EMPIRICAL EVIDENCE OF BENEFITS OF INTEGRATED CROP-LIVESTOCK FARMING SYSTEM AMONG RURAL HOUSEHOLDS IN NORTH-WEST NIGERIA

[1]SULAIMAN, Muhammad, [2]OLADIMEJI, Yusuf Usman, [2]EGWUMA, Henry and [3]YUSUF, Hannatu Ohunene

[1]Department of Economics, Federal College of Education, Zaria, Kaduna State, Nigeria.
[2]Department of Agricultural Economics, Institute for Agricultural Research, Ahmadu Bello University, Kaduna State, Nigeria.
[3]Department of Agricultural Extension and Rural Development, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Corresponding Author: Oladimeji, Y. U. Department of Agricultural Economics, Institute for Agricultural Research, Ahmadu Bello University, Kaduna State, Nigeria. **Email:** yusuf.dimeji@yahoo.com **Phone:** +234 8032220000

Received *September 21, 2020;* ***Revised*** *November 07, 2020;* ***Accepted*** *November 09, 2020*

ABSTRACT

Empirical evidence from literature revealed that the studies of integrated crop-livestock farming systems (ICLFS) are scanty in Nigeria. Hence, the study estimated the benefits of ICLFS and factors associated with profit among rural households in north-west Nigeria. Primary data was obtained using structured questionnaire administered to the crop-livestock farmers (CLF). 428 CLFs were sampled from 84 villages belonging to seven Local Government Areas. State-wise, this translated to 178, 128 and 122 CLFs in Kaduna, Kano and Katsina states respectively. Descriptive statistics, net farm income and multiple regression models were used to achieve the objectives. The results of the mean output indicated that ICL farmer produced 3,302.66 ± 749.70, 2,955.45 ± 350.90, 1,004.24 ± 20.98, 3,971.55 ± 932.12 and 1,026.29 ± 144.91 kg of maize, sorghum, cowpea, rice and soybean per hectare/year respectively. Findings established that the mean number of large ruminant, small ruminant and poultry reared per farmer were 19.00 ± 2.70, 24.00 ± 13.56 and 149.00 ± 119.01 herds respectively. The mean benefit-cost ratio of 1.64 ± 0.21, 1.39 ± 0.53, 1.44 ± 0.39, 2.67 ± 0.27, 2.30 ± 0.31 and 1.52 ± 0.15 were estimated for crop production per ha, dairy cow, beef cattle, goat, layer and broiler bird respectively. Coefficients of farm size (1.06), livestock worth (0.54), household size (0.10), extension contact (0.13), farming experience (-0.13) and credit accessed) (-0.01) were factors determining profit among CLFs. Farmers are encouraged to increase the farm size and livestock to seek opportunities of economic of scale, income and food security.

Keywords: Integrated crop-livestock (ICL), Food security, Income, North-west Nigeria

INTRODUCTION

Agriculture involves production of animals, crops, fishes and forest resources for the consumption of man and supplying the agro-allied product required by other Nigeria sub-sectors. It is inherited and dominant occupation employing about 70 % of rural households in the country (Hussaini *et al.,* 2019). Though, majority of Nigerian farmers are small scale and subsistence in nature, *albeit*, agriculture was regarded as the life-wire of the economies of the nation in the 1960s before the discovery of oil and gas. The greater percentage of Nigeria

rural population engage in agriculture related activities and producing farm goods on a subsistence level, and often do not get optimum economic returns on their produce (Akaakohol and Aye, 2014). Therefore, it is germane to examine farming system or enterprise combinations that will response to the present socio-economic needs and focus on sustainable use of resources. A farmer, who integrates crop and livestock, all things being equal, has potential of earning more income compared to one producing only either crops or livestock and thereby improves the farmer's economic status. Integrated crop-livestock also promote environmental management and the mission of sustainable development. These include ensuring good life on land, protect, restore and promote sustainable use of terrestrial ecosystems and natural resources. Sustainable Development Goals (SDGs) have put forth the pressure for the adoption of proper methods to protect the environment across all enterprise (Villeneuve *et al.,* 2017) one of which is ICL enterprise.

According to Chan (2004), integrated farming system also known as integrated agriculture is a commonly and broadly used word to explain integrated approach to farming as compared to monoculture and monocropping systems of agriculture. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as integrated bio-systems. In this system, an inter-related set of enterprises are used so that the waste from one component becomes an input for another component of the system, which reduces cost and improves production and income.

Manjunatha *et al.* (2014) enumerated the advantages of ICL farming to include increase productivity through proper utilization of resources which boosts outputs per unit area. Others advantages consist of improve profitability through reduction in costs due to recycling of wastes and conservation of natural resources among others. However, from available records in literature, there have been inadequate researches on empirical study of integrated CLF systems, particularly in north-west zone of Nigeria. Most studies dwelled on review of concepts and theoretical importance of integrated CLF (Al Mamun *et al.,* 2011; Gupta *et al.,* 2012; Witjaksono *et al.,* 2018; Nientao *et al.,* 2019). The few available empirical studies in Nigeria (Iyiola *et al.,* 2015; Obasi *et al.,* 2016, Malgwi *et al.,* 2017; Oladimeji and Isah, 2019) were location specific. Thus, this study is expected to provide crucial information to the scanty documentation of quantitative and qualitative benefits of ICL farming system in north-west Nigeria. In addition, the study will also showcase empirically, the implication of ICL as a strategy to boost food security and ensure environmental management. Specifically, the study intends to estimate the benefits of ICL farming system and factors determining profit among rural households in north-west Nigeria.

