INFO BRIEF 4

Economic analysis of climate-smart agriculture interventions for goat farming households in Nepal and their marginal costs of abatement

1. Highlights

- The first brief (Brief 1) in this series presents the results of the RHoMIS household (HH) surveys, which amongst other things, found a link between certain components of Heifers programming and higher levels of CSA adoption.
- That following two briefs (Brief 2 and Brief 3) explored the impact of CSA adoption on a number of environmental indicators including greenhouse gas emissions, land and water use intensity, and soil heath.
- This brief assesses the economic impact of CSA adoption through the use of a benefit-cost analysis (BCA), and the marginal cost of greenhouse gas mitigation under Heifer programming using a Marginal Abatement Cost Curve (MACC).
- The BCA revealed that all the practices covered in the assessment improved the profitability of production. The introduction of improved fodder offered the highest BCR at 23.3, mostly driven by the low costs of implementation. Other highly profitable practices included intercropping or crop rotation with legumes (BCR 2.3-3.2), the introduction of feed additives (BCR 2.5), and the construction of improved sheds (BCR 2).
- The overall mitigation impact of Heifer programming in Nepal was calculated at 331,182 tCO_2e per year, with the potential to rise to 2.6 million tCO_2e per year if 70% participating HH were to perform as well as the best performing Heifer supported HH.
- The MACC revealed that the program level costs of GHG mitigation differ considerably by region, ranging from \$5 – \$50/tCO_2e, with an average cost of \$13/tCO_2e mitigated. These values fall well below the \$100 threshold for cost effective mitigation measures, and in many instances fall below the recommended \$25 price floor for carbon.
- The results highlight the potential of Heifer supported cooperatives to contribute to Nepal's mitigation targets under the updated Nationally Determined Contribution and Net-zero strategy.
- To support this transition there is a need to scale Heifer programming that has been found to boost CSA adoption (Brief 1) by addressing some of the constraints faced by goat farming HH.

2. Introduction

Heifer Nepal works with more than 12,500 self-help groups, 255 cooperatives, and three District Unions, across 43 districts. Running a series of large programmes that support the development of competitive and resilient agricultural value chains, through improving farmers' access to a range of enterprise support services. With the aim to raise overall household incomes through means that have minimal negative impact on the environment.

Participating HH have benefitted from a series of Heifer implemented projects that supports climate resilient livestock production and marketing; including training under the Improved Animal Management (IAM) program, increased access to AgroVet services through 662 Community AgroVet entrepreneurs (CAVE), and increased access to improved breeds through the Community Initiative for Genetic Improvement in Goats (CIGIG) program.

This research aims to contribute to Heifer Nepal's programming by providing greater insight into the context, challenges, and opportunities for Nepal's smallholder goat farmers, with special focus on Heifer's work to promote the use of CSA techniques and their potential to reduce carbon emissions. The research was conducted in three districts encompassing the main agro-ecological contexts in which Heifer Nepal works, including Sarlahi (Eastern Terai), Chitwan (Inner Terai), and Surkhet (Mid-West Hills). The research outputs are divided into four separate, but complementary information briefs:

- **BRIEF 1 – *"Assessing the impact of Heifer Nepal programming on the use of Climate-Smart Agriculture practices in smallholder goat farming systems",*** this brief aims to provide greater insight into the farming systems of the three study regions and their application of CSA practices, comparing uptake between Heifer supported cooperatives and non-Heifer supported cooperatives, using data gathered though the Rural Household Multi-Indicator Survey (RHoMIS).

- **BRIEF 2 – *"Comparative analysis of goat farming systems in Nepal and their mitigation potential: Comparing results from Heifer and non-Heifer supported cooperatives"*** presents the results of a modelling analysis of farming systems from the three study sites, shedding light on the potential greenhouse gas mitigation potential of improved goat production systems as promoted by Heifer Nepal.

