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Economic and financial returns of livestock agribusiness in the high mountains of Nepal

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Abstract

Development partners and donor agencies often target programs and projects in poverty stricken and vulnerable regions around the world. However, there is paucity on economic and financial analysis of such investments. This study contributes to the literature by assessing financial internal rate of return (FIRR) and economic internal rate of return (EIRR) of livestock agribusiness, a vital component of 'High Mountain Agribusiness and Livelihood Improvement' (HIMALI) project supported by the Asian Development Bank (ADB) from 2011 to 2018 in ten mountain districts of Nepal. The analysis employs a unique dataset on annual cost (investment, operation and labour) and revenue of 138 livestock agribusiness from 2013 to 2017. The study estimates the EIRR and FIRR of six important livestock species namely, goat, sheep, mountain goat known as *chyangra*, *chauri* (a cross-bred of yak and local hill cow), cattle and pig raised in high uplands of Nepal. The overall EIRR of livestock agribusiness is 15 % with the highest EIRR observed for sheep (18 %), followed by goat (16 %), *chauri* (14 %), *chyangra* (14 %) and pig (12 %) farm enterprises. By contrast, the overall FIRR of livestock agribusiness is just 12 %. Sensitivity analysis shows that the livestock agribusiness is highly sensitive to changes in revenue and operation costs. Some of the major challenges identified are lack of veterinary services and capital to scale-up agribusiness, inadequate market linkages, and limited pasture land. Among livestock agribusiness, sheep, goat, *chyangra*, and *chauri* have a high potential in high mountains. However, the low FIRR indicates a high risk to agribusiness. The study therefore recommends local, provincial and federal governments to deliver reliable extension services, improve market access and provide financial support to ensure the financial sustainability of livestock enterprises in the most difficult and economically lagged region of the country.

Keywords: Livestock, economic returns, financial returns, agribusiness, mountains, sustainability, Nepal

1 Introduction

Given the harsh climatic conditions and difficult geographical terrain, mountain dwellers in Nepal experience more hardships than people living elsewhere in the country (Hunzai *et al*., 2011). With limited road networks, lack of basic facilities such as healthcare and education, and scarce employment opportunities, poverty is deep and widespread in the mountains of Nepal (Ellis-Jones, 1999; Rijal, 2011). Although agriculture is a lifeline for majority of mountain people, mere farming has been unable to enhance their livelihood and resilience (Burris, 2015). Own food production is not enough to meet annual household consumption, leading to high-level of food insecurity and under-nutrition (prevalence of stunting and underweight in children under 5 years of age), particularly in high mountains of Nepal (NDHS, 2011; NPC, 2013; Thapa, 2016).

Climate change has been a major threat to mountain livelihood. Erratic rainfall, increasing floods and landslides, drying up of springs and water bodies coupled with rising cases of livestock diseases and crop pests have become more prominent in high mountains of Nepal and adjoining Himalayan belt (Rasul *et al*., 2019). Degradation of vegetation cover and loss of soil nutrients due to erosion have reduced livestock productivity (Afzal *et al*., 2008). Though local breeds of livestock are an important source of food for mountain people, its population has been declining over the years in high uplands due to climate-induced degradation of rangelands and varying preferences for types of livestock (Rasul & Hussain, 2015; Wu *et al*., 2016; Rasul *et al*., 2019). These have severe implications for mountain livelihood.

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In this backdrop, development partners and donor agencies in Nepal have increasingly prioritised programs and projects aimed at improving livelihood of mountain people. They have supported agriculture and livestock development projects of the Government of Nepal. For instance, the World Bank has been supporting 'Nepal Livestock Sector Innovation Project' aimed at increasing productivity, enhancing value addition, and improving climate resilience of smallholder farms and agro-enterprises. The World Bank has recently completed 'Project for Agriculture Commercialization and Trade' aimed at improving competitiveness of smallholder farmers and agribusiness in selected commodity value chains (World Bank, 2014). The Asian Development Bank (ADB) has successfully supported 'Third Livestock Development Project' from 1996 to 2003. The project aimed at improving livestock productivity and developing alternative market outlets for livestock and livestock products (ADB, 2006). ADB also supported 'Commercial Agriculture Development Project' from 2006 to 2014 that prioritised commercial farming via marketing and processing of high value crops (ADB, 2015). Despite the implementation of multimillion-dollar projects on agriculture and livestock development, literature on assessment of financial and economic returns of such projects is scarce. This paper contributes to the literature by estimating economic and financial rate of returns of livestock agribusiness, a vital component of 'High Mountain Agribusiness and Livelihood Improvement' (HIMALI) project supported by ADB in Nepal.

The Government of Nepal implemented HIMALI project from 2011 to 2018 in ten mountain districts (ranging from 2,500 – 5,000 m asl) of Nepal. The major objectives of the project were to: a) achieve a sustainable improvement in the livelihood of mountain people; b) initiate value chain development of niche products; and c) create additional income and employment through agribusiness (ADB, 2011). The project provided grants of about 80 % of the total investment cost for starting or scaling up agribusiness to targeted households. The remaining 20 % of the investment was financed by project beneficiaries. They were selected based on the submitted business proposals that justified financial and economic viability and were in accordance with project objectives. The selection was done by an independent committee called Grant Assessment Committee consisting of three members: business development expert, finance expert and social safeguard expert. The project financed 640 farm and livestock agribusiness, also known as sub-projects (SPs), including agro-processing enterprises across Nepal's Himalayan region. These farm enterprises are owned and operated by private entrepreneurs. Many of them are registered with cooperatives. The range of grant supported was from minimum of Rs 2,40,840 ($ 2,230) to maximum of Rs 22,499,978 ($ 208,333)[1].

