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4 Objectives

1. Assess which data exist for calculation of GHG emissions for selected ACIAR-MPI smallholder livestock projects and identify a sub-set of projects that could be taken forward in a subsequent larger project.
2. Consult with livestock project researchers, and their in-country livestock project teams, to better understand the opportunities and challenges for incorporating livestock MRV data collection and/or analysis in ACIAR/MPI livestock development projects longer term.
3. Through consultation with the project teams, supported by linkages with the GRA-LRG and other ACIAR-NZ co-funded projects, gain a better understanding of the interests, needs, motivations and potential recipients for future capacity building and training activities in livestock GHG accounting.

5 Methodology

Activity 1: Review international Tier 1 and 2 GHG emissions accounting & LCA methods to identify the most appropriate data requirements in each livestock project

Part 1 - Structured review focusing on the studies assessing the GHG emissions from livestock in the countries selected

The literature search was performed using “Web of Science”, “Science Direct” and “Google Scholar” search engines. The search was carried out using all combinations of the following keywords: "life cycle assessment"; "LCA"; "carbon footprint"; "greenhouse gas emission"; "GHG"; "livestock"; "beef"; "sheep"; "dairy" and "goat" filtered by each country selected (refer to activity 2). There were no restrictions regarding the year of the publication. All studies found were further screened for relevance based on the title. Relevant titles were then screened by abstract, and the full text was then reviewed. Further, the references of studies retrieved were screened. Papers/reports that studied the development of emission factors (e.g., measuring emissions from manure application to soil) and described approaches for data sampling and/or strategies were excluded. The final database (studies that estimated the GHG emissions from livestock activities) included nine studies. For each publication, a specific study code was assigned. The following characteristics were recorded in the database: author, year, country, type of publication, theme of the study, data sampling technique, if the authors classify the study as LCA, and how the emissions of GHG were calculated (models used and/or IPCC Tier used). Table 1 summarises all the information retrieved from the published studies.

Part 2 – Review IPCC international Tier 1 and 2 livestock GHG emissions accounting tools

The IPCC Tier 1, 1a and 2 GHG emission accounting tools were reviewed to identify the most critical data that need to obtain from the targeted livestock projects. A spreadsheet was developed with a set of guidelines for project leaders to use to calculate major GHGs (Spreadsheet 1). When develop this spreadsheet, we focused on the livestock related GHG emissions, as they are the dominant contributors of LCA (refer to Activity 1, Part 1). For instance, the enteric methane emission usually accounts for 70 to 80% of the total GHG emissions in a “cradle to farm-gate” LCA (Hristov et al., 2013). Given the importance of methane emissions, it is imperative that the methodology and data employed to estimate these emissions are as robust as possible to reliably underpin mitigation policies and management strategies (Hristov et al., 2013).

Equations from the Chapter 10 and 11 of "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" were summarised in the spreadsheet. Livestock related emission calculations in the spreadsheet were categorized into six groups: Enteric methane (CH_4) emission, Manure CH_4 emission, Direct nitrous oxide (N_2O) emission from manure management, Indirect N_2O emission from manure management, Direct N_2O emissions from managed soils, Indirect N_2O emissions from managed soils. Further, the required data was categorized into different groups: book values and country specific data, activity data (e.g., data from individual projects).

1. Nugrahaeningtyas et al., 2018	Indonesia	Peer-reviewed paper	GHG emissions for the livestock sector	National statistics	No	N/A	Tier 1	Tier 1	Tier 1	Not mentioned	Not mentioned	Not mentioned	N/A
2. Widi et al., 2015	Indonesia	Peer-reviewed paper	Effect of crossbreeding cattle on GHG emissions	Household survey (252 farms)	Yes	N/A	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Eco invent 2.2	Based on Live Weight produced and economic
3. de Vries et al., 2019	Indonesia	Peer-reviewed paper	Reduction of GHG in small- scale dairy farms	Household survey (300 farms)	Yes	GLEAM	Used GLEAM methodology						
4. Zuratih, 2019	Indonesia	Conference proceedings	Literature review to obtain secondary data on livestock population	National statistics	No	ALU tool	Tier 1	Tier 1	Tier 1	Tier 1	Not mentioned	Not mentioned	N/A

5. Habib, 2019	Pakistan	Peer-reviewed paper	GHG emission from livestock	National statistics	Yes	GLEAM		Used GLEAM methodology		
6. Habib, 2018	Pakistan	Peer-reviewed paper	CH4 emission from livestock	National statistics	No	GLEAM		Used GLEAM methodology		
7. Ijaz et al., 2019	Pakistan	Peer-reviewed paper	Emission profile of agriculture	National statistics	No	NAIIS		Tier 1		N/A
8. Mayuni et al., 2019	Malawi	Peer-reviewed paper	GHG emission of dairy farms	National statistics	No	GLEAM		Used GLEAM methodology		
9. Galea et al., 2020	Cambodia and Lao PDR	Peer-reviewed paper	GHG emissions of replacing fish with beef protein	National statistics	No	N/A	Tier 2	Not mentioned		N/A

Activity 2: Undertake a series of questionnaires and consultations with existing livestock project leaders - and their key in-country personnel - to better understand the project background, data availability, level of engagement with the Ministry responsible for the national inventory and current national capacity/interest for being involved with future livestock MRV projects

At the beginning of the project, there were 19 potential projects offered by ACIAR and MPI that could be considered to participate this project. The initial assessment was carried out by sending a Microsoft Excel file with the type of data necessary for the Tier 1, Tier 1a, Tier 2 and LCA calculation to the project leaders. This file was mainly related to information about the type and number of animals on farm or project, the manure management systems used and data around the inputs they had (e.g., feed and fertiliser). In this initial stage, we asked them to answer only about the availability of the data, with simple answers as "Yes – data available", "No – data not available", or "Data can/can't be collected".

Based on the initial response from project leaders and further consultation with ACIAR and MPI, ten projects (Table 2) were selected out of 19 projects, for conducting a semi-structured questionnaire survey (Zoom) with individual project leader and their research team members. The survey intended to understand the project background, data availability, completeness of the data, interest in and possibility for additional data collection in future projects/activities and current national capacity/interest for being involved with livestock MRV activities in longer term.

Table 2. Selected projects for conducting semi-structured questionnaire survey.

No.	Project	Project leader	Funder	Industry	Region
1	Improving smallholder dairy and beef profitability by enhancing farm production and value chain management in Pakistan	David McGill	ACIAR	Dairy and beef	Asia
2	Profitable feeding strategies for smallholder cattle in Indonesia	Karen Harper	ACIAR	Cattle	Asia
3	Promoting business development pathways for more productive and profitable smallholder cattle systems in Vanuatu	Simon Quigley	ACIAR	Cattle	Pacific
4	Intensification of beef cattle production in upland cropping systems in Northwest Vietnam	Stephen Ives	ACIAR	Beef	Asia
5	Goat production systems and marketing in Lao PDR and Vietnam	Stephen Walkden-Brown	ACIAR	Goat	Asia
6	Zambia dairy transformation: supporting smallholder farmers to improve productivity and milk quality	Tania Thomson	MPI (IFAD)	Dairy	Africa
7	Lao quality beef initiative: commercial development of the Lao beef industry	Dennis Radford	MPI (IFAD)	Beef	Asia
8	Rwanda Dairy Development project	Francesco Rispoli	MPI (IFAD)	Dairy	Africa
9	Enhanced smallholder Livestock Investment Programme in Zambia	Ambrosio Barros	MPI (IFAD)	Sheep/Goat	Africa
10	Transforming agriculture through diversification and entrepreneurship programme in Malawi	Ambrosio Barros	MPI (IFAD)	Dairy and beef	Africa

Activity 3: Discuss any data shortfalls with livestock project leaders and identify interest in and possibility for additional data collection in future projects/activities, and how the ensuing products/outputs (tools etc) would be used in-country longer term.

