AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 13, No 2, pp 205-211, 2021
Published by Faculty of Agriculture, Trakia University, Bulgaria
ISSN 1313-8820 (print)
ISSN 1314-412X (online)
http://www.agriscitech.eu
DOI: 10.15547/ast.2021.02.033

Assessing resource utilisation in beef cattle feedlot system in Adamawa State, Nigeria

M.R. Ja'afar-Furo[1]*, M.Y. Hamid[1], A.Y. Thlaffa[1], A. Sulaiman[2]

[1]Department of Agricultural Economics and Extension, Faculty of Agriculture, Adamawa State University, PMB 25, Mubi, Nigeria
[2]Department of Agricultural Economics and Extension, School of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Nigeria

(Manuscript received 20 July 2020; accepted for publication 24 March 2021)

Abstract. *This study assessed resource utilisation in beef cattle fattening units in Adamawa State, Nigeria, with the intent of highlighting some crucial areas that may require policy intervention for improvement. Purposive, multistage and random sampling methods were employed in selection of 270 beef cattle fatteners in the area studied. Structured questionnaire and group discussion were used in sourcing for data. The latter were analysed through descriptive statistics and efficiency methods of Data Enveloping Analysis (DEA). Results indicated that Sokoto gudali (72.60%) and Rahaji (20.00%) were the major cattle breeds adopted for fattening. While a total of 70.70% of fatteners fed bulls for a period of 4-6 months and in the open without shade (77.80%), the use of combination of crop residues and conventional feeds was the most popular (74.81%) in feeding stock in the State. Further, the most important resources were initial cost of bulls and cost of feeds with ₦169,056.00 and ₦10,559.00 per bull, respectively. Resources were found to be efficiently utilised within the beef cattle feedlot farms with Constant Return to Scale (CRS), Non-Increasing Return to Scale (NIRTS), Variable Return to Scale (VRS), Scale Efficiency (SE) and Return to Scale RTS) models mean scores of 84.44%, 84.44%, 91.48%, 84.74%, and 100%, respectively. Conclusively, it could be stated that indigenous breeds of Sokoto gudali and Rahaji were the main bulls used for fattening in the State, and a mixture of crop residues and conventional feeds was the popular plane of feeding stock, with most farms utilising resources efficiently. Stemming from the findings, soft credit facilities to accord fatteners afford initial off-setting cost of bulls and frequent extension services to same, for modernisation of beef cattle feedlot system are highly recommended*.

Keywords: beef, cattle, costs, feedlot, indigenous breeds, system

Introduction

Resources are referred to as those factors that are used in the production of goods and provision of services that meet human needs and wants. They are generally grouped into natural, human and capital resources. In agriculture, they are assets or inputs that are utilised in the production processes to realise outputs in enterprises like livestock, crops, fisheries, forestry and other agro-related fields. It is a known fact that for these resources to be optimally utilised, the management of these agricultural enterprises have to make rational allocation of same. Gabdo et al. (2020) ascertained that the combination of inappropriate scale of production and some managerial hick-ups are the main reasons for inefficiency in cattle feedlot system in Nigeria. This misuse of resources is more pronounced in rural settings, noted Salendu et al. (2019), where traditional management instead of eco-friendly system persists. This method has been widely in practice in beef cattle production systems in developing economies such as Bangladesh (Sarma et al., 2014), Timor-Leste (Bettencourt et al., 2015), Nigeria (Gona et al., 2017), Ethiopia (Mekuria, 2016; Dinku, 2019), and Indonesia (Salendu et al., 2019; Elly et al., 2019), among several others. Therefore, as the population of these nations exceedingly outgrow the protein requirements or demand of the citizenry, there should be a corresponding effort towards marching the demand, thereby necessitating a robust system of management that improves the beef production methods and by extension of the yield.

In Nigeria, agriculture was regarded as the mainstay of its economy before the discovery of oil, accounting for 24.0% of the national Gross Domestic Product (GDP), and employing nearly 70.0% of the active labour force (World Bank, 2017). Further, cattle alone contributed a total of 12.7% of the agricultural GDP in the country, providing about two-thirds of the protein obtained from the entire ruminants, and serving as capital reserve more especially in the event of food scarcity among the poor resource famers. In spite of these immense advantages and large herd sizes, the livestock sub-sector still does not meet the

*e-mail: jaafar436@adsu.edu.ng

nation's protein requirements, thereby leaving a huge deficit. Among the suggested remedies proffered, Gabdo et al. (2020) advanced the feedlot system of management as one of many. Apart from adding to the value of beef requirements, beef cattle fattening serves as source of employment, increased revenue to the participants, and providing additional foreign exchange to the nation in instances of export.