MATERIALS AND METHODS

The Study Area: Nigeria is located in the tropical zone of West Africa between Latitudes 4°N and 14°N and Longitudes 2°2'E and 14°30'E and has a total area of 923,770 km^2 (NPC and ICFI, 2014). The study was conducted in the north-west (NW) of Nigeria. The zone consists of seven states which are namely: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara (NPC and ICFI, 2014). The zone accounts for about 25 % of the Nigerian population with over 48,942,307 million people (NBS, 2018). The zone has an annual rainfall of 657.3 mm and prolonged dry season of 6 to 9 months. The states in NW are ecologically more of Sudan savannah with exception of Kaduna State which is more of north guinea savannah (Egbetokun *et al.,* 2014). The main economic crops that are cultivated in the zone include maize, rice, millet, beans, wheat and cotton. The focal animal husbandry of the zone includes cattle, sheep and goats rearing, poultry and piggery. Hence, agricultural activities are the main sources of livelihood in the zone.

Data Collection and Sampling Procedure: Primary data was used for this study. The data were obtained through the use of an interview method with structured questionnaire which were administered to the crop-livestock farmers in the study area between February to

November 2019. A multi-stage sampling procedure was used for this study. Firstly, three states namely Kaduna, Kano and Katsina were purposefully selected out of the seven states. These states share boundaries, having similar ecosystem, produce common crops and livestock. In the second stage, Kaduna north, Kano south and Katsina south were also purposively selected, respectively for the same reasons. In the third stage, seven Local Government Areas (LGAs) each from the selected states zones were randomly selected which comprises of Ikara, Kubau, Kudan, Lere, Sabon-Gari, Soba and Zaria LGAs (Kaduna State); Bebeji, Doguwa, Garko, Kibiya, Kiru, Rogo and Tudun-Wada (Kano State); Bakori, Dandume, Danja, Funtua, Kafur, Malumfashi and Sabuwa (Katsina State). In the fourth stage, 84 villages, four from each of the selected LGAs, were randomly selected due to the prevalent of ICL farming system. In the last stage, only 33% of the total numbers of ICL farmers in each of the 84 villages were randomly selected for this study. This represents a total sample size of 428 crop-livestock farmers using Slovin's formula for determination of sample size adopted from Sani and Oladimeji (2017). The formula is expressed as: $n = N / 1+ N (e)^2$ where n = sample size, N = population size and e = level of precision (5 %). The minimum sample size ($n=\geq$) was determined as follows: $n = 1296 / 1 + 1296(0.05)^2 = 1296 / 1297(0.0025) = 1296 / 3.2425 = 399.69 = \geq 400$. This translates to 178, 128 and 122 CLF in Kaduna, Kano and Katsina states respectively. The components of the crop-livestock integration includes: M = Maize, Sg = Sorghum, Sb = Soybeans, C = Cowpea, R = Rice and L = Livestock.

Analytical Techniques: Descriptive statistics, net farm income and multiple regression models were used to achieve the objective of the study. Net farm income analysis was used to measure the benefit accrued to crop-livestock integration. The model is mathematically expressed following Al-Mansi *et al.* (2015) and Abdulazeez *et al.* (2019) as follows: $TR = Q*Py$, $TC_{ij} = TVC_{ij} + TFC_{ij}$ and $\Pi = TR - TC$, where TR = total revenue (Naira/ha), TC = total costs (Naira/ha), TFC = total fixed cost (Naira/ha), TVC = total variable cost (Naira/ha), Π = net benefit (return), *Py* = average price of output (₦/kg) and Q_i = quantity of output i (kg).

Profitability indices used were operating expense ratio (OER), gross margin ratio (GMR), return on investment (ROI) and profitability index (PI). OER is a measure of profitability where cost of securing a variable input is compared to the income generated. It was adopted from Ameh *et al.* (2020) and calculated as: OER = Total Variable Cost (TVC) /Total Revenue (TR) . GMR is a profitability indicator that shows how much an enterprise has left from total revenue to pay operational and other business expenses. The GMR adopted by Ameh *et al.* (2020) was expressed thus: GMR = Gross Margin (GM) / Total Revenue (TR). The rate of ROI is another way of considering profit in relation to capital invested in the business. The ROI adopted from Abdulazeez *et al.* (2019) was expressed as follows: ROI = Net Return (NR) / Total Cost (TC). The PI is a useful tool in ranking investment projects and revealing the value created per unit of investment. The ratio was expressed in Ameh *et al.* (2020) as follows: PI = Net Return / Total Revenue (TR).

Multiple regression models was used to determine factors influencing profit of crop-livestock based output. The Cobb-Douglas production function adopted by Abdulazeez *et al.* (2019) was applied as follows: $InY = \beta_0+\beta_1X_1+\beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5+ \beta_6X_6+ \beta_7X_7+ \beta_8X_8+ \beta_9X_9$, where Y = the total ICL profit per hectare. Both crops and livestock output were converted into maize output using grain-livestock equivalent weight (GEW) adopted from Clark and Haswell (1970). X_1 = farm size (ha), X_2 = age of farmer (years), X_3 = livestock worth (₦), X_4 = marital status (married =1, single =0), X_5 = level of education (nil = 0, adult education = 1, primary = 2, secondary = 3, tertiary = 4), X_6 = household size (number of persons), X_7 = farming experience (years), X_8 = loan accessed (₦), X_9 = extension contact (number of visits), βo = constant and $\beta_1 - \beta_9$ = parameter to be estimated.