Further communication with selected ten project leaders, only eight were available or interested in further participating in the survey. Projects 8 and 9 (both from MPI (IFAD)) had complicated structures from an organisational and team perspective. Generally, IFAD has a "Regional Manager" that is responsible for several projects. The contact with the project team "on the ground" would be mediated by the general manager. Preliminary meetings with the general managers from these two projects, both mentioned the difficulty in obtaining the data requested and that IFAD has already used one GHG accounting tool (i.e., GLEAM) to perform analysis. Based on this feedback, these two projects were excluded from the list. After consultation with MPI and ACIAR, those projects were replaced with another two projects funded by ACIAR (Table 3).

Table 3. Projects 11 and 12 (funded by ACIAR) that replaced projects 8 and 9.

No.	Project	Project leader	Funder	Industry	Region
11	Best practice health and husbandry in cattle and buffalo Lao PDR	Russell Bush	ACIAR	Cattle and buffalo	Asia
12	Management practices for profitable crop livestock systems for Cambodia and Lao PDR	Matthew Denton	ACIAR	Crop livestock	Asia

Activity 4: In conjunction with GRA-LRG members from the project countries, undertake a Training Needs Analysis for future MRV capacity building that incorporates priorities, delivery mechanisms (e.g., virtual vs face to face etc) and possible alignment (and/or duplication) with other donor efforts.

A guided group zoom discussion was performed with 17 livestock project researchers/in-country personnel from all projects. The discussion started with a presentation from Paul Cheng and Andre Mazzetto to highlight the project objectives and key up-to-date findings (i.e., from activities 1, 2 and 3). The project team then used a pre prepared document (Appendix 3) to collect key information regarding training needs. The document intended to capture information from four areas: 1) desired and existing level of skills and expertise, 2) capacity gaps in GHG emissions/MRV requiring further training, 3) best mode of training, and 4) alignment/duplication with other donor activity on the areas of GHG emissions, data collection and validation, as well as GHG emissions calculation. The summary information was distributed to participants for confirmation before finalising it for reporting (Table 5).

6 Achievements against activities and outputs/milestones

Activity 1: Review international Tier 1 and 2 GHG emissions accounting & LCA methods to identify the most appropriate data requirements in each livestock project

no.	activity	outputs/ milestones	completion date	comments
1.1	Structured review focusing on the studies assessing the GHG emissions from livestock in the countries selected	Nine greenhouse gas emissions accounting and life cycle assessment (LCA) studies were found and summarised	1/3/2022	N/A
1.2	Review IPCC international Tier 1 and 2 livestock GHG emissions accounting tools	A spreadsheet was developed with a set of guidelines for project leaders to use to calculate major GHGs	1/3/2022	N/A

Activity 2: Undertake a series of questionnaires and consultations with existing livestock project leaders - and their key in-country personnel - to better understand the project background, data availability, level of engagement with the Ministry responsible for the national inventory and current national capacity/interest for being involved with future livestock MRV projects

no.	activity	outputs/ milestones	completion date	comments
2.1	Undertake a series of questionnaires and consultations with existing livestock project leaders - and their key in-country personnel - to better understand the project background, data availability, level of engagement with the Ministry responsible for the national inventory and current national capacity/interest for being involved with future livestock MRV projects	Ten projects were selected out of 19 projects, for conducting a semi-structured questionnaire survey	1/3/2022	N/A

Activity 3: Discuss any data shortfalls with livestock project leaders and identify interest in and possibility for additional data collection in future projects/activities, and how the ensuing products/outputs (tools etc) would be used in-country longer term

no.	activity	outputs/ milestones	completion date	comments
3.1	Discuss any data shortfalls with livestock project leaders and identify interest in and possibility for additional data collection in future projects/activities, and how the ensuing products/outputs (tools etc) would be used in-country longer term	Two MPI projects selected from activity 2 were replaced by 2 ACIAR projects	1/3/2022	N/A

Activity 4: In conjunction with GRA-LRG members from the project countries, undertake a Training Needs Analysis for future MRV capacity building that

incorporates priorities, delivery mechanisms (e.g., virtual vs face to face etc) and possible alignment (and/or duplication) with other donor efforts

no.	activity	outputs/ milestones	completion date	comments
4.1	In conjunction with GRA-LRG members from the project countries, undertake a Training Needs Analysis for future MRV capacity building that incorporates priorities, delivery mechanisms (e.g., virtual vs face to face etc) and possible alignment (and/or duplication) with other donor efforts	Training needs analysis was completed with a summary table developed for future MRV capacity building that incorporates priorities, delivery mechanisms (e.g., virtual vs face to face etc) and possible alignment (and/or duplication) with other donor efforts	1/3/2022	N/A

7 Key results and discussion

Activity 1:

The country with the most relevant published studies is Indonesia (n = 4) and Pakistan (n = 3) focused on country livestock emissions (not specific to sectors). Malawi (n = 1 each), and Cambodia and Lao PDR (n = 1 covering both countries) were the countries with fewer studies. No studies were found for Zambia, Vanuatu and Vietnam. Most studies used the Global Livestock Environmental Assessment Model (GLEAM) for calculating the GHG emissions. All studies mentioned that the IPCC methodology was followed, using different Tiers depending on the amount of information available. Most of the studies did not manage to use Tier 2, possibly due to data limitation.

From the nine studies, most of them did not consider (or claimed to be) LCAs and only used GHG emission accounting for the main sources. Further analysis of these LCA studies showed that the model did not contain enough information for an LCA. This clearly shows that LCA was not well modelled in the previous publications and future research is needed in this space.

In summary, the Part 1 literature review showed that multiple countries being considered under our "Climate Lens" project are currently developing studies regarding GHG emissions in the livestock sectors. This may be related the research agenda movement/funding direction of specific countries/funders, which support the calculation and reporting of GHG emissions. However, based on our search, countries like Pakistan, Cambodia and Lao PDR only had studies at the country level. Most studies used readily available tools, such as GLEAM. Such tools are helpful but still need to be complemented with extra data if the study is to be used for LCA purposes. The main data gaps found in the studies were information about electricity, fuel and animals bought/sold. In order to account for that specific information, simple models can be developed using more straightforward tools like Excel spreadsheet, being customisable for the amount of data required and allowing the possibility of including region-specific emission factors when those are available to use.