As productivity is very low in the management of livestock sub-sector in Nigeria (World Bank, 2017), and by extension of the cattle feedlot system, modernisation and boosting of same become imperative. And for these to be attainable, adequate information has to be made available. Assessment of resource efficiency, types of breeds used and the level of application in cattle feedlot system is one facet of many in the livestock sub-sector that requires investigation for the purpose of provision of meaningful policy that would improve the system. Therefore, this study becomes apt.

Material and methods

Study area

This study was conducted in Adamawa State, Nigeria, in 2018. The State is situated in the North-eastern part of the country, and lies between Latitude 7° and 11° North of the Equator and between Longitude 11° and 14° East of the Greenwich Meridian. It shares international border with the Republic of Cameroon on the eastern aspect, Taraba State in the South and West, Gombe State in the North West, and Borno State in the North (Adebayo and Tukur, 1999). The State covers a land area of 39,742.12 km^2 with a projected population of 4,633,160 based on a 2.49% growth rate used on NPC's (2006) population of 3,178,959 as baseline.

The majority of the inhabitants of the State are farmers engaging in cultivation of cereals and root crops like maize, rice, sorghum, millet, and cassava, potato and yams, respectively. However, livestock involving ruminants such as cattle, sheep and goats are raised largely on extensive methods of management. Specifically, cattle are regarded as the main source of protein for the people of the State and beyond. Therefore, cattle feedlot system is an improvement of increasing the quality and the quantity of protein intake of the inhabitants in the State.

Sampling procedure and data collection

The application of purposive, multistage and simple random sampling methods were used in sourcing the respondents, referred to as the cattle fatteners or cattle feedlot farmers in the State. As the State is being divided into four agricultural zones, a Local Government Area (LGA) was purposely selected from each zone, giving a total of four LGAs due to the intensity of fattening engagement among the farmers (stage 1). In each of the LGAs considered as stage 2, a district was equally selected purposely due to the concentration of these cattle fatteners, thereby making a total of four. This was followed by selection of three wards from each district, making a number of 12 (stage 3). From the latter, a sampling frame of 540 cattle feedlot farmers was generated thereby giving a widespread and good representation of the fatteners. A total of 50% of the feedlot farmers were therefore, randomly selected from the sampling frame (570) to generate a sample size of 270 respondents for the study.

Data analysis

Descriptive statistics and DEA method of efficiency analysis were applied in the analysis of data. Specifically, frequency distribution, mean and percentage were used to realise the aspect of type of breed fattened, duration of fattening, type of housing, labour input in terms of man/hour, and description of assets used in the fattening exercise. And the DEA was applied in realisation of the aspect of resource-use efficiency in the cattle fattening farming. According to Abatania et al. (2012), Technical efficiency (TE) can be measured, thus:

$$TE_i(X_{ki}, Y_{mi}) = \min \theta_i (\theta : X_{ki}, Y_{mi}) \quad (1)$$

$$y_{mi} \leq \Sigma^I_{i=I} Z_i Y_{mi},\ m = 1, 2, \ldots m,$$

$$\Sigma^I_{i=I} Z_i X_{ki} \leq \theta X_{ki},\ k = 1, 2, \ldots k,$$

$$Z_i \geq 0,\ i = 1, 2, \ldots i,$$

In explaining the above variables, the definition of TE is imperative. Amor and Muller (2010) stated that TE in feedlot system is said to mean, given a set of inputs and level of technology, the ability to produce maximum output, whereas inefficiency means the inability to achieve the highest possible level of output with available sets of inputs and technology. Therefore, Vu (2010) affirmed that TE is captured within the values of 0 – 1. In an instance the TE=1, means that cattle fattening efficiency is efficient. But if TE<1, it shows that cattle fattening has varying degrees of inefficiency. Therefore, with available sets of inputs and output in cattle feedlot system in the study area, TE in DEA was estimated. In the above model advanced by Abatania et al. (2012) and adopted for this research, *n* represented the sample of the feedlot farmers known as the observations that used X_1, X_2,...X_7 to produce output Y. Hence, X_n and Y_n represented input and output variables for n^{th} cattle feedlot farmers, respectively.