RESULTS AND DISCUSSION

Table 1 indicated the summary of the output produced per ha and number of livestock owned by a farmer. An ICL farmer produced 3,302.66 ± 749.00, 2,955.45 ± 350.90, 1,004.24 ± 20.98, 3,971.55 ± 932.12 and 1,026.29 ± 144.91 kg of maize, sorghum, cowpea, rice and soybean per ha respectively. Findings also established that the mean number of large ruminant, small ruminant and poultry reared per farmer were 19.00 ± 2.70, 24.00 ± 13.56 and 149.00 ± 119.01 herds of animal respectively. The coefficient of variation of both large and small ruminants and poultry owned was high. This implied that there was wide variation between livestock owned among the farmers. This agreed with the findings of Majekodunmi *et al.* (2017) on extensive production and livelihood diversification amongst Fulani pastoralists in northern Nigeria where the respondents in the study areas practiced ICL farming system.

Benefits and Profitability Analysis in ICL Production: The result in Table 2 demonstrated that the estimated crop production mean total revenue was ₦ 306,406.92 ± 28,093.12 per ha. The mean of crops output expressed in maize equivalent using grain-livestock equivalent weight (GEW) was 2,452.04 ± 521.30 kg per ha. The result also showed the estimated TVC and TFC per ha were 73.53 and 26.47 % of total cost respectively in the study area. The result further revealed the estimated gross margin was ₦169, 454.06 ± 7,321.09 and GMR of 0.55 ± 0.09. This implied that, 55 % of the total revenue generated by ICL farmers constituted the total cash benefit (profit). The net farm income (NFI) was calculated to be ₦120, 136.54 ± 6,984.80, while the PI was 0.39. The result also revealed that the benefit-cost ratio and rate of ROI were 1.64 ± 0.21 and 0.64 ± 0.20 respectively. This implied that for every ₦1 invested in crops production, 64 kobo was realized as profit in the study area. Hence, it can be concluded that crops production in the study area was profitable. This was in agreement with the findings of Abdulaleem *et al.* (2017) on the cost and return on maize production among small-scale farmers in Osun State, Nigeria.

Cost-Benefit of Rearing Large Ruminants in ICL Farming: Result in Table 3 showed the cost, return and average net income (benefit) realized by ICL farmers from rearing large ruminants (cattle). In dairy production, the finding showed that an ICL farmer averagely owned 9.00 ± 3.08 dairy cattle that produced natural milk in the study area. The mean total cost comprising labour, feeds, medications, depreciation of fixed items and miscellaneous costs amount to ₦56, 103.02 ± 21,240.60. The mean gross income and net income realized by an ICL farmer were ₦78, 033.26 ± 30,175.45 and ₦21, 930.24 ± 986.51 respectively. This indicated that dairy production in the study area was profitable as for every ₦1.00 invested, 0.39 kobo was realized as profit. This was in agreement with the findings of Saleh *et al.* (2016) on the performance of dairy cattle among farmers in northern Nigeria using improved technologies.

Furthermore, the results in Table 3 also showed the benefit from sale of beef by ICL farmers per annum. The mean total cost per herd (comprising of cost of labour, imputed feeds, medication and depreciation of fixed items) was ₦55,572.56 ± 30,175.90. The ICL farmer earned an average net income of ₦24, 369.95 ± 1,034.76 per herd with 0.44 kobo gain for every ₦1.00 invested in beef cattle production. This implied that the business of purchasing, rearing and selling of large ruminants was profitable in the study area. This was in agreement with the findings of Gona *et al.* (2017) on the profitability of cattle fattening among farmers in Kebbi State, Nigeria.

Cost-Benefit of Rearing Small Ruminants in ICL Farming: Result in Table 4 revealed that the mean cost of purchasing goat or sheep was ₦2, 031.54 ± 1,468.40 and reared for 365 days. The mean total cost of rearing goat or sheep for one year, consisting of costs of labour, feeds, medications and depreciation of fixed items was ₦5, 455.28 ± 1,687.32.

Table 1: Estimated crop and livestock output among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Items	Variable	Mean	Max	Min	CV
Crop output (kg)	Maize	3,302.66 ± 749.00	4,266.67	700.12	22.70
	Sorghum	2,955.45 ± 350.90	4,060.83	523.64	18.64
	Cowpea	1,004.24 ± 20.98	1,404.24	861.54	2.08
	Rice	3,971.55 ± 932.12	4,625.11	636.36	23.47
	Soybean	1,026.29 ± 144.91	1,280.20	686.80	14.12
	Average total output	2,452.04 ± (521.30)	-	-	-
Livestock owned (Number)	Large ruminant	19.00 ± 2.70	89.00	2.00	142.00
	Small ruminant	24.00 ± 13.56	64.00	4.00	56.46
	Poultry	149.00 ± 119.01	526.00	23.00	79.87

CV = coefficient of variation, min = minimum value, max = maximum value, - value not estimated