- **BRIEF 3 – *"Assessing the soil health of three goat farming districts in Nepal: Insights for improved farm management"*** identifies promising soil management practices based on the soil characteristics and current management practices in each district.

- **BRIEF 4 – *"Economic analysis of climate-smart agriculture interventions for goat farming households in Nepal and their marginal costs of abatement",*** to support agenda setting on priority CSA interventions for the attainment of National mitigation targets under Nepal's updated NDC.

3. Methods

The analysis conducted in this brief first uses a benefit-cost analysis (BCA) to assess the profitability of the different CSA interventions being implemented by goat farming HH in Nepal. The BCA was conducted using experimental data gathered from relevant literature which was cross-referenced with the results of the RHoMIS HH survey (See Brief 1 in the series for details on the HH survey). Building on the results of the BCA, a Marginal Abatement Cost Curve (MACC) was developed. MACC shows the relationship between the marginal costs and carbon mitigation potential of emission reduction measures (Yang et al., 2017).

This brief sets out to answer the following questions, to support Heifer programming and national priority setting for GHG mitigation in the goat sector:

1. How profitable are CSA interventions for goat farming HH in Nepal?
2. How much emissions are mitigated and at what cost across all Heifer supported HH and what is the scaling potential?

A benefit-cost analysis (BCA) is widely used to guide decisions on whether an investment is profitable and should be implemented given limited resources (Lan et al., 2018; Pannell, 2019; Sain et al., 2017). An ex-ante BCA is employed to anticipate the costs and benefits of policy or agricultural interventions before implementation. In our study, the adoption of climate-smart agriculture (CSA) practices and technologies will be assessed for profitability compared to their non-adoption. CSA practices included in the study are composting, legume intercropping or rotation, improved fodder production, improved sheds, and feed additives (CIAT et al., 2017; Poudel et al., 2017). Further details on each CSA practice and their environmental impact can be found in Brief 2.

The study uses common BCA indicators of Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), and Payback Period (PP). A positive value of NPV indicates a positive net incremental benefit hence the adoption of CSA practice is profitable. A BCR value greater than 1 indicates that the benefits of the CSA practice outweigh the costs and vice versa. IRR is the discount rate that sets the NPV equal to zero and the BCR equal to one, if this value is higher than the current discount rate the intervention is profitable. For this analysis a discount rate of 10% was used. PP is calculated to estimate the number of years before the investment reaches the break-even point, with faster breakeven points preferred by investors, and in particular farmers who think on short term time horizons and lack investment capital.

In this brief a MACC was developed at a program level to represent the total mitigation potential and marginal abatement costs of emissions reductions resulting from Heifer programming in each of the three regions. The mitigation potential per region was calculated based on the transition from a non-Heifer low adopt scenario to a Heifer supported medium adopt scenario—based on survey data (See Brief 2 for details). These figures were extrapolated across the 314,000 Heifer supported HH, of which 50% are located in the Eastern Terai, 30% in the Inner Terai, and 20% in the Mid-Hills. For the costs, Heifer Nepal's annual program expenses were averaged for the last 5 years and shared equally across participating HH in each region using the 50:30:20 breakdown presented above.

4. Benefit-cost analysis

All of the practices assessed through the BCA were found to increase the profitability of production for implementing farmers, creating a strong case for CSA adoption (Table 1). Many of the CSA interventions provided benefits to farmers that were 2-3 times greater than the implementation costs, offering good returns on investment for those who chose to adopt. One of the major barriers faced by smallholder farmers is the delay in tangible benefits, but for most of the practices and regions the benefits of CSA adoption would be realised in under a year.

Table 1: Estimation of economic parameters for various CSA practices over a 10-year period per goat/ha.

