughterhouse facility. In accordance to mentioned factors in the earlier sections of this paper a model has been designed and the diagrammatic representation is as mentioned in Figure 2, each of these nodes represent the factors that contribute to the effective operation of an slaughter house facility based on the knowledge acquired from the various literature review. The arrows in the network of model also depict the causal relationship among the variables. The values for the mentioned factors are calculated for the factors and are depicted in the below section.

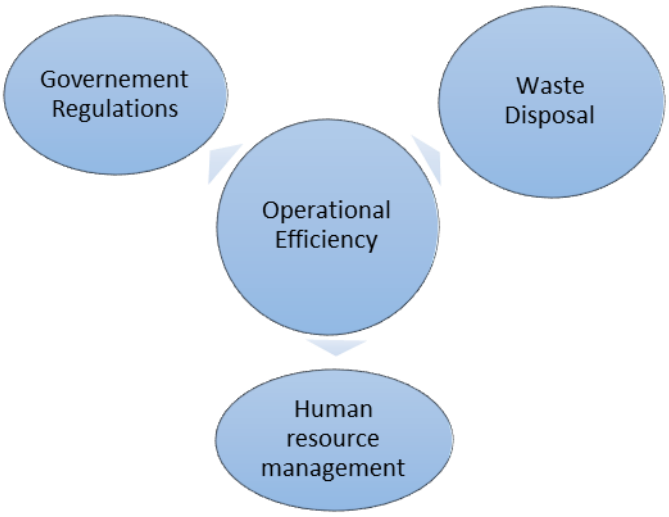

Fig. 2. *- The relationship among factors*

5. Data analysis

(i) Waste disposal:

Even with the existence of the state of the art technologies, waste disposal is one of the key areas that need attention with the rise of pollutant from the Slaughterhouse s due to huge investment behind it. Apart from the waste generated from the carcass there are lot of air pollution due to the contribution of Ammonia, Sulphur compounds and other effluents from the rendering process. When considering the statistics of live meats parts only 35 -55% seems to be edible rest of the portion needs to discarded as waste (Petrovic, et al , 2015). The details regarding the statistics of cattle by percentage of weight typically for slaughtering are depicted in Figure 3. Animals that are slaughtered in the slaughterhouse include cow's sheep's, goat's, camels and veal's.

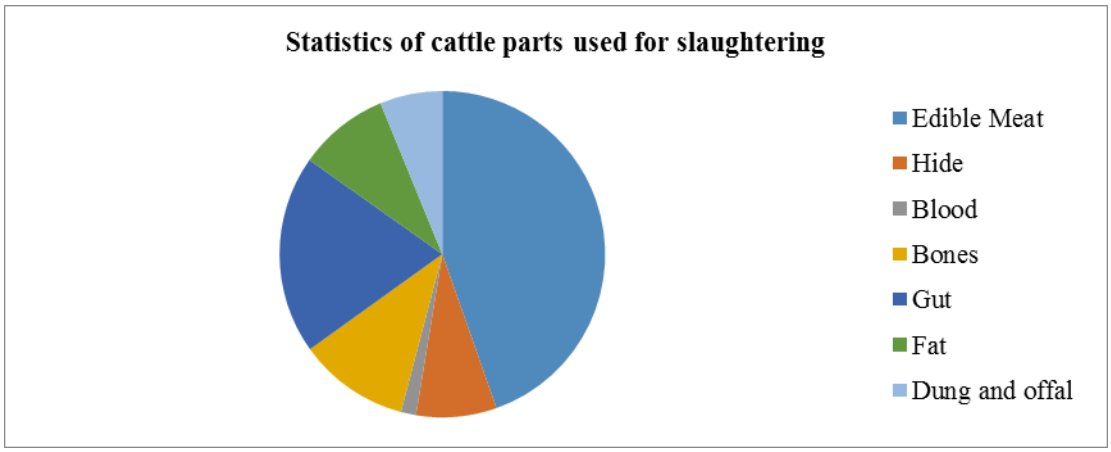

Fig. 3. *- Statistics of cattle parts used for slaughtering (source: Omele, et al 2013)*

As mentioned earlier in the literature review with environment impact is of the highest concern around the globe, eco efficiency is being introduced to various industries. In the meat industry the requirement of safe environment is of highest factors due to rising risk of environmental changes that are encountered in the recent year. According the existing statistic, only the dung or manure is used for treatment process in sewage plants that contributes to 10% of the total waste products from goat.

