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Trend Analysis of Cattle Production in the United States, 1997 – 2019

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Abstract Since the mid-1990s, cattle production in the United States has taken a downward trend. Although the U.S. is still the biggest producer of cattle in the world, the implications of such trend on domestic and global food security cannot be ignored. This study examines this trend of cattle production in detail within the period 1997-2019, with the sole purpose of determining the factors responsible for this trend and what should be done to reverse same. The study takes a look at various variables over the time-frame which could be said to represent the factors of production – land, labor, capital and entrepreneurship and establish the relationship between them. It also includes a novel variable to the mix – degree change in temperature during the year to accommodate for the effects of global warming as an environmental factor. A simple regression model is then estimated to capture the factors that might have contributed to the variation in total cattle produced in the U.S. Findings reveal that land use, employees in agriculture and credit advances to cattle farmers are all low in the U.S., contributing to the plummeting output of cattle production. The analysis does point out that making more land and employees available will increase the production of cattle in the United States. However, higher credit flows might not guarantee improved cattle production. The study, therefore, concludes that the U.S. authorities should consider increased land use and labor supply for agricultural purposes as the means of consolidating the gains of large-scale cattle production in the U.S. The study does not consider other variables which include a shift in consumer taste or the availability or lack of water due to drought on the farm. This is a limitation of the study and makes for areas of further research. These findings will be of immense benefit to policy makers, legislators, farmers and even land use planners to be able to put in action plans that will help enhance food security especially regarding beef production, thereby ensuring the United States' place as the premier cattle producer in the world.

Keywords Cattle Production, Trend Analysis, Food Security, United States

1. Introduction

In 2020, the United States accounted for about 20% of total beef output in the world, producing 12.4m metric tons [1]. Ahead of Brazil (10.1m metric tons), the EU (6.9m metric tons) and China (6.7m metric tons), this projected the United States as the largest producer of beef worldwide. Expectedly, the production of cattle in the U.S. is high enough to meet the increasing demand in the general population [1]. Given the importance of the U.S. in beef availability globally, Broom [2] noted that a shortfall in cattle production in the U.S. could generate global consequences on food security.

However, evidence from extensive studies such as [2], [3] and [4] pointed out that the interest of Americans in cattle production has been plummeting since the 1990s. In particular, land availability for agricultural purposes has been on a downward trend [2]. In addition, not only are fewer workers finding cattle rearing attractive [4], credit facilities hardly flow to the agricultural industry in the U.S. [3].

This study looks at the trend of cattle production in the United States between 1997 and 2019. This study is important because,1. the United States is the world's highest producer of cattle, and 2. the figures have been declining over the last twenty-five years. As recent events in Ukraine and Russia have shown us, external disruptions have large reverberating impacts on the supply of commodities across the world and could trigger scarcity, inflation, and even a recession. The study used variables that represented the factors of production - land, labor, entrepreneurship, and capital. Temperature change, to represent the effects of global warming was also thrown in the mix. It reveals that land use and labor have direct impacts on cattle production and the study concludes that land-use planners need to make more agricultural land available for cattle production, while significant investments into manpower to increase their quantity and competency should be encouraged.

This research contributes to existing knowledge by identifying those critical areas needing intervention to ensure that the United States continues to be the world's largest cattle producer, a position being threatened by decreasing cattle production numbers over the last quarter of a century. This will help prevent inflation and possible food insecurity.

This study is therefore aimed at examining the stylized facts on the trend of cattle production in the United States from 1997 to 2019 as well as various factors (land use, agricultural employees, and agricultural credit facilities) which might have affected the cattle production processes. The study also assesses other intervening variables such as the size of the population, temperature change, and sectoral contribution of agriculture to the GDP.

Following this introduction, the paper reviews the relevant literature on the impact of land use, employees in agriculture, and credit advances on cattle production. This is followed by data issues and model specifications. Empirical results are then presented and discussed. Finally, the study concludes, noting the practical implications of the findings.