CSA Practice	NPV	BCR	IRR	PP
Compost rice-wheat (ha)	480	1.27	33%	2.3
Feed additives	158	2.64	179%	0.5
Improved goat breeds	337	2.51	41%	1.9
Improved fodder	151	23.3	229%	1.1
Intercrop wheat-lentil (ha)	1,094	2.29	142%	0.7
Rotation rice-lentil (ha)	1,589	3.24	197%	0.5
Improved sheds	201	2.04	116%	0.9

Composting

The BCA for composting revealed a positive influence on agricultural productivity and income compared to non-adoption, with NPV and IRR returning positive values at the farm level. The evaluation results return a NPV of $480 per hectare over the 10 years. The positive NPV is the result of composting driving up the yields of rice and wheat by 17% and 13% respectively, while reducing the inorganic N requirement by 23-25% (Ahmad et al., 2008; Kabato et al., 2022; Sarwar et al., 2007). These benefits offset the increased costs associated with the purchase of the 11 ton/ha of compost, with the model assuming compost is purchased and not home produced by the farmer. The NPV would increase further if farmers were to produce their own compost. The payback period is 2.3 years (the longest of all practice assessed) as it takes time for compost to decompose into the soil and to realise the benefits. The analysis was also run for lower value crops such as Maize, where the increase in yield failed to compensate for the cost of purchasing the compost, returning a negative NPV. The implementation of composting was also found to be constrained by high labour requirements that may act as a deterrent for an intervention with the lowest BCR of all those assessed.

Feed additives

The introduction of feed additives into the feed basket of goats returns a positive NPV of $158 if implemented for a single goat each year for 10 years, with a BCR of 2.64. The modelled scenario for this assessment is the transition from a feed basket where feed additives and concentrates contribute 25% of the feed basket to one where they contribute 50%, more than doubling the per goat feeding cost (Joshi et al., 2004). This was however found to be profitable as these increased costs were offset by the higher live weight gain (LWG) of goats under this improved feeding system. The practice also offered one of the lowest payback periods at 6 months. Despite this, many of the HH consulted through the survey identified high costs as a barrier to adoption, which highlights the need to increase awareness around the potential benefits. Some HH also faced issues in sourcing additives, which needs to be addressed for the practice to be effectively scaled.

Improved goat breeds

The adoption of improved goat breeds has a positive influence on productivity, with a NPV of $337 per goat over a 10-year period. These productivity benefits are the result of increased LWG and higher feed conversion ratios. For this analysis the LWG of an indigenous Khari goat was assessed alongside a Khari Boer crossbred goat. The LWG of the crossbred goat (47 g/day) was almost double that of the local Khari goat (23 g/day) (Sapkota et al., 2016). These increases in LWG more than offset the purchase price of a doe, and the increased feeding, veterinary, and breeding service costs. The model assumed the doe would produce on average 2.55 kids per year. Due to the high initial costs of purchasing a doe, the payback period for the practice is 1.9 years.

Improved fodder

The production of improved fodder (tanki and dabdabe) to supplement the goats feed basket was found to have a positive impact on productivity, with an NPV of $151 per goat over 10 years. The practice offers the highest IRR and BCR of all the practices due to the low implementation costs, with planting improved fodder estimated to cost $3 per goat every 4 years. There is a payback period of 1.1 years as it is assumed the crop will only be available for feed in the second year.

Legume intercropping/rotation

Two scenarios were explored for the incorporation of legumes into cropping systems, intercropping wheat and lentil, and rotating rice and lentil. Both of the interventions were found to improve productivity, with an NPV of $1,094 and $1,589 per ha over a 10-year period respectively. The reason the NPV is higher than other values is that here we focus on the per ha NPV rather than the per goat NPV. However, both practices were extremely profitable with BCR ranging from 2.3 to 3.2. Much of the recorded benefits come from the additional income generated from selling the lentils that were added to the system, although there will also be a reduction in inorganic N costs as legumes fix N into the soil.

