Australian Government

Australian Centre for International Agricultural Research

Final report

Small research and development activity

project	**Forages - taking stock and identifying research needs**
project number	LS/2018/186
date published	22/02/2022
prepared by	Lava Prakash Yadav
co-authors/ contributors/ collaborators	Davina Boyd, Werner Stur, Rob Cramb
approved by	Dr Anna Okello
final report number	FR2021-079
ISBN	978-1-922787-02-6
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

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1 Acknowledgments

We would like to acknowledge ACIAR for financially supporting the SRA and the program manager Anna Okello for her encouragement and advice over the duration of the project.

We are most grateful to the coordinators, collaborating scientists and the survey teams of each of the country partners. In Laos, we would like to thank the country coordinator Dr. Phonepaseuth Phengsavanh along with the collaborating scientist Dr. Ammaly Phengvilaisouk for coordinating with government and local officials to conduct the forage stocktake and organize all the case study activities. We are also much obliged to Dr Malavan Chittavong for her support in conducting the survey activities.

In Cambodia, we would like to thank the country coordinator Dr. Sorn San. Mr. Lorn Sophal's role as the collaborating scientist was most crucial both for the stocktake activities as well as for overseeing the survey activities. Dr. Sareth Chea and his team were the driving force behind the actual survey implementation and data collection which required additional responsibilities due to COVID19 related disruptions.

In Vietnam we would like to acknowledge the country coordinator Dr. Le Thi Thanh Huyen and the collaborating scientist Mr. Dang Vu Hoa. We would like to extend a very special thank you to Dr. Huyen for taking charge of all project activities and also to her survey team for executing data collection activities.

The project would not have been possible without the generosity of all survey participants. We would thus like to thank the different stakeholders from each of the case study villages that were willing to spare the time to engage in the survey activities. We would particularly like to acknowledge the crucial role of the village leaders in each of these case study sites for their input and for helping identify suitable farmers.

2 Executive summary

Large ruminants (cattle and buffaloes) have long made a significant contribution to mixed farming systems operated by smallholders throughout Mainland Southeast Asia (MSEA), providing draught power, manure, and occasional income. With increasing demand for meat and dairy products across the region and beyond, sustainable intensification and commercialisation of cattle production provides a promising pathway out of poverty. Many smallholders have responded to this demand by transitioning from traditional grazing systems to more productive systems which require more and better-quality feed. While farm-grown forages have been promoted widely as one of the solutions to meet the higher feed demands, effective uptake of forage technologies is slow, and they have not spread easily beyond project sites.

A small research activity (SRA) was designed to develop a better understanding of this situation. Cambodia, Lao PDR, and Vietnam were chosen for this research as they have a long history of forage introductions and encompass the main agro-ecological zones of the region. The research was carried out by a multi-country team from The University of Queensland (UQ), Australia; the General Directorate of Animal Health and Production (GDAHP), Cambodia; the Cambodian Agricultural Research and Development Institute (CARDI), the National Agriculture and Forestry Research Institute (NAFRI), Lao PDR; and the National Institute for Animal Science (NIAS), Vietnam between June 2019 and June 2021.

The overall aim of the SRA was *to identify critical factors that promote or impede demand-driven uptake of forages by smallholders involved in cattle production to provide ACIAR and country governments recommendations for future investments in forage research and development*. The study involved the following activities: 1) an inception visit; 2) a literature review of past forage and cattle development in the MSEA region; 3) a stocktake to document the extent of forage development in Cambodia, Lao PDR, and Vietnam; 4) development of a conceptual framework on the growth and expansion of farm-grown forages; and 5) a comparative analysis of forage development in 12 contrasting case study sites in the three countries where forages have been adopted by smallholder farmers. The main outputs of these activities were summarised in three working documents: (1) *Status of forage development in Cambodia, Lao PDR, and Vietnam*; (2) *Changes in large ruminant production and the uptake of planted forages in Mainland Southeast Asia: a review*; and (3) *Factors contributing to and impeding the adoption of planted forages by smallholder farmers: A comparative analysis across Laos, Cambodia, and Vietnam.*