2. Review of Literature

Land Use and Cattle Production

Peters et al. [5] measure land use as the land required for producing the crop ingredients needed to supply aggregate feed intake per unit energy and per unit protein. They compare the land-use efficiency across seven livestock products in the U.S. Their results reveal that cattle production (beef and dairy) is by far the largest land user, compared to other livestock production such as poultry and swine. This suggests variations in the land use requirements to produce different livestock products. Similar findings have been reported by Wirsenius et al. [6] who focus on continental cattle production in North America.

On the trend of land allocation for agricultural activities, Spangler et al. [7] analyze data on agricultural land use in the U.S. between 1945 and 2012. They bring into the limelight that there is a modest decrease in the share of national land use in agriculture from 23.7% in 1945 to 20.7% in 2012. At disaggregated levels, land use in urban areas increases by 0.8% of the national share in the same period. It follows that urban populations are gradually claiming the land previously meant for agricultural production. The data also discloses that production of grassland, pasture, and range decreases by 0.03%, implying less feed supply for cattle production. This analysis agrees with Ramankutty et al. [8] who report that agricultural land use is declining nationally, though expanding globally.

Earlier, Benayas et al. [9] examine the degree of land abandonment for animal agriculture worldwide. Their findings argue that agricultural land has been decreasing since the 1970s. They also describe leading effects of decreasing land use for animal production including loss of biodiversity, increasing intensity or frequency of wildfire, and decreases in cultural or aesthetic values.

Although researchers share the submission that agricultural land use is on a downward trend in advanced countries, there is a mixed conclusion on the effect that this development generates the agriculture sector. For example, Pellegrini and Fernández [10] maintain that agricultural production in the U.S. has benefited hugely from mechanization and industrialization processes that lead to less land available for agriculture. The industrial sector supplies state-of-the-art technology and materials to accelerate agricultural production. While this submission is not out of order, MacDonald and Hoppe [11] warn that competition for declining land amongst farmers constitutes a drag on the production of crops and livestock.

The most contributing factor to decreasing land use for agricultural purposes in the US is the increasing urban sprawl. According to the USDA Forest Service [1], development in the U.S. (urban and other forms) would expectedly increase to 77% between 2010 and 2060. Intuitively, more land for urban activities (housing, industry, recreation, etc) implies fewer farmlands and pasturelands for crop and animal production. For example, Phoenix, AZ metropolitan area was predominantly agricultural for centuries. The city has however experienced exponential growth in urban cover with an accompanying decrease in agricultural lands for cotton, citrus crops, alfalfa, and grain fields [12]. As a result of this, urban development has negatively affected sources of feed meant primarily for beef and dairy cattle [13].

Broom [2] estimates the land required to produce one-tonne beef cattle under five production systems. He focuses on the required land to produce feed, land occupied by animals, and land to process meat. His findings show that 27 ha is required for extensive un-modified pasture, 20.7 ha for feedlots with pre-feedlot extensive conditions,

8.9 ha for feedlots with pre-feedlot irrigated pasture conditions, 10.0 ha for fertilized irrigated pasture, and 2.2 ha for semi-intensive silvopastoral systems. Nguyen et al. [14] investigate a similar subject matter in the EU. However, they contrast land required for two breeding systems: suckler beef and dairy bull. Their findings also explain the differential in land requirements (the former requires 43 ha per tonne while the latter requires 17 ha per tonne).

Employees in Agriculture and Cattle Production

Ramsey et al. [15] obtain standardized performance analysis (SPA) data for cow-herd in Texas, Oklahoma, and New Mexico. Having organized the SPA data into financial and productive sets, they perform a generalized least squares regression analysis to determine the factors responsible for beef cow-herd production, cost, and profits. They find in part that variables leading to increasing costs, output, and profits are associated with the management decisions of the farm managers. In particular, effective management of farm materials and employees reduces production losses and this can help bolster output, minimize costs and boost profits. This research output is similar to those earlier reported by Dunn [16] and Miller et al. [17].