Based on the nature of commodities, the SPs were classified under five sub-sectors, namely, i) Fruits; ii) Livestock; iii) Medicinal and aromatic plants and non-timber forest products; iv) Vegetables and spices and v) Miscellaneous. Given the significant share of investment in livestock subsector (Table 1) and its importance at the household and national level, this study focuses on the livestock sector. Livestock products contribute about 11.5 % of Nepal's gross domestic product (GDP) and 25.7 % of agricultural GDP [CBS, 2011; MoALD, 2014]. They not only provide draught power and organic manure but also nutritious food in the form of meat, milk and dairy products. Although the contribution of livestock to household income has reduced from 8.8 % in 1996 to 5.5 % in 2011 in Nepal, it still contributed an average of about Rs 8,239 ($76.3) to annual household income in 2011 (CBS, 2011).

The study estimated the financial internal rate of returns (FIRRs) and economic internal rate of returns (EIRRs) of complex and real-world livestock interventions targeted in high mountains of Nepal. Although, there are several livestock enterprises supported by the project, we considered only those investments with a share of at least 5 % (Table 2). The livestock enterprises included in this study are cattle (cows and buffalo), goat, sheep, pig, mountain goat known as *chyangra*, and *chauri* (a cross-bred of yak and local hill cow) husbandries. These six enterprises contributed about 94.2 % of the total investment on livestock sub-sector. The study also explored challenges in promoting and sustaining livestock agribusiness and provided policy recommendations to upscale these. This is a unique study that estimates economic and financial returns of livestock agribusiness covering ten mountain districts of Nepal.

2 Materials and methods

2.1 Study context

The Himalayas of Nepal lies in the Hindu Kush Himalayan (HKH) belt that stretches 3,500 km across eight countries ranging from Afghanistan in the west to Myanmar in the east (ICIMOD, 2020). Livestock has been an integral part of a large majority of subsistence households in the HKH region and played an important role in human food and nutritional security and livelihood enhancement. The most raised livestock species in the case of mixed crop farming in the

[1] 1 US dollar equivalent to Nepali Rupee 108 used as per the average annual exchange rate in 2016.

Table 1: *Distribution of sub-projects and investment allocated to the sub-sectors of the High Mountain Agribusiness and Livelihood Improvement (HIMALI) project.*

Sub-sectors	*Number of sub-projects*	*Share of sub-projects (% of total)*	*Investment (ten thousand US $)*	*Share of investment (% of total)*
Fruits	81	12.7	275	13.7
Livestock & Poultry	348	54.4	1034	51.6
Medicinal aromatic plants and non-timber forest products	97	15.2	359	17.9
Miscellaneous*	32	5.0	158	7.9
Vegetables & Spices	82	12.8	181	9.0

* Miscellaneous sub-sector includes rainbow trout, bee-keeping, agro-tourism, bakery production, bio-briquette production, black grams/beans production, herbal tea production, incense production, and local food processing.
The entire analysis uses US $1 equivalent to NPR 108 as per the average annual exchange rate prevalent in 2016.

Table 2: *Number of sub-projects and amount of investment in livestock agribusiness of the High Mountain Agribusiness and Livelihood Improvement (HIMALI) project.*

Sub-sectors	*Number of sub-projects*	*Share of sub-projects (% of total)*	*Investment (ten thousand US $)*	*Share of investment (% of total)*
Cattle Farming*	27	7.8	100.00	9.7
*Chyangra**	25	7.2	59.54	5.8
Goat Husbandry*	138	39.76	365.74	35.4
Slaughterhouse	4	1.2	14.17	1.4
Dairy establishment	3	0.9	8.88	0.9
Mule	1	0.3	1.49	0.1
Piggery*	22	6.3	62.87	6.1
Rural Poultry/Hatchery	1	0.3	6.08	0.6
Sheep Husbandry*	71	20.4	212.96	20.6
Wool, Pashmina	2	0.6	3.75	0.4
Yak Cheese	4	1.2	25.28	2.4
Yak/*Chauri* Husbandry*	50	14.4	173.15	16.7
Total	348	100	1033.92	100

* Indicates those livestock agribusiness sectors considered in the analysis.

HKH region are cattle, sheep and goats (CBS, 2011). Although a mountain household in Nepal typically raises about ten head of livestock in 1998 (Shrestha, 1998), the size has reduced to about six head of livestock in 2017 (MoALD, 2017). The HIMALI project provided grant including technical know-how, extension services and market linkages to promote agro- and livestock enterprises in high mountains of Nepal.

This paper analyses economic and financial viability of goat, sheep, pig, *chyangra*, *chauri* and cattle enterprises given their vital contribution to mountain livelihood. Various studies argue that goat husbandry is a more lucrative livelihood option in high mountains compared to other livestock species for many reasons (Tulachan & Neupane, 1999; Baruwa, 2013; Monteiro *et al*., 2017). First, goats can feed on a wide range of fodder, grass and shrubs that grow around the homestead. Their feed requirements are nominal compared to large ruminants like cows and buffaloes (Tulachan & Neupane, 1999). Second, goat farming can be done with low capital but promises a high return on investment in two years' time. Third, goats are enduring and can adapt to harsh climatic conditions compared to other livestock species (Baruwa, 2013; Monteiro *et al*., 2017). Goats require relatively low level of inputs for a moderate level of production and reach maturity early; thus making goat farming a profitable venture (Devendra & Burns, 1980; Monteiro *et al*.,

2017). Afridi *et al*. (2009) estimate costs, returns and factor productivity in livestock enterprises in the northern areas of Pakistan. The study argues that livestock is a crucial element of the farming system and find that goats and sheep are more profitable ventures due to high grazing and reproduction potential.