(ii) Government Regulations

From the literature reviewed in this article a set of factors were listed (Cost of the product, operations management in the slaughterhouse, waste management, location) and their requirement for 100% compliance were analysed and tabulated in the table 1. Further the percentage of contribution of government regulation on the slaughterhouse s operating efficiency was calculated based on the number of factors that needs to undergo 100% compliance with the regulations. Also due to the lack secondary data's and journals regarding all the factors mentioned, a generic approach of analysis is selected for the analysis of the Government regulation factors. The analysis of these factors is based on the calculation of the percentage of the effect of these represented sub factors by government regulation. The conclusion to these factors is based on review of government regulation on slaughterhouse management. The conclusion to these factors is based on the review of government regulation on slaughterhouse management and halal food regulation. The percentage calculation is based on a compliance perspective of the factors based on the Government regulations as well as on

input from an interview session with the employees of the slaughterhouse facility.

Tab. 1. *- Contribution of factors*

Factors requiring 100% compliance to Government regulation	**Yes or No**	**Compliance Percentage**
Costing of the product	No	57.14%
Operations management in the slaughterhouse	No	
Waste management	Yes	
Location	Yes	
Hygiene management system	Yes	
Design and Equipment	No	
Implementation of halal slaughtering process	Yes	

The above table shows that 57.14% of the operation in the slaughterhouse is in compliance to the government regulation.

(iii) Human resource allocation and utilization

The model was created in Arena simulation software; the parameters are taken from the real life observation. The observation is based on time recorded by a sheep through the entire slaughterhouse process until the product, consumable meat is processed. For this observation, the slaughterhouse was visited and real time data were collected. The parameters and their observations recorded were noted and were analysed to figure the inputs to the software. The following are the key fundamental blocks constituting the model of a functioning slaughterhouse:

Tab. 2. *- Process Involved*

Sl No	**Process involved:**
1.	Sheep arrival dock
2.	Preparation for Halal slaughtering
3.	Slaughtering process
4.	Meat processing section
5.	Cleansing unit
6.	Slicing process
7.	Packaging process

6. Initial model

The mentioned process and the data's observed for the parameters are modelled using the software and the model as shown in Figure 4. The simulation model was tested and run for a period of 12 hours per day at a replication of 10 number. From the model, we can understand that many of the resources are utilized for system performance. For example in the cattle preparation area, a massive amount of water is used for the cattle preparation and cleansing of blood substrates from the meat to make the product hygienic and edible for human use. It is

estimated that a sheep would require 100 -150L of water per animal from the simulation report. In this software the key main function used is process function with the triangular time function with minimum, most likely, and maximum.

