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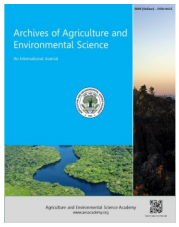

ORIGINAL RESEARCH ARTICLE

Use of double-hurdle model to crop residues usage among farming households in Argungu Local Government Area, Kebbi State, Nigeria

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ABSTRACT

The objective of this research is to examine the crop residues use and its determinants in Argungu Local Government Area of Kebbi State, Nigeria. A cross sectional data from 120 households selected through a multistage and simple random sampling techniques. This research is timely given the fact that, Nigerian Government is now shifting emphasis from oil-based to agricultural diversified economy. Data collected were analyzed using descriptive statistics and double hurdle. Such an approach has never been previously been applied to analyze crop residue usage in the study area and the state at large. The descriptive statistics shows that, farmers preferred using crop residue for feeding (44.1%) than any other purpose. Other important and competing uses of crop residue included stall feeding, fire wood, house construction and mulching. The intensity of legume crop residue was positively and statistically influenced by household education, land ownership, extension service and access to credit. However, the intensity to use cereal crop residues was positively influenced by household education, extension service and access to electricity ($p<0.05$). The study concludes crop residues were mainly used for own animal feeding in the area. Extension contact to farm families, socio-economic variable (educational attainment, access to credit) and quantity of crop residues influenced both the decision and intensity of CRs usage in the study area.

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INTRODUCTION

Crops residues (CRs) are a form of roughages available to livestock for feeding livestock after crops were harvested. They are distinct from other agricultural by-products (such as bran, oil cakes etc.) which are produced when crops are processed. Generally, any plant materials that remain after food crops were harvested are classified as a crop residue (Jibrin *et al.,* 2013). Crop residues have variety of uses among farmers in Nigeria. However, CRs are principally; used as a livestock feed, fuel firewood for roofing, construction of local houses, and mulching in most rural areas. Crop residues for livestock feeding are either pilled in stacks near homesteads for subsequent livestock feeding or are left on the farm for the animal to feed. The pilled stacks are given to fattened animals in small quantity in the morning and evening, sometimes to working oxen before and after work (Jibrin *et al.,* 2013). Alternatively, the residues are left in the threshing ground and consumed by animals together with the standing straws, which are left for aftermath grazing (KEFTASA, 1987; Akinola *et al.*, 2015). As such, crop and livestock integration is an integral part farming system in Nigeria for livelihood enhancement of many rural households. It is on record that, majority of smallholder farmers in Nigerian are involved in crop, livestock, or crop-livestock agriculture. Nigerian agricultural system is dynamic. Farmers who were hitherto involved only in crop production have diversified into crop-livestock production. Similarly, transhumant pastoralists are increasingly turning in to agro-pastoralists to observed sedentary life (Agyemang *et al.*, 1993). This change is on increased based on perceived reciprocal benefits the two systems can offers.

The presidential committee on livestock production identified biological limitations of the indigenous breeds of animals, seasonal availability of production inputs such as feed, water, and good quality pasture to be among the major constraints of livestock production in Nigeria.

The small ruminant's holders in Nigeria do experience a cyclical feed and pasture shortages for many years. During dry-season both small and large ruminants lost weight and

in extreme cases some deaths do occur (Jibrin *et al.,* 2013). The scarcity of pasture triggers the migration of pastoralist to the southern part of the country. The availability of crop residue varies with season of the year and geographical region. In some regions, there is a scarcity of crop residue only for certain months of the year, while in others, the perennial scarcity may prevail. Improvement in the management of crop residue enables efficient utilization of this potentially useful feed resource for livestock production. One of the way towards achieving self-sufficiency in protein for teaming Nigerian population is through improved crop residue utilization in Nigeria by Fulani herdsman. This could be achieve through the introduction of better technology such as crop residue crushing machine, by so doing the meat and milk production can be enhance (Jibrin *et al.,* 2013).