Sheep farming is highly popular among smallholder farmers in high mountains of Nepal (Ghimire, 1992; Upreti & Shrestha, 1996). The farming can be initiated with low level of investment as the materials for constructing sheds can be sourced locally. Their wool can be sheared at about 1.5 years of age and are easily sold in the market. Sheep and goats can graze in rocky mountain terrain and alpine pastures, which are not accessible to other livestock species. They can adapt to varying climatic conditions. Depending on the availability of pastureland, they can be either stall-fed or grazed (Ghimire, 1992). In mountains of Nepal, sheep farming is more dominant as they provide a stable source of cash earnings, meat as a source of protein and manure for enriching soil fertility (Rauniyar *et al*., 2000; Neupane *et al*., 2018). Interestingly, HIMALI project has largely emphasized on goat and sheep husbandries with 138 SPs on goat and 71 SPs on sheep farming. These two commodities contribute more than 50 % of the investment allocated in the livestock sub-sector. Cattle farming is one of the common livestock species in the mixed crop-livestock farming system, prevalent in the Himalayan subtropical mountains of Nepal and India (Tulachan & Neupane, 1999; Partap, 2011). It not only provides draught power but also meat, milk and manure for households. HIMALI project supported twenty-seven SPs on cattle farming (about 10 % of the livestock investment) with the major objective of meeting milk demand at the district level. Improved cow breeds were provided to grant recipients. The project also supported 22 SPs on pig farming, comprising 6 % of the livestock investment.

chyangra, a local name for Himalayan goats, are localised species in the Trans-Himalayan region. They are well adapted in high mountain districts like Mustang, Humla and Dolpa of Nepal. The value of *chyangra* farming lies in the meat and is considered as a niche product. Its meat is of high demand and sold in the domestic market at premium prices. Besides meat, they produce the finest quality of cashmere wool used for making pashmina and shawls. These products fetch high market prices in local and international markets (GIZ, 2012). Nepal pashmina industries association has created a unique brand for their products by launching the *chyangra* pashmina logo in 2011. This has resulted in a remarkable export growth over the years. The brand has been trademarked in 47 countries (Tran & Ramsay, 2018). Furthermore, *chyangra* farming for pashmina can be a good source of employment and curb the increasing outmigration (Prevot, 2011; GIZ, 2012).

The project also supported yak/*chauri* husbandry that constitute an investment share of about 17 %. *chauri* (cross bred of yak and local hill cow) husbandry is popular in high mountains where there is well managed grazing/pastureland. They are more productive than naks (female yaks) and are adaptive to lower altitudes. *chauri*s are mainly reared for milk and milk products such as yak cheese which is popular among tourists. The project supported construction of four slaughterhouses and three dairy establishments in the districts to enhance meat and milk value chain linkages. The project also provided agribusiness management trainings, organized workshops and demonstration visits to different districts to enhance livestock agribusiness skills of the entrepreneurs.

2.2 *Data collection*

The Project Management Unit (PMU), established by the Ministry of Agriculture and Livestock Development, formed a survey team to collect field data. Enumerators were hired and special training was provided for data collection. Majority of the enumerators were social mobilizers from project beneficiary districts. The project collected data on investment, operation and labor cost, and revenue generated per year by all sub-projects (640) from 2013 to 2017. However, this study solely focused on the livestock SPs (348) as more than 50 % of the total SPs were allocated to the livestock sector. As shown in Table 3, the SPs were targeted based on the livestock development potential of the different districts. For example, *chyangra* and yak are suitable in Mustang, Humla and Dolpa while goat and sheep are suitable in most of the mountainous districts. Therefore, the total number of SPs were the highest for goats followed by sheep, yak/*chauri*, cattle, *chyangra* and pigs.

During the project implementation, telephone numbers of all the beneficiaries were collected. Although, we tried to call all of them to validate the field observations, we were only able to contact 132 of them[2]. The other objectives of telephone calls were to understand challenges faced by livestock enterprises and assess their sustainability[3].

2.3 *Economic and financial analysis*

Cost and revenue data of individual sub-projects from 2013 to 2017 formed the basis for conducting economic and

[2]In the absence of valid sampling approach, we do not claim that these beneficiaries are representative of enterprises and districts selected for the study.

[3]The telephone interviews with grant recipients were conducted from November to December 2019.

Table 3: *Distribution of sub-projects over the project districts.*

Row label	*Dolakha*	*Dolpa*	*Humla*	*Jumla*	*Manang*	*Mugu*	*Mustang*	*Rasuwa*	*Sankhuwasabha*	*Solukhumbu*	*Grand Total*
Goat Husbandry	42	16	19	6	1	12	2	24	10	6	138
Sheep Husbandry	4	15	9	19	3	9	4	4	4		71
Yak/*Chauri* Husbandry	11	7	6	1	9	1	5	8		2	50
Cattle Farming	11			2		3	2	1	5	3	27
Chyangra		4	5		3		13				25
Piggery	13							1	6	2	22
Yak Cheese	1				1		1			1	4
Meat			1			3					4
Milk			1				1	1			3
Mule			1								1
Rural Poultry/Hatchery		1									1
Wool, Pashmina		1				1					2
Grand Total	82	44	42	28	17	29	28	39	25	14	348

financial efficiency of livestock sub-sector. The revenue, operation and labour cost beyond project implementation period were forecasted based on current assessment from field observations, literature review and interactions with beneficiaries and subject specialists. A model was developed for each commodity, where appropriate, under the current scenario and suitable assumptions were made while projecting benefits and cost streams. In commodities such as goat and pigs, some beneficiaries'/grant recipients had shut their business operations. In such cases, terminal value of stock was assigned, and future streams of revenue and cost were adjusted accordingly.