Table 2: Estimated cost-benefit of crop production per hectare among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Items	Variable	Mean value (₦)	%TVC	%TC
Return	i-Average crops output (kg/ha)	2,452.04 ± 521.30	-	-
	ii- Average price (₦/kg)	124.96 ± 11.01	-	-
	Total revenue (TR) = (i*ii)	306,406.92 ± 28,093.12	-	-
Variables cost	a- Seeds	7,817.90 ± 246.00	5.71	4.20
	b- Fertilizer	22,815.21 ± 5,213.71	16.66	12.25
	c- Labour	95,839.93 ± 17,061.25	69.98	51.45
	d- Agrochemicals	10,479.82 ± 1,682.31	7.65	5.63
	Total variable cost (TVC)	136,952.86 ± 19,000.64	100.00	73.53
Fixed cost	e- Land rent (₦/ha)	44,813.76 ± 384.91	-	24.06
	f- Depreciation (₦)	4,503.76 ± 450.04	-	2.42
	Total fixed cost	49,317.52 ± 11,041.32	-	26.47
	Total cost	186,270.38 ± 15,337.21	-	100.00
Cost-benefit	Gross margin	169,454.06 ± 7,321.09	-	-
Indices	Gross margin ratio	0.55 ± 0.09	-	-
	Net farm income (NFI)	120,136.54 ± 6,984.80	-	-
	Profitability index = (NFI/TR)	0.39 ± 0.06	-	-
	Operating expense ratio = (TVC/TR)	0.45 ± 0.11	-	-
	Benefit-cost ratio = (TR/TC)	1.64 ± 0.21	-	-
	Rate of return on investment	0.64 ± 0.20	-	-

Rate of return on investment = (NFI/TC), - value not estimated

Table 3: Estimated cost-benefit of rearing a large ruminant among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	Mean	Max	Min	CV
Cost estimate of dairy production				
Dairy cattle (number)	8.83 ± 3.08	17.00	4.00	34.88
Milk production duration (number of days/cattle)	151.91 ± 21.62	165.00	90.00	14.23
Total cost	56,103.02 ±21,240.60	954,462.08	108,093.10	37.86
Gross income	78,033.27 ± 30,175.45	1,288,608.8	145,935.31	38.67
Milk average net income	21,930.24 ± 986.51	-	-	-
Benefit-cost ratio (BCR)	1.39 ± 0.53	-	-	-
Cost estimate of beef cattle production				
Beef cattle number	10.17 ± 4.17	72.00	1.00	41.04
Rearing duration (number of days/cattle)	325.95 ± 77.31	540.00	270.00	23.72
Total cost per head	55,572.56 ± 30,175.90	150,886.37	21,545.21	54.30
Respondents who sold part of their cattle (number)	55.00	-	-	-
Cattle selling price / total revenue per head	79,942.51 ± 47,070.15	190,000.00	40,000.00	58.88
Net farm income	24,369.95 ± 1,034.76	-	-	-
Benefit-cost ratio (BCR)	1.44 ± 0.39	-	-	-

CV = coefficient of variation, min = minimum value, max = maximum value, - value not estimated

Table 4: Estimated cost-benefit of rearing small ruminant among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	Mean	Max	Min	CV
Cost estimate of goat / sheep rearing				
Small ruminant (number)	24.00 ± 13.56	64.00	4.00	51.16
Rearing duration (number of days / head)	364.83 ± 62.13	540.00	300.00	17.03
Breed	2,031.54 ± 1,468.40	11,070.99	495.72	72.28
Labour / man-day	1,348.46 ± 749.34	3,029.38	550.80	55.57
Feed	821.82 ± 448.39	1,837.82	40.39	54.56
Medication	250.49 ± 85.67	526.32	122.40	34.20
Depreciation cost of fixed items	1,003.00 ± 164.29	2,109.02	130.18	16.38
Total cost	5,455.31± I,687.32	18,573.53	1,339.49	30.93
Return estimate from goat sale per head				
Respondents who sold small ruminants (number)	292.00	-	-	-
Total cost per head	5,455.28 ± 1,687.32	18,573.53	1,339.49	30.93
Head selling price / total revenue (₦ / head)	14,578.77 ± ,036.65	35,000.00	12,000.00	13.97
Net farm income	9,123.49 ± 2,998.89	21,907.50	3,987.11	32.87
Benefit-cost ratio (BCR)	1.67 ± 0.27	-	-	-

CV = coefficient of variation, min = minimum value, max = maximum value, - value not estimated

The goat or sheep was sold at an average cost of ₦14, 578.77 ± 2,036.65. The integrated farmer earned ₦9, 123.49 ± 2,998.89 as net income (benefit) with ₦1.67 ± 0.27 gain for every ₦1.00 invested in the production of ruminants. Thus, the act of purchasing, rearing and selling of small ruminants was profitable in the study area. This was in agreement with the findings of Bamigboye *et al.* (2017) on the profitability of goat rearing in Ado Ekiti metropolis, Ekiti State, Nigeria.

