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Implication of Livestock Rearing on Advancing Household Food Security and Nutrition: A Study of Push-Pull Technology and Livestock Production

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Abstract

Livestock rearing link to food security and nutrition is an important aspect to farmers and research institutions. Push-pull technology, an innovation at International Centre for Insect Physiology and Ecology (ICIPE), has been distinguished as an advocate to livestock growth and production. This Push-pull novelty follows a chain to income boost and household food purchase power. This study sought to establish the perfect link of Push-pull livestock production to an enhanced household food security and nutrition in a case-control study design, where non Push-pull was a control group. The study found that 31% of farmers interviewed were male and 69% were female, a reliability to the study. On number of livestock reared, cattle were 91 in PPT and 88 in NPPT, goats were 59 in PPT and 23 in NPPT, chicken were 526 in PPT and 610 in NPPT, sheep were 54 in PPT and 30 in NPPT and pigs were 26 in PPT and 24 in NPPT (where the n value was 50 households for both PPT and NPPT). Number of egg production was 71/day in PPT and 101/day in NPPT as milk production was 88.5 litres/day in PPT and 40.8 litres/day in NPPT. Income gains from livestock were Kshs. 225,000 in PPT and Kshs. 157,000 in NPPT in cattle which translated to Kshs. 49,000 in PPT and Kshs. 8,000 in NPPT for food purchases respectively. Cattle income had contributed majorly to food purchase. Out of 71 eggs laid in PPT, 54 eggs were consumed and out of 101 eggs laid in NPPT, 81 eggs were consumed within the households. Foods were bought in variety and classified on a household dietary diversity framework and presented on nutrient significance. Finally, the multiple linear regression had reflected several significance values at $p \leq 0.05$ on livestock variables: PPT - 0.000, NPPT - 0.001 for cattle; PPT - 0.036, NPPT - 0.098 for chicken; PPT - 0.000, NPPT - 0.000 for sheep; PPT - 0.000, NPPT - 0.280 for pigs; PPT - 0.000 for eggs; and [PPT, NPPT] - 0.000 for milk. The study concluded that Push-pull in livestock production is efficient and has full aptitude to advance household food security and nutrition. It however recommends a study where equal number of livestock is used in both PPT and NPPT.

Keywords: *Livestock Production; Animal Source Foods (ASF); Food Security; Nutrition; Push-Pull (PPT); Non Push-Pull (NPPT)*

Introduction

Livestock's contribution goes beyond the production of meat, milk and eggs, and a number of factors determine their overall impact on food security [1]. Positive contributions include: (1) the direct supply of essential macro- and micro-nutrients; (2) the contribution of domesticated animals to agricultural productivity through manure and draught power; and (3) the income generated by livestock production at household and national level [2].

Benefits from livestock to food and nutrition security arise both directly (by improving household diet through increasing access to animal source foods) and indirectly (by improving income and ability to purchase more diverse foods) [3,4]. With adequate livestock nutrition, renewable animal source foods (ASF), such as eggs and milk, provide an opportunity for a steady supply of essential micro- and macro-nutrients. Indeed, Drewnowski [5] demonstrated that milk and eggs are one of the lowest cost sources of protein amongst plant and animal source foods.

While some of the global discussion on food security may address the question of the feed/food competition, it often fails to mention the diversity of animal diets around the world and the various levels of efficiency in production systems [6,7]. Animal source foods are a major source of iron, zinc, calcium, riboflavin, vitamin A, vitamin B_{12} and retinol, and increasing the intake of ASF and the micronutrients they contain may have numerous positive benefits including on linear growth, improved educational attainment and health status, leading to long term improvements in income and productivity [8-14].

Animal milk is an excellent source of both macronutrients and micronutrients that promote good nutrition. Milk provides high-quality protein as indicated by the high protein digestibility-corrected amino acid score [15]. Whey and casein concentration combined with high mineral content in cow's milk is recognised to support rapid growth in children [16]. Milk also offers linoleic acid and α-linoleic fatty acids which are important for nervous system development [17]. Milk contains several other critical micronutrients such as calcium, vitamin A, riboflavin and vitamin B_{12} that are essential for growth and development of children older than 12 months [15,18-21].