Animal feeds constitute at least 60 percent of the total variable costs in livestock production in Nigeria. The ruminants feed mainly came from forages and crop residues that are usually affected by seasonality. Hence, ruminants experience seasonal fluctuation in weight annually, especially during the early wet season and extreme dry periods of the year when the rainfall was about to start.

Increased cropping areas have reduced the availability of water and grazing land resources to pastoralist in Nigeria, consequently, leading to incessant conflicts among pastoralists, anglers, and farmers who are the major users of land and water resources. The quest to increase the agricultural production in all facets is clarion call of the present government of President Muhammadu Buhari for intensification of crop production by way of increasing cultivated areas and adoption of improved technology, and in CRs processing for efficient utilization by livestock. Livestock rearers especially (small and large ruminants) are constantly face with problem of feed shortage especially during the dry season. This is as a result of the fact that, they solely relied on crop residues, that is though cheap but in short supply. Hence, ruminants experience seasonal weight gain/loss during the wet/dry periods respectively during the year (Philip *et al.*, 2009). More so, conflicts do arise between crop farmers and herders over the use of crop residues.

To achieve improvement in animal production, Powell and Williams (1995) asserted that crop production must have been expanding by 4% annually. This will require further intensification of land use. Under these conditions, full integration of crop and livestock production could be achieved and the greatest potential for increasing agricultural productivity in the Nigeria.

The use of crop residues as a livestock feed and mulching material have been documented in the current literature for example (Moritz, 2010; Jibrin *et al.,* 2013; Akinola *et al.,* 2015). However, studies on the determinants and factors that influence the decision of farmers to allocate crop residues among the competing uses is yet to be fully analysed and understood in the study area. The application of double-hurdle econometric methodology employed in this study takes into account the fact that the dependent variable contains zero crop residues usage. The approach has never been applied previously in analyzing crop residues usage in Kebbi state and the study area in particular. Therefore, this study has provides interesting insights and implications for the design of policy toward reducing livestock feed scarcity especially during the lean season.

MATERIALS AND METHODS

About the study area: Argungu Local Government Area is located between latitude $12^0$30'33"N to $12^0$40'54"N and longitude $4^0$20'54"E to $4^0$30'54"E covering an area of 428 km^2 and elevation of 241 meters above sea level. It is bounded by Yabo Local Government area of Sokoto state to the North-East, in the South by Gwandu and Birnin Kebbi Local Government areas, while to the North and West by Augie and Arewa Local Government areas respectively. The study area enjoys tropical continental type of climate, which is largely controlled by two air masses namely; tropical maritime and tropical continental blowing from Atlantic and Sahara desert, respectively. The air masses determined the two dominant seasons, wet and dry. Humidity is 27% while wind blow at 11Km/h in ESE direction. Argungu L.G.A receive a mean annual rainfall of 800mm between May to September with a peak period in August, the remaining period of the year is dry. The average temperature is 26^0C and can rise up to 40^0C in the peak of hot season (March-July). However, during *harmattan,* season (December- February) temperature falls to 21^0C.

Sampling technique and data analysis: A multi-stage sampling technique was used for this study. The first stage involved a purposive selection of three Districts out of seven districts and in each district 2 villages were selected. The second stage involved a purposive selection of6 villages based on the intensity of crop-livestock production management system, marketing and utilization prevailing in the area. Thirteen (13) households were selected, making 40 households per village. Overall, 120 households were interviewed using a structured questionnaire. The sample size could have presented a limitation on the ability of the study to capture effects adequately at household level. However, in view of the concentration of households that use crop residue in the study area and the sample can to a large extent describe the scenario of crop residues usage. Data collected was analyzed using descriptive statistics and double hurdle model.