On the labor requirements to produce cattle, Asem-Hiablie et al. [4] characterize the regional beef production practices in Eastern United States. Data were collected from 817 farms and ranches, representing 1.2% and 1% of beef cows in the Northeast and Southeast, respectively. The results are revealing that average labor requirements per annum per animal fed are considerably different. In the Northeast, the mean annual labor requirements were 12.9 person-h/animal compared to 57 person-h/animal in the Southeast. It is interesting that the feedlot operations with the greatest labor requirements (as high as 130 person-h/animal) finish at or below their capacity whereas those operations reporting the least labor requirements (as low as 2.6 person-h/animal) operate above capacity. It, therefore, follows that labor requirements are not as important as they are put into efficient use. The general tone of these findings does not vary widely from those reported by the same authors in 2017 for the western United States.

Working with the purpose of producing animals such as cattle can be daunting or rewarding depending on how the challenges are addressed by the farm managers. This is because the workers' satisfaction is the main driver of their productivity. Viljoen and Wiskerke [18] assert that the interest of workers in the beef-production enterprises should be well taken care of so that they deliver with optimum capacity.

In their inquiry into the productivity of cattle by workers on semi-intensive silvopastoral farms in Colombia and Mexico, Calle et al. [19] argue that with good welfare packages for the farm labor, workers declare their love for their job and claim they prefer to stay in their jobs to working with conventional farms. This goes to show that the effectiveness of employees at producing cattle is hinged primarily on how the workers' satisfaction is maintained.

However, with regard to the findings of Latruffe [20] and Hume et al. [21], education of agricultural employees is more important than their satisfaction towards boosting productivity. In their disparate studies, they declare a positive relationship between education and the technical efficiency of farm labor. This is telling that the high-level education of farm employees promises to develop cattle production.

Using a stochastic profit frontier model, Bahta and Baker [22] analyze the determinants of productivity and profit efficiency of smallholder beef production in Botswana. They present major drivers of productivity and profitability to include on-farm and off-farm employment of agricultural labor. According to them, the farm is unlikely to generate optimal sales and profits in beef cattle production if it does not employ off-farm markers to clear market and credit bottlenecks that can hamper productivity. This finding echoes the main conclusions of other studies such as Alemayehu [23].

In another perspective, Utami et al. [24] evaluate the determinants of productivity of smallholder cattle farming in Indonesia. They employ multiple-regression model to test many factors that may shape the income and productivity of cattle farmers. Experience and earnings of farm labor are reported as significant factors that can cause a variation in how much cattle are produced and how much the cattle farmers earn. This shows that number of years spent working by farm employees matters in influencing cattle production.

In a recent study, Kibona and Yuejie [25] proclaim that age of farm employees has a significant effect on the number of cattle produced. They state that the age of cattle farmers has a positive relationship with farm productivity and is significant at 5%. Naturally, farmer's age is closely connected to decision making. Older famers are bound to have accumulated necessary experience and expertise in beef cattle production. This would make them afford to implement good strategies towards boosting production. These results agree to previous findings such as Randela et al. [26].

Credit Advances and Cattle Production

Hoppe et al. [11] note that 91% of U.S. farms are small. That is, these farms have a gross cash farm income of less than $250,000. They compare the finances and operations of small farms and large farms. Their results show that small farms that depend solely on on-farm incomes lag behind on access to large finances and production compared to big-scale farms that have access to off-farm sources of income. Thus small farms in the U.S. are characterized by financial losses and unprofitable

operations.

Similarly, Khanal and Omobitan [3] conduct primary survey on the impact of credit constraints on the financial performance of small farms versus large farms in Tennessee, United States. They also analyze factors determining financial constraints such as farm operators' gender, off-farm work, land acreage holdings, farm specialization, and the use of smartphone to access credit. Their findings indicate that financial performance (gross farm sales) of credit-deficit small farmers is significantly lower than that of unconstrained small farmers. The difference in sales of the two groups of farmers is between $32,000 and $39,000. It follows that farmers of beef cattle with limited access to credit facilities are bound to produce significantly lower cattle than their counterparts with easy access to credit advances. The main cause of this result is that credit constraint implies that the farmer cannot venture into new profitable areas of agriculture business, cannot purchase necessary inputs and cannot effectively manage risks [27].