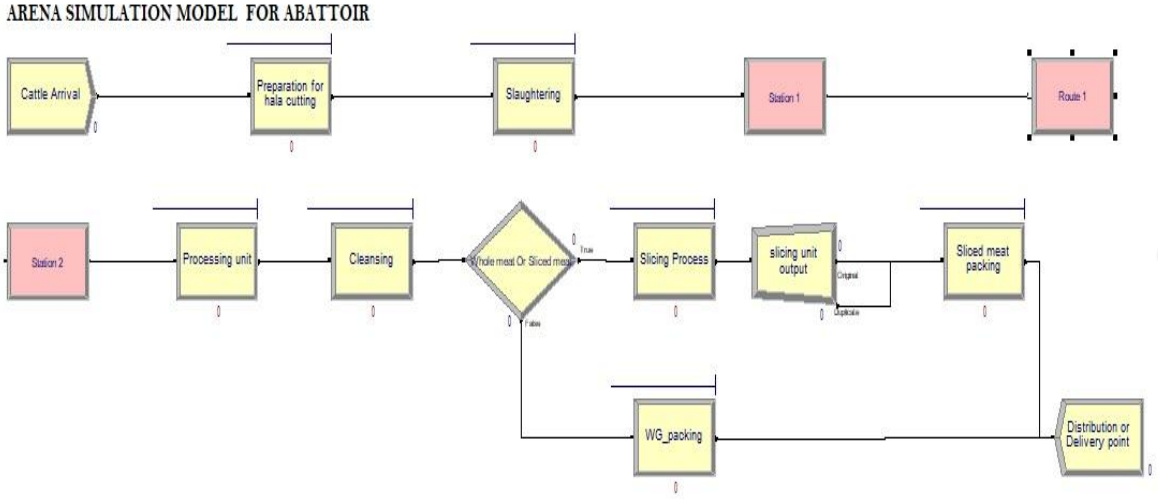

Fig. 4. - *Arena Simulation model for the slaughterhouse*

7. Simulation and analysis of result

Based on the description provided in the above section a model was created and a report was generated respectively. The model was run for a replication of 10 with the working hours of 12 hour per day. From the result, it was found that in the system a lot of queue was observed at the following areas:

1. Preparation of halal cutting.
2. Processing unit
3. Sliced meat packing unit

The result was evaluated in minutes for the entire testing of the model. It helped to conclude that the average value time for a sheep was found to 10.5 minutes and the overall time a sheep would in waiting time to be 46.8 minutes, in depth analysis of the report has provided the time consumption of an average entity (sheep) in queue through the various processes in the system. In addition, the report showcases that at an average rate there are about 20 sheep's in the processing centre and 18 at the sliced meat packing section in queue from the testing carried out. The resource usage in this analysis has recorded highest utilization of resources at the processman_1 and SPacker_1 with 98.8% and 87.4% while the least utilization of resources' were cleaningStaff_1, resource manpower, and WGPAcker_1 with 10%, 16%, and 15%.This is being represented in the table below. Since this study focuses on the operational efficiency of the slaughterhouse functioning, many flaws can be identified in the process flow related to the functions. From the field observation, the area that was least focused on the simulation but plays an important role to elevate the efficiency of the slaughterhouse as mentioned in the earlier sections is the bio coding mechanism. It is a tracing techniques employed in many places but difficult to trace throughout the process due to the vast number of handling and process across the supply chain by the time the product reaches the slicing unit. Also the tracking and traceability is found to be poor after the slicing of the meat is carried also when the sliced product are packed the degree of traceability is very low. At this point, there seems to be no traceability as the number of sliced parts that are

produced. Hence, apart from resource utilization there needs to an efficient tractability management and feedback system that can improve the quality of the quality of operation in the slaughterhouse.

From the slaughterhouse staff interview it was found that the processes in the meat processing unit have not changed from its beginning. The changes that they observe in the facility are the management's steps to maintain quality by repeated quality checks. The report from the Arena simulation has provided the insight that resource utilization is partly been into efficiency that is the processing unit and the cleansing unit. As the process involved in the process unit cannot be tailored due to the risks involved, the only way to increase the output is by structuring the process layout and optimizing the resource utilization.

On further looking into the operations of any process oriented business model the needs for proper utilization of resource is necessary. For this, the result from the Arena modelling discussed above is analysed on the human resources utilization from the resource utilization. The results of the percentage of various resources employed in the operation line are as mentioned in the table below.

Further, based on an assumed scenario, the model was run to see the impact of human resource allocation and utilization in the Arena software. To test the simulation, the input of the capacity of resources was changed to analyse its impact on the model. From the data received from the slaughter house the following changes mentioned in Table 3 were altered in term of the number of resources assigned were altered and tested to verify the usage of the human resources employed at each of the processes involved in the facility.

Tab. 3. *- Tested values for resources*

Resource name	Capacity
Slaughter_1	2
Process man_1	10
Cleaning staff_1	2
Butcher man _1	2
WGPacker_1	1
Spacker_1	5
Water	1
Resource manpower	2

Testing the model with the above-mentioned resources for the same number of replication and length as of the original case test-run parameters were carried out and the result was obtained. By analysing the two reports the utilization usage of resources in the changed scenario with the changes have increased compared to the original case scenario and the outputs of the original case and the created scenario has varied from 38.39 to 45.72%. It is clear that the number of products produced remained the same for both the cases; this proves that there is scope for improvement in the resource utilization in the slaughterhouse facility as contrasted in the Table 4.