Theoretical model: The use of standard regression analysis will provide a misleading and inconsistent estimates due to presence of zero observation in the in the intensity of crop-residues usage. The application of double-hurdle model initially proposed by Cragg (1971) will take care of the inherent limitations associated with standard regression including the Tobit model. The double-hurdle model has been widely applied in the study of technology adoption (Damisa *et al.,* 2007; Damisa *et al.,* 2011; Asfaw *et al.*, 2011; Akinola *et al.,* 2015). Aristei and Pieroni (2011) applied double-hurdle modeling in tobacco consumption in Italy. Newman *et al.* (1995) modeled Irish household expenditure on prepared meals. More recently, a paper by Eakins (2014) studied household expenditure using Central Statistics Office (CSO) data from 2419523 vehicles using

petrol and diesel in Ireland.

The Agricultural Household Model is an appropriate theoretical framework for the study crop residues use. The main aim of the household is to maximize its expected utility and profit subject to several constraints such as income, time and farm inputs. The AHM model treats farms or agricultural households as producers and consumers as against the traditional economic theory that dealt with them separately.

In this study crop residue usage in Argungu Local Government are modeled under the framework of Agricultural Household Models (AHMs) as proposed by (Singh *et al.,* 1986). A number of scientists provide a theory that used the model in the allocation of time by household in the production processes. According to (Singh *et al.,* 1986; Aristei and Pieron, 2011) among others, defined the utility function of the household as:

$$U=U\,(dCR_1, CR_2 \ldots\ldots CR_n : w) \qquad (1)$$

Where, CR_1 is the quantity of CR utilized (with Price P_i), CR_2…….CRn represents all the alternative uses of CRs, w is a represent covariates of all socio-economic variables that influence decision of crop residue users, and d is a latent variable which is equals to one, if an individual uses crop residues as livestock feed and zero otherwise (i.e. for uses other than livestock feed).

Econometric model specification: Recent studies have shown that use of standard Tobit to analyze cross sectional data such as on crop residues usage has some deficiencies, hence the importance of double hurdle model (Labeaga, 1999; Eakins, 2014; Akinola *et al.,* 2015). The double-hurdle model has the advantage of modeling participation decision and the extent of crop residue usage and their determinants separately. The double-hurdle model was originally by Cragg (1971), the model work on assumption that two separate hurdles or decisions must be crossed. The first hurdle is the decision on the adoption of crop residue for livestock feed. While the second hurdle is the share of crop residue that will be allocated for livestock feed (intensity) of crop residue usage, which is conditional on the first decision (adoption to use crop residue as livestock feed).

It is reasonable to assume that, decision to participate or use crop residue as livestock feed is not only an economic decision but is also influenced by socio-economic and demographic variables, which can appear in both models but may have different effects on the dependent variable. The two hurdles are assumed to be linear in parameters (α&β), with disturbances terms ε and ν randomly distributed with a bivariate normal distribution. The ƛ and x are the vectors of explanatory variables that are assumed to influence participation and intensity of crop residues usage as a livestock feed, respectively.

i) Observed consumption:

$$y = z.yi^{**} \qquad (2)$$

ii) Participation equation:

$$w_i = Z_i'\alpha + \mu_i \;\; \mu_i \sim N(0,1) \qquad (3)$$

$$d = \begin{matrix} 1\ if\ w>0 \\ 0\ other\ wise \end{matrix} \qquad (4)$$

iii) Intensity of crop residue use

$$yi^* = X_i'\beta + v_i, v_i \sim N(0, \delta^2) \qquad (5)$$

$$y_i^{**} = y_i^*\ if\ y_i^* > 0 \qquad (6)$$

$$0\ other\ wise$$

y* is positive usage of crop residue as a livestock feed, (d=1) and actual uses (y**)

Empirical model: The double hurdle model fitted the cross sectional data generated by the researcher. The dependent variable, which is both the participation and intensity decisions to use crop residue as livestock feed by the farmers, were postulated to be influenced by the explanatory variables such as (Table 1.).