When it comes to accurately model GHG emissions from livestock production, modelling livestock related GHG emissions in the form of CH4 and N2O are of great importance. This is because they are the major contributors (70%+) to the whole emission profile from LCA (Part 1). Further, Activity 4 discussion highlighted the need to provide standardised method for emission accounting, that can be used for different countries and livestock classes. Therefore, the Part 2 review purposely and comprehensively assessed the IPCC methods and developed Spreadsheet 1, using IPCC method to allow users easily understand and find the requirements for calculating livestock related GHG emissions using either IPCC Tier 1, 1a or 2 from their projects. The review and spreadsheet are complementary to the review of LCA (Part 1). Further, such spreadsheet tool allows project team to visualise the additional data that is required to calculate GHG emissions using higher Tier than the current data can support (e.g., moving from Tier 1 to 2 calculation).

Activity 2 & 3

In summary, the goals of the engaged livestock projects include: supporting the smallholder livestock farmers in partner countries to create strategies to increase their resilience, improve their production, livestock health and/or creating more value for their products. This is achieved by for example, improving pasture management systems, creating better rations and forage options, helping to improve cattle supply chains, and improving market linkages for farmers. The engaged projects covered a wide range of farming systems and regions, from dairy to beef and to goat production in Asia, Africa, and Pacific (Table 2 and Table 3).

There were varying degrees of data availability within these projects (Table 4). Using survey data and Spreadsheet 1, we developed Appendix 2 to summarise potential use of tier systems to model CH4 and N2O from each livestock project, which will support the development of phase II "Climate Lens" project. Four projects mentioned having "almost all data" available. When necessary to collect extra or missing data, all projects answered that it will be possible, except one projected from MPI (IFAD). This was due to the project was scheduled to start in October 2021, so the project leader couldn't confirm the data accuracy or availability. All projects ranked the data available as reliable or very reliable. It was mainly due to 1) data was organised in spreadsheets and/or reports/thesis, 2) data is available to download from the cloud and 3) consistent methodology was used for collecting data.

The main challenge for all projects around data collection is that smallholder farmers usually don't keep a record of their data. Also, the management is subjected to cultural influences. For example, cows are culled for a festival in the village as required as opposed to culling when the animals get to a certain age or weight. It is important to note that farmers sometimes may not be willing to share the correct information on how many animals they have due to cultural suppression or tax reasons. Although there are such challenges in estimating the GHG emissions from these projects/farms, this may be improved, as mentioned by Apdini et al. (2021), who showed that the variability in the carbon footprint of Indonesian smallholder dairy farms is reduced by increasing the number of visits per farm per year.

Further, the project leaders usually rely on senior/junior local scientists (especially when there is a language barrier) or combine different datasets to collect the data necessary. To make data collection easier and more reliable, some projects used a customisable app for continuous data collection (e.g., CommCare). The data is available as Microsoft Excel files and are uploaded directly from the mobile/tablet to the cloud, avoiding errors such as typos during the transcription of the data from written to digital. As a strategy for consistently collecting data, the project leaders highlighted the need to train farmers and/or local partners. This may be better achieved by offering small incentive and clearly explain the importance of data collection to the person who collects the data.

Estimating GHG emissions relies on the availability of feed quality data (IPCC, 2019). Unfortunately, in some smallholder farm systems feed quality data is hard to evaluate, since animals are raised "free" and browse pasture, bushes, and trees anywhere in the village. Overall, limited projects have data available on feed quality.

Although most of the projects don't currently measure the GHG emissions from the smallholder farm systems, most projects mentioned that they would "likely" or "very likely" incorporate a GHG accounting tool into their current/future projects (Table 4). The main reasons for this are 1) the policies around climate change and the need to evaluate the GHG emissions from the projects/countries, 2) the contribution to ACIAR/MPI broader objectives, and 3) the possibility to increase the capacity of the project team.

The lack of expertise and experience with GHG accounting was the main challenge for most projects, and this is particularly true when consider in country team capability (which is low). This reinforces the need for a simple tool that can account for most calculations, whilst having a "user-friendly" interface to provide the project leaders with the results. However, direct application of GHG estimation tools from developed countries may lead to over/underestimation of GHG emissions (FAO, IDF and IFCN, 2014). Therefore, local studies are required to validate and/or adapt the approaches to increase the estimation accuracy (Munidasa et al., 2021). Further, it reinforces the need of training for the correct use of such tool(s).

Table 4.1. Questionnaire with answers for Activity 2 and 3.

Project name and country	**Promoting business development pathways for more productive and profitable smallholder cattle systems in Vanuatu**	**Profitable feeding strategies for smallholder cattle in Indonesia**	**Zambia dairy transformation: supporting smallholder farmers to improve**	**Transforming agriculture through diversification and entrepreneurship programme - Malawi**
Project Leader	Simon Quigley	Karen Harper	Tania Thomson	Felix Lombe is TRADE Coordinator as of 1st of August 2021
Key country personnel/institution	Department of industry – Ministry of Trade Department of livestock – Ministry of Agriculture Vanuatu Agriculture Research and Technical Center – Ministry of Agriculture	Universities and research stations within Indonesia (Many collaborators)	Tania has a team in Zambia linked with local govt and industry Ministry of Fisheries and Livestock – main Ministry of Agriculture, Ministry of Health, Ministry of Commerce Trade and Industry	Malawi govt - Project management unit (PMU). Contact person – PMU (Felix Lombe), James Ntupanyama and Ambrosio Barros
Timeframe of the project	Phase 1 (2016 – 2020) Phase 2 (2021- 2025) – will start soon	2017-2021	2017 - 2021	(2020 – 2026) – will start soon

Main project objectives	Phase 1 - Understand the role of cattle in livelihood of smallholder farmers in Vanuatu, get baseline data and understand the key constraints for production, economic and marketing Phase 2- A farm planning approach to increase productivity and profitability of smallholder cattle systems in Vanuatu	Help Indonesian smallholder farmers to create better ration that would give them better liveweight gain and profitability	Increase the quantity and quality of the milk for commercial sale by smallholder farmers	Increase value chain commercialization and resilience of rural poor and smallholder production Provide institutional support for value chain development in Malawi
Data availability	Almost all data is available	Almost all data is available	Some data is available	Data is not available as project only starts 2021
Possibility to collect all the shortfall data **Yes/No**	Yes	Yes	Yes	Maybe
What are the extra steps/ method required to collect the shortfall data? **Require any resources and training to collect the shortfall data?**	Empowering farmers to collect data, small incentive is needed (e.g., pay for the data uploads)	Connect with local senior/junior scientists Training project staff for GHG modeling	Combine two data sets to extra some shortfall data Govt has climate change project, their survey data may be utilized	N/A

			Training is needed for data collection, farmers or farm workers can involve in this process	
Does your project continuously collect the existing data? **When did you start to collect the data?**	Yes Phase 2 will continuously collect the data	Yes 3-year continuously collected the data	Yes Annual and monthly data	N/A
What are the purposes for collecting existing data?	Research, monitoring, and evaluation	Research	Monitoring and evaluation of the project/policy development, monthly data is to encourage farmers to change their practice	N/A
According to your knowledge/view, how reliable is the existing data?	Very high (8/9)	Highly reliable (9/9)	High (7/9) - Monthly data collection Moderate (5/9) – Annual data collection	N/A
How does your project collect/ measure the following data? **Feed quality/Feed quantity**	NIR based On research station – Biomass cut Farm – Visual observation (not calibrated)	Wet chemistry Offered - refusal	N/A	N/A