Tab. 4. *- Comparison of results*

Resource names	**Percentage of utilization**(Original condition)	**Percentage of utilization**(Scenario condition)
Butcher man	38.78	58.16
Cleaning staff	10.4	15.61
Process man	98.8	98.8
Resource manpower	16	39.91
Slaughtering section man	2.76	5.5
Spacker	87.4	87.4
WG packer	14.7	14.7
Total % utilization of the human resources	38.39	45.72

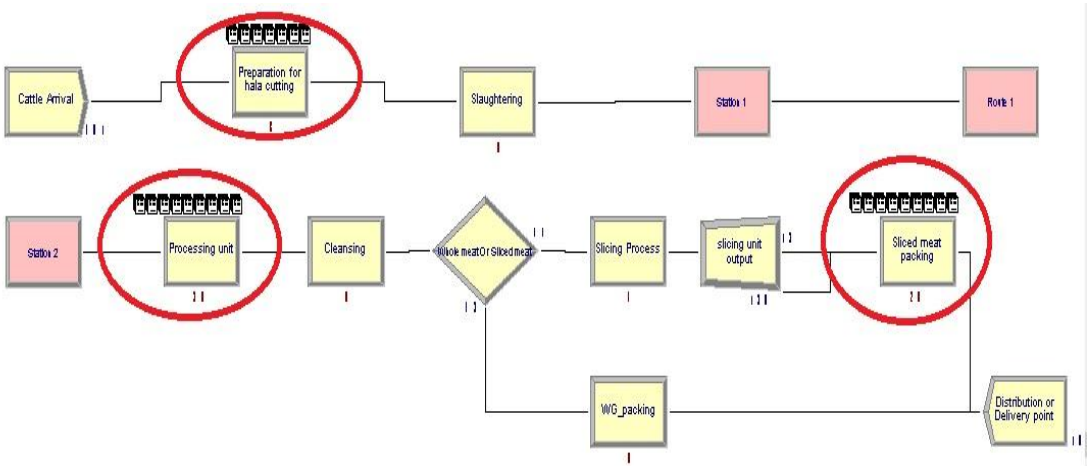

Figure 5: *Revised Arena model after streamlining the operations*

From The revised model presented in Figure 5, the factors contributing to the efficiency is measured based on the Overall Operational Efficiency (OOE) (Nakajima, 1988).

$O.O.E = (Performance) * (Availability) * (Quality)$ **..... (Eqn 1).**

The relation is based on the basis that the overall efficiency of system is the probability of success that the factor influence on the operations. In general, for a system the operations are influenced by these factors: Performance and Availability and Quality. Based on the context the parameters, Government Regulations, Human resource Management and Waste Management are considered respectively for the analysis in this paper. Hence applying the same logic based on the formation of equation1 by (Nakajima, 1988) where the author formulated the equation for overall equipment effectiveness, the below formula was derived:

$O.E = (\boldsymbol{Government\ Regulation}) * (\boldsymbol{HR\ M}) * (\boldsymbol{Waste\ Management})$**.....(F1)**

Hence applying the values obtained for the parameters from the above section would help to calculate the overall effectiveness of the abattoir operations. The values used in this

formula obtained by the calculation form the analysis of effect of factors in the operation from the above section.

From F1 with case 1 output for HR usage

$$Operative\ Effectiveness = (\mathbf{0.5714}) * (\mathbf{0.3839}) * (\mathbf{0.10}).$$

$$Operative\ Effectiveness = \mathbf{0.02193}$$

From F1 with case 2 output for HR usage

$$Operative\ Effectiveness = (\mathbf{0.5714}) * (\mathbf{0.4572}) * (\mathbf{0.10}).$$

$$Operative\ Effectiveness = \mathbf{0.02612}$$

The proposed method of analysing the operational efficiency using Arena simulation software, the parameters were varied and new resource utilization was obtained. By testing the new values into the relationship it was found that the operational efficiency has improved to the initial results 0.2193 to 0.2612. This study thus indicates that there is room for improvement in the slaughterhouse facilities to achieve sustainability, and eco-friendliness by increasing the operational efficiency. This could also be assumed from the graphical representation of the result as mentioned below in Figure 6 and Figure 7.