A unit of the cattle fatteners is termed technically efficient when θ=1. But values of θ<1 were technically considered inefficient. However, being on Constant Return to Scale (CRS) model in equation 1 above, all the cattle fattening farms were operating at optimum level of production (Mugeura and Featherstone, 2008). But as agricultural production is faced with imperfections, it became absolutely difficult for this situation to be attainable. In this regard, imposition of additional constraints to cattle fattening farms functioning under Non-Increasing Return to Scale (NIRTS) and Variable Return to Scale (VRS) were made. Thus:

VRS constraints $\Sigma^I_i = {}_1Z_I = 1$ and

NIRTS constraints $\Sigma^I_i = {}_1Z_I < 1$

In estimation of Scale Efficiency (SE), it is calculated by obtaining the ratio of two efficiencies measured above which is 0 and 1, as SE similarly falls in the range of 0-1 ($0 \leq SE \leq 1$). If the SE=1, it shows efficiency economic to scale, however, when SE<1, it indicates that the output is not scale efficient. In other words, the farm is operating under increasing or decreasing return to scale. This is obtained as:

$$SE_j = (\theta_j^{CRS} / \theta_j^{VRS}) = TE_j / EE_j \quad (2)$$

Where:

θ_j^{CRS} - Technical efficiency under CRS;

θ_j^{VRS} - Technical efficiency under VRS.

SE as reported by Vu (2010) can also decompose farms with SE into either Increasing Return to Scale (IRS) or Decreasing Return to Scale (DRS) by imposition of NIRTS to DEA by simply adding another convexity constraint ($\boxtimes^n_i = I_i \Phi 1$) to the first TE equation. Thus:

$$TE_j = \theta_j^{NIRS} = \theta_j \, CRS^{min}{}_x \, \theta_j^{CRS} + \Sigma^n_{J=i} \, I_j \quad (3)$$

Where:

$\Sigma^n_{J=i} = I_j \leq 1$, θ_j^{NIRS} = TE under non-increasing returns to scale and other variables as earlier defined

In this particular research, measurement or estimation of efficiency was made according to 7 variable inputs (X_1, X_2,... X_7) and one (1) variable output (Y) defined as:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, U)$,

Where:

Y = Output, known as fattened bulls (₦);
X_1 = Initial cost of bulls (₦);
X_2 = Cost of feeds (₦);
X_3 = Cost of labour (₦);
X_4 = Cost of equipment (₦);
X_5 = Cost of medication (₦);
X_6 = Cost of water (₦);
X_7 = Cost of salt lick (₦);
U = Error term.

Results and discussion

This section of the study presents the results and discusses the findings using tables and graphs and segment it into frequency distribution of cattle fattening units by types of breeds used, duration of fattening, types of housing applied, labour inputs, statistics of resources in fattening, and resource-use efficiency in the area.

Types of breeds, types of housing and duration of the cattle fattening

The findings of this study on the breeds of beef cattle used in fattening, the length of period engaged and the types of housing for animals are shown in Table 1. A popular local breed known as *Sokoto gudali* accounted for majority (72.6%) of the breeds used for fattening purposes in the State. This is followed by another local breed referred to as *Rahaji* (20.0%). A composition of fatteners who used others breeds formed the minority. The popularity of this particular breed in the area stemmed from the perception of farmers of its ability to resist most diseases and minor infections of cattle. However, Madziga et al. (2013) in a comparative experiment conducted on four breeds of cattle for fattening at Northwestern aspect of Nigeria reported that *Sokoto gudali* and *Rahaji* breeds had better values for feeds consumed and therefore, weight gained and return on investment over *Azawakh* and *Bunaji.* Similarly, Table 1 gives a reflection of length of period spent in fattening bulls before sale. Most of the cattle feedlot farmers (70.7%) keep bulls for a duration of 4-6 months before selling them off in the State. Those fatteners that feed their stock for a period of 1-3 months only, followed in terms of percentage, with farmers who keep the bulls for over six months. In terms of housing used for the bulls, a larger chunk (77.8%) of the fattening units was in the open with mostly fences made of thatched roofs. In other words, the animals were left in the open without shade, basing this act on the believe that fattened bulls that are exposed to sunshine tend to take lots of water, and in turn enhance digestibility of feeds thereby leading to accumulation of fats and by extension gain weight fast. Fatteners that constructed shade over their bulls using mud huts with thatched roofs were fewer, and those making use of corrugated iron sheets were in the minority.