Improved sheds

The construction of improved sheds is an indicator that goat farming HH are transitioning from extensive to semi-intensive/intensive goat rearing methods. As such improved sheds also go hand in hand with other practices such as stall feeding/ zero grazing, the introduction of feed additives into the feed basket, and improved manure management. The combination of these practices along with the improved sanitary conditions and protection from the elements result in higher LWG amongst goats reared with this practice (Chandrappa & Kiran, 2019). Improved sheds were found to provide net incremental benefits to farmers who adopt, with a per goat NPV of $201 over a 10-year period and a BCR of 2. The payback period based on the data used for this study was just under a year, although this may vary depending on the size of the shed and the number of goats it houses.

5. Program level assessment

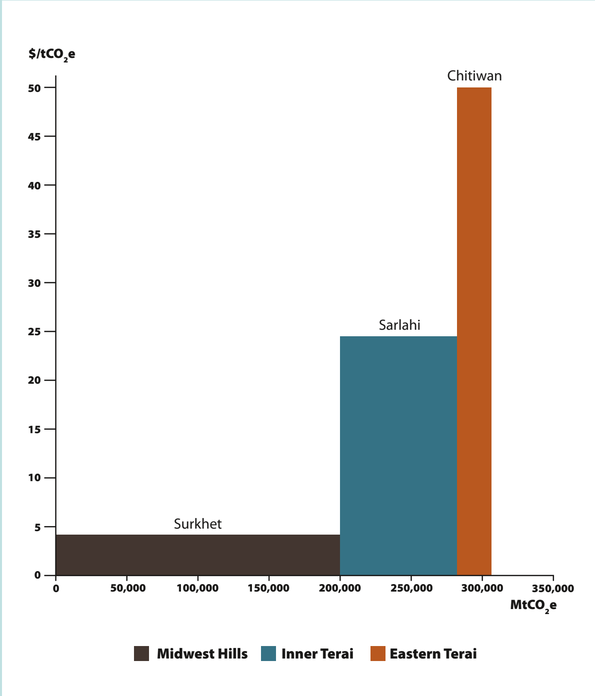
To understand the aggregate abatement potential of transitioning to improved livestock management practices, the abatement potential of transitioning between the low adopt (non-Heifer), medium adopt (Heifer), and high adopt (aspirational) typologies was used (see Brief 2 – Table 2). Table 2 presents the current abatement of the Heifer program assessed as the difference between the per HH emissions of the non-Heifer HH versus the Heifer supported HH (assuming the same number of goats), extrapolated across the whole Heifer program in Nepal covering the 314,000 HH[1]. Of which it is estimated that 50% are located in the Eastern Terai, 30% in the Inner Terai, and 20% in the Mid-Hills. The current aggregate abatement of the Heifer program is assessed to be 305,856 tCO_2e per year. In terms of the current abatement the Mid-hills is the largest contributor with Heifer supported HH already having a much larger share of their feed basket coming from improved feeds compared to the non-Heifer supported HH[2]. The impact of this is a reduction in land use requirement linked to extensive grazing systems and reduced emissions for enteric fermentation due to the introduction of higher quality feeds into the feed basket.

Table 2: Current and potential abatement through shifting farming HH between low – Medium – and high CSA adoption typologies.

Region	Type	Abatement ($MtCO_2e$)
Eastern Terai	Current	-82,333
	Potential	-875,605
Inner Terai	Current	-24,095
	Potential	-1,411,446
Mid-Hills	Current	-199,428
	Potential	-114,293
Total	**Current**	**-305,856**
	Potential	**-2,401,343**

The analysis also models a possible future scenario, where through continued support, 70% of Heifer supported HH were to further improve their management practices transitioning to the aspirational "high adopt" typology. Under this scenario the program would abate 2.4 million tCO_2e per year.

Figure 2: MACC for Heifer Nepal's programming across the three regions.



By combining the above emissions data with Heifers program expenses in each region, it is possible to develop a MACC for Heifers current programming in Nepal (Figure 2). The results highlight the potential of improved feeding practices such as those adopted by Heifer HH in the Mid-Hills as cost effective mitigation measures, with a marginal abatement cost per tCO_2e is under \$5. While in Chitwan where fewer Heifer HH are implementing improved feeding practices, this value increases tenfold to \$50. While across the whole grogram the average cost per ton of CO_2e mitigated is \$13. This is below the \$25 /tCO_2e which has been proposed by the IMF as the floor price for low-income countries (Parry, Black and Roaf, 2021) and well below the \$100 /tCO_2e threshold for "cost effective" mitigation measures (Roe et al., 2021).