Are there any difficulties in obtaining accurate measurements or data collection?	Yes	Yes	Yes	N/A
If "Yes", have you found ways to improve the accuracy (e.g., methods, communication/use of local language etc.)?	Frequent (e.g., fortnightly) communication Short reports with photos Phase 2 – small office will be setup in the field, central to the 3 villages that the project will work	Improved communication, training and country/site visits help to improve the accuracy of the data collection	Allowing time for staff to understand the reason for data collection	N/A
Have you had any other issues during existing data collections? Yes/No	Yes	No	Yes	N/A
What are those issues?	The wet season is difficult to access field sites. Poor phone network to communicate with farmers	N/A	Farmers do not want to share the correct information on how many animals that they have – cultural suppressions or tax reasons	N/A
How did you overcome them?	N/A	N/A	Better communication with the farmers	N/A
Is the existing data well organised and in an	Yes	Yes	Yes	N/A

electronic format that is easy to access?				
If we build tools (e.g., simple spreadsheets) to estimate GHG emissions of your project, how likely are you to incorporate them into your current/ future project?	Extremely likely	Extremely likely	Extremely likely	Likely
What is the reason for the above answer?	Win-win for everyone Effective way to frame the productivity	This will help to manage the project sustainably	This would help the project to provide the data to ministry as a part of GRA project Zambia government would interest in this project as government has a project related to climate change/ climate mainstreamed through existing projects	This will help to strengthen the capacity of the monitoring and evaluation Tools that are simple to use will contribute quantification and reporting efforts
Do you think estimating GHG emissions from your project is important to complement some of your project/ research objectives?	Very helpful	Very helpful	Very helpful	Very helpful

What are the opportunities for incorporating livestock measurement, reporting and verification (MRV) data collection and/or analysis in livestock development projects longer term?	Sustainable management of the project Achieve the obligations (and policy objectives) of government/ Paris Agreement Attract more funding/projects Building capability in agricultural greenhouse gas emission estimation	Sustainable management of the project Achieve the obligations (and policy objectives) of government/ Paris Agreement Attract more funding/projects Building capability in agricultural greenhouse gas emission estimation	Achieve the obligations (and policy objectives) of government/ Paris agreement Attract more funding/projects Building capability in agricultural greenhouse gas emission estimation Identifying potential greenhouse gas mitigation strategies To inform policy – currently people talk about GHG emission, but they do not have data show the real impact	Sustainable management of the project Achieve the obligations (and policy objectives) of government/ Paris Agreement Building capability in agricultural greenhouse gas emission estimation Identifying potential greenhouse gas mitigation strategies and evaluate the impact of such activities
What are the challenges for incorporating livestock MRV data collection and/or analysis in livestock development projects longer term?	Understanding the vulnerability to climate change at low level in both policy and farmer level	If method/ model can be developed in a simple way challengers will not occur	Lack of expertise and experience in livestock MRV Lack of country specific methodologies	Lack of expertise and experience in livestock MRV Resource constrains (e.g., human resources at local level) Lack of country specific methodologies

			Lack of real understanding of peoples' on GHG emission and climate change	
Can you think of any other points around the availability of data, data collection or MRV that might be helpful?'	Projects(s) have good relationships with senior policy makers exist in Vanuatu If policy support, this would trickle down to the farm level but would need to be framed effectively Regional approaches would be more effective (e.g., working as cluster of countries)	Simple app will be useful to collect necessary data online and offline Capacity building is important	Having a simple form/ app would be useful Research should be pragmatic	It would be important to share the information about greenhouse emissions and mitigation strategies with farmers and avoid the risk that such information remains confined to technicians, researchers, and decision makers

Other points	Farmers need to understand the direct benefits to them of adopting practice change or establishing monitoring systems that provide transparency around their GHG footprint – increased production, increased incomes (either direct or indirect from policy/carbon credits)	N/A	Existing connection with different projects in Zambia (e.g., World Bank and IFAD funded projects) Ministry of Fisheries and Livestock has developed a project proposal together with Tania *Submitted to GRA to get the funding towards developing a Tier 2 accounting system for emission reporting to IPCC	IFAD already has partnership with FAO and uses GLEAM-i tool in select number of projects for measuring carbon footprint The project includes dairy and beef value chains Goat value chain may be included later stage of the project Parallel project funds by ILRI, Solidaridad SAF, and Global Roundtable for Sustainable Beef (GRSB)

Table 4.2. Questionnaire with answers for Activity 2 and 3.

Project name and country	**Lao Quality Beef Initiative – LQBI**	**Improving smallholder dairy and beef profitability by enhancing farm production and value chain management in Pakistan**	**Intensification of beef cattle production in upland cropping systems in Northwest Vietnam**	**Goat production systems and marketing in Lao PDR and Vietnam**
Project leader	Dennis Radford	David McGill	Stephen Ives	Stephen Walkden-Brown
Key country personnel/institution	Department of Livestock and Fisheries, Provincial and district administrators	In country primary partner organization University of Veterinary Animal Science Lahore and 20 others implementation partners from Lahore including government, NGOs, research organizations, private organizations (extension programs)	National Institute of Animal Science Ministry and Department of Agriculture and Rural Development Local universities (Vietnam National University of Agriculture / Thai Nguyen University of Agriculture and Forestry)	Ministry of Agriculture National Agricultural and Forestry Research Institute Lao National Animal Health Laboratories Laboratory Lao PDR National Institute of Animal Sciences Vietnam Hanoi Agricultural University Huwei Hue Agricultural University of Agriculture and Forestry
Timeframe of the project	July 2017 – June 2022	2017 – June 2022	2017 – June 2022	SRA – 2017-2018 Main project - July 2019-June 2023

Main project objectives	Improving the cattle supply chain Improving pasture management system	Improving smallholder livelihood in Pakistan Development of smallholder production systems Understand smallholder beef value chains	Improving market linkages for farmers Increasing forage options Encouraging collective action through co-operatives Improving livelihood (women and children focus)	Evaluate goat production systems in Lao PDR to develop technical, social and economic benchmarks against which improvements can be assessed Assess major constraints and identify and evaluate potential solutions Reduce market risk and increase marketing opportunities through improved understanding of the factors affecting demand and pricing of goats in Lao PDR and Vietnam, and of the associated value chains Build capacity for research and development of goat production in Lao PDR and initiate scaling out of project findings
Data availability	Almost all data is available – monthly collected for focus farmers	Some data is available	Some data is available	Some data is available

Possibility to collect all the shortfall data **Yes/No**	Yes	Yes	Yes	Yes
What are the extra steps/ method required to collect the shortfall data? **Require any resources and training to collect the shortfall data?**	Contract team to collect data	Extra sampling of data Research papers/reports from previous ACIAR projects in Pakistan Contacts in the country	Conduct extra surveys to collect missing data (needs funding) Extract from master projects – language is Vietnamese Conduct master projects (funding) Data can be obtained from new project	Conduct extra surveys to collect missing data Collaboration with others PhD research (if successful)
Does your project continuously collect the existing data? **When did you start to collect the data?**	Yes Monthly data collection	No Mainly qualitative data are available	No Baseline survey (pre and post survey) Feeding trial has continuous data during the trial period	Yes