Following an inception visit to confirm partnerships and discuss research details, country partners documented the current status of forage development by reviewing latest information and contacting key informants. This process also helped in identifying potential areas for the case studies. Concurrently with the country stocktake, a literature review and a conceptual framework for analysis were developed. From the stocktake, 12 areas located in diverse agro-ecological zones were identified for detailed case studies. The studies consisted of group and individual interviews with 305 stakeholders including farmers, cattle and forage traders, extensionists, credit providers, and local government officials. The case studies in Lao PDR were carried out by a team of Australian and national partners prior to the imposition of travel restrictions in early 2020. As case studies could no longer be conducted by the same team, a more structured methodology was developed to enable our partners in Vietnam and Cambodia to conduct the case studies with remote assistance from the Australian team. The case study results were written up separately and provided the basis for a comparative analysis using the conceptual framework. This provided insights into smallholder forage and cattle development and a basis for identifying factors that have promoted and impeded demand-driven uptake of forages in the different agro-ecosystems.

Across most case-study sites we found that raising cattle to sell to the beef market has become an important economic activity for many smallholders. However, with dwindling natural feed sources, the adoption of farm-grown forages has become increasingly important to ensure adequate nutrition and increased cattle productivity. We not only observed a general trend towards higher uptake of planted forages, but also an adaptation of forages to evolving opportunities and constraints. These variations ranged from grazing systems to intensive cut-and-carry systems, while some farmers specialized in growing forages for the emerging forage market. The trajectories related to forage expansion and development were found to be dependent upon a range of factors starting with the nature of forage introductions and the level of continued support for forage and cattle production. While in some cases limited agricultural extension has constrained the extent of forage adoption, in others, entrepreneurial or champion farmers have stepped in to aid in technology dissemination or to compensate for missing markets by supplying planting materials or linking forage growers to forage markets. Competition from other farm and non-farm livelihood opportunities along with household resource constraints were found to greatly influence the path of forage adoption. Trade-offs between these factors have induced some farmers to specialize in cattle production while others retain cattle production as a side enterprise or even abandon cattle raising altogether to specialize in other activities. Recognising that forage production plays an essential role in improving the incomes of cattle-producing households in all agro-ecological zones, but that not all households have the interest or resources to make forage and cattle production a major component of their farming system, the recommendations from this study are adapted for a range of livelihood scenarios.

The SRA concludes that the introduction of planted forages to a range of farming systems in MSEA, despite being initially met with a limited response and largely confined to particular project sites, has provided the basis for the dramatic growth of commercial cattle production over subsequent decades. There is now clear evidence of the growing importance of forages in mixed-farming systems from the lowland plains to the extensively-farmed uplands, and of the potential for further research in support of more productive and sustainable forage systems and more widespread and rapid scaling out. This research needs to be diagnostic, well-targeted, and nuanced to be able to respond to the opportunities and constraints of the various systems that are emerging, and to go beyond the farm to include the value chains with which forage and cattle producers are engaged. The main priorities are:

- Identify additional forage and fodder species and improve access to a range of suitable forage seeds and planting material;
- Improve the sustainability of forages through better management, including fertilisation, irrigation, and grazing management;
- Investigate ways to address dry-season feed shortages, including suitable varieties, better forage management, and forage conservation;
- Document key lessons regarding the role of local actors, farmer-to-farmer learning, and other diffusion strategies (e.g., use of social media) in addressing obstacles to scaling out forage technologies; and
- Develop and evaluate service provision options to improve fodder markets, implement forage conservation, alleviate labour constraints through labour-saving technologies, and alleviate capital constraints through appropriate credit schemes.

3 Introduction

Livestock contribute to nutrition and food security while providing additional income for smallholders throughout Southeast Asia. The higher opportunities associated with the rising demand for meat and dairy imply a promising pathway out of poverty through livestock production for many smallholders. However, poor livestock productivity as a result of inadequate nutrition has been known to keep smallholders from achieving this reality.

The effectiveness of farm-grown fodder in improving cattle production has been widely recognized as a vital component of most cattle (and small ruminant) development projects. While forage development tends to be seen as critical and beneficial by both project managers and farmers, effective uptake is slow and has been observed not to spread without project intervention. As such, the overall aim of this SRA was to identify critical factors that promote or impede demand-driven uptake of forages by smallholders involved in cattle production to provide ACIAR and country governments recommendations for future investments in forage research and development.