In a women-focused goat development programme evaluation done in Ethiopia, Ayele and Peacock [22] find a positive effect on milk consumption among recipients, especially among children 6 - 72 months old. A positive association between livestock ownership and nutritional outcomes has also been documented in Uganda [23] and Rwanda [24].

Ownership of livestock can give households more opportunities to increase the consumption of ASF if it translates into cheaper or more reliable access to ASF supplies. This may be likely when markets are poorly developed, and more so for highly perishable products such as milk and dairy, which require investments in refrigeration and other equipment which may not be economically justified in the presence of sparse effective demands for such goods [25].

Whether a link between ownership of livestock and consumption of ASF exist, and under what conditions, is therefore an empirical question. A few studies have attempted to rigorously establish the existence of such a link, and most of them are based on small samples, and rely on data that make it hard to carefully identify the existence of a causal relationship between animal ownership, increased ASF consumption, and nutrition. In a large-scale randomised evaluation study of targeted asset transfer (largely livestock) and skill development programme in rural Bangladesh, Bandiera., *et al*. [26] find a positive impact of the programme on earnings, (food and non-food) consumption, and household food security.

In another evaluation study of a livestock transfer and training programme in India, Banerjee, Duflo, Chattopadhyay, and Shapiro [27] find a significant positive effect on consumption, nutritional intake, and food security. Pimkina, Rawlins, Barrett, Pedersen, and Wydick [28] find a dairy cow and meat goat donation programme in Rwanda to have a positive impact on dairy and meat consumption, respectively. The study also found dairy cow and meat goat acquisition to improve stunting and wasting measures, respectively.

Livestock production is known to provide many incentives at family level including income, quality food, fuel, draft power, building materials, and fertilizer, thus contributing to livelihood of household, food security, and nutrition [29].

A range of interventions have been implemented globally to address malnutrition, ranging from micronutrient supplementation programmes to food-based interventions. For example, school-based food programmes have focused on delivery of animal source foods including milk and meat to children with some positive gains recorded in terms of improvements to cognitive and physical development [30]. And with introduced agricultural interventions involving mixed farming, quality and quantity in livestock production have been witnessed. Quality fodder from the planted farms used to feed the domesticated animals have improved the production of livestock and their products.

It is essential to deliver nuanced, scientifically informed messages about livestock's roles in relation to food systems, livelihoods and their economic and environmental performance [31]. This is because most of the domination goes around crop farming for food. Livestock delivery to food systems is therefore a subject of importance to the country.

In respect to livestock production and its role in food security and nutrition, Push-pull technology (PPT) has been distinguished as a rich contributor of both animal and human nutrition. This is a novel technology that was once invented to manage pests from the farm where crops were planted. Pests such as stemborers and striga had largely subdued crops planted for food. There was eventually little cereal production within different households which hampered food security state. Push-pull technology introduced involved attracting stemborers with Napier grass (*Pennisetum purpureum*), planted on the border of the field as a trap plant (pull),while driving them (both stemborer and striga) away from the main crop using a repellent intercrop (push) such as desmodium forage legumes (*Desmodium* spp.) [32]. Figure 1 shows a Push-pull plot where healthy crops are evidenced. This strategy was identified as a pest management and a cereal production booster. Further more, both Desmodium and Napier grass, grown perennially, continually provided valuable year-round quality animal fodder while the sale of desmodium seeds generates additional income for the farmers. Indeed push-pull farmers have reported the benefits above in addition to increased milk production [33]. Figure 1 displays the layout of the Push-pull strategy.

Figure 1: *A Push-pull technology plot.*

With push-pull, farmers have also been able to establish new enterprises such as dairy and poultry farming which are directly benefiting from push-pull products, with poultry benefiting more from increased grain yields that serve as feed; and from Desmodium leaves, which have become an important protein source for these birds [33]. Figure 2 below shows a photo of cattle revelling in chopped fodder (a feed composed of mixed Napier grass and Desmodium).