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 householdage + \beta_2 household\ educational\ level + \beta_3 householdsize \\ & + \beta_4 livestockownership + \beta_5 farmsize + \beta_6 extensioncontact \\ & + \beta_7 access\ to\ electricity + \beta_8 access\ to\ credit + \mu \end{aligned} \qquad (7)$$

RESULTS AND DISCUSSION

Table 2 summarizes crop residues uses by type and purposes. The legume and cereals crops residues uses were identified, They can be used for redistribute nutrient in the farming systems, grazed by other animals; sold to others on filed; sold later, and the export of nutrients out of the farming system (e.g. fire wood, construction and used for other purposes. This is agreement with (Akinola *et al.,* 2015) ten purposes for which crop residues were used in Kano State, Nigeria.

The result shows that, 52.5% and 37.17% legumes and cereal crop residues were allocated for own animal feeding within the farm. Hence, majority of farmers preferred using crop residue for feeding than mulching. Other competing uses of crop residues included stall feeding, fire wood and house construction. Table 2 indicates that, 22% of legumes residues are sold either on the field or later. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). However, most of the legumes crop residues were used within the farm or community (52.52%) while only small amount (0.83%) was exported to Niger Republic in particular.

Determinants of participation in crop residues usage as a livestock feeds: The estimation results presented in this section emphasize the two main goals of the study: First section presents the various factors that influence the decisions to use crop residue among the competing uses, and to evaluate the intensity of crop residues usage among

the smallholder farmers in Argungu Local Government Area of Kebbi State, Nigeria. The model was estimated by maximizing the log-likelihood function. The coefficients in the first hurdle indicate how a given variable affects the likelihood (probability) to use CRs as livestock feed or otherwise. The second hurdle denotes how a variable influences the level of usage, given that a decision is made to utilize crop residue as livestock feed.

Factors influencing the participation or adoption of cereal and legume crop residues as livestock feeds were analyzed and the results presented in Table 3. The decision to participate in the usage of cereal and legume crop residues as livestock feeds was positively and significantly influenced by extension contact, quantity of cereal residue used and quantity of legume crop residue used available to the farmers. An increase in extension service by one contact would lead to 0.9% increase in the probability of using cereal and legume crop residues as feeds for livestock. However, a one percent increase in quantity of cereal crop residues increase the probability of using cereal and legume crop residues used as feeds for livestock by 5%. On the other hand, a one percent increases in quantity of legume residues resulted in 05% increase in probability of adopting cereal-legume crop residues as livestock feed. As regard intensity of use of cereal and legume crop residues used for livestock feed, increase in farming experience used as proxied for extension indicated that 1% increased the quantity of cereal and legume crop residues used for livestock feed by about 1.2%. Household heads that have access to extension service preferred using their crop residues for livestock feeds than selling it. Access to information made available by increased education has positive and statistical significant influence on the quantity of crop residues used for the livestock feeding. One (kg) increase in quantity of cereal crop residues increased the quantity of cereal and legume crop residues used for feeding livestock by about 6%. However, availability of alternate source of feed like legume crop residues has a positive influence on the quantity of cereal and legume crop residues used for feeding. This may indicate that farmers are less to know the importance of combining cereal and legume crop residues to maximize livestock production.

Factors influencing the intensity legumes crop residues use as livestock feed: Factors influencing the adoption of adoption of legume crop residues were investigated and results presented in Table 4. Education has positive and statistical significant influence on the quantity of legume crop residue used for the livestock feeding. Better educated a farmer is the less willing want to sell his legume crop residues but rather use it as feed. One-year increase in formal schooling will bring about an increased in the quantity of crop residues used for feeding livestock by about 9%. The size of the farm own by the household also has positive and significant influence on the decision to use legume crop residues as feeds for livestock. An increase in land ownership by one percent increased probability of using legume crop residues as livestock feeds by about 9%. Extension facilities made available through the use of face to face contact, farm visit, mobile phones and radio was a significant variable positively influencing decision to use legume crop residues as livestock feed and not for sales. One percent increase in access to extension facilities increased the probability of farmer's intensity to use legume crop residues as livestock feed by about 0.1%. This is because mobile phones provide a medium for farmer-to-farmer interaction through which information is spread on technological adoption. A one percent increase in access to credit resulted to 3% increase in probability of adopting legume crop residue as feed for livestock. This might not be unconnected with increased production because of better funding ability of farming households. The adoption of use of legume crop residue as livestock was influenced by education, land ownership, extension and access to credit.