The SPs cost included investment (grants and recipients' contribution), annual operation expenditure and labour cost. Project net-benefits were calculated by deducting annual gross revenue from annual total cost. While calculating cost-benefit analysis, one should quantify net-gain/net incremental benefit of the project employing 'with and without' scenarios. But before the project intervention, all the beneficiaries of HIMALI were basically engaged in subsistence farming with little or no commercial farming at all. Therefore, economic analysis of the project did not account for value/benefit of 'without project' scenario. The indirect benefits from livestock agribusiness development were not considered in the analysis because of difficulty in monetizing approximate benefits on huge spill-over effects. Since there were several potential indirect and non-quantifiable benefits such as improved environmental sustainability of livestock activities, the estimated economic returns of the livestock agri-business were likely to be downward biased.

We assumed life of the project to be 20 years (2013-2032) including project implementation period. A 12 percent discount rate[4] was used as an opportunity cost of using capital to bring the future value of enterprises into the present value and estimate net-present values. These assumptions were based on ADB (2017) i.e. the ADB guidelines for the economic analysis of the project. The life of the 20 years and the 12 % discount rate was a standard rate used for any economic analysis of the project. Given the remoteness and very limited or no connectivity with international markets, we assumed that livestock and livestock products of high Himalayas were traded locally. Therefore, all goods and services were treated as non-traded and thus financial prices have been converted into economic prices using 0.9 as the standard conversion factor[5]. All labour employed were assumed to be unskilled and so, shadow wage rate of 0.75 of the market wages has been used to compute economic values. All the economic values are expressed in nominal prices. Thus, no deflator has been used to adjust for inflation. Any transfer payments (taxes, subsidies etc.) were excluded in calculating economic values. The benefits for different commodities were estimated based on the assumption that a farm enterprise maintains a constant herd of livestock with rising productivity. For majority of the commodities, cost and revenue streams were assumed to increase till the tenth year (2022) and remained constant from the eleventh year (2023) onwards. While conducting financial analysis, actual cost (operation, labour, investment) and revenue received were used in addition to accounting for depreciation of capital investment and tax paid by enterprises. The depreciation of fixed assets has been estimated using straight

[4]It is the interest rate used in discounted cash flow analysis to determine the net present value of future cash streams. The 12 percent discount rate is used because this is what one could earn as an average annual interest on fixed deposit savings in finance companies operating in Nepal.

[5]All goods and services were treated as non-traded means that the products (such as ghee, milk, wool etc.) obtained from the SPs were mainly the niche products and were consumed within the domestic markets.

line method. We estimated net-present values (NPVs), internal rate of returns (IRRs) and benefit-cost ratios (BCRs). NPV was the cumulative present worth of investment cash flow using a specified discount rate (12 % in our case) to account time value of money. Whether the livestock sub-sector added value and worth investment or not has been assessed using NPV. The NPV was estimated as follows:

$$\text{NPV} = \sum_{t=2013}^{2032} \frac{R_t}{1+i^t} - R_0 \quad (1)$$

where R_t is the net-benefits during a single period t, R_0 is the total investment cost (NRs), i is the discount rate that could be earned in an alternative investment and t is the time period initiating from 2013 to 2032. The evidence of NPV greater than zero indicates value-addition from projects i.e. revenue exceeds anticipated costs in present value, leading to profitability of the business.

The IRR of an investment is the discount rate at which net present value of costs (negative cash flows) equals net present value of benefits (positive cash flows) of the investment. The higher IRR of a project indicates that the investment is favourable. However, IRR should exceed the weighted average cost of capital in general for a project to be worth investing. Using Microsoft excel, the IRR was calculated by setting NPV to zero. IRR estimation relied on a similar formula as used for calculating NPV:

$$\text{NPV} = 0 = \sum_{t=2013}^{2032} \frac{R_t}{1+IRR^t} - R_0 \quad (2)$$

BCR is widely used to assess returns on a project. It is the ratio of present value of cash outflow to the present value of cash inflow. A BCR greater than 1 indicates positive return while BCR equal to 1 indicates cost-neutral project.

We also conducted sensitivity analysis to assess how sensitive are economic and financial returns to changes in variables of interest (such as investment, revenue, and operation cost). Sensitivity indices (SIs) and switching values (SVs) were calculated for each livestock species as well as the whole livestock agribusiness. S.I. is the ratio of change in EIRR to the change in adverse variance, while S.V. is the percentage change in a variable required to reduce the EIRR to 12 % or NPV at 12 % to zero. An SI of less than 2.0 was taken to indicate low sensitivity.