Figure 2: *Cattle enjoys being fed on chopped Napier grass and Desmodium leaves.*

The push-pull adopters have intensified this novel technology from a mere pest management to fodder production for livestock feeding. The PPT chain to achieving food security and nutrition through livestock production has therefore been made longer; fodder (Napier grass and Desmodium leaves) production for animal feeds, improved health of animals, animals delivery through milk, eggs and meat, household consumption and income, and household nutritional achievement (macro- and micro-nutrients).

This study sought to establish the perfect chain of push-pull livestock production to an enhanced household food security and nutrition. The basic parameters for this study were identification of livestock rearing practice amongst the push-pull farmers and the contribution chain they made all way to achieving the goal of increased food security and nutrition.

Materials and Methods

Study Design

The study applied a case-control study design [34]. In this design, the case group was defined as Push-pull households (PPT), whereas the control group was the non Push-pull huseholds (NPPT). The PPT case was identified from the registered list of push-pull farmers found in icipe's push-pull database (of registered adopters) and followed up through icipe's regional field staffs. The control group (NPPT) was identified from the PPT adopters neighborhoods to place them centrally for the ease of data collection. For every PPT farmer identified, an NPPT farmer was identified (a matched case-control study). This aided in equitable study of variables.

This study also considered specific types of livestock to be included, that is; cattle, goats, sheep, pigs and chicken. Livestock products were also included; eggs and milk. The variables of the study regarding livestock and livestock products were; type and number of domestic animals reared, livestock that have been sold in the previous six months and income obtained, income used to buy food and the varieties of foods bought.

Study Sites

The study was conducted in Busia, Siaya, Kakamega, Vihiga and Kisumu Counties of Kenya. These counties were selected because they dominantly exhibit a wide range of push-pull farmers [35]. Push-pull technology was initially tried on a Mbita point and established to other areas of the Western Kenya. The dominance of PPT in these areas was attributed to the years of research and tests to make the technology more convenient and advanced. Figure 3 shows the map of the study sites.