Cost-Benefit of Poultry Production in ICL Farming: Result in Table 5 showed the cost-benefit of poultry production by ICL farmers in north-west Nigeria. In terms of eggs production, the mean total cost per layer obtained covering costs of labour, feeds, medications and depreciation of fixed items was ₦1, 319.98 ± 515.19. The average gross income of ₦3,039.13 ± 1,148.49 was realized by the ICL farmer. The benefit-cost ratio was 2.30 ± 0.31 which implied that eggs production in the study area was profitable as for every ₦1.00 invested, ₦1.30 was realized as profit. This was in agreement with the findings of Girei *et al.* (2018) on cost and return of poultry egg production in Lafia Local Government Area of Nasarawa State, Nigeria. Similarly, an ICL farmer producing broilers chicken for meat in the study area had a total mean production cost of ₦1, 031.03 ± 954.63 which comprised of labour, feeds, medications and depreciation of fixed items. The net (benefit) income per bird was ₦533.26 ± 0.15 .The benefit-cost ratio was 1.52 which implied that poultry meat production in the study area was profitable as for every ₦1.00 invested, ₦0.52 was realized as profit. This result was in agreement with the findings of Ebukiba and Anthony (2019) on the economics of broiler production in Karu Local Government Area of Nasarawa State, Nigeria.

Average Estimates of Crops Chaff and Straw Production per Hectare: Result in Table 6 showed the total by-products produced by ICL farmers from maize, sorghum, cowpea, rice and soybean cultivation as well as its monetary worth in the study area. The result showed a sum total of 967,148.96 kg of crops chaff and straw which were produced by ICL farmers from maize, sorghum, cowpea, rice and soybean. Out of this, 40.14 % (388,222.50 ± 21,008.50 kg) came from maize production and an average maize farmer produced 975.43 ± 114.97 kg of the by-product followed by cowpea with about 29.11 % (281,522.75 ± 36,980.90 kg), with an average of 1,135.17 ± 67.05 kg per farmer. Soybean had the least chaff by-product 4.20 % (40,587.20 ± 1,664.70 kg) with an average of 676.45 ± 53.05 kg per farmer. This implied that crop chaff/straw production was of great concern since it provided feeds for the farmers' livestock in the study area.

Furthermore, the results in Table 6 disclosed that cowpea and rice chaffs produced the highest and lowest gross income of ₦85, 164.70 ± 5,612.35 and ₦13, 100.50 ± 2,052.90 respectively. About ₦190, 628.00 ± 4,000.10 worth of crops chaff and straw were produced per farmer from all crops in the study area. This implied that ICL farmers saved money that would have been incurred in purchasing crops chaff and straw to feed their livestock. This also increased the level of profitability in livestock production in the study area. This was in agreement with the findings of Bergonzoli *et al.* (2020) in an innovative system for maize cob and wheat chaff harvesting in Italy. Furthermore, the result of this study was consistent with report of Owen *et al.* (2012) on the use of technologies to improve maize cob and wheat chaff for animal nutrition in developing countries. The results showed that it was possible to harvest 1.72 and 0.67 tons per ha of maize cob and wheat chaff, respectively.

Average Estimates of Farm Yard Manure (FYM) Production per Hectare: The total FYM produced by livestock rearing activities of ICL farmers and its monetary worth in the study area is presented in Table 7. It should be noted that some farmers adopted extensive or free range system of grazing and as such their waste was not collected during that period of the study area. The results showed that 4,104.35 ± 1,321.90 kg (54.78 %), 2,077.52 ± 907.09 kg (27.73 %), and 1,310.83 ± 85.92 kg (17.49 %) of FYM were produced from large and small ruminants, and poultry waste respectively.

Table 5: Estimated cost-benefit of poultry production among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	Mean	Max	Min	CV
(i) Descriptive statistics of egg production				
Number of layers reared (2 cycles per year)	353.00 ± 93.58	514.00	201.00	26.51
Eggs production duration (number of days)	81.00 ± 24.40	120.00	35.00	30.12
Cost and return estimate per layer head				
Total cost	1319.98 ± 515.19	2542.32	68.35	39.03
Proceed from eggs sales	848.28 ± 34.02	900.00	800.03	4.01
Spent layer	870.87 ± 279.38	1300.05	870.21	32.08
Gross income	3039.13±1,148.49	4174.12	956.58	37.79
Net income (profit)	1843.22 ± 387.08	2498.04	1643.31	21.00
Benefit-cost ratio	2.30 ± 0.31	-	-	-
(ii) Descriptive statistics of broiler production				
Number of broilers reared (2 cycle per year)	115.00 ± 74.75	526.00	23.00	0.65
Rearing duration (number of days)	167.00 ± 106.71	300.00	45.00	63.90
Total cost	1031.03 ± 954.63	3744.86	45.79	92.59
Proceed from a broiler sales	1,564.29 ± 244.03	2,300.00	700.00	15.60
Gross income	1564.29 ± 978.62	9113.89	94.91	62.56
Average net income	533.26 ± 0.15	-	-	-
Benefit-cost ratio	1.52 ± 0.15	-	-	-

CV = coefficient of variation, min = minimum value, max = maximum value, - value not estimated