The key questions this project addressed were:

- What is the status of forage development across the countries of study?
- What are the key factors that have promoted and impeded forage adoption and expansion amongst smallholders?
- How can findings from this project contribute to future livestock development programs?

In order to address these questions, the SRA:

- Undertook a ‘stocktake’ of all forage development activities in the SRA’s target countries (Laos, Cambodia, and Vietnam) (see Working Paper 1 – Appendix 1)
- Conducted a literature review for developing a conceptual framework on the growth and expansion of farm-grown forages (see Working Paper 2 – Appendix 2)
- Evaluated the status of forage development in 12 cases in the target countries (representing all major agro-ecological zones and cattle production systems across MSEA) in order to test the conceptual framework, identify factors that are promoting and impeding demand-driven uptake of forages, and develop a set of recommendations for future investments in forage research and development (see Working Paper 3 – Appendix 3)

Figure 1: A Buffalo being led for supervised grazing by children in Khangphanien Village, Nonghet District, Xiengkhaung Province, Laos

4 Objectives

The overall aim of the SRA was to identify critical factors that promote or impede demand-driven uptake of forages by smallholders involved in cattle production to provide ACIAR and country governments recommendations for future investments in forage research and development. Within this broader goal the three main objectives were:

1. Identify critical factors contributing to the success and failure of forage development programs in Cambodia, Lao PDR and Vietnam
2. Systemise identified critical factors of success in a conceptual framework and refine this framework through selected case studies to provide decision support for future forage R&D investments.
3. Formulate, verify, and communicate strategies for effective forage R&D to ACIAR, partner governments, and the wider livestock R&D community.

Figure 2: A cattle trader with two bulls in Preaek Preah Ang Village, Preaek Bak commune, Stueng Trang District, Kampong Cham Province, Cambodia,

5 Methodology

The SRA began with a broad literature review of the evolution of farming and more specifically, cattle production systems in MSEA. This review was utilized to develop a conceptual framework on the growth and expansion of farm-grown forages and their role within the context of the broader farming systems. To test the hypothesis identified through the conceptual framework and to refine it further, a case study methodology was developed; this methodology is detailed in Working Paper 3 (Appendix 3) and summarised here.

1. Inception visits to partner countries

A project inception visit was made to each of the partner countries to communicate details of the SRA and to confirm the main partner agency and researchers. Contacts were also made with key informants in Thailand (as the country with the most advanced use of forages and seed supply in the region), Cambodia, Laos, and Vietnam to discuss their experiences with cattle and forage development.

2. Stocktake of forage introduction and development activities

A compilation of forage development activities was undertaken by the partner country researchers using secondary data sources as well as engagement with key informants.

3. Selection of case study sites

The identification of case study sites involved the following steps:

a. In each country, two to three provinces with a long history of forage adoption and/or greater extent of forage adoption were identified to ensure the case study sites selected were endowed with a wide range of forage adopters and forage related experiences.
b. The selected provinces were visited by partner country researchers to collect more on-site information in addition to identifying potential districts and villages best suited for conducting the case studies.
c. A total of four case study villages were selected within each country while ensuring that collectively the case study sites represented the diversity of the main forage and cattle production systems, included all five major agro-ecological zones in MSEA, included all major ethnic groups, etc.

Figure 3 below shows the locations of all 12 case study sites distributed across the different agro-ecological zones.