3 Results

We first examined trends on investment cost, operation cost and revenue generation of livestock sub-sector projects from 2013 to 2017 (Fig. 1). Goat agribusiness received the highest investment (35.37 %) followed by sheep (20.69 %), yak/*chauri* (16.75 %), cattle (9.67 %), pigs (6.08 %) and *chyangra* (5.76 %) (Table 2). Goats were given higher priority by the project. Majority of the SPs were funded in 2015 and 2016. It is because the proposals were called in batches and more people came to know about the calls for proposals and grants only after 2013 – the second year of project implementation. Figure 1 indicates that livestock enterprises in the initial years of operation faced losses but with rising productivity they started accruing positive net-returns. This was mainly due to high investment cost in the initial years of agribusiness operation. It usually took a year or so for livestock such as sheep, goats, *chyangra* and pigs to reproduce or be fully grown to be sold.

We also examined cost and revenue trends of various livestock categories from 2013 to 2017 (Fig. 2). Although cattle business received high investment in 2014, majority of other livestock enterprises (*chyangra*, sheep, and *chauri*) received grants in 2015. Goats and pig farming enterprises received grants in 2016. The revenue from cattle, pigs, and *chauri* agribusiness slightly declined between 2016 and 2017 while that for goat, sheep and *chyangra* agribusiness increased from 2015, exceeding the operation cost and generating positive net-returns. This showed that goat, sheep and *chyangra* have high potential to continuously realise returns given their high productivity and quick turnover compared to cattle and *chauri*.

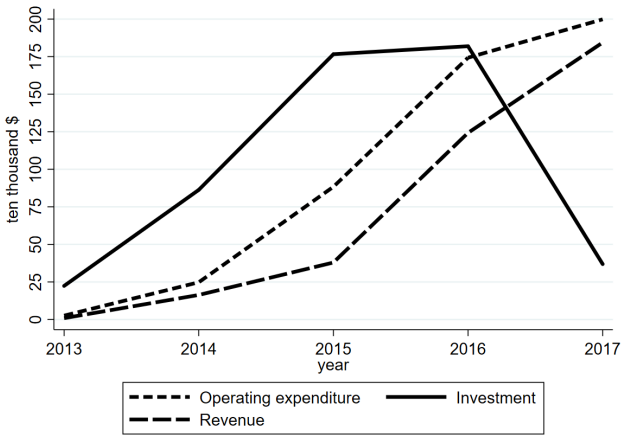

Fig. 1: *Investment cost, operation expenditure and revenue of livestock agribusiness.*

Table 4 shows economic returns of livestock agribusiness supported by HIMALI project. The EIRR was 15 %, above the cut-off discount rate of 12 %, suggesting that mountain livestock enterprises were economically viable. The NPV was positive and BCR was greater than 1, indicating additional value generated by the project. The FIRR of livestock enterprises was 12.16 % and benefit cost ratio was 1.04,

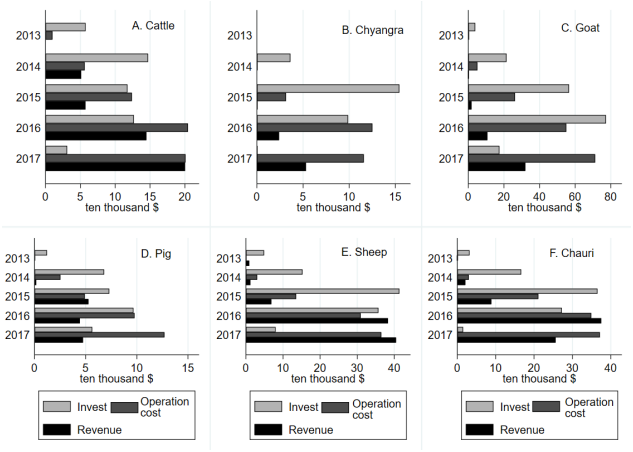

Fig. 2: *Category-wise annual cost and revenue generation of livestock agribusiness.*

signifying financial viability of mountain livestock agribusiness (Table 4). While examining operation cost, revenue and net-income, we noticed a clear pattern of low and negative net-benefit during the initial years of investment (till 2017). The net-benefit gradually became positive, then increased till 2022 and remained constant for some years before tapering off during period-end of project life cycle. However, in the last year of the project, revenue generation was high due to attribution of terminal/salvage value from sale of aged animals.

Table A1 through Table A5 show the economic returns of livestock enterprises separately for each commodity (goat, sheep, cattle, *chauri*, *chyangra* and pigs). The EIRR of sheep farming was highest at 18 % followed by goat (16 %), *chauri* (15 %), chyagra (14 %), cattle (13 %) and pig (12 %). The EIRR of higher than or equal to 12 % suggested that all the enterprises positively contributed to the rural economy and were worth investing in.

Table 5 shows financial returns from various livestock enterprises. Although livestock business at aggregate level was financially viable (about 13 %), none of the livestock business exceeded a 12 % discount rate except for sheep and goat farming. With FIRR at 16 %, sheep farming was found to be financially the most viable agribusiness followed by goat farming at 14 %. The least FIRR was obtained for pig farming at 8 %. Although, there were several lowlands in mountainous district like Dolakha, where pig farming was suitable, some of the beneficiaries for pig farming simply transformed their businesses into other enterprises due to high cost of feeding piglets.

The highest NPV was obtained for goat followed by sheep farming. At the discount rate of 12 %, pig, *chyangra*, *chauri*, and cattle yielded negative NPVs. These results showed that goat and sheep farming possess high financial potentiality in high mountains of Nepal. On the other hand, *chauri* and cattle farm enterprises are not attractive as indicated by their low FIRRs below 12 %. This is due to limited market access, leading to low prices for milk and cheese ultimately dampening agribusiness. In terms of economic viability, livestock agribusiness was performing well in high mountains and generating employment opportunities to local people. However, for business to be sustainable, financial viability matters. The FIRR for cattle, *chyangra*, pig and *chauri* did not exceed the threshold discount rate of 12 %. These categories of livestock business demand an immediate attention from concerned stakeholders.