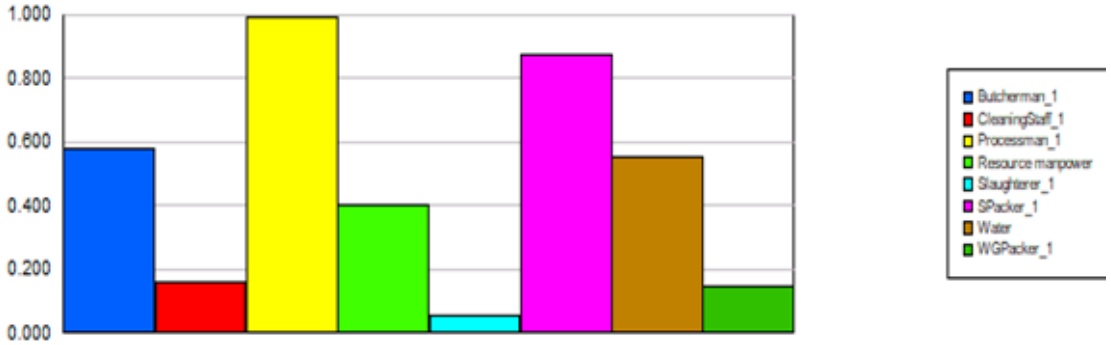

Fig. 6. *- Result of simulation for original case*

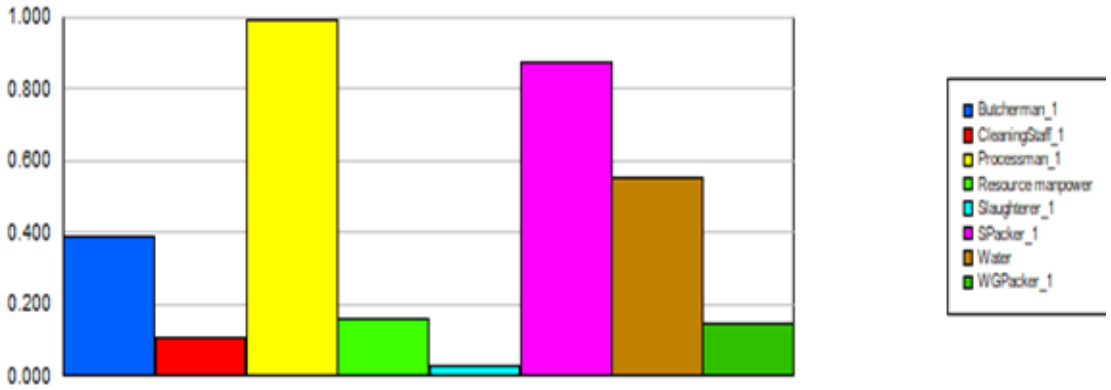

Fig. 7. *- Result of simulation for the scenario case*

Therefore, managers and strategic decision makers are required to decide on the appropriate mix of factors that would contribute to the improvement of slaughterhouse operational performance.

8. Conclusions

This study recommends improvisation of slaughterhouse facilities in this region thus able to meet the food (meat) requirements of the residence with utmost quality and by reducing the impact on environment from such facilities which is a growing concern at present.

Limitations

In this paper due to the less number of international journal based on the operative effectiveness some of the assumption are based on the trends and methods observed from the field data collected and brain storming sessions which cannot be statistically backed up due to lack of large samples. The low number of slaughterhouse facility in the region and the restriction based on the gathering of information has constrained the understanding of factors involved in the operations to a certain level. However, a deeper study would definitely enhance the possibilities of achieving a better and efficient facility with minimal impact on the nature. As the enlisted factors are based on the limited information available from the journals has reduced the scope for the generalization of the findings. Also the prioritization of factors needs to be perfected with the better understand and data collection. Last but not least, the student version of the Arena software employed in this study has some limitation in terms of use of advanced process and advanced transfer such as conveyors machines, facility routes and operations.