Table 6: Estimated cost-benefit of crops chaff and straw production per hectare among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	Composition of chaff and straw by a farmer (₦)					Total (₦)
	Maize	Sorghum	Cowpea	Rice	Soybean	
Number of farmers	398.00	280.00	248.00	110.00	60.00	428.00
Total chaff (kg)	388,223.00 ±21,008.50	133,957.00 ±27,003.60	281,523.00 ±36,980.90	122,860.00 ±7,764.20	40,587.20 ±1,664.70	967,149.00 ±45,980.40
% From total chaff	40.14	13.85	29.11	12.70	4.20	100.00
Mean chaff produced (kg)	975.43 ±114.97	478.42 ±98.50	1,135.17 ±67.05	1,116.91 ±241.09	676.45 ±53.05	3,265.5 ±398.76
Mean unit selling price	513.86 ±54.03	2,277.55 ±126.52	1,875.59 ±209.06	293.23 ±41.00	1,061.74 ±208.21	-
Mean gross income	20,049.50 ±4,597.35	43,584.70 ±4,715.86	85,164.70 ±5,612.35	13,100.50 ±2,052.90	28,728.60 ±4,849.4	190,628.00 ±6,543.09
Maximum	49,200.00	225,600.00	912,200.00	27,600.00	55,000.00	-
Minimum	1,250.00	6,800.00	30,400.00	5,600.00	12,320.00	-
CV (%)	22.93	10.82	6.59	15.67	16.88	-

Unit selling price for all crops was ₦/25kg, - value not estimated

Table 7: Estimated benefit of farm yard manure (FYM) production among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	FYM produced from livestock rearing			Total
	Large ruminant	Small ruminant	Farm yard manure	
Number of farmers*	221.00	355.00	313.00	428.00
Manure produced (kg)	4,104.35 ± 1321.90	2,077.52 ± 907.09	1,310.83 ± 85.92	7,492.50 ± 832.90
Percentage (%)	54.78	27.73	17.49	100.00
Unit price per 100 kg	485.78 ± 185.09	1,270.55 ± 64.30	2,277.11 ± 142.80	-
Mean gross income	19,938.09 ± 8,970.00	26,395.95 ± 11,000.60	29,844.51 ± 298.07	76,178.55 ± 17,089.54

**integrated crop-livestock, - value not estimated*

The waste from three livestock translated to a total income of ₦76,178.55 ± 17,089.54. This amount could have been used in purchasing inorganic fertilizers for crops production. The utilization of this on-farm organic fertilizer that lead to increased level of profitability in crops production was in agreement with study of Järvan *et al.* (2017).

Other Benefits Derived from ICL Farming System: The perception of ICL farmers on non-monetary benefits derived from the ICL farming system in the study area are presented in Table 8. The findings showed food security as the top most benefit derived by the entire 428 farmers in the study area. This may be because the most fundamental human basic need is food, which ICL farming system provided in forms of crops and livestock. Increase in crop yield ranked second (85 %) as farm yard manure supplied nutrients required for crop growth. Others were: source of income (84 %), reduction in cost of farming (79 %), fodder availability (77 %) and nutrient recycling (75 %). The farmers sold a portion of their crops produced as well as livestock raised for money in order to finance domestic demands. The results of this study were in agreement with the findings of Ezeaku *et al.* (2015) on the Integration of crop-livestock farming system for sustainable agricultural production in Nigeria, Witjaksono *et al.* (2018) on the development of ICL farming system as a strategy for growth and development of low income countries, and Dahiya *et al.* (2019) on the integration of livestock with crop for sustainable development of India.

Factors Affecting Profitability of ICL Farming System among Rural Households: The factors determining profit among ICL farmers in north-west Nigeria are presented in Table 9.The adjusted R^2 of 0.66 implied that the explanatory variables fitted for each model were able to explain the variation in the profitability of ICL farming system by 66.29 %. The F-test with a value of 107.10 revealed that the model was statistically significant at the 1% level of probability.

The positive and statistically significant coefficients of farm size (1.06), livestock worth (0.54), household size (0.10) and extension contact (0.13) revealed that the profit earned from ICL system was directly related to the socio-economic and input variables used. This implied that as the coefficients of these variables increase, the profit earned from the enterprise also increased. However, the profit earned by crop-livestock farmer was negatively related to the farming experience (-0.13) and access to credit (-0.01). That suggested that as the values of the coefficients of these variables decrease, the profit earned from the enterprise decreased. The result of this study was comparable to the findings of Ajao and Oladimeji (2013) on factors determining the contribution of apicultural practices to household income in Kwara State, Nigeria.

Conclusion: It can be concluded that ICL farming systems are profitable and has enormous benefits among rural households in north-west, Nigeria. The result established that socio-economic, institutional and production inputs were factors determining profit among rural households in north-west Nigeria. The following recommendations were made based on the findings of the study: (i) Farm size was positive and statistically significant. Hence, farmers are encouraged to increase the farm size for increase economic of scale, yield, diversification, self-sufficiency, income and food security. (ii) Extension contact was statistically significant; hence farmers should collaborate with extension agents and other relevant agencies to assist in organizing workshops, and trainings to encourage and improve the level of ICL farming. (iii) Credit facilities should be made available and accessible to the farmers to promote improves ICL productivity. Finally, there should be synergy between crop, livestock and the scientists (extension agent and agricultural economists) to bring into bearing the needs for farmers to imbibe enhanced ICL farming as to achieve optimum level of efficiency.