Outside the United States, Mahendri [28] examines the famers' demand for credit, the supply of credit (from formal lending institutions) and the institutional environment in which this credit arrangement takes place. He uses cattle sector of Indonesia as the case study. His results identify that access to credit finances plays an important role in cattle fattening, particularly with regard to purchase of feeder cattle, feed and infrastructure. The research then reports high demand for bank loans amongst farmers with cattle fattening practices. In addition, his analysis demonstrates that although supply of credit to cattle farmers is robust, information gaps constitute the major constraint for easy flow of credit in the cattle breeding sector.

In addition, Swinnen and Gow [29] analyze the impact of information constraints on financing central and eastern European agriculture. They are concerned about why credit markets work imperfectly, even in well-developed agricultural markets in Europe. Their conclusions point out that credit rationing from lenders and moral hazards from borrowers constitute huge transaction and information costs, making agricultural credit unattractive to farmers.

On the likelihood of obtaining agricultural credit, Carranzaand and Niles [30] claim that the gender of the head of the farm matters. They explore the relationships between access to different types of agricultural finances among male and female-headed farms and the role of gender on the spending decisions of the obtained financial resources. They find that there is not much difference in the propensity to borrow among male and female-headed farms. However, access to financial resources has a high chance of success if the head of the farm is male compared to the female head. This tells that credit providers do not share a judgment that female heads of farms would efficiently use the credit advances for agricultural purposes, but male heads of farms can put the resources into purposes that deliver optimal outcomes. Similar findings have been reported by Perez et al. [31] and Croppenstedt et al. [32].

3. Materials and Methods

This study includes seven variables on the U.S. economy. These variables are the number of cattle produced, agricultural land use, credit facilities for agricultural purposes, population, employees in agriculture, temperature change, and agriculture share in the GDP. Data on these variables for the period 1997–2019 are sourced from the National Agricultural Statistics Services of the U.S. Department of Agriculture and the Food and Agricultural Organization of the United Nations. Descriptive statistics of the data are first obtained. This is followed by a discussion of correlation coefficients among the variables. A simple regression model is also estimated using the method of ordinary least squares. The model is specified as follows:

$$Y_t = \beta + \sum_{i=1}^{3} \alpha_i X_{it} + \varepsilon_t$$

Where Y is the number of cattle (the dependent variable), X_1, X_2, and X_3 are all independent variables. The regressors in this model are these three variables for two reasons. First, the literature favors them as the primary drivers of cattle production. Second, including the rest of the variables in the model turns all estimates to be statistically insignificant. β and ε are constant and error terms, respectively. Finally, α's are parameters.

4. Results

Descriptive statistics

As Table 1 contains, of the total credit available in the U.S. economy, about 1% moves towards the agriculture sector. In fact, the highest agricultural share in the total credit facilities since 1997 is 1.52% while the lowest has been 0.77%. Given that the highest share was recorded in 1997 and the lowest in 2019, it follows that credit flows to the agriculture sector have been plunging for a long time. Similar trajectories are true of labor in the agricultural industry relative to total employees in the U.S. Total agricultural employees, on average, are simply 1% of total labor supply in the U.S. Both standard deviations of shares of credit supply and labor supply are low to imply low volatilities of these variables. The contribution of agricultural activities to the GDP of the U.S. also averages 1.1% for the 23-year period covered in this study. Given that this sectoral share in total economic activity – which is the highest in the world – has been low for a long time, the U.S. economy can be said to be less reliant on agricultural production. In part, this can explain the low shares of the credit and labor supply to the sector.

Furthermore, as Table 1 indicates, the mean number of cattle in the U.S. in the period 1997-2019 is about 95 million. Given low standard deviation and the proximity of maximum and minimum values, this mean value is less prone to volatilities. This trajectory of cattle production is similar to that of agricultural land use whose average value is close to 410million ha during the sample period. The U.S. population has been relatively stable in the recent past. This suggests that although the U.S. is the third most populous country in the world, its population growth rate has been constantly low. However, the measure of temperature seems to be characterized by high fluctuations.