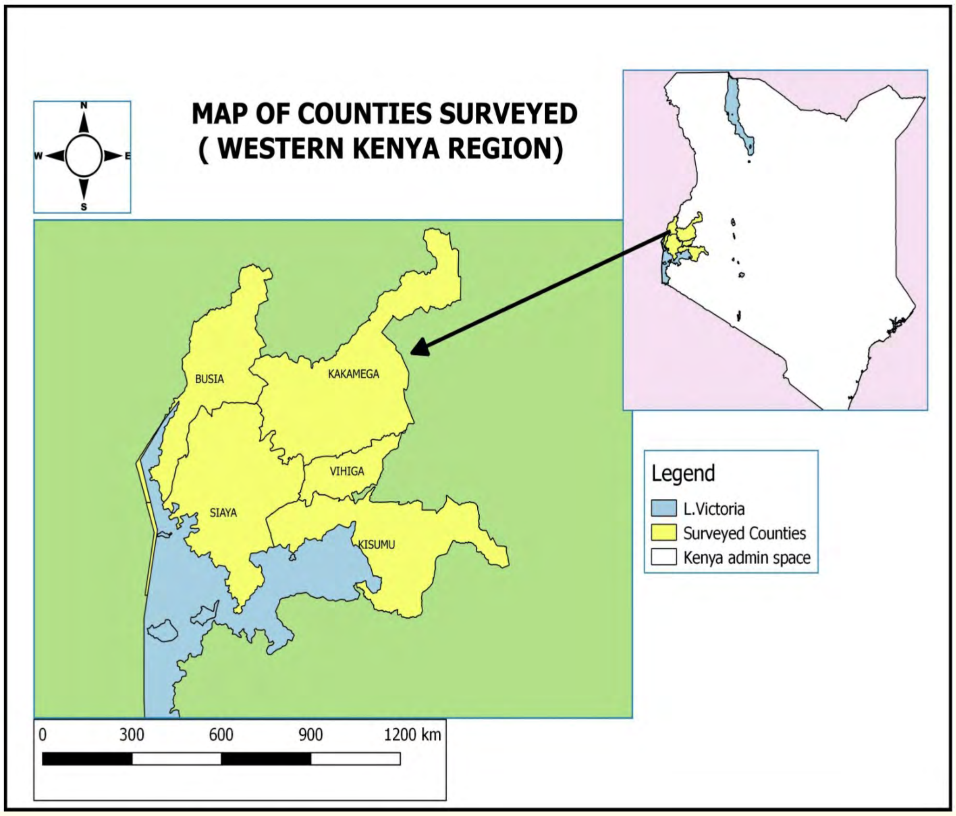

Figure 3: *Map of the study site.*

Target Population

This study targeted the Push-pull and non Push-pull households that reared livestock. A household was defined as people who shared the same cooking pot [36]. Ten (10) Push-pull and ten (10) non Push-pull households were selected for the study per single county of below reference.

Inclusion Criteria

Push-pull and non Push-pull households provided in the list by the field staffs were included in the study. The missing households were replaced by the households not provided in the list but meeting the required criteria for inclusion [34].

Exclusion Criteria

Households selected that did not rear any livestock were excluded from the study. They were rather replaced with households meeting the required criteria for the study.

Sampling Procedure

Two sampling frames were generated; for PPT and NPPT [34]. For every PPT sampled, one NPPT was picked. Sampling was done using clustered random sampling. The controls were identified in the community by the field staffs. The assumption was that each locality of study had same features of the study across the push-pull dominating regions.

Therefore, the sample size was calculated using Eng [37] formula for comparing proportions: The two groups comprising N were assumed to be 1/3 cases and 2/3 controls in number. Therefore, a significant level of 0.05 and a power of 0.95 were chosen with assumption that the difference between the proportions in the control and case groups was 0.17. The equation yielded the sample size of 145 households, out of which 48 households were cases and 97 were controls.

In this study, the adoption of the formula was imitated as precisely as follows: The two groups comprising N formed a half-based proportions to be ½ cases and ½ controls in number, that is, 50-PPT and 50-NPPT. Therefore, a significant level of 0.05 and a power of 0.95 were chosen, with assumptions that the difference between proportions in the control and case groups was 0.5. The equation yielded the sample size of 100 households, out of which 50 households were cases and 50 households were controls.

Data Collection

An open questionnaire was used to collect data from 100 households. The questionnaire was prepared in English and had clearly defined instructions for both case and control groups. The questionnaire was pretested for quality control purposes.

Data Analysis

Data collected were analyzed using statistical package for social sciences (SPSS version 22). Using multiple linear regression, livestock income used to buy food was regressed on number of livestock reared, quantity of fodder produced and the livestock income. Multivariable analyses were conducted using a backward elimination selection process where variables were removed from the model if p values were > 0.05. Associations, where p < 0.05, were retained in the final model. Variables whose removal resulted in a > 20% change in coefficients were considered to have a confounding effect and were included in the final model. Residuals were plotted against the predicted income used for food [38].

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The data on eggs and milk production were checked for accuracy, and analyzed using descriptive statistics. Proportions positive were determined for categorical variables, and ranges, means, quartiles, and medians were determined for continuous variables [39].

Results

Demographic Information

The study featured 28 (28%) of fathers heading the farming activities, 67 (67%) of female heads, 3 (3%) of brother heads, 1 (1%) of sister heads and 1 (1%) other heads. Gender headship presented 31 (31%) of the farmers as male and 69 (69%) as the female. On the households' marital status, 5 (5%) of the farmers interviewed were single, 77 (77%) were married, 18 (18%) were widowed and none was divorced. The mean number of the household members featured in the two groups of households, that is, Push-pull and non Push-pull, were 7.38 and 7.08 respectively. Table 1 shows the demographic statistics obtained from computation of data.