Recommendation

From the analysis, it is evident that the scope for improvement is high. Based on the impact of government regulations, waste management and resource utilization, the evaluation is performed. It is clear that the operational effectiveness can be incremented with the change in the efficiency of the related factors influencing the operations. From the study with the increase in the human resource utilization from 38.39% to 45.75% has increased the operative effectiveness from 0.021 to 0.026. Similarly, by increasing the efficiency of sustainable waste management would definitely increase the overall operative effectiveness of the abattoir. Thus being able to improve the management of abattoir facilities to achieve optimum progression.

Future Research

The future scope of the research lies in the automation of the abattoir process so as in reduce the risk due to contamination, effective use of resources and for better process structured functioning. With the recent environmental changes and the rise in temperature across the globe, the need for sustainable abattoir management is to be researched.

References

Al Halaseh, L. and Sundarakani, B. (2012) ‘Study on quality attributes of halal food supply chain’, International Journal of Logistics Economics and Globalisation, Vol. 4, Nos. 1/2, pp.20–34

Bogataj, M., Bogataj, L. & Vodopivec, R. (2005). Stability of Perishable Goods in Cold Logistics Chains. International Journal of Production Economics, 93-94, pp.345-356.

Bonne K., Verbeke W., 2008. Religious values informing halal meat production and the control and delivery of halal credence quality. Agriculture and Human Values, 25, 35–47.

Bourlakis, M.A., & Weighman, P. W.H. (2004), Introduction to the UK food supply chain, In Bourlakis, M.A., & Weighman, P. W.H. (Eds.), Food Supply Chain Management, Blackwell Publishing. 179-198.

Cherlebois S, MacKay G., (2010). World ranking food safety performance, Regina, Saskethewan Graduate School of public policy, https://grad.usask.ca/programs/public-policy.php [Accessed 06/05/2018]

De Burgos J., Cespedes Lorentte J.J., (2001). Environmental Environmental performance as an operations objective. International Journal of Operations and Management, 21(12),1553-72.

Delener N., (1994). Religious Contrasts in Consumer Decision Behaviour Patterns: Their Dimensions and Marketing Implications, European Journal of Marketing, 28 (5), 36-53.

Fattahi, F., Nookabadi, A, and Kadivar. M, (2013). A model measuring the performance of meat supply chain, British Food Journal, 115 (8), 1090-111.

Folinas, D., Manikas, I., & Manos, B. (2006), Traceability data management for food chains, British Food Journal, 108(8), 622-633.

Gemma C. Harper, Aikaterini Makatouni, (2002) "Consumer perception of organic food production and farm animal welfare", British Food Journal, Vol. 104 Issue: 3/4/5, pp.287-299

Grunert, K. G., (2005). Food quality and safety: Consumer perception and demand. European Review of Agricultural Economics 32, 369–391.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., Meybeck, A., (2011). Global Food Losses and Food Waste. Food and Agriculture Organization of the United Nations, USA

Krystallis, A., Arvanitoyannis, I., (2006). Investigating the concept of meat quality from the consumers' perspective: The case of Greece. Meat science, 72, 164-76.

Moschini, G., and K.D. Meilke. (1989) Modeling the pattern of change in US meat

demand. American Journal of Agricultural Economics, 71:253–261.

Nakajima, S., (1988) Introduction to TPM: Total Productive Maintenance, Productivity Press Inc., Cambridge, MA, USA

Opara, L. U. (2003), Traceability in agriculture and food supply chain : a review of basic concepts, technological implications , and future prospects. Food, Agriculture & Environment, 1(1), 101-106.

Petrovic Z., Djordjevic V., Milicevic D., Nastasijevic I., Parunovic N. (2015). Meat production and consumption: Environmental consequences. Procedia Food Science, 5 235 – 238.

Prafitt, J., Barthel, M, Macnaughton S., (2010). Food waste in food supply chains: quantification and potential for changes to 2050, Philosophical transactions of the royal society B-Biological Science, 365 (1554), 3065-3081.

Rosegrant, M. W., (2009). Looking into the future of agriculture and AKST. In: Mclntyre B.B, Herren H. R. (eds.) Agriculture at a crossroad, Washington DC Island press, pp.307-376.

Sack, D. (2001). White bread Protestants, Food and Religion in American Culture. New York, New York: Palgrave.