Table 1. Descriptive statistics of variables

	Mean	Standard Deviation	Maximum	Minimum
Number of Cattle	94,925,152	3,318,421	101,655,700	88,526,000
Agric Land Use (‘000 ha)	409,593	4336.17	414,944	403,081
Credit to agric, forestry and fishery as a % share of total credit	1.022	0.200736	1.519	0.768
U.S. Population (‘000)	301,370	17,144.25	327,096	271,714
Employees in agric as a % of total employees	1.029	0.255641	1.5899	0.8184
Temperature change in °C during the meteorological year	0.9686	0.454194	2.229	0.215
Agriculture, forestry, and fishing, value added (% of GDP)	1.099	0.125499	1.336	0.9169

Source: Authors’ computations

Correlation coefficients

Table 2. Correlation coefficients among the variables

	Number of Cattle	Agric Land Use	Credit to Agriculture	U.S. Population	Number of Employees	Temperature change	Agric share in GDP
Number of Cattle	1						
Agriculture Land Use	0.878**	1					
Credit to Agriculture	0.668**	0.661	1				
U.S. Population	-0.863 **	0.914 **	-0.840**	1			-
Number of employees	0.635 **	0.438	0.892**	-0.646**	1		
Temperature Change	-0.239	-0.234 **	-0.200	0.330	-0.330	1	
Agric share in GDP	0.128	0.217	0.557 **	-0.438*	0.340	-0.422*	1

** indicates that the coefficient is significant at 1%

* indicates that the coefficient is significant at 5%

Source: Authors’ computations

5. Discussion

Summarized in Table 2 are correlation coefficients among the variables. The highest positive (0.914) correlation is between agricultural land use and the U.S. population. This implies that as the population of the U.S. increases, the craving for agricultural land increases as well. This suggests that more Americans are interested in farming, forestry, fishing and the rest of agricultural activities. The lowest positive correlation (0.128) occurs between number of cattle and agric GDP. Of course, this solidifies the argument that as the U.S. economy relies little on agricultural output, cattle production also accounts for little in the agricultural share of the GDP. It is also noteworthy that the number of cattle is positively correlated with agricultural credit (0.668) and agricultural employees (0.635). This lends credibility to the assertion that cattle production in the U.S. would expand if there are more supplies of credit and labor in the U.S agric sector.

However, it is catchy that there is a negative relationship between the number of cattle and the U.S. population (-0.863). This explains the degree of attraction to cattle production among Americans. Given a high, positive association between agricultural land use and the U.S. population, it appears that the interest of Americans in agricultural activities is simply not majorly in cattle production. That is, as the population increases, fewer U.S. residents are interested in producing cattle. Credit to agriculture and the U.S. population also move in the opposite direction (-0.84), suggesting that number of people living in the U.S. increases causing credit facilities to move away from the agric sector.

Cattle production seems to consider unfavourable temperature change as a drag, as the correlation coefficient between it (temperature) and all other variables are negative except the U.S. population (0.33). Coincidentally, the correlation between temperature and employees in agriculture is -0.33. It follows that this negative relationship is a result of low interest of American employees to work in the agricultural industry.

6. Regression Results

The estimation results are summarized as follows:

$$\begin{array}{lccc} number\ of\ cattle = & (709)\,agric\ land\ use + & (10336162)\,agric\ employees - & (10154786)\,agric\ credit \\ & \{8.295\} & \{4.103\} & \{-2.796\} \\ & [0.00] & [0.00] & [0.01] \end{array}$$

Where figures in ( ) are coefficient estimates, figures in { } are t-statistics and figures in [ ] are probability values. The regression results show that an increase in agricultural land use by 1,000 ha increases the cattle produced by 709. Although the effect is less than one-to-one, more allocation of land for agricultural purpose would expand cattle produced. Furthermore, if employees available in the agricultural sector increase by 1%, the output of cattle produced increases by about 10.3 million. Apparently, more labor supply for cattle production would bolster the output. However, the coefficient of the agricultural credit is puzzling. If agricultural credit receives a boost of 1%, number of cattle produced would reduce by close to 10.2 million. While explanation for this effect is less straightforward, it is worthy of noting that cattle production is less attractive to U.S. production. This suggests that making credit more available for cattle production might make managers divert the funds towards other uses. The t-statistics (all being above 2 in absolute terms) and p-values (all being less than 0.05) imply that the coefficients are all statistically significant at 5%.