Table 6 shows economic returns from various livestock enterprises and their sensitivity analyses. Based on estimated EIRR of 18 %, sheep farming was the most economically viable agribusiness followed by goat farming (16 %). The least EIRR was obtained for pig farming at 12 %. Overall, the EIRR revealed economic viability of all livestock enterprises. The highest NPV was obtained from goat farming followed by sheep and yak husbandries. The largest employment was generated from sheep agribusiness followed by *chauri* and goat husbandry. With a sensitivity index (SI) of 3, sensitivity analysis indicated that sheep agribusiness was highly sensitive to an increase in investment cost. Similarly, with a SI of 2, cattle and *chyangra* enterprises were highly sensitive to an increase in operation cost and with a SI of above 2, all livestock enterprises (except goat) were highly sensitive to a decrease in revenue stream. Switching value (SV) indicated that cattle and pig enterprises were most sensitive to changes in revenue streams. The SV of 1 % indicated that if revenue was reduced by 1 % then project EIRR reduced to 12 % or its NPV to zero.

Table 7 illustrates results from sensitivity analyses assessing robustness of economic viability of livestock subsector of the project. The SI of below 2 indicated that economic viability was not sensitive to an increase in operation cost, investment, labour cost, and delays in investment by a year. Since FIRR was just 12.14 % and livestock agribusiness was marginally viable, we conducted sensitivity analysis for EIRR only. With a SI of 2.8, livestock agribusiness was sensitive to adverse changes in revenue. The business was also highly sensitive to changes in revenue and cost simultaneously. An increase in operation cost by 10 % and a decrease in revenue by 10 % led to a sharp decline in EIRR from 15 % (base case) to 8 %. However, livestock agribusinesswas not sensitive to an increase in investment, operating cost and project delay by a year. The SV indicated that livestock agribusiness should be delayed by at least 4 years to reduce the overall EIRR to 12 % or NPV to zero.

Table 4: *Economic returns of livestock agribusiness (ten thousand USD).*

Year	Investment (A)	Operation cost (B)	Labour cost (C)	total cost (D=A+B+C)	Total revenue/ benefit (E)	net income/ benefit F=E-D
2013	13.76	0.93	0.66	15.35	-	-15.35
2014	65.36	14.01	5.09	84.47	5.12	-79.34
2015	144.83	66.45	23.86	235.14	23.46	-211.68
2016	153.38	93.64	33.11	280.13	92.60	-187.53
2017	32.05	98.69	37.13	167.88	117.66	-50.22
2018	0	102.61	37.10	139.71	168.73	29.01
2019	0	114.85	39.99	154.84	205.49	50.65
2020	0	131.38	43.58	174.96	256.50	81.54
2021	0	148.39	45.44	193.83	324.52	130.70
2022	0	172.56	50.97	223.52	384.15	160.62
2023	0	174.41	52.08	226.49	396.96	170.47
2024	0	174.41	52.08	226.49	396.96	170.47
2025	0	174.41	52.08	226.49	396.96	170.47
2026	0	174.41	52.08	226.49	396.96	170.47
2027	0	174.41	52.08	226.49	396.96	170.47
2028	0	161.99	46.68	208.67	342.29	133.62
2029	0	161.99	46.68	208.67	342.29	133.62
2030	0	161.99	46.68	208.67	342.29	133.62
2031	0	161.99	46.68	208.67	342.29	133.62
2032	0	165.12	46.68	211.80	489.16	277.36
EIRR		15 %				
NPV		$ 94.84				
NPV labour		$ 242.22				
B/C ratio		1.07				

EIRR: economic internal rate of return; NPV: net-present values; B/C ration: benefit-cost ratio

Table 5: *Financial returns of livestock agribusiness.*

Sectors	*FIRR*	*NPV@12 % ('000 $)*	*B/C ratio*
Cattle	8.48 %	-158.88	0.96
chyangra	11.32 %	-20.49	1.02
Yak/*chauri*	9.84 %	-169.47	0.99
Pig	8.09 %	-147.62	0.94
Goat	13.97 %	244.23	1.16
Sheep	15.87 %	155.16	1.12
Average	12.62 %		1.04

FIRR: financial internal rate of return; NPV: net-present values; B/C ration: benefit-cost ratio

Sensitivity analysis conducted for the aggregated livestock enterprises may mask the nuances arising from specific enterprises. Therefore, we conducted sensitivity analysis for each enterprise (Table A7–A12). Except goat business, all other enterprises were highly sensitive to reduction in revenue. In addition, cattle enterprise was sensitive to increase in the operation cost. Overall, the sensitivity analysis suggested that the livestock enterprises in the high mountains were highly sensitive to the factors influencing revenue such as changes in market prices and decline in productivity.

Based on telephone interviews with selected grant recipients, several problems faced by farm entrepreneurs during business operations were identified. Among 132 SPs contacted, about 9 % (12) SPs were found to be permanently closed in 2019 for various reasons. Lack of veterinary services, snow/harsh weather and market access were some of the major reasons for permanent closure of livestock enterprises. These are pressing issues particularly in the high mountains of Nepal where extension services are very limited. Further, difficult terrain and harsh climatic conditions adversely affect the timely accessibility of such services, risking the sustainability of agribusinesses. Among the project districts, 9 out of 82 SPs were permanently closed in Dolakha and 3 out of 17 SPs in Manang.