Variable	Category	N	Mean	SEM	SD	Range
Heads	Father	28	1.8	0.064	0.636	4
	Mother	67				
	Brother	3				
	Sister	1				
	Others	1				
	Total	100				
Gender	Male	31	1.69	0.046	0.465	1
	Female	69				
	Total	100				
Marital Status	Single	5	2.31	0.083	0.825	3
	Married	77				
	Divorced	0				
	Widowed	18				
	Total	100				
Mean Number of households members	PPT (n = 50) = 7.38, NPPT (n = 50) = 7.08					

Table 1: *Descriptive Statistics of Demographic variables for all households.*

SEM: Standard Error of Mean; SD: Standard Deviation; N: Number of Households (100)

Livestock and Livestock Products Production, Income and Food Expenditure

In this study (case-control study), the results of the case was run alongside the control to determine the distinction. This means that the statistical values, quantities and amounts of variables from Push-pull households (case) was compared to those from non Push-pull households (control). On this statistical aspect, the total number (sum) of cattle reared was 91 in PPT and 88 in NPPT, goats were 59 in PPT and 23 in NPPT, chicken were 526 in PPT and 610 in NPPT, sheep were 54 in PPT and 30 in NPPT, and pigs were 26 in PPT and 24 in NPPT. Eggs and milk were the most considered livestock products featured in this study. The data computed was for a daily basis on egg laying or milking season (a sum obtained in both groups of households). Eggs produced in PPT households (n = 50) were 71/day while NPPT households (n = 50) produced 101/day. Milk produced in PPT households (n = 50) was 88.5 litres and 40.8 litres in NPPT households (n = 50).

The sales of the livestock dated from the past six months. This was captured as a household income from the specific livestock. The values do not mean that all the households had sold the livestock. Only few households from both groups had sold their livestock owing to the needs they had at hand. Income figures showed that cattle had a higher amount of income in both PPT and NPPT with PPT having Kshs. 225,000 and NPPT, Kshs. 157,000. Goats obtained Kshs. 11,900 in PPT and Kshs. 6,500 in NPPT, chicken had Kshs. 52,600 in PPT and Kshs. 40,250 in NPPT, sheep had Kshs. 9,000 in PPT and Kshs. 14,800 in NPPT, and pigs had Kshs. 41,000 in PPT and Kshs. 41,300 in NPPT. Eggs and milk had also given a daily contribution of (Eggs) Kshs. 310/day in PPT while 0 in NPPT, and (milk) Kshs. 3,200/day in PPT while NPPT obtained Kshs. 1,213/day.

The income obtained by farmers from livestock and livestock products was further investigated on how much they attributed to the food expenses. Push-pull households had spent 21.8% of cattle income on food while NPPT had spent 0.05% of the cattle income on food. Income from goats had a nil contribution for food in both groups. Chicken income contributed 16.5% in PPT for food and 17.3% in NPPT. Sheep income had contributed 0% for food in PPT and 0.03% in NPPT. Pigs income had contributed 25.6% for food in PPT and 0.02% for food in NPPT. For eggs and milk, there was essential contribution for food in PPT per single day. The income from eggs had contributed 80.6% for other foods per day in PPT. NPPT had no income gained from eggs. While income from milk contributed 28.8% for other foods in PPT and 66% in NPPT. Table 2 summarizes the descriptive statistics of the livestock and livestock product's number/quantity, income gain and income used for food.

Livestock and livestock products	Number Reared/Quantity Produced		Income obtained from sales		Income used for other foods	
	PPT (n = 50) (Sum)	NPPT (n = 50) (Sum)	PPT (n = 50) (Sum in Kshs)	NPPT (n = 50) (Sum in Kshs)	PPT (n = 50) (Sum in Kshs)	NPPT (n = 50) (Sum in Kshs)
Cattle	91	88	225,000	157,000	49,000	8,000
Goats	59	23	11,900	6,500	0	0
Chicken	526	610	52,600	40,250	8,700	6,950
Sheep	54	30	9,000	14,800	0	500
Pigs	26	24	41,000	41,300	10,500	1000
Eggs	71[a]	101[a]	310[c]	0[c]	250[c]	0[c]
Milk	88.5[b]	40.8[b]	3200[c]	1213[c]	921[c]	800[c]

Table 2: *Descriptive statistics of livestock and income comparing between PPT and NPPT Households.*

[a]: Number of eggs produced per day

[b]: Quantity of milk produced in litres per day

[c]: Amount in Kshs obtained/used per day

Household Consumption of Eggs and Milk

Livestock products (that is, eggs and milk) contributed quite fairly to the household food consumption. Out of 71 eggs laid in PPT, 54 were consumed within the households - which is 76.1% consumption of eggs laid, while NPPT had consumed 81 eggs out of 101 - which is 80.2% consumption of eggs laid. For milk, 16 litres were consumed in PPT households - 18.1% of the milked quantity and 8.3 litres were consumed in NPPT households - 20.3% consumption of milked quantity. Table 3 shows the number of eggs and quantity of milk consumed per day and their proportions.