A year increase in education increased the quantity of crop residue used for feeding livestock by about 11%. A unit increase in the size of land ownership increased the quantity of legume crop residue by 10.3%. Extension facilities also played significant role in influencing the quantity of legume crop residue used for livestock feed. Increase in access to extension facilities by 1 unit increased the quantity of legume crop residue used by 0.12%. Similarly, a unit increase in access to credit increased the quantity of legume crop residue used by about 4%. This implied that majority of the household have no alternative to access to credit. Access to credit will provide alternative means of getting fund for livelihood capital.

Factors affecting the intensity of cereals and crop residue used as a livestock feeds; Factors influencing adoption and intensity of adoption of cereal CR as livestock feeds are shown in Table 4. The decision to adopt cereal crop residues as livestock feed was positively and significantly influenced by household education, extension, and access to electricity available to the farmers. A year increase in education of average household increased the probability of using cereal crop residue as feeds for livestock by about 1%. A one percent increase in extension service increased the probability of using cereal crop residues by about 1.3%. On the other hand, a one percent increase in access to electricity resulted to 1.2% increase in probability of adopting cereal crop residues as livestock feed. As regard intensity of use of cereal, legume crop residues for livestock feed, increase in farming experience used as proxied for extension indicated that 1% increased the quantity of cereal, legume crop residues used for livestock feed by about 2%. Household heads that have access to extension service preferred using their crop residues for livestock feeds than selling it. Adequate information/ communication, innovation training to the farmers would motivate and encourage farmers to know the importance of using crop residues for livestock feeds than immediate gain of trading that may not be profitable in the long run. Access to information made available by increased education has positive and statistical significant influence on the quantity of cereal crop residues used for the livestock feeding. A one year increase in education increased the quantity of crop residue used for feeding livestock by about 1.2%. Similarly, one-unit increase in access to electricity increased the quantity of cereal crop residue used for livestock feeds by 1.4%.

Table 1. Description and definition of the key variables.

Variable	Description	Units
Y dependent variable	Quantity of crop residues	Kg
Household age	Age of the household head in years	Years
Household head educational level	Number of years of formal education completed by the household head	Years
Household size	Number of people living together under the same roof and eating from the same pot	
livestock ownership	Livestock holding of the household converted tropical livestock unit equivalent	TLU
farm size	Plot size measured in hactres	hactres
Extension contact	An ordinal measures of training on crop residues use proxied by household possession of radio or mobile phone which are reliable channels of communication in the study area: 1 If possessed, 0 If not.	
access to electricity	Access to electricity. An ordinal measure 1 If there was access, 0 Otherwise.	
Aceess to credit	Access to credit measured by the farmers access to source of credit such as cooperative society at a reasonable cost. 1 If there was access, 0 otherwise	

Table 2. Percent of crop residue usage by purpose and type.

Crop Residues Uses (%)	Cereals (N=120)	Legumes (N=120)
Within the Farm (on Farm)		
Stall Feeding	21.67	44.17
Mulching	0.50	3.33
Grazed by own animals	15.00	5.02
Subtotal on farm	37.17	52.52
Within the system (on site)		
Graze by other animals	12.00	3.98
Sold to other on field	10.13	22.50
Sold later	30.69	20.17
Subtotal on site	52.82	46.65
Outside the system (exported)		
Used as fire wood	4.17	0.83
Used for construction	4.17	0.00
Used for other purposes	1.67	0.00
Subtotal exported	8.34	0.83
Total percentage	100.00	100.00

Source: Field Survey (2016).