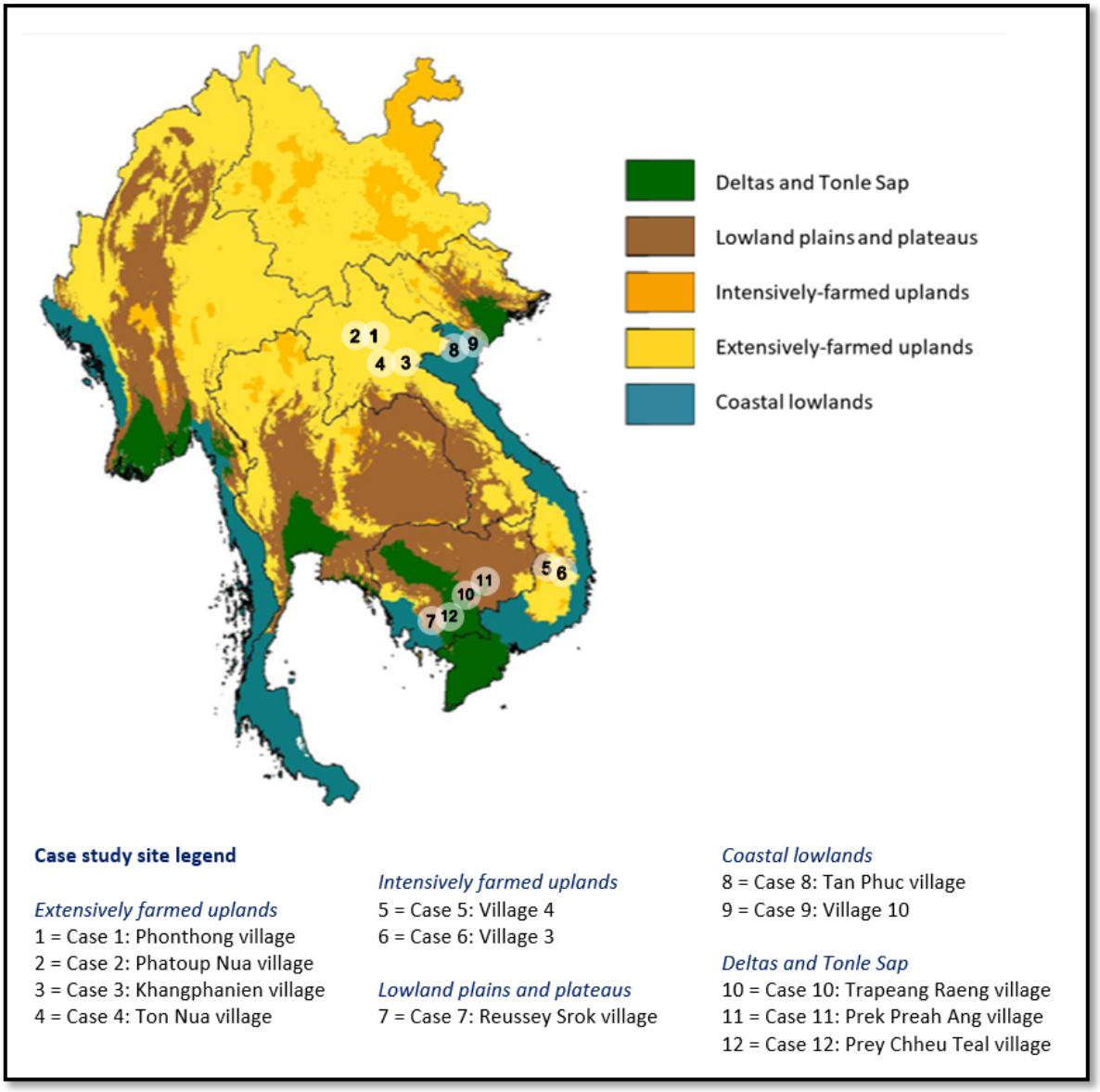

Figure 3: Location of the 12 case study sites across the different Agro-ecological Zones of the Greater Mekong area (Adapted from Johnston et al. 2009).

4. Selection of stakeholders for survey interviews and focus group discussions

The selection of stakeholders was not only to ensure collection of detailed information related to forage adoption and cattle production but also to allow for perspectives from multiple angles. A range of stakeholders of forage and cattle development were identified and selected for the survey interviews and focus group discussions, which included: provincial and district agricultural and livestock officers, financial institutions and banks, cattle traders, forage traders, village leaders, and farmers. For the farmers, effort was made to include a range of farm and farm household characteristics such as farm size, age, and gender, as well as to capture a diversity of cattle and forage production experiences including the extent of forage adoption and degree of commercialisation. Similarly, to capture a range of attitudes and perspectives, the focus group discussions were separated by gender as well as forage adoption status.