Products	PPT Households		NPPT Households	
	Number/Quantity Consumed	Proportion (%)	Number/Quantity Consumed	Proportion (%)
Eggs (number)	54*	76.1	81*	80.2
Milk (litres)	16	18.1	8.3	20.3

Table 3: *Comparative analysis of eggs and milk consumption between PPT and NPPT households.*

**: Composed of both hatched and domestically consumed eggs.*

Food Variety by Purchases

An analysis done on the variety of foods purchased by the PPT households on a spread timing had showed significant groups of foods as in table 4. The study was specific on PPT because it was the case group and it encompassed quite a range of food groups (a classification in the household dietary diversity score framework).

Food Groups	List of food items bought in the PPT households
A: Any foods made from maize, sorghum, millet, rice, wheat	Maize, sorghum, rice, wheat
B: Any potatoes, yams, cassava etc	Irish potatoes, sweet potatoes
C: Any vegetables	Traditional vegetables, kales, tomatoes, onion
D: Any fruits	*Occasionally obtained
E: Any meat or meat products	Meat
F: Any eggs	*Obtained from the laid eggs
G: Any fish	Dagaa, tilapia, nile perch
H: Any foods made from beans, peas, lentils or nuts	Green grams
I: Any milk or milk products	Milk
J: Any foods made with oil, fat	Cooking fat/oil
K: Any sugar or honey	Sugar
L: Any beverages e.g. coffee, tea or cocoa	Sugar, salt, tea leaves

Table 4: *Varieties of food purchased within PPT Households in wide range period.*

Multiple Linear Regression

The study used multiple linear regression to determine if livestock quantity and sales/income was a possible predictor of food expenditure in food security and nutrition. The regression statistics showed several significances in both PPT and NPPT. Cattle, sheep and milk variables showed significances at $p \leq 0.05$ for both PPT and NPPT. Goat variable had no significance in PPT and was not computable in NPPT. Chicken variable was significant in PPT and insignificant in NPPT. Eggs variable was significant in PPT and uncomputable in NPPT. Table 5 shows the regression statistics done on livestock production and income for food.

Variable	R Square		Regression Mean Square		F-Value		t-Value		Significance value	
	PPT	NPPT	PPT	NPPT	PPT	NPPT	PPT	NPPT	PPT	NPPT
Cattle	0.440	0.298	149408103.7	2853905.44	11.800	6.512	5.287	4.097	0.000**	0.001**
Goat	0.012	N/C	4066871.45	N/C	0.186	N/C	-0.100	N/C	0.906	N/C
Chicken	0.100	0.127	427223.958	288191.141	1.708	2.223	2.162	2.609	0.036**	0.098
Sheep	0.799	0.837	65238.124	57246.957	60.889	35.946	12.729	-0.413	0.000**	0.000**
Pigs	0.346	0.281	4042499.853	25831.131	7.953	1.317	4.028	0.514	0.000**	0.280
Eggs	0.902	N/C	8595.072	N/C	217.204	N/C	2.221	N/C	0.000**	N/C
Milk	0.632	0.848	20253.947	60679.906	15.658	130.962	0.760	0.670	0.000**	0.000**

Table 5: *Multiple linear regression statistics on livestock production and income for food.*

*** Significant at $P \leq 0.05$*

N/C: Not Computable

a: Dependent variable (predictor variable): Income for food.

b: Independent Variables: Quantity of fodder for livestock feeding, Number of livestock and livestock products, and income gained following livestock sales.