Table 6: *Economic returns from various livestock agribusiness and their sensitivity analysis.*

	Economic Values ('000 $)			*Annual*	*Sensitivity Indices (SI)*			*Switching Values (SV)*		
	Investment		*Labour*	*labour*						
Enterprises	*EIRR (%)*	*NPV*	*NPV*	*(days)*	*Investment*	*Operation cost*	*Revenue*	*Investment*	*Operation cost*	*Revenue*
Livestock										
Cattle	12.52	22.51	562.88	24,250	0.50	2.40	4.30	9.00 %	2.00 %	1.00 %
Goat	15.77	442.07	36.46	96,000	0.70	0.90	1.70	36.00 %	27.00 %	14.00 %
Sheep	17.95	220.50	16.08	46,250	3.00	1.60	3.00	29.00 %	21.00 %	11.00 %
chyangra	14.49	70.81	211.80	14,250	3.30	2.00	3.30	5.00 %	9.00 %	5.00 %
Pig	12.45	15.19	392.15	16,000	0.40	1.50	3.10	9.00 %	2.00 %	1.00 %
Yak/*chauri*	14.67	198.87	43.45	54,000	3.70	1.90	3.70	5.00 %	10.00 %	5.00 %

EIRR = economic internal rate of return; NPV = net present value.
A simple conversion factor of 0.9 is employed to obtain economic investment.

Table 7: *Sensitivity analysis of economic returns of livestock agribusiness.*

Cases	*Change %*	*EIRR %*	*NPV @12% ('000 $)*	*S.I.*	*S.V. %*
Base Case (Economic values)					
Whole Project		15 %	$948		
Adverse scenarios					
Investment cost increased	10	14	665	0.65	30
Revenue reduced	10	11	-422	2.82	7
Operating cost increased	10	13	198	1.54	13
Combined case*	10	8	-1172	4.51	4
Project delayed by a year	10	14	661	0.05	4

EIRR = economic internal rate of return; NPV = net present value.; S.I. = Sensitivity Indices; S.V. = Switching Values.
* Benefits reduced and operating cost increased together.

Figure 3 shows percent of grant recipients facing several challenges. About 42 % of respondents mentioned that lack of access to veterinary services and failure to timely treat diseased livestock was a major challenge. Due to remoteness, well trained and skilled technicians/veterinary doctors avoid serving in such difficult areas. While assessing the performance of one of the subprojects, the team was informed of mass mortality of goats in Solukhumbu district. The principal reason behind this was the inability to provide timely treatment to sick livestock.

Procuring additional capital to run business in full-scale has been another challenge facing rural farm entrepreneurs. Baruwa (2013) finds that the most important factors hindering small-scale goat husbandry in Nigeria are lack of adequate capital, high mortality rate and poor foundation stock. While large farmers can access institutional credit, small goat farmers are at a disadvantage given their limited capital for collateral security (Baruwa, 2013). Interestingly, about 33 % of the respondents mentioned lack of access to subsidised credit as another hurdle in expanding or even upgrading their business. Since majority of them were marginal farmers, they were simply not be able to re-invest in their businesses.

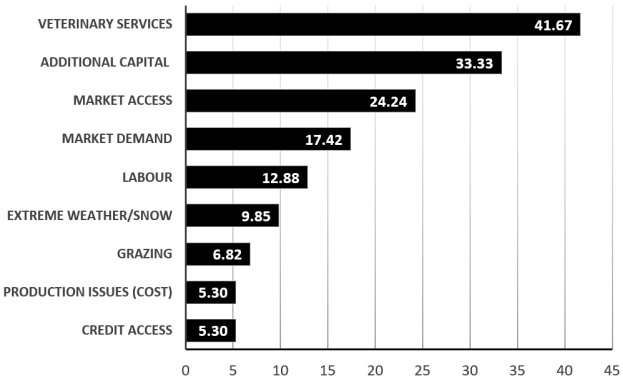

Fig. 3: *Percent of grant recipients (n=132) indicating challenges faced in sustaining livestock agribusiness.*

Small and medium farms located in remote areas incurs higher transaction costs in comparison to large farms (Afridi *et al*., 2009). Further, success of livestock enterprises also depends on a reliable market access (Huyen *et al*., 2011). About 24 % of the respondents said that limited market accessibility was another pertinent issue hindering their business operations.

Net recurrent cash income becomes more prominent and visible in the case of market-oriented livestock systems. But in the absence of well-organized markets and limited market demand, farm entrepreneurs face difficulty in selling agriculture, livestock, and livestock products (Huyen *et al*., 2011; Shah *et al*., 2017). This is the case in high uplands of Nepal. About 17 % of the respondents mentioned low market demand as one of the concerns in operating their business successfully. For livestock enterprises to flourish, well-functioning markets for resources, production and services are crucial (Moll, 2005). Government support mechanisms are equally important for ensuring sustainability of farming systems (Shah *et al*., 2019).