Table 1. Distribution of cattle fattening units based on type of breed, duration of fattening and type of housing used

Parameter	Frequency	%
Type of breed of cattle fattened		
Sokoto gudali	196	72.6
Rahaji	56	20.0
Other breeds	18	6.7
Total	270	100.0
Duration of fattening		
1-3 months	64	23.7
4-6 months	191	70.7
Over 6 months	15	5.6
Total	270	100.0
Type of housing		
Corrugated iron sheets	19	7.0
Mud hut with thatched roofing	41	15.2
No shade constructed/open space	210	77.8
Total	270	100.0

Source: Computed from field data (2018)

The implication of the above result indicates that cattle feedlot system is still not appropriately modernised in the area of study. This is taking into cognizance the types of housing in which the animals were exposed to harsh weather conditions thereby limiting their performances; and the long duration of keeping animals which economically is irrational as shortening the fattening period would have increased returns on investment. All these indices are pointed toward maintaining old methods of practices within the domain. The indigenous or traditional system of cattle feedlot practices was earlier documented by Madziga et al. (2013), Worku et al. (2016) and Agus and Widi (2018) in Nigeria, Ethiopia and Indonesia, respectively.

Types of feeds used by cattle feedlot farmers

The availability of feeds in terms of quantity and quality for livestock production, noted Amole and Ayantunde (2016) and Jimma et al. (2016), has been one of the most difficult issues to contend with in the Sahelian zone of West Africa as most of the stock owners heavily rely on wild grasses and crop residues for raising their animals. A reflection of this finding is shown in Table 2. The latter revealed the distribution of cattle feedlot farmers according to types of feeds used in fattening in Adamawa State, Nigeria. Majority (74.81%) of the feedlot farmers used a combination of crop residues and conventional feeds for fattening bulls in the surveyed sites. But all the farmers (100%) made use of salt licks and/or multivitamins to provide stock with additional supplements for the fulfilment of nutrient requirements. A few of the farmers (22.96%) fed their bulls with crop residues only, while those that fed their stock with conventional feed stuffs only accounted for the minority, and therefore, absolutely negligible. Agus and Widi's (2018) report stated that in both feedlot and extensive systems of management, the utilisation of low-quality feeds, mainly from crop residues or agricultural by-products and other non-conventional feedstuffs is a common practice, because they are in abundance and inexpensive. This is a clear indication of the prominent position of feeds and feedings of fattening stock in the area.

Table 2. Distribution of cattle fattening units by type of feeds used by cattle feedlot farmers

Type of feed	Frequency	%
Conventional feeds only	6	2.22
Crop residues only	62	22.96
Crop residue/convl. feeds	202	74.81
Salt lick/multivitamins	270	100.00

Note: Multiple responses were recorded; Convl.= conventional;
Source: Computed from field data (2018).

Summary of statistics on resources used in cattle feedlot system

Six inputs used in cattle feedlot farming in the State are summarised and presented in Table 3. The foremost of the variables in terms of importance for the farmers is the initial cost of bulls for fattening (first in ranking). It could be seen from the Table 3 that a total mean cost of ₦ 68,830 only was recorded as initial price per bull for starting a cattle feedlot unit, with a maximum sum of ₦ 205,000 only and minimum of ₦ 90,000 only. This amount was considered to be on the higher side for a typical rural farmer who may want to start-up a cattle fattening enterprise. Feeds are considered the second most important resource in the business in the area. This further confirmed Smith's (2018) emphasis on availability of natural resources, and more importantly access to feedstuff, and robustness of the economy as essential factors in determining the perception of beef supply sustainability in a locality. Furthermore, water, equipment and medications accounted for the 3rd, 4th and 5th positions in terms of ranking of resource requirements for setting-up cattle feedlot units in the State. Although labour and saltlicks are equally important resources, the involvement of these variables in cattle fattening processes could be substituted. For one, members of households can heavily be relied upon as source of labour in the fattening units, and saltlicks may be forgone in the event of appropriate medications, yet attaining a desired weight gain or output.

The implication of the findings discussed above shows the relevance of initial cost of purchasing fattening stock and cost of feeds as absolutely crucial in beef cattle feedlot system in the area, and by extension the capital intensiveness, thereby limiting the population of participating farmers in the enterprise.