Discussion

The roles of livestock in the developing world are many, spanning from the social to the economic, to the environmental. At the same time, they can be positive (i.e. income) or negative (i.e. pollution). These roles can shift depending on location. Whether for its positive or negative roles, livestock are in the spotlight. It is essential to dissect the discussion on the roles of livestock, as the economic development of different countries, their structure of production, the demand for livestock products, the competition with other sectors and others shape these roles, making broad generalisations about the livestock sector useless (and dangerous) for informing the current global debates on food security and the environment [31].

This study determined how efficient livestock rearing aided in household food security and nutrition. The demographics featured more female heads than males. A study by Ogot., *et al*. [35] showed that gender equality had remained a major target amongst many regions and that the transformation can be enhanced with improved information about the range of inequalities and specific constraints facing women. That study further stated that a simultaneous and integrated pursuit of such information and transformation is essential for gender equality and food security strategies to complement each other and maximize their synergy.

Marital status composing of both father and mother (married couples) as the majority in marital status provided a stability and reliability for this study. Ogot., *et al*. [35] states that with the households of more married couples, the nutritional status anticipated was a majority of nutritionally normal children. Finally, the average number of household members was also an important aspect of food security determination; still PPT showed a slightly more value. The number of the family members in PPT shows the extent to the provision and distribution of household food expenditure.

The number of livestock in PPT households was relatively more than in NPPT households except in chicken. Chicken were likely dominant livestock reared amongst the households with PPT having 526 and NPPT - 610; cattle, goats, sheep and pigs followed in descension. The number of animals kept have always acted as reservoirs of wealth. Deshingkar., *et al*. [40] states that although livestock ownership is often seen as a sign of wealth - household typically move up the 'livestock ladder' from poultry to goats or sheep, to cattle/buffalo. In time of requirement or need, they are sold to avail income for other needs and the higher the 'livestock ladder', the better the income. According to nationally representative data from across the developing world, 68% of households earn income from livestock [41].

Most of the farmers have majorly used income from livestock for household education and health expenses. However, this study focused on the livestock income contributed for food; a basis to determining food security and nutrition. The income obtained from livestock in both PPT and NPPT is quite comprehensive with PPT incomes having comparatively greater amounts. The significance of PPT lies on number of livestock and income obtained which runs far above NPPT's values. Cattle income is quite enormous and contribute a relatively more cash for food, but with PPT's amount six times as NPPT's. All PPT's livestock amounts that contributed to food exceeded the NPPT's.

Eggs and milk have shown a precise correspondence on number of chicken and cattle producing them respectively. Chicken were more in NPPT than in PPT; so the number of eggs produced per day are more in NPPT than in PPT. The case applies with milk production where, on daily basis, the quantity of milk produced per day in PPT was more than in NPPT (over twice the value of NPPT's) as seen in table 2. Milk production is highly attributed to the fodder production. Napier grass and Desmodium have been established to be greater contributor to milk production due to its richness in essential nutrients for cattle's health. PPT offers these livestock feeds from farm and feeds the livestock even for more milk production. Therefore, milk is obtained in a relatively higher quantity in PPT than in NPPT that have no these fodder crops.

Furthermore, the income obtained from eggs and milk are quite opposite to the number/quantity produced. Non Push-pull households evinces higher number of eggs produced but with a lower income gain compared to PPT, and it so applies in income used for food.

Carlo., *et al.* [25] findings confirmed that the herd size bore a significant effect on animal source foods consumption after controlling of confounding factors, potentially endogenously correlated with their variable of interest. Apparently, in this study, NPPT consumes more eggs at 80.2% of number produced per day owing to the larger number of chicken and egg production. With milk, PPT consumption features double the quantity of milk consumed in NPPT per day owing to fodder richness by PPT. There are more quantities sold and more quantities consumed altogether in PPT while quantities sold and quantities consumed in NPPT household are quite less in comparison.

The diversity of foods purchased by the PPT households is explained on the basis of nutrient composition. The household dietary diversity score food grouping provides a framework to define the nutritional attainment by the PPT households. Table 6 highlights the food groups in correspondence to nutrients.