			Next project (3 projects)- monitoring data will be collected (continuous)	
What are the purposes for collecting existing data?	Monitor business performance	Observe farm practice change Address specific challenges (animal nutrition, feed quality)	Observe changing attitude and behavioral change of the participants Feeding trial (objective) – Observe liveweight gain	Benchmarking the systems and measuring changes accordingly Measure the change/impact from the project
According to your knowledge/view, how reliable is the existing data?	Very high (8/9)	Very high (8/9)	High (7/9)	High (7/9)
How does your project collect/ measure the following data? **Feed quality/Feed quantity**	N/A - Can help with getting average quality of the different feed but any assessment by local team will need to be simple and easy	N/A – have data for the most important crops	Data from trials	N/A
Are there any difficulties in obtaining accurate measurements or data collection?	Yes – calibration of scales	Yes – lack of field experience in collecting field data	Yes	Yes
If "Yes", have you found ways to improve the accuracy (e.g., methods,	Help farmers to understand the reason for data collection (needs to add value for them), then the	Use trained people to assist and check the method of data collection	Provide clarification about how data is collected - questions need to be explained well, it helps	Improved the relevance of the questionnaires over time and developed improved animal weighing methods

communication/use of local language etc.)?	accuracy of the data getting improvement	Use the Comcare app to design method to get accurate data	understand the reason for data collection	
Have you had any other issues during existing data collections? Yes/No	No	Yes	No	Yes
What are those issues?	N/A	Lack of farm record keeping - farmers cannot remember all the information about their herd	N/A	Ensuring presence of registered ear tagged goats during village visits. Not all goats are available We have encountered some survey fatigue amongst villagers – the monthly survey is quite extensive
How did you overcome them?	N/A	Use the trained team (where possible) to ensure the quality of numbers and recording. If not possible, then had a team member on location for training the local staff	N/A	Didn't overcome
Is the existing data well organised and in an electronic format that is easy to access?	Yes - kept in spreadsheets and reports	Yes – using the Comcare app (for continuous data collection) and hand-written data sheets	Yes – well organized	Yes - stored directly to cloud using Comcare – available for download as Excel files

If we build tools (e.g., simple spreadsheets) to estimate GHG emissions of your project, how likely are you to incorporate them into your current/ future project?	Likely	Extremely likely	Extremely likely	Extremely likely
What is the reason for the above answer?	It depends on how easy to use the tool is	Possibility to link with the some of the projects Add environmental aspect to the project	There is a new policy in Vietnam to reduce GHG emissions, so any data produced by our projects will contribute to the countries inventory	Highly likely to use as part of meeting the environmental impact aspects of our project Contribute to ACIAR broader objectives
Do you think estimating GHG emissions from your project is important to complement some of your project/ research objectives?	Very helpful	Very helpful	Very helpful	Moderately helpful

What are the opportunities for incorporating livestock measurement, reporting and verification (MRV) data collection and/or analysis in livestock development projects longer term?	This depends on objectives of the Lao Govt and Dept of Livestock It will happen if donors insist on it as that will influence govt uptake. It is at the advanced end of where Lao is at present from environmental perspective	Sustainable management of the project Achieve the obligations (and policy objectives) of government/Paris Agreement Attract more funding/projects Building capability in agricultural greenhouse gas emission estimation	Achieve the obligations (and policy objectives) of government/Paris agreement Identifying potential greenhouse gas mitigation strategies	Sustainable management of the project Achieve the obligations (and policy objectives) of government/ Paris Agreement Attract more funding Building capability in agricultural greenhouse gas emission estimation Identifying potential greenhouse gas mitigation strategies and evaluate the impact of such activities
What are the challenges for incorporating livestock MRV data collection and/or analysis in livestock development projects longer term?	Lack of expertise and experience in livestock MRV Resource constrains Lack of country specific methodologies	Lack of expertise and experience in livestock MRV Resource constrains Lack of country specific methodologies	Lack of expertise and experience in livestock MRV Lack of country specific methodologies	Lack of expertise and experience in livestock MRV Resource constrains Gap in measurements

	Lack of wider policy framework that promoting of GHG considerations in the project			
Can you think of any other points around the availability of data, data collection or MRV that might be helpful?'	N/A	Government department database – May be available some of the required data Verification platform Have link with key personals who manage this	N/A	Current data collection software (Comcare) does not have graphics capability or ability to show farmers data in longitudinal or summary format. Therefore, hard to compare and can't visualize data
Other points	N/A	N/A	N/A	Project team (MPI/Uni of Melb) needs to consider if your goals are compatible with our project work which is with animals grazing/browsing undefined areas of land i.e., they are free ranging most of the time

Table 4.3. Questionnaire with answers for Activity 2 and 3.

Project name and country	**Cambodia/Lao PDR** **Best Practice Health and Husbandry in cattle and buffalo Lao PDR; Best Practice Health and Husbandry of Cattle, Cambodia; Village-based biosecurity for livestock disease risk management in Cambodia; Enhancing transboundary livestock disease risk management in Lao PDR; Development of a bio secure market-driven beef production system in Lao PDR**	**Cambodia/Lao PDR** **Management practices for profitable crop livestock systems for Cambodia and Lao PDR**
Project leader	Russell Bush	Matthew Denton
Key country personnel/institution	Cambodia: General Directorate of Animal Health and Production Lao: Department of Livestock and Fisheries Universities in each country	Cambodia: Cambodian Agricultural Research and Development Institute (CARDI) Royal University of Agriculture, Cambodia (RUA) Livestock Development for Community Livelihoods Organization (LDC) Laos: National Agriculture and Forestry Research Institute (NAFRI) National University of Laos (NUoL)
Timeframe of the project	1 Cambodia / 1 Lao (2007 to 2012) and 1 Cambodia / 2 Lao (2015 to 2018/2020)	2016 - 2024

Main project objectives	Smallholders Cambodia: improve health and production – implementation of vaccination protocol, forage growing and feeding, husbandry and management interventions (across all farm species) Lao PDR: compare vaccination/biosecurity (no vaccination)/combined – production and disease data in large ruminants Lao PDR: improve amount of product entering the supply chain – market driven beef, promoting forage growing, improved health and production 2 groups: low intervention (2007 project) and high intervention – change to medium intervention (2015 project)	Phase I (2016-2020) Determine the productivity potential for integrated crop/fodder/livestock production systems in sandy terrain in Cambodia and southern Laos. Define soil and water management practices in crop/ livestock production systems that increase resilience and profitability, allow greater integration, and diversify enterprises. Identify potential models for intensification of crop/ livestock production systems on low fertility sands using a participatory methodology and evaluate the socioeconomic impacts of system changes. Extend new knowledge in integrated crop/livestock production systems and increase research capacity among stakeholders. Phase II (2021-2024) Confirm the impact of increased potassium and sulfur nutrition on forage productivity in Cambodia and Laos and extend this information to next users.