Table 3. Results of summary of statistics of cattle fattening units' resources

Resources	Min (₦)	Max (₦)	Mean (₦)	Ranking
Disposable price of fattened bull (Y)	90.000	205.000	169.056	
Initial price of fattening stock (X_1)	55.000	90.000	68.830	1st
Feeds (X_2)	7.500	13.900	10.559	2nd
Equipment (X_3)	3.300	4.100	3.687	4th
Labour (X_4)	1.235	1.270	1.252	6th
Medications (X_5)	2.400	5.000	3.496	5th
Water (X_6)	4.000	6.000	5.190	3rd
Salt licks (X_7)	300	550	424	7th

Note: US$1 = ₦420;
Source: Computed from field data (2018).

Labour as input in beef cattle feedlot system in the study area

The result on labour input in terms of man/hour for the operations in cattle feedlot units in the State is shown in Table 4. It could be observed that feeding of animals accounted for the largest chunk (50.0%) of labour input in the beef cattle fattening system in Adamawa State. Provision of water to animals and cleaning of housing trailed with 25.0% and 20.0%, respectively. Of course, medication/healthcare, as expected, recorded the least. The fact remains that this service occurs when the need arises, and it may be even once in the entire period of the exercise. However, family labour which is perceived by the individual farmers as service without cost, accounted for 90.1% of the whole total input in the exercise, with only 9.9% provided by hired labour.

What this finding implied is that labour as crucial input as it is in the cattle feedlot system in the State is majorly supplied by members of farming households. This is also an indication of how low the level of sophistication of management applied in achieving output. In other words, using cheap labour is a coping strategy to minimise cost of production in order to maximise outputs.

Table 4. Labour inputs for the fattening period of 150 days (man/hour per animal)

Operation	Family labour	Non-family labour	Total	%
Feeding of animals	600	27.6	627.6	50.0
Watering	300	13.8	313.8	25.0
Cleaning of housing	228	23.1	251.1	20.0
Medication/Healthcare	2.55	60.3	62.85	5.0
Total	1130.55 (90.1%)	124.8 (9.9%)	1255.35 (100.0%)	100.0

Note: Values in parentheses are percentage of total;
Source: Computed from field data (2018).

Level of resources utilisation in beef cattle feedlot system

The findings in Table 5 show summary of the level of resource utilisation in beef cattle feedlot units in the area studied. The results are in the range of minimum, maximum and mean TE frequency score with regard to CRS, NIRTS, VRS, SE and RST models of the DEA. However, the patterns or trends of efficiency indicators among beef cattle feedlot units in the study area are further explained in Figures 1-5 accordingly.

Table 5. Summary of level of resource utilisation in beef cattle feedlot units

Level of TE	CRS, Frequency	NIRTS, Frequency	VRS, Frequency	SE, Frequency	RTS, Frequency
Minimum	0.6755	0.6755	0.6755	0.6755	1.0000
Maximum	1.0000	1.0000	1.0000	1.0000	1.0000
Mean	0.8444	0.8444	0.9148	0.8474	1.0000

Note: TE-Technical Efficiency, CRS- Constant Return to Scale, NIRTS- Non-Increasing Return to Scale, VRS- Variable Return to Scale, SE- Scale Efficiency, RTS- Return to Scale;
Source: Computed from field data (2018).

Patterns of resource utilisation in beef cattle feedlot system in the State

Figure 1 shows patterns of resource utilisation distribution of TE score among the cattle feedlot units in the State under the CRS. Given a mean efficiency score of 0.8444 under this model revealed that on average, the fattening units were 84.44% efficient, meaning that a total of 228 of the 270 cattle feedlot units were performing efficiently. The implication of this finding is that, resources are optimally used in beef cattle fattening units in the area of study, and by extension.