7. Conclusions

This study examines the trend of the number of cattle produced in the United States. It also assesses the relationship of cattle production with agricultural land use, employees in agriculture, credit advances, population, temperature change, and agricultural share in the GDP. It is noteworthy that agricultural credit advances, agricultural labor supply, and agricultural production have each been roughly 1% of their respective aggregate value in the U.S. national economy. This demonstrates that the U.S. relies very marginally on the agricultural industry. The correlation coefficients between the number of cattle produced and each of land use and employees are notably high, but low for agric share in national output. The study however does not look at the impact of availability of water as well as shifting consumer tastes in favor of other types of meat (pork, chicken, goat, sheep, etc) in the production of cattle. Although the estimated regression coefficients are all statistically significant, land use and agricultural employees confer more explanatory power on cattle production. It, therefore, follows that the U.S. authorities should recognize land use and labor supply as primary determinants of cattle production and availability in the U.S. In essence, they should extend more land to cattle farmers and make cattle farming more attractive to Americans, so that the U.S. consolidates its stance as a key producer of beef in the world.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

REFERENCES

[1] USDA Forest Service (2012) "Future of America's forest and rangelands: Forest Service 2010 resources planning act assessment," General Technical Report, WO-87, Washington, DC

[2] Broom, D. M. (2021) "A Method for Assessing Sustainability with Beef Production as an Example," *Biological Reviews,* 96(5), 1836–1853

[3] Khanal, A. R., & Omobitan, O. (2020)"Rural Finance, Capital Constrained Small Farms, and Financial Performance: Findings from a Primary Survey," *Journal of Agricultural and Applied Economics,* 52(2), 288–307

[4] Asem-Hiablie, S., Rotz, C. A., Stout, R., and Place, S. (2018) "Management characteristics of beef cattle production in the eastern United States," *The Professional Animal Scientist,* 34(4), 311–325

[5] Peters, C. J., Picardy, J. A., Darrouzet-Nardi, A. and Griffin, T. S. (2014) "Feed conversions, ration compositions, and land use efficiencies of major livestock products in U.S. agricultural systems," *Agricultural Systems*, 130, 35–43

[6] Wirsenius, S., Azar, C. and Berndes, G. (2010) "How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030?"*Agricultural Systems*, vol. 103, issue 9, 621-638

[7] Spangler, K., Burchfield, E.K. and Schumacher, B. (2020) "Past and Current Dynamics of U.S. Agricultural Land Use and Policy," *Frontiers of Sustainable Food Systems*, 4:98

[8] Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., et al. (2018) "Trends in global agricultural land use: implications for environmental health and food security," *Annual Review of Plant Biology*, 69, 789–815

[9] Benayas, J. M., Martins, R, A., Nicolau, J. M. and Schulz, J. J. (2007) "Abandonment of agricultural land: An overview of drivers and consequences" in CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 2. No. 057

[10] Pellegrini, P., and Fernández, R. J. (2018) "Crop intensification, land use, and on- farm energy use efficiency during the world widespread of the green revolution," *Proceedings of the National Academy of Sciences of the United States of America*, 115:2335–2340

[11] Hoppe, R. A., MacDonald, J.M. and Korb, P. (2010) "Small Farms in the United States: Persistence under Pressure," EIB-63, U.S. Department of Agriculture, Economic Research Service

[12] Berardy, A. and Chester, M. V. (2017) "Climate change vulnerability in the food, energy, and water nexus: concerns for agricultural production in Arizona and its urban export supply," *Environmental Research Letters,* 12(3), 035004

[13] Tolleson, D. and Meiman, P. (2015) "Global effects of changing land-use on animal agriculture," *Animal Frontiers*, vol. 5, No. 4

[14] Nguyen, T. L. T., Hermansen, J. E. and Mogensen, L. (2010) "Environmental consequences of different beef production systems in the EU," *Journal of Cleaner Production*, 18, 756–766