		Determine influence of topo sequence and soil type on seasonal soil water use and production of perennial forages in sand-textured soils of Cambodia. Identify and promote opportunities to strengthen institutional arrangements to sustain and scale forage production in Cambodia and Laos.
Data availability	Most of the data are available	Medium data availability
Possibility to collect all the shortfall data **Yes/No**	Yes	Yes
What are the extra steps/ method required to collect the shortfall data? **Require any resources and training to collect the shortfall data?**	Contact people Get data from the hard drive Averages/proxies Thesis/scientific paper	Additional field trip/survey
Does your project continuously collect the existing data? **When did you start to collect the data?**	Yes, longitudinal surveys 3 or 4 times per year	No Since project started

What are the purposes for collecting existing data?	Determine season differences and intervention impacts Use as baseline for household scenario modelling in Integrated Assessment Tool (IAT)	
According to your knowledge/view, how reliable is the existing data?	High (6/9)-1 Very high (8/9)-2	
How does your project collect/ measure the following data? **Feed quality/Feed quantity**	In initial project conducted feeding trial with proximate analysis of ration ingredients to determine quality. Measured offered and refusals to determine quantity consumed. Used published data to specify correct harvest protocols in subsequent projects.	Number of animals in each class – Survey of farm Average weight of the animal in each class – Not measured (could be estimated) Production data Milk/ meat production – No (households do not slaughter or milk) Feed Quality and quantity – Yes (multiple experiments involving feed production and quality data collection)
Are there any difficulties in obtaining accurate measurements or data collection?	Yes	Yes
If "Yes", have you found ways to improve the accuracy (e.g., methods,	Using students and project officers liaising with local teams/prioritize activities	Our survey teams are made of local researchers. The locations are remote, often hard to access because of weather and COVID restrictions.

communication/use of local language etc.)?		
Have you had any other issues during existing data collections? Yes/No	Yes	Yes
What are those issues?	Farmer availability/competing needs Logistic Farm Survey - short/time In-country staff is lack of understanding of objectives	We have had plant and soil samples lost or destroyed due to poor local practice/storage.
How did you overcome them?	Additional training of staff and coordinating farmer activities with incentives, such as livestock vaccinations to encourage participation	We changed partners.
Is the existing data well organised and in an electronic format that is easy to access?	Yes	No - It is in electronic format, but organization could be improved. We would have to reorganize it before it could be shared.
If we build tools (e.g., simple spreadsheets) to estimate GHG emissions of your project, how likely are you to	Extremely likely	Extremely likely

incorporate them into your current/ future project?		
What is the reason for the above answer?	Interested before from other projects Options for mitigation (policy perspective)	Environmental/climate impacts are a major concern for ACIAR, and it would be useful to have a tool to monitor them.
Do you think estimating GHG emissions from your project is important to complement some of your project/ research objectives?	Very helpful	Moderately helpful
What are the opportunities for incorporating livestock measurement, reporting and verification (MRV) data collection and/or analysis in livestock development projects longer term?	Sustainable management of the project Achieve the obligations (and policy objectives) of government/Paris agreement Attract more funding Building capability in agricultural greenhouse gas emission estimation Identifying potential greenhouse gas mitigation strategies	Achieve the obligations (and policy objectives) of government/Paris agreement. Attract more funding.

What are the challenges for incorporating livestock MRV data collection and/or analysis in livestock development projects longer term?	Capacity in-country for collecting the data	Lack of expertise and experience in livestock MRV. Resource constrains. Remote location.
Can you think of any other points around the availability of data, data collection or MRV that might be helpful?'	Survey information – using digital tools (survey apps)	-

Activity 4

The group discussion confirmed that the existing level of skills and expertise on GHG emissions, data collection and validation, and GHG emissions calculation are different from livestock project to project. In general, Australian/New Zealand teams have a moderate to good understanding of GHG emissions, but such understanding is limited in partner country teams (Table 5). This is mainly due to low motivation and limited incentive is offered to them to consider GHG emissions. It is interesting to hear that Indonesia and Vietnam governments are moving into this space, with a potential to accelerate the needs for the in-country team to learn/calculate GHG emissions (Nghia, Hai, & Hoan, 2019; Nugrahaeningtyas, 2018).

To explore the capacity gaps and training needs, project leaders in the discussion identified some major areas that require attention in the future work: 1) better recognise the existing knowledge and knowledge gaps in partner countries, 2) ensure local team understands the purpose of training session and expected outcomes, 3) provide local team with useful and flexible tools (e.g., WiFi) and methods (e.g., Commcare) for data collection as well as GHG emissions calculation, and 4) better engage with key senior people on the ground (i.e., adopt a top down approach) and support local institutions capacity building, particularly through training young scientists/postgraduate programs (Table 5).

To support the calculation of GHG emissions, project leaders emphasised the importance to clearly explain about the differences between Tier 1, 1a and 2 methods to the in-country teams. Further suggested to the future work to consider ways to standardise method to calculate GHG emissions, allowing comparison of data from multiple projects/years (Table 5).

Almost all the project leaders agreed that face-to-face training is the most preferred way because it helps to build personal connection and better identify the suitable level of knowledge/gaps from participants, which in turn to provide timely support to participants. However, online delivery mode may also be used to supplement (but not to replace) face to face delivery. Importantly, an ongoing, short-term training is highly required, otherwise the participants may get fatigue with reduced learning effectiveness (Table 5). Two project leaders mentioned that an annual refresher training is useful for in-country teams to familiarize relevant knowledge and gain updates. To improve engagement, four project leaders believed that training should be structured with a clear timeline, objective, and involve interactive sessions. It was also identified that higher/theoretical/policy level master classes should be provided for senior staff, while more mechanistic/data entry/interpretation training should be offered to junior staff. Finally, it is recommended that trainings should be carried out in different places to attract more people to attend.

It was agreed at the discussion that seeking cooperation with the country government agencies is the main way to delivery possible alignment with these donor efforts. Project leaders highlighted New Zealand MPI, CSIRO in Australia, as well as the potential government departments in European countries such as from Netherland are the possible donors in this research area. These donors generally work with industry, government, and the leading research community around the world in agricultural science and technology field.

Table 5. Training Needs Analysis on Greenhouse Gas emissions (GHGE) and Measurement, Reporting and Verification (MRV) activities.

Area	1) Desired level of skills and expertise on GHGE/MRV (Project team member discussions and desktop review)	2) Existing level of skills and expertise on GHGE/MRV (Discussion with project leaders/key personnel via video conference)	3) Capacity gaps in GHGE/MRV requiring further training (Analysis to identify the capacity gaps and training requirements)
GHGE	An understanding of GHGE sources and sinks	• Moderate to good level (scored 7-8 out of 10) in Australia/New Zealand side • Low level (scored 2-3 out of 10) in partner country teams due to low motivation and deficient incentive	• Understand relevant country policy to establish links and identify key in country personnel. • Senior managers need to be identified and involved to ensure ongoing engagement between project team and end users (top-down approach). • Identify country personnel knowledge gaps and involve them to help operating the project. • Need stepwise and ongoing training. • Build local university capacity and develop learning Apps. • Deliver training to multiple locations to attract new attendees. • Training should align with regional community agreements and single country policy.
Data collection and validation	Use of robust data collection methods (e.g., the principles of Transparency, Accuracy, Completeness, Consistency, Comparability (TACCC))	• Moderate to good (scored 7-8 out of 10)	• Identify and refer to previous project resources. • Provide refresher training to staff in teams. • Ensure local team understands the objectives and appreciate the importance of collecting accurate data. • Identify in country personnel needs and provide essential resource, such as motorbike and Wi-Fi to perform duties. • Build and use Apps (e.g., Comcare) to collect and validate data. • Support postgraduate students to learn.