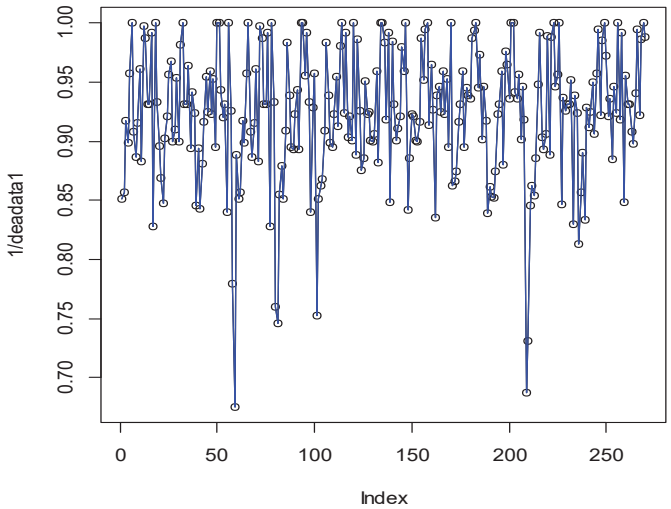

Figure 1. Trend of efficiency indicators among cattle feedlot units by Constant Return to Scale (CRS) in the State (mean = 0.8444)
Source: Computed from field data (2018)

Similarly, Figure 2 indicates the trend of distribution of cattle fattening units in Adamawa State, Nigeria, under NIRTS. The TE mean score of 0.8444 showed that the cattle fatteners were operating on 84.44% efficiency, implying that, of the 270 cattle fattening farms surveyed, 228 units were operating efficiently. The result under this model also suggested profitability of the cattle fattening business in the State. However, resource utilisation was equally efficient under the CRS model and the NIRTS model.

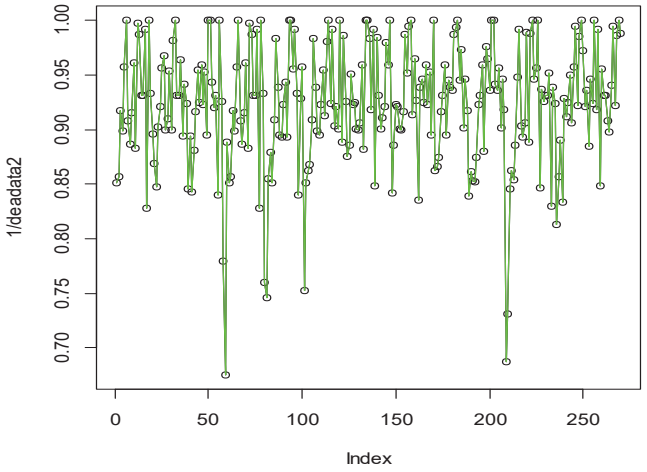

Figure 2. Trend of efficiency indicators among cattle feedlot units by Non-Increasing Return to Scale (NIRTS) in the State (mean = 0.8444)
Source: Computed from field data (2018)

Figure 3 reveals the trend of distribution of cattle feedlot units under the VRS model in Adamawa State, Nigeria. With this model, the mean score of TE was 0.9148, meaning that on average, the cattle feedlot units were 91.48% efficiently utilising the production resources. In other words, a total of 247 cattle feedlot units utilised inputs appropriately out of the 270 fattening units studied.

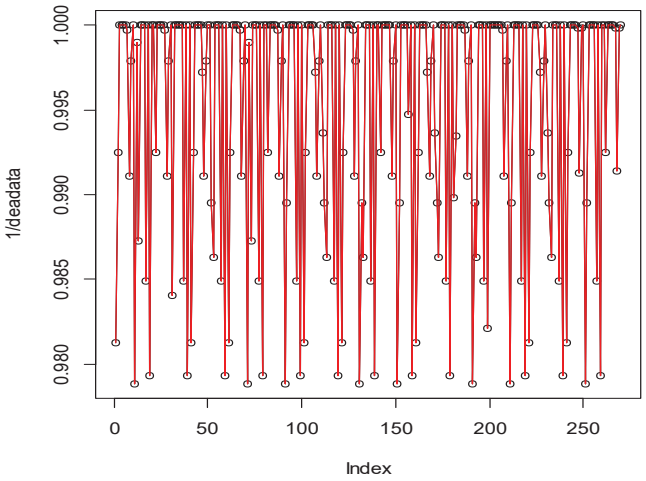

Figure 3. Trend of efficiency indicators among cattle feedlot units by Variable Return to Scale (VRS) in the state (mean = 0.9148)
Source: Computed from field data (2018)

The result in Figure 4 shows trend of distribution of efficiency indicators of cattle fattening units under SE model in the State. A mean score of TE of 0.8474 was obtained under the SE model for the cattle feedlot units in the State. This showed that a total of 84.74% of the entire cattle feedlot units studied were operating efficiently. In other words, about 229 out of 270 cattle fattening units were utilising inputs efficiently.