Food Groups	List of food items bought in the PPT households	Main Nutrients
A: Any foods made from maize, sorghum, millet, rice, wheat	Maize, sorghum, rice, wheat	Carbohydrates, protein, fibre, B vitamins, folate, thiamin, riboflavin, niacin, iron, Vitamin E, Zinc, Magnesium, Phosphorous
B: Any potatoes, yams, cassava etc	Irish potatoes, sweet potatoes	Carbohydrates, proteins , potassium, zinc, magnesium, copper, iron, manganese, vitamin K, folates, thiamin, pyridoxine (vitamin B-6), riboflavin, and pantothenic acid
C: Any vegetables	Traditional vegetables, kales, tomatoes, onion	Potassium, dietary fiber, folate (folic acid), vitamin A, and vitamin C.
D: Any fruits	*Seasonally obtained	Potassium, dietary fiber, vitamin C, and folate (folic acid).
E: Any meat or meat products	Meat	Protein, B vitamins (niacin, thiamin, riboflavin, and B6), vitamin E, iron, zinc, and magnesium.
F: Any eggs	*Obtained from the laid eggs	Iron, vitamins (A,D,E, B12), folate, protein, selenium, lutein and zeaxanthin and choline
G: Any fish	Dagaa, tilapia, nile perch	Protein, Omega-3-fatty acids, vitamin D, riboflavin, Calcium, phosphorous, iron, zinc, iodine, magnesium and potassium
H: Any foods made from beans, peas, lentils or nuts	Green grams	Protein, alphalinolenic acid, carbohydrates, folate, iron, zinc, calcium, magnesium, fibre, isoflavones, lignans, protease inhibitors and phytoestrogens in soy beans.
I: Any milk or milk products	Milk *Also seasonally obtained from the cattle milked.	Protein, carbohydrates, Vitamins(A, B12, B6, D), riboflavin, niacin, thiamine, pantothenic acid, folate, calcium, magnesium, phosphorous, potassium, zinc and Potassium
J: Any foods made with oil, fat	Cooking fat/oil	Monounsaturated and polyunsaturated fatty acid, Vitamin K and E
K: Any sugar or honey	Sugar	Carbohydrates
L: Any beverages e.g. coffee, tea or cocoa	Sugar, salt, tea leaves, coffee	Calcium, vitamin D, Sodium, Potassium and Chloride

Table 6: *Varieties of foods purchased and their nutrient fulfillment in HDDS framework [35].*

Regression statistics points out the predictability of income for food attributed by fodder quantity, livestock number and income gain from livestock sales. The significance values indicate that feeding the livestock with Push-pull's fodder promote their production (in number and products produced) and income gain from sales of livestock contribute effectively to income for food (an element to diet diversity).

Conclusion

Livestock rearing has the greatest potential to achieving household food security and nutrition. This study has reflected several statistical and theoretical significances from main variables defining the study. The number of livestock have shown a crucial bearing on products produced and income gained. The income gain is also identified to attribute to income used for household food expenditure. The foods purchased are varied and fits in a balanced diet model through the HDDS framework. However, there are distinct differences between the values of PPT and NPPT. The study derives an inclusive conclusion on significantly greater values observed in PPT as compared to NPPT.

As a case-control study, the case group occupies the positive position because PPT contribution through livestock rearing is notable, and advancement of food security and nutrition is easily identified. Furthermore, the regression statistics mark the significance values which indicate that livestock production is efficient and effective towards contribution of food security and nutrition through product consumption and income (specifically for food).

Therefore, livestock rearing in PPT has a full aptitude to advance household food security and nutrition and can promote a healthy and nutritionally stable households with less cases of malnutrition.

Recommendation

In an open case-control study, it is difficult to equalize the variables of both groups. This study may further require a threshold where the number of livestock studied in both groups are the same. To determine the completeness of food security and nutrition by livestock, a timely study sshould be done in the closet of the objectives, and the variables should include specific and same quantities of fodder in Push-pull livestock (Napier grass and Desmodium) and in non Push-pull livestock (other feeds used for livestock feeding). With equalized numbers of livestock, eggs and milk production, income obtained sand income used to buy food for households can be accurately determined to showcase the difference in efficiency between PPT and NPPT in livestock rearing. Nutritional assessment through diet diversity and anthropometry can then be used to optimize the study.

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