[15] Ramsey, R., Doye, D., Ward, C., McGrann, J., Falconer, L. and Bevers, S. (2005) "Factors Affecting Beef Cow-Herd Costs, Production, and Profits," *Journal of Agricultural and Applied Economics,* 37(01), 91–99

[16] Dunn, B.H. (2000) "Characterization and Analysis of the Beef Cow-Calf Enterprise of the Northern Great Plains Using Standardized Performance Analysis," Ph.D. Thesis, South Dakota State University

[17] Miller, A.J., Faulkner, D.B., Knipe, R.K., Strohbehn, D.R., Parrett, D.F. and Berger, L.L. (2001) "Critical Control Points for Profitability in the Cow-Calf Enterprise," *The Professional Animal Scientist*, 17:295-302

[18] Viljoen, A. and Wiskerke, J.S.C. (2012) *Sustainable Food*

Planning: Evolving Theory and Practice. Wageningen: Wageningen Academic Publishers

[19] Calle, A., Montagnini, F. and Zuluaga, A. F. (2009) "Farmers' Perceptions of Silvopastoral System Production in Quindio, Colombia," *Bois et Forets des Tropiques* 300, 79 –94

[20] Latruffe, L. (2010) "Competitiveness, Productivity and Efficiency in the Agricultural and Agri-Food Sectors," O*ECD Food, Agriculture and Fisheries Papers* 30, OECD Publishing

[21] Hume, D. A., Whitelaw, C. B. A. and Archibald, A. L. (2011) "The future of animal production: Improving productivity and sustainability," *Journal of Agricultural Science*

[22] Bahta, S. and Baker, D. (2015) "Determinants of Profit Efficiency among Smallholder Beef Producers in Botswana," *International Food and Agribusiness Management Review*, Volume 18 Issue 3

[23] Alemayehu, K. (2011) "Value chain assessment of beef cattle production and marketing in Ethiopia: Challenges and opportunities of linking smallholder farmers to the markets," *Livestock Research for Rural Development***,** 23 (12)

[24] Utami, H. D., Yakin, A. and Seruni, A. P. (2018) "Determinants Affecting on Smallholder Madura Cattle Farming at Pamekasan Regency, East Java, Indonesia," *IOP Conference Series: Earth and Environmental Science,* 119, 012063

[25] Kibona, C.A. and Yuejie, Z. (2021) "Factors that influence market participation among traditional beef cattle farmers in the Meatu District of Simiyu Region, Tanzania," *PLoS ONE* 16(4): e0248576

[26] Randela, R., Alemu, Z.G. and Groenewald, J.A. (2008) "Factors enhancing market participation by small-scale cotton farmers," *Agrekon*, 47, 451–469

[27] Akwaa-Sakyi, E.K. (2013) "Impact of Microcredit on Rural Farming Activities: The Case of Farming Communities within Sunyani Area," *Management Science and Engineering* 7(4):23–29

[28] Mahendri, I.G.A.P. (2018) "Financing Small-Holder Cattle Fattening in Indonesia: Integrating Demand, Supply and Institutions," School of Agriculture and Food Sciences, The University of Queensland, PhD Thesis

[29] Swinnen J. F. M. and Gow, H. R. (1999) "Agricultural Credit Problems and Policies during the Transition to a Market Economy in Central and Eastern Europe," *Food Policy* 24, 21–47

[30] Carranza, M. and Niles, M. T. (2019) "Smallholder Farmers Spend Credit Primarily on Food: Gender Differences and Food Security Implications in a Changing Climate," *Frontiers in Sustainable Food Systems,*3

[31] Perez, C., Jones, E. M., Kristjanson, P., Cramer, L., Thorntond, P. K., Förchd, W., et al. (2015) "How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective," *Glob. Environ. Chang*. 34, 95–107

[32] Croppenstedt, A., Goldstein, M., and Rosas, N. (2013) "Gender and agriculture: inefficiencies, segregation, and low productivity traps," *World Bank Res. Obs*. 28, 79–109