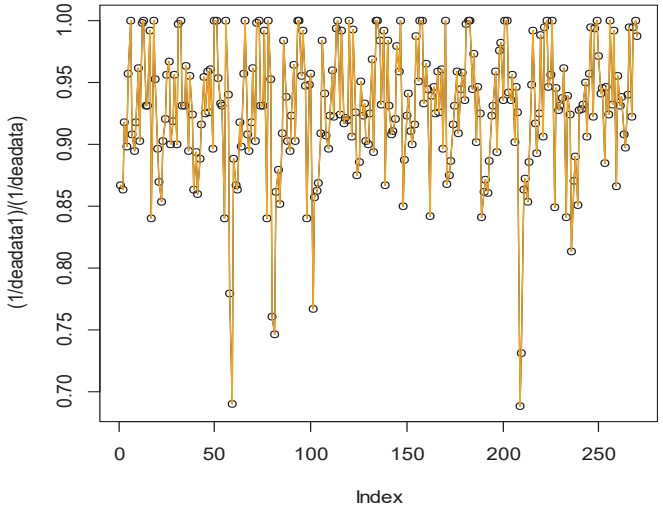

Figure. 4. Trend of efficiency indicators among cattle feedlot units by Scale Efficiency (SE) in the State (mean = 0.8474)
Source: Computed from field data (2018)

The finding in Figure 5 indicates the distribution of efficiency indicators for beef cattle feedlot units by RST model in the State. An absolute value (1.0000) was recorded for the model. What this result implies is that, ceteris paribus, the entire cattle fattening units in the State were operating efficiently. In other words, there was efficient resource utilisation in the cattle fattening units in the State, and by extension the enterprise is profitable.

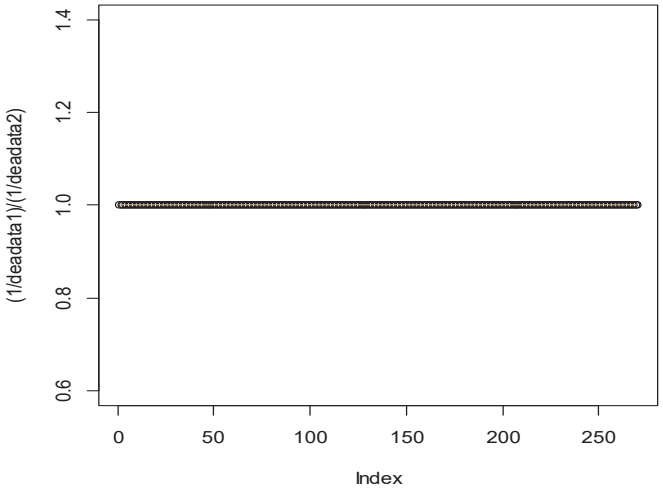

Figure 5. Trend of efficiency indicators among cattle feedlot units by Return to Scale (RTS) in the State (mean = 1.0000)
Source: Computed from field data (2018)

Conclusion

Conclusively from the findings of the study, it could be stated that indigenous breeds of *Sokoto gudali* and *Rahaji* were the main bulls used for fattening in Adamawa State, Nigeria, and a mixture of crop residues and conventional feeds was the popular plane of feeding stock, with most farms utilising resources efficiently. However, there was still avenue for improvement. Stemming from these findings, soft credit facilities to accord fatteners leverage of initial off-setting the cost of bulls and frequent extension services to same, for modernisation of beef cattle feedlot system in the domain are highly recommended .

Acknowledgment

The authors wish to sincerely thank all the enumerators who participated in the timely collection of data, and the entire beef cattle feedlot farmers for their patience and cooperation during the period of this research in the State. Also, Dr. Bashir H. Gabdo of the Department of Agricultural Economics and Extension, Adamawa State University, PMB 25, Mubi, Nigeria, deserved mention for assisting in making the data analysis.

References

Adebayo and Tukur AL, 1999. Adamawa in Maps, First Edition, Paraclete Publishers, Yola, Nigeria.

Abatania LN, Hailu A and Mugera AW, 2012. Analysis of farm household technical efficiency in northern Ghana using bootstrap DEA. A Paper Presented at the 56th Annual Conference of the Australian Agricultural and Research Economics Society, Fremantle WA, 7th-10th February.