Table 8: Perceived qualitative benefits of crop-livestock integration among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Benefits	Frequency	Percentage	Ranking
Food security	428	100.00	1st
Increase in crop yield	365	85.28	2nd
Source of income	361	84.35	3rd
Reduction in cost of farming	339	79.20	4th
Fodder availability	330	77.10	5th
Nutrient recycling	321	75.00	6th
Soil productive capacity	158	37.00	7th
Self-sufficiency	115	26.86	8th
Diversification	75	17.52	9th

Table 9: Factors determining profit among rural households of integrated crop-livestock farmers (ICLFS) in North-west Nigeria

Variables	Coefficient (β)	Standard error	T-value	P-value
Intercept	8.37	0.35	23.77	0.00
Farm size	1.06	0.05	23.60	0.00
Livestock worth	0.54	0.09	6.10	0.00
Age	0.04	0.10	0.40	0.69
Marital status	0.07	0.14	0.55	0.58
Educational level	0.03	0.05	0.59	0.55
Household size	0.10	0.05	2.02	0.04
Farming experience	-0.13	0.04	-2.85	0.00
Access to credit	-0.01	0.00	-2.46	0.01
Extension contacts	0.13	0.05	2.81	0.00
Regression statistics				
Number of observation	428.00	-	-	-
Multiple regression (r^{-2})	0.66	-	-	-
F-value	107.10	-	-	-
Level of significant	0.00	-	-	-
Standard error of the regression	0.27	-	-	-

- *value not estimated*

ACKNOWLEDGEMENTS

I wish to acknowledge the management of Federal College of Education, Zaria for their support and sponsorship in pursuing my PhD and the entire staff of Department of Agricultural Economics, Ahmadu Bello University, Zaria, Nigeria. I am indebted to numerous authors of articles used and anonymous reviewers for their contributions that help to improve the quality of the manuscript. This article is a product of my PhD thesis.

REFERENCES

ABDULALEEM, M. A., OLUWATUSIN, F. M. and KOLAWOLE, A. O. (2017). Analysis of costs and returns on maize production among small-scale farmers in Osun State, Nigeria. *Report and Opinion,* 9(5): 89 – 92.

ABDULAZEEZ, R. O., ABDULRAHMAN, S. and OLADIMEJI, Y. U. (2019). Economic diversification strategies of farmers under the Kogi Accelerated Rice Production Programme (KARPP). *Nigerian Journal of Agricultural Economics*, 9(1): 56 – 69.

AJAO, A. M. and OLADIMEJI, Y. U. (2013). Assessment of contribution of apicultural practices to household income and poverty alleviation in Kwara State, Nigeria. *International Journal of Science and Nature*, 4(4): 687 – 698.

AKAAKOHOL, M. A. and AYE, G. C. (2014). Diversification and farm household welfare in Makurdi, Benue State, Nigeria. *Development Studies Research, An Open Access Journal,* 1(1): 168 – 175.

AL MAMUN, S., NASRAT, F. and DEBI, M. R. (2011). Integrated farming system: prospects in Bangladesh. *Journal of Environmental Science and Natural Resources,* 4(2): 127 – 136.

AL-MANSI, O. K., MAHMOOD, Z. H. and ABBAS, N. K. (2015). Estimating the profit cost functions, economic and technical efficiencies of corn production in Babylon Province in Iraq. *International Journal of Applied Agricultural Sciences*, 1(3): 66 – 73.

AMEH, J., OLADIMEJI, Y. U. and OUAGBABE, O. O. (2020). Economic analysis and factors influencing maize efficiency in Kaduna State, Nigeria. *Dutse International Journal of Social and Economic Research,* 4(2): 128 – 138.

BAMIGBOYE, F., SODIQ, A. and OLUWASUSI, J. (2017). Profitability analysis of goat marketing in Ado Ekiti metropolis, Ekiti State, Nigeria. *Nigerian Journal of Animal Production*, 44(3): 178 – 185.

BERGONZOLI, S., SUARDI, A., REZAIE, N., ALFANO, V. and PARI, L. (2020). An innovative system for maize cob and wheat chaff harvesting: simultaneous grain and residues collection. *Energies*, 13(5): 1265. http://dx.doi.org/10.3390/en13051265

CHAN, G. L. (2004). *Integrated Farming System. What does Integrated Farming System do*? Sustainable Communities/ZERI-NM, Santa Fe, NM 87504, USA. http://www.scizerinm.org/chanarticle.htm

CLARK, C. and HASWELL, M. R. (1970). *The Economics of Subsistence Agriculture.* 4th Edition, Palgrave Macmillan Publishers, United Kingdom.

DAHIYA, S. P., KUMAR, S. and KUMAR, M. (2019). Integration of livestock with crop production for sustainable development. *International Journal of Science, Environment and Technology,* 8(1): 177–184.

EBUKIBA, S. E. and ANTHONY, L. (2019). Economic analysis of broiler production in Karu Local Government Area, Nasarawa State, Nigeria. *IOSR Journal of Agriculture and Veterinary Science*, 12(3): 49 – 56.

EGBETOKUN, O. A., OMONONA, B. T. and OGBENNA, G. C. (2014). Effect of climate variability on maize production in selected agro-ecological zones of Nigeria. *African Journal of Food, Agriculture, Nutrition and Development,* 14(5): 2087 – 2101.

EZEAKU, I. E., MBAH, B. N., BAIYERI, K. P. and OKECHUKW U, E. C. (2015). Integrated crop-livestock farming system for sustainable agricultural production in Nigeria. *African Journal of Agricultural Research*, 10(47): 4268 – 4274.

GIREI, A. A., OHEN, S. B., SAINGBE, N. D. and HABILA, A. (2018). Costs and return analysis in poultry egg production in Lafia Local Government Area (LGA) of Nasarawa State, Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, 24(1): 1 – 10.