Table 3. Factors affecting adoption of crop residues usage as livestock feed.

Variables	First hurdle Coefficient	z-value
Household age	0.463^{NS}	-0.73
	(0.023)	
Household educational level	0.251^{NS}	-1.15
	(0.051)	
Household size	0.963^{NS}	-0.05
	(0.048)	
Livestock ownership	0.284^{NS}	-1.07
	(0.005)	
Access to credit	0.574^{NS}	0.56
	(0.310)	
Farm size	0.624^{NS}	0.49
	(0.057)	
Extension contact	0.009^{***}	2.60
	(0.371)	
Quantity cereal used	0.058^{**}	1.90
	(3.06)	
Quantity of legumes used	0.005^{***}	5.04
	(0.001)	
Constant	0.783^{NS}	0.28
	(1.131)	
Number of observations	120	
Wald $chi^2(9)$	33.64	
Log likelihood ratio	-46.527373	
Pseudo R^2	0.3724	
Goodness-of-fit testHosmer-Lemeshowchi^2(8)Prob> chi^2	0.7713	

Source: Field Survey, (2016). Note: The figures in parenthesis indicate the standard error, NS indicate the variable is not significance, (***) indicate significance at 1% level, (**) indicate significance at 5% level and (*) indicate significance at 10% level.

Table 4. Factors affecting intensity of crop residues usage as livestock feeds.

Legume crop residue used			**Cereal crop residue used**	
	Second hurdle		**Second hurdle**	
Variables	**Coefficient**	**t-values**	**Coefficient**	**t-values**
Household age	0.757^{NS}	0.31	0.355^{NS}	0.93
	(0.579)		(227.6)	
Household educational level	0.088**	-1.72	0.010***	-2.61
	(4.211)		(2028.8)	
Household size	0.143^{NS}	1.48	0.277^{NS}	-1.09
	(1.484)		(708.8)	
Livestock ownership	0.086**	-1.73	0.380^{NS}	0.88
	(0.147)		(70.4)	
Farm size	0.870^{NS}	-0.16	0.896^{NS}	0.13
	(0.180)		(86.6)	
Extension contact	0.001***	3.40	0.013***	-2.51
	(9.861)		(4711.5)	
Access to electricity	0.473^{NS}	0.72	0.012***	2.54
	(18.246)		(8929.5)	
Access to credit	0.029***	-2.21	0.699^{NS}	0.39
	(10.127)		(4837.6	
constant	0.911^{NS}	0.11	0.351^{NS}	0.94
	(26.338)		(12668.9)	
Number of observations		120		120
LRchi^2(8)		21.85		18.53
Log likelihood		-633.08624		-1365.5289
Prob> chi^2		0.0052		0.0176
Sigma		48.50654		23178.06

Source: Field Survey, (2016). Note: The figures in parenthesis indicate the standard error, NS indicated the variable is not significance, (***) indicate significance at 1% level, (**) indicate significance at 5% level and (*) indicate significance at 10% level.

Conclusions

The main aim of this paper is to identify the factors that determine both the probability of using crop residue as a livestock feed and those influencing the intensity of the use. Therefore, it is essential to go ahead of the typical binary dependent variable methods applied to cross-sectional and time diary surveys. To this end, this study uses the double-hurdle model to address the phenomenon under investigation. The results show that the use of CRs for livestock feeding follows two independent decisions: the decision to use it as a feed and the decision concerning intensity of use. The estimation results also reveal that decision to use CRs as feed was positively and significantly influenced by extension, quantity of cereal crop residue and quantity of legume crop residue available to the farmers. As regard intensity of use of cereal, legume crop residues for livestock feed, increase in farming experience used as peroxide for extension indicated that 1% increased the quantity of cereal-legume crop residues used for livestock feed by about 1.2%. Household heads that have access to extension service preferred using their crop residues for livestock feeds than selling. In contrast, the intensity of CRs utilization was is mainly determined by respondents' education level attained, access to electricity and extension services.

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