Smith, J. N. (2005), Specialized Logistics for a Longer Perishable Supply Chain, World Trade, 18(11), pp.46-48.

Tamimi,M. Sundarakani, B. and Vel, P (2010), Study of Cold Chain Logistics Implementation Strategies: Insights from UAE Industry, 21st Annual POMS Conference, Vancouver, British Columbia, Canada, May 7-10.

Trienekens, J.H., Wognum, P.M., Beulens, A.J.M., & van der Vorst, J.G.A.J. (2012), Transparency in complex dynamic food supply chains, Advanced Engineering Informatics, 26(1), 55–65.

WHO. (2002), WHO global strategy for food safety: safer food for better health. Retrieved from http://www.who.int/entity/foodsafety/publications/general/en/strategy_en.pdf [Accessed 06/05/2018].

WHO. (2007), Food safety and foodborne illness, World Health Organization. Retrieved from http://www.who.int/mediacentre/factsheets/fs237/en/ [12/05/2018].

APPENDIX 1

SHEEP ARRIVAL

NOTE: This the entry section where the cattle are collected or arranged to be sent to cleaning section or halal preparation section. It was observed that sheep arrive the cattle docks in batches. The observations are as mentioned below:

Time of arrival for the batches	No of batches
10:00	5
11:00	4
12:00	3
13:00	2

Batches	No of sheeps
#1	9
#2	7
#3	5
#4	5
#5	14
#6	9
#7	5
#8	7
#9	12
#10	7
#11	10
#12	8
#13	3
#14	6
AVERAGE SHEEP/ BATCH	**8**

PREPARATION FOR HALAL CUTTING

Note: The time taken for preparation of sheep for halal cutting. The recording were calculates on the basis of time taken for 15 sheep

No of sheeps	Time taken (min)
#1	2
#2	4
#3	3
#4	3.5
#5	2
#6	4
#7	3
#8	4
#9	3
#10	2
#11	2
#12	1
#13	2
#14	4
#15	3
Avg time taken	**3**

SLAUGHTERING SECTION

Note: Here the time taken to slaughter a sheep is recorded. The recording are based on a count of 15 sheeps

No of sheeps	Time taken
#1	1.3
#2	0.5
#3	0.3
#4	1
#5	1.2
#6	0.3
#7	0.9
#8	0.7
#9	1.3
#10	1
#11	1.5
#12	0.7
#13	0.8
#14	0.8
#15	0.6
Avg. time	**0.9**

Also after this process there is lag time of 4 min for the slaughtered sheeps to reach the processing centre where they are skinned gutted and trimmed

PROCESSING UNIT

Note: Here the sheep after the slaughterin is taken to the processing unit for gutting, skinning and trimming. Here the recording are taken on 15 sheeps

No of sheeps	Time taken(min)
#1	11
#2	10
#3	14
#4	10
#5	10
#6	13
#7	15
#8	10
#9	14
#10	13
#11	10
#12	12
#13	10
#14	15
#15	12.5

Avg time taken	**12**

CLEANSING UNIT

Note: Cleansing of the processed meat to remove bloodstains and colt formed at the time of processing. The recordings of 15 sheep's were observed.

No of sheeps	Time taken(min)
#1	2
#2	2
#3	3
#4	1
#5	1.5
#6	2
#7	2.5
#8	3
#9	2
#10	1.5
#11	1
#12	2
#13	3
#14	2
#15	2.5

Avg time taken	**2**

SLICING PROCESS

Note: This is the unit where the meat is sliced for consumers for sliced Meat portions. The observations are made on the basis of 15 sheep's

No of sheeps	Time taken(min)
#1	11
#2	9
#3	12
#4	10
#5	8.5
#6	10
#7	11.5
#8	9.5
#9	10
#10	11
#11	12
#12	8
#13	9
#14	12
#15	8

Avg time taken	**10**

PACKAGING UNIT

Note: This is the unit that packs the sliced unit for customer to purchase them. The recordings are observed on the basis of 15 packages on this

No of units packed	Time Taken(min)
#1	6
#2	6
#3	6
#4	5
#5	6
#6	5
#7	7
#8	5
#9	6
#10	7
#11	6
#12	5
#13	6
#14	5
#15	7
Avg time taken	**6**