GONA, A., MOHAMMED, I. and BABA, K. M. (2017). Evaluation of profitability among cattle fattening enterprises in Kebbi State, Nigeria. *Proceedings of the 18th Annual National Conference of the Nigerian Association of Agricultural Economists*. Held at Federal University of Agriculture, Abeokuta, Nigeria, October16th – 19th 2017.

GUPTA, V., RAI, P. K. and RISAM, K. S. (2012). Integrated crop-livestock farming systems: A strategy for resource conservation and environmental sustainability. *Indian Research Journal of Extension Education, Special Issue,* 2: 49 – 54.

HUSSAINI, A. S., OLADIMEJI, Y. U., SANNI, S. A. and ABDULRAHMAN, S. (2019). Determinant and profitability of rice farmer's investment in value addition activities in Kebbi State Nigeria. *Dutse International Journal of Social and Economic Research,* 3(2): 101 – 109.

IYIOLA, T., ANNATTE, I., ADESINA, M. A., OJO, O. A., BUBA, W., NUHU, S., BELLO, M., SALEH, I., YUSUF, A. M., TUKUR, A. M. and HUSSAINI, A. T. (2015). Evaluation of crop-livestock integration systems among farm families at adopted villages of the National Agricultural Extension and Research Liaison Services. *Journal of Agricultural Extension*, 19(2): 46 – 58.

JÄRVAN, M., VETTIK, R. and TAMM, K. (2017). The importance and profitability of farmyard manure application to an organically managed crop rotation. *Zemdirbyste-Agriculture,* 104(4): 321 – 328.

MAJEKODUNMI, A. O., DONGKUM, C., LANGS, T., SHAW, A. P. and WELBURN, S. C. (2017). Shifting livelihood strategies in northern Nigeria-extensified production and livelihood diversification amongst Fulani pastoralists. *Pastoralism: Research, Policy and Practice*, 7(1): 19. https://doi.org/10.1186/s13570-017-0091-3

MALGWI, C. J., MAILUMO, S. S. and AKPOKO, J. G. (2017). Comparative estimation of the costs and returns of integrated fish-based farming systems in Kaduna Metropolis, Nigeria. *Asian Research Journal of Agriculture*, 6(3): 1 – 9.

MANJUNATHA, S. B., SHIVMURTHY, D., SUNIL, A. S., NAGARAJ, M. V. and BASAVESHA, K. N. (2014). Integrated farming system - an holistic approach: a review. *Research and Reviews: Journal of Agriculture and Allied Sciences*, 3(4): 30 – 38.

NBS (2018). *2017 Demographic Statistics Bulletin.* National Bureau of Statistics (NBS), Abuja, Nigeria.

NIENTAO, A., MWANGI, D., AYUYA, O. I. and KERNA, A. O. (2019). Resource optimization in crop livestock integrated production system among small-scale cotton farmers in southern Mali. *Advances in Agricultural Science,* 7(1): 85 – 98.

NPC and ICFI (2014). *Nigeria Demographic and Health Survey 2013*. National Population Commission (NPC), Abuja, Nigeria and ICF International, Rockville, Maryland, USA. https://dhsprogram.com/pubs/pdf/fr293/fr293.pdf

OBASI, P. C., NWAIWU, I. U. O., KORIE, C. O. and TIM-ASHAMA, A. (2016). Evaluation of productivity and profitability of mixed farming enterprises in Imo State, Nigeria. *Sky Journal of Agricultural Research*, 5(4): 56 – 63.

OLADIMEJI, Y. U. and ISAH, S. A. (2019). Economic and potential benefits of recycling used concrete pond water in vegetable production among fish farmers in Kwara State Nigeria. *Nigerian Journal of Fishery and Aquaculture*, 5(2): 104 – 113.

OWEN, E., SMITH, T. and MAKKAR, H. (2012). Successes and failures with animal nutrition practices and technologies in developing countries: A synthesis of an FAO e-conference. *Animal Feed Science and Technology*, 174(3-4): 211 – 226.

SALEH, M. K., ATALA, T. K., OMOKORE, D. F., BEN, A., ALI, F. S. and KAJANG, G. Y. (2016). Performance of improved dairy cattle technologies among farmers in northern Nigeria. *Journal of Agricultural Extension,* 20(1): 1 – 12.

SANI, A. A. and OLADIMEJI, Y. U. (2017). Determinants of technical efficiency among sorghum farmers under agricultural transformation agenda in Gombe State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment,* 13(3):122 – 127.

VILLENEUVE, C., TREMBLAY, D., RIFFON, O., LANMAFANKPOTIN, G. Y. and BOUCHARD, S. (2017). A systemic tool and process for sustainability assessment. *Sustainability,* 9(1909): 29 http://dx.doi.org/10.3390/su9101909

WITJAKSONO, J., SUHARYANTO, and INDRASTI, R. (2018). Developing

integrated crop-livestock farming system as a strategy for green growth in low income countries: a brief review. *Animal and Veterinary Sciences,* 6(1): 12 – 16.

ZAILANI, S. A., MADU, H. K., ABUBAKAR, N. and OMAR, N. A. (2016). Feasibility for a sustainable and profitable local goats production in Nigeria. *Journal of Livestock Science,* 7: 126 – 132.