	An understanding of resources and methods that will be required to collect missing data		
	Document if there are inconsistent data sources (e.g., have methods to collect data changed over time?)		
	Annual average populations accurately estimated		
	Consistency of data across different animal ages (e.g., what age is a calf)		
	Ability to assess the quality of data and identify priorities for continuous improvement		
Record-keeping	Good record-keeping techniques for data (TACCC)	Moderate to good (scored 7-8 out of 10)	• Need simple recording excels to keep/track data easily. • Locally relevant data capturing systems and location specific training is required, due to different skills between countries. • Train young scientists to perform record-keeping. • Consider digitalising record keeping.
	A record of data gaps and future requirements		
	A record of the methods used for when data is incomplete or of insufficient quality		
	A record of methods used if data are missing and therefore estimated		

Calculating GHGE	An understanding of the methods used to calculate GHGE, and the key inputs required	Moderate (scored 5-6 out of 10)	• Train in country personnel to use standardised method to calculate GHGE. • Junior/young local scientists and senior staff should be trained with different levels and targets. • Explain to in country teams the differences between Tier 1, 1a and 2 methods, and support them to decide the best method to calculate GHGE.
	Ability to enter data into a spreadsheet model that will calculate Tier 1, 1a, and 2 GHGE		
	Ability to use and understand the outputs from spreadsheet models when calculating Tier 1, 1a, and 2 GHGE Verify that the model outputs are realistic and accurate		

8 Impacts

8.1 Scientific impacts – now and in 5 years

The Australian and New Zealand (NZ) governments share common interests in investing and assisting partner countries to improve livestock production and productivity. greenhouse gas (GHG) emission from livestock is a crucial area for international agricultural R&D for both countries. Scientifically, the literature review targeted specifically to the developing countries identified in this project, provided a strong scientific basis to identify gaps and support future exploration of emissions accounting and life cycle assessment. Further, the development of spreadsheet tool from this project would allow researchers to calculate their livestock GHG emissions and explore mitigation strategies.

8.2 Capacity impacts – now and in 5 years

A major part of the project was about capacity building, through:

1. Undertake a series of questionnaires and consultations with existing livestock project leaders - and their key in-country personnel - to better understand the project background, data availability, level of engagement with the Ministry responsible for the national inventory and current national capacity/interest for being involved with future livestock MRV projects.
2. Discuss any data shortfalls with livestock project leaders and identify interest in and possibility for additional data collection in future projects/activities, and how the ensuing products/outputs (tools etc) would be used in-country longer term.
3. In conjunction with Global Research Alliance on Agricultural Greenhouse Gasses network members from the project countries, undertake a Training Needs Analysis for future MRV capacity building that incorporates priorities, delivery mechanisms (e.g., virtual vs face to face etc) and possible alignment (and/or duplication) with other donor efforts.

Such knowledge and experience learnt from this project, together with the spreadsheet tool and training needs discussion would positively impact on project participants. Further, it allows funders to identify gaps and consider investment priorities.

8.3 Community impacts – now and in 5 years

This project attempted to link with existing ACIAR, NZ Ministry of Foreign Affairs and Trade (MFAT) and Ministry of Primary Industries (MPI) livestock project teams and through the Global Research Alliance on Agricultural Greenhouse Gasses (GRA) network to build linkages and relations with in-country partners responsible for both monitoring and reporting livestock GHG emissions, with the intent to gain a better understanding of available data (including data gaps) and associated challenges and/or opportunities with livestock monitoring, reporting and verification (MRV) into the future. The community of funders, project leaders, and in country personnel are all benefiting from this project directly as highlighted in section 8.1 and 8.2.

8.3.1 Economic impacts

There is no direct economic impacts from the project. However, the knowledge from the project would allow better data capturing and calculations of GHG emissions from

developing countries. This in turn would results in a long term economic gain, as livestock industry from these countries may claim carbon credit from their production system.

8.3.2 Social impacts

During the training and discussion, we promoted to the project leaders and in country personnel to think and appreciate future sustainable livestock production, which involves farming with a social licence requires not just a high production performance, but also high welfare standard and minimal GHG emissions.

8.3.3 Environmental impacts

The training provided to project participants would allow them to gain insights of the GHG emissions quantification and become more conscious about the implication of GHG emissions impact economically, environmentally, and socially in their region. The project also supported team members peer learning and highlighted the GHG emission quantification and reduction are important aspects to consider for livestock production, as they directly contribute to the current and future climate change.

8.4 Communication and dissemination activities

Results were presented at 2022 NZ MPI annual meeting.

9 Conclusions and recommendations

9.1 Conclusions

The literature review confirmed that there was limited publication assessed the GHG emissions from livestock in the countries selected for this project. Most of the published studies did not manage to use the most advanced Tier 2 GHG emission accounting system, possibly due to data limitation. In addition, the review clearly showed that LCA was not well modelled in the previous publications and future research is needed in this space. The development of Spreadsheet 1, as a lookup tool would allow livestock project team to easily understand and find the requirements for calculating livestock related GHG emissions using either IPCC Tier 1, 1a or 2 from their projects. This tool can also support the movement of livestock projects to use higher Tier systems for GHG emission accounting, through planning and collection of more detailed MRV data in the future. The ten livestock projects we engaged for survey covered a wide range of farming systems and regions, from dairy to beef and to goat production in Asia, Africa, and Pacific. The survey found livestock project team are “likely” or “very likely” to incorporate GHG emission accounting tools in their projects, with almost all data needed for accounting can be made available.

9.2 Recommendations

The major challenges/opportunities for future work in this space including develop a system allowing better data collection/validation, accurate assessment of feed quality, provide opportunity to allow project team members to be trained and experience with GHG accounting. It was highlighted in the group discussion that ongoing training to the in-country personnel and collaboration with local/international donors are needed to support the capacity building.

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10.2 List of publications produced by project

N/A

11 Appendixes

11.1 Appendix 1

Semi-structured questionnaire (1.5 hours)

Project - Livestock Climate Lens Part 1: Data Landscape Analysis

Objective – To understand the project leaders' interest and potential to collect additional data in future projects/activities to estimate greenhouse gas (GHG) emissions using Tier 1 and/or Tier 2 approaches.

1. **Project background**
    a. Project name, funding code and country
    b. Project leader's name
    c. Key country personnel/institution
    d. Timeframe of the project
    e. Project objectives
    f. Does your project already use any tool to estimate GHG emission or have research on measuring GHG emissions? Yes/No

        - If "Yes", explain briefly about it.

    g. Shortfall data (highlighted) for estimating GHG emission using Tier 1 and/or Tier 2 approaches

List of data for estimating GHG emission using Tier 1 and/or Tier 2 approaches

Critical data

Animal

- Inventory - (number of animals in each class e.g., cows, steers, calves, etc.)
- Average weight
- Average animal daily weight gain
- Number of animals bought/sold
- Milk/meat production
- Hours of the day (or month) spent on pasture / hours spent on paddock/milking parlour
- Diet (only pasture, concentrate, supplements, etc.)
- If supplemented: type, amount and origin (produced on farm or off-farm)

Farm

- Farm size
- Land use (area and type of pasture, crop, forest, etc.)
- Grazing strategy (extensive, rotational, confined, etc.)
- Use of fertilizer (type and rate)
- Use of lime (rate)
- Manure management
- Nitrogen inputs from all sources
- Feed quality (Dry matter digestibility and crude protein)

Valuable data

Beef

- Animal timing (month of sale)

Dairy

- % of fat and protein in the milk
- Milk solids per cow
- Replacement rate
- Animal timing (month of typical calving)

Nice to have data

- Share of manure stored / spread

Dairy

- Lactation length
- Dry period (day or months)
- Average number of lactations per cow
- Age of first calving
- Calving interval

• Average age when cows are culled

2. Identify the possibility of collecting the required missing data

2.1. Do you think, there is a possibility to collect all the shortfall data?

Yes (go to section 2.1.1)/ No (go to section 2.1.2)

2.1.1. If **"Yes",**

a. What are the extra steps required to collect the shortfall data?