Labour supply in remote mountain areas has been another challenge. About 13 % of the respondents indicated that labour shortage led to either shutting down or downsizing their farm enterprises. Out-migration for foreign employment has become a popular trend in Nepal to escape from rural poverty. This in turn has led to labor shortage particularly in the farming sector and reduced livestock holding by a household (Maharjan *et al*., 2013). Extreme weather patterns have a negative impact on livestock population in mountain district of Nepal (Koirala & Shrestha, 2017). This is consistent with our findings as nearly 19 % of the respondents mentioned extreme weather (heavy snowfall) as one of the challenges facing farm entrepreneurs. During winter season, livestock grazers face problem in reaching the sheds which are located far away from their dwellings. About 7 % of the respondents said that availability of grazing land specially for sheep, *chyangra* and *chauri* has been a huge concern to expand production. Other challenges mentioned are higher operation cost, lack of livestock insurance services and occasional attacks from wild animals.

4 Discussion and conclusion

This study estimated economic and financial returns (NPV, IRR and BCR) of livestock agribusiness (goats, sheep, *chyangra*, cattle, pigs, *chauri*) in ten mountain districts of Nepal. The study further examined constraints faced by rural farm entrepreneurs in operating livestock agribusiness. Given the very limited research on economic analysis of livestock farming, this study contributes to the literature by estimating economic and financial rate of return of livestock agribusiness in high mountain settings.

Sheep farming was the most economically viable agribusiness (18 % EIRR) followed by goat (16 %), *chyangra* (14 %), *chauri* (14 %), cattle (13 %) and pig (12 %). Overall, the EIRR of 15 % revealed economic viability of all livestock enterprises. However, the FIRR of livestock enterprises was just 12 %, indicating risky business. Only sheep and goats were financially viable, exceeding FIRR of 12 %. Except goat enterprises, all other livestock agribusiness were sensitive to changes in revenue. Any factor that negatively influences the productivity or causes to plummet market prices will adversely affect the viability and sustainability of the livestock business.

The economic and financial analysis of livestock enterprises showed insightful results. The project has enthused prospective entrepreneurs to initiate agribusiness in remote highlands previously considered to be of high risk. The economic internal rate of returns for goat and sheep husbandries were relatively higher compared to cattle and other livestock enterprises. This signifies that in high altitudes of 2000 meters and above, farmers can be relatively well off with goat and sheep farming compared to other livestock species. First, mountain people had been raising goat and sheep as one of their main livelihood options since prehistoric times. Second, goats have lower mortality rate compared to other livestock species and do not require substantive pasture land. While goats can withstand harsh climatic conditions, mountain geography does not suit the rearing of cattle, pigs and other livestock species. Third, goats and sheep can be sold easily in the market, providing an immediate source of income to mountain people in times of necessities. These livestock species act as buffer against harsh conditions for mountain people.

While assessing the performance of selected livestock agribusiness, the study found that few enterprises were permanently closed in some districts. Specifically, pig enterprise was the one that was unsuccessful. Dolakha and Manang were two project districts that witnessed high prevalence of permanent business closure. Therefore, due attention to specific reasons for closure should be provided in future while targeting similar project interventions in mountain districts.

Despite remoteness, harsh agro-ecological conditions, social marginalisation and fragile environment, livestock agribusiness (particularly of sheep, goat, *chyangra*, and *chauri*) has a high potential in high mountains. However, for long-term sustainability of livestock enterprises, technical back-up, periodic monitoring and follow-up by local governments at sub-national levels are needed. To further scale up

such initiatives, a structural change towards market-oriented livestock business along with adoption of hybrid/improved breeds are needed. The challenges pertaining to poor managerial and marketing skills and limited access to subsidised credit must be addressed to further enhancing such enterprises in remote high lands of Nepal. The study found a plethora of issues faced in sustaining livestock agribusinesses in high mountains. For instance, survey respondents prominently raised the issue of depleting rangelands for grazing livestock. This finding resonates with the study that argues about degradation of vegetation cover due to overgrazing and climate-induced changes such as erratic rainfall in high mountains (Afzal *et al*., 2008). Further, the study found that limited market access, lack of extension services and subsidised credit, among others are other pertinent issues faced by livestock agribusinesses in high uplands of Nepal. These findings were consistent with studies that suggested that improving credit access, extension services, market linkages and insurance facilities for livestock are crucial for enhancing livestock productivity and food and nutrition security in the Hindukush Himalayan region (Rasul *et al*., 2019).

Accessibility to subsidised credit for livestock farmers will be crucial to acquire good quality exotic breeds and expand farm enterprises. Similarly, accessibility to livestock insurance schemes will help minimise losses in case of livestock deaths due to a calamity. Livestock offices at the provincial level along with livestock units housed within rural municipalities must be technically and financially sound to provide livestock and veterinary extension services. For creation of an efficient and well-functioning local market for livestock enterprises, modern slaughterhouses need to be established. Establishment of dairy industries in mountain areas are essential for value addition of milk. More importantly, road networks in the mountain districts of Nepal need to be upgraded at least up to the national standards for better market linkages and promotion of livestock enterprises. Issues related to high input prices and degrading pasture land faced by farm entrepreneurs must be allayed through government support in the form of tax deduction, input subsidies and such other mechanisms.

There are some limitations of this study. Net-returns of the project were estimated at enterprise level and not at the beneficiary level. As a result, the study could not conduct economic and financial analysis based on ethnicity, gender and at district level. Due to absence of detailed socioeconomic characteristics before and after the project intervention, the paper could not assess the project impact on household welfare of beneficiaries. Future studies should focus on assessing the impact on poverty reduction, and food and nutrition security outcome of mountain people.

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The views expressed are those of the authors and do not necessarily reflect the views and policies of the Asian Development Bank or its Board of Governors or the governments they represent.

Conflict of interest

The authors declare that they have no conflict of interest.

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