Agus A and Widi TSM, 2018. Current situation and future

prospects for beef cattle production in Indonesia - A review. Asian-Australian Journal of Animal Sciences, 31, 976-983. https://doi.org/10.5713/ajas.18.0233

Amole TA and Ayantunde AA, 2016. Assessment of existing and potential feed resources for improving livestock productivity in Niger. International Journal of Agricultural Research, 11, 40-55. doi: 10.3923/ijar.2016.40.55

Amor TB and Muller C, 2010. Application of stochastic production frontier in the estimation of technical efficiency in irrigated agriculture in Tunisia. Agricultural Journal, 5, 50-56. http://dx.doi.org/10.3923/aj.2010.50.56

Bettencourt EMV, Tilman M, Narciso V, Carvalho MLDS and Henriques PDDS, 2015.The livestock roles in the wellbeing of rural communities of Timor-Leste. Revista de Economia e Sociologia Rural, 53, S063-S080. https://doi.org/10.1590/1234-56781806-94790053s01005

Dinku A, 2019. Assessment of constraints and opportunities in small-scale beef cattle fattening business: Evidence from the West Hararghe Zone of Ethiopia. International Journal of Veterinary Science and Research, 5, 058-068. https://dx.doi.org/10.17352/ijvsr

Elly FH, Lomboan A, Kaunang CL, Rudengan M, Poil Z and Syarifuddin S, 2019. Development potential of integrated farming system (Local Cattle - Food Crop). Journal of Animal Production, 21, 143-147.

Gabdo BH, Ja'afar-Furo MR, Hamid MY and Thlaffa YA, 2020. Estimation of technical efficiency of cattle feedlot system in Adamawa State, Nigeria: Comparison among estimators. Agricultural Science and Technology, 12, 24-30. doi: 10.15547/ast.2020.01.005

Gona A, Mohammed I and Baba KM, 2017. Evaluation of profitability among cattle fattening enterprises in Kebbi State, Nigeria. In: Proceedings of the 11th Annual National Conference of the Nigerian Association of Agricultural Economists, Held at Federal University of Agriculture, Abeokuta, Nigeria. 16th-19th October, 2017.

Jimma A, Tessema F, Gemiyo D and Bassa Z, 2016. Assessment of available feed resources, feed management and utilization systems in SNNPRS of Ethiopia. Journal of Fisheries and Livestock Production, 4,183-192. doi: 10.4172/2332-2608.1000183

Madziga II, Alawa CBI, Lamidi OS, Goska DY and Adesote AA, 2013. Feedlot assessment of four indigenous breeds of cattle in Nigeria. International Journal of Life Science and Medical Research, 3, 35-38. doi: 10.5963/LSMR0301006

Mekuria SA, 2016. Cattle fattening, constraints and marketing system in North Western Ethiopia. World's Veterinary Journal, 6, 59-65.

Mugeura AW and Featherstone AM, 2008. Backyard hog production efficiency. Asian Economic Journal, 22, 267-287. http://dx.doi.org/ 10.1111/j.1467-8381.2008.00278.x

Salendu AHS, Lumenta IDR, Elly FH, Leke JR, Syarifuddin S and Polakitan D, 2019. Development strategy of beef cattle based on environment and potential resources. Journal of Animal Production, 21, 136-142.

Sarma PK, Raha SK and Jorjensen H, 2014. An economic analysis of beef cattle fattening in selected areas of Pabna and Sirajgonj Districts. Journal of Bangladesh Agricultural University, 12, 127-134.

Smith SB, Gotoh T and Greenwood PL, 2018. Current situation and future prospects for global beef production: overview of special issue. Asian-Australasian Journal of Animal Science, 31, 927-932. https://doi.org/10.5713/ajas.18.0405

Vu LH, 2010. Efficiency of rice farming households in Vietnam: A DEA with Bootstrap and Stochastic Frontier Application. University of Minnesota, USA, pp. 1-34.

Worku Z, Tilahun S, Tolemariam T and Jimma W, 2016. Assessment of the prevailing cattle fattening practices in Jimma Zone, South-Western Ethiopia. Global Veterinaria, 17, 105-113. DOI: 10.5829/idosi.gv.2016.17.02.10391

World Bank, 2017. Project Information Document/ Integrated Safeguards Data Sheet (PID/ISDS). Report No: PIDISDSC20544 - Updated: 17 July 2017.