Data type	**Extra steps required to collect the shortfall data**

b. Do you/your team require any resources and training to collect the shortfall data?

Data type	**Resources and training needed**

2.1.2. If **"No",**

a. What are the data that you will not be able to collect?

Critical data	**Valuable data**	**Nice to have data**

b. What are the barriers/ difficulties with collecting the data?

Data type	**Reason (s)**

c. How can we assist with resources and training needed to collect the required data?

Data type	**Resources and training needed**

d. What are the alternative approaches that you can suggest us to fill in the data shortfall of your project (e.g., book values, subset of data, government reports)?

Data type	**Alternative approach**

3. Data collection and data quality

3.1. Does your project continuously collect the existing data?

Yes / No

3.1.1. If **"Yes"**, when did you start to collect the data?

3.1.2. If **"No"**, what is the duration of existing data collection?

3.2. What are the purposes for collecting existing data?

3.3. According to your knowledge/view, how reliable is the existing data?

0 = not reliable at all 9= highly reliable

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

3.4. How does your project collect/ measure the following data?

a. Animal
    - Number of animals in each class –
    - Average weight of the animal in each class –

b. Production data
    - Milk/ meat production –

c. Feed
    - Quality –
    - Quantity –

3.5. Are there any difficulties in obtaining accurate measurements?

Yes/No

3.5.1. If **"Yes",** have you found ways to improve the accuracy (methods, communication/use of local language etc)?

3.6. Have you had any other issues during existing data collections?

Yes/No

3.6.1. **If "Yes"**

a. What are those issues?

b. How did you overcome them?

3.7. Is the existing data well organised and in an electronic format that is easy to access?

Yes/ No

3.7.1. Reason for your answer?

4. If we build tools (e.g., simple spreadsheets) to estimate GHG emissions of your existing project or future projects, how likely are you to incorporate them into your project (tick only one option)?
    a. Extremely likely
    b. Likely
    c. Neither likely / unlikely
    d. Unlikely
    e. Extremely unlikely

    - What is the reason for the above answer?

5. Do you think estimating GHG emissions from your project is important to complement some of your project/ research objectives (tick only one option)?
    a. Very helpful
    b. Moderately helpful
    c. Slightly helpful
    d. Not at all helpful

6. What are the opportunities for incorporating livestock measurement, reporting and verification (MRV) data collection and/or analysis in livestock development projects longer term?

    a. Sustainable management of the project
    b. Achieve the obligations (and policy objectives) of government/ Paris agreement
    c. Attract more funding
    d. Building capability in agricultural greenhouse gas emission estimation
    e. Identifying potential greenhouse gas mitigation strategies
    f. Other, specify ……..

7. What are the challenges for incorporating livestock MRV data collection and/or analysis in livestock development projects longer term?

    a. Lack of expertise and experience in livestock MRV
    b. Resource constrains
    c. Lack of country specific methodologies
    d. Lack of wider policy framework that promoting of GHG considerations in the project

e. Other,
specify……
…….

8. Who are the key country government or non-government organizations that your project work with and level of connection you have?

Organization	Level of connection (1=Low, 5=extremely high)

9. Can you think of any other points around the availability of data, data collection or MRV that might be helpful?

10. Discussion.

11.2 Appendix 2

Potential use of tier systems to model GHG emissions for each selected livestock project.

Project title and project leader initial	Enteric methane (CH_4) emission	Manure CH_4 emission	Direct nitrous oxide (N_2O) emission from manure management	Indirect N_2O emission from manure management	Direct N_2O emissions from managed soils	Indirect N_2O emissions from managed soils
Improving smallholder dairy and beef profitability by enhancing farm production and value chain management in Pakistan (DM)	T2	T1a	T1a	T1a	T1a	T1a
Intensification of beef cattle production in upland cropping systems in Northwest Vietnam (SI)	T2	T1a	T1a	T1a	T1a	T1a
Goat production systems and marketing in Lao PDR and Vietnam (SWB)	T1a	T1a	T1a	T1a	T1a	T1a
Promoting business development pathways for more productive and profitable smallholder cattle systems in Vanuatu (SQ)	T2	T2	T2	T2	T1a	T1a
Profitable feeding strategies for smallholder cattle in Indonesia (KH)	T2	T2	T2	T2	T1a	T1a
Best Practice Health and Husbandry in cattle and buffalo Lao PDR; Best Practice Health and Husbandry of Cattle, Cambodia; Village-based	T1a	T1a	T1a	T1a	T1a	T1a

biosecurity for livestock disease risk management in Cambodia; Enhancing transboundary livestock disease risk management in Lao PDR; Development of a biosecure market-driven beef production system in Lao PDR (RB)						
Management practices for profitable crop livestock systems for Cambodia and Lao PDR (MD)	T1	T1	T1	T1	T1	T1
Lao Quality Beef Initiative – LQBI (DR)	T2	T2	T2	T2	T1a	T1a
Zambia dairy transformation: supporting smallholder farmers to improve (TT)	T1a	T1a	T1a	T1a	T1a	T1a
Transforming agriculture through diversification and entrepreneurship programme - Malawi (IFAD)	No data available at the time of this survey was conducted					

11.3 Appendix 3

Area	1) Desired level of skills and expertise on GHGE/MRV (Project team member discussions and desktop review)	2) Existing level of skills and expertise on GHGE/MRV (Discussion with project leaders/key personnel via video conference)	3) Capacity gaps in GHGE/MRV requiring further training (Analysis to identify the capacity gaps and training requirements)	4a) Best training of training	4b)Alignment/duplication with other donor activity
GHGE	An understanding of GHGE sources and sinks				
Data collection and validation	Use of robust data collection methods (e.g., the principles of Transparency, Accuracy, Completeness, Consistency, Comparability (TACCC))				
	An understanding of resources and methods that will be required to collect missing data				
	Document if there are inconsistent data sources (e.g., have methods to collect data changed over time?)				
	Annual average populations accurately estimated				

Group interview template from Activity 4

	Consistency of data across different animal ages (e.g., what age is a calf)	
	Ability to assess the quality of data and identify priorities for continuous improvement	
Record-keeping	Good record-keeping techniques for data (TACCC)	
	A record of data gaps and future requirements	
	A record of the methods used for when data is incomplete or of insufficient quality	
	A record of methods used if data are missing and therefore estimated	
Calculating GHGE	An understanding of the methods used to calculate GHGE, and the key inputs required	

Ability to enter data into a spreadsheet model that will calculate Tier 1, 1a, and 2 GHGE	
Ability to use and understand the outputs from spreadsheet models when calculating Tier 1, 1a, and 2 GHGE	
Verify that the model outputs are realistic and accurate	