1 See Brief 2 Box 1 for details on the limitations in directly attributing these impacts to Heifer programming, including challenges with the selection of an effective control.

2 See Brief 2 for details why this reduction in grazing may not be directly attributed to Heifer programming but to other inherent differences in the farming systems between the cooperatives.

6. Outlook

The widespread adoption of the identified CSA interventions has considerable potential in supporting Nepal in meeting the mitigation targets set out for the agriculture and livestock sectors. Nepal ranks 89/193 countries in terms of total emissions, falling to 167 in terms of emissions per capita. The current per capita emissions in Nepal of 1.69 tCO_2e falls well behind the 2030 global average (2.3 tCO_2e/capita) required to keep global warming to below 1.5⁰C (Gore, 2021). In 2019, Nepal emitted 48.37 $MtCO_2e$ (0.1% of global emissions), with the agriculture sector accounting for 26 $MtCO_2e$ (53.76%) (WRI, 2022). Within the agriculture sector, 54% of emissions were from enteric fermentation (FAOSTAT, 2018).

Despite being a minor contributor to global GHG emissions, the Government of Nepal (GoN) has signalled its commitment to adopt mitigation measures. In 2020, the GoN submitted their second NDC for the period 2021-2030 (Government of Nepal, 2020). The updated NDC does not include explicit GHG mitigation targets for the agriculture sector, or for any sector. Instead, it highlights a number of strategic actions for the period 2021-2030, including measures to increase soil organic matter content from 2-3.95% across agricultural lands, increased production of organic fertilizer, increasing the number of improved cattle sheds from 100,000 to 500,000, the construction of 200 climate-smart villages and 500 climate-smart farms, and the promotion of intercropping, agroforestry, conservation tillage, and livestock and agricultural waste management (Government of Nepal, 2020).

Nepal's long-term strategy is built around their target to achieve Net-zero emissions by 2045 (Government of Nepal, 2021b). Under "Nepal's long-term strategy for net-zero emissions" mitigation targets are set for 2030 and 2050 for a range of strategic actions, including agriculture fermentation management practices and technologies (GHG focused genetic selection/breeding and the promotion of low emissions feeds), Improved soil carbon storage and fertility management, manure management, the integration of Nitrogen-fixing crops into rotation, and improvements to agropastoral systems (Government of Nepal, 2021b). Measures focussed on climate change adaptation are covered through the National Adaptation Plan (NAP) process, including targets on the introduction of improved breeds and the conservation of the genetic resources

for indigenous breeds (Government of Nepal, 2010, 2021a).

The results of the BCA highlight how many of the interventions promoted as promising measures for Nepal's NDC targets and transition to Net-zero, also present positive returns on investment to implementing HH. As seen in Brief 1, Heifer programming has supported participating HH in increasing their adoption of CSA interventions through providing services—savings and loan groups, women's groups, AgroVet services, and information on crop related CSA practices—that remove barriers to adoption. These interventions resulted in varying levels of GHGe mitigation amongst Heifer supported cooperatives in each of the regions (Table 2). The results of the MACC demonstrate that when mitigation measures—improved feeding practices in particular—are effectively promoted and implemented through Heifer Nepal programming, they are a cost-effective means to support Nepal's attainment of mitigation targets set out under their NDC and Net-zero strategies.

There are however a range of factors that persist in limiting the adoption of CSA interventions, with many HH identifying labour constraints, technical knowledge, and access to inputs as adoption barriers. There is need for continued support in addressing these constraints, to facilitate the transition of farming HH to the aspirational "high adopt" scenario, mitigating emissions and unlocking improvements in productivity.

Citations

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