5. Design and development of survey instrument

Unique survey instruments were developed to cater to each of the stakeholder categories listed above and survey type (one-on-one interviews and focus group discussions). The survey instruments were then translated into the respective languages of the countries.

Figure 4: Discussion with a team of village leaders in Khangphanien Village, Nonghet District, Xiengkhuang Province, Laos

6. Survey implementation

For implementation of field activities in Laos, the Australian team worked together with the Lao country team in the field. However, subsequent country visits by the Australian team to Cambodia and Vietnam were cancelled due to COVID19 related travel restrictions. The alternative data collection methods in these two countries first involved updating the surveys to more structured formats. This was followed by the identification and training of in-country research teams for conducting all field work.

Surveys were conducted with a total of 305 participants across the three countries as shown in Table 1 below. This included one-on-one interviews with 69 farmers and focus group discussions with a total of 186 farmers.

Table 1: Total number of survey participants by interview type and country

Stakeholder	Number of participants			
	Laos	Cambodia	Vietnam	Total
Provincial agricultural and livestock officers	1	2	2	5
District agricultural and livestock officers	3	4	3	10
Financial institutions and banks	2	4	2	8
Cattle traders	3	5	4	12
Forage traders	1	4	2	7
Village leaders	4	4	4	12
Farmers (focus groups)	31	66	89	186
Farmers (individual one-on-one)	20	24	25	69
Total	**65**	**111**	**129**	**305**

Figure 5: Group discussion with female farmers in Phatoup Nua Village, Phonxai District, Luangprabang Province, Laos

6 Achievements against project activities and outputs/milestones

6.1 Achievements to date

Objective 1: Identify critical factors contributing to the success and failure of forage development programs in Cambodia, Lao PDR and Vietnam.

No.	Activity	Outputs	Comments
1.1	A literature review of the evolution of livestock systems in Southeast Asia.	Working paper on the status of forage development and factors hypothesized to have contributed to successful forage development programs.	A literature review has been completed and attached with this report as Working Paper Number 2 (Appendix 2) – "Changes in large ruminant production and the uptake of planted forages in Mainland Southeast Asia: a review."
1.2	Stocktake of forage development programs and activities in Laos, Vietnam and Cambodia		July 2019 – August 2019: Between the 12th of July 2019 and 4th of August 2019, a visit was made by Werner Stur and Harry Campbell-Ross (ACIAR) to each of the partner countries of the SRA. During this visit key agencies involved in livestock and forage R&D were contacted and informed of the aim and activities of the SRA and the following partner agencies and researchers for collaborating with the SRA were confirmed. Cambodia: General Directorate of Animal Health and Production (GDAHP) and the Kampong Cham Department of Agriculture, Forestry and Fisheries: Dr Sorn San and Mr Lorn Sophal. Laos: National Agriculture and Forestry Research Institute (NAFRI): Dr Phonepaseuth Phengsavanh and Dr Ammaly Phengvilaisouk. Vietnam: National Institute of Animal Science (NIAS): Dr Le Thi Thanh Huyen and Mr Dang Vu Hoa. During the visit, plans for conducting a stocktake of current forage development in partner countries were made. Discussions were also held on topics related to forage and cattle production systems over the last 10-15 years and changes in forage seed production and trade with key informants to guide further studies. The detailed trip report is available on request. August 2019 – February 2020: Stocktake of current forage development involving a compilation of current forage development was carried out by country partners. Information about forage development was solicited from provincial Animal Health and Production offices, and a visit by country partners to 2-3 provinces with considerable forage development. A working paper on the status of forage development has been completed and attached with this report as Working Paper Number 1 (Appendix 1) – "Status of forage development in Cambodia, Lao PDR, and Vietnam."
1.3	Consultation with key informants linked to forage development initiatives		

Objective 2: Systemise identified critical factors of success in a conceptual framework and refine this framework through selected case studies to provide decision support for future forage R&D investments.

No.	Activity	Outputs	Comments
2.1	Develop a conceptual framework on the growth and expansion of farm-grown forages and their role within the context of the broader farming systems.	Working paper on the conceptual framework related to the adoption of farm-grown forages.	Along with a literature review in *activity 1.1* a conceptual framework on the growth and development of farm grown forages and their role within the context of the broader farming systems was developed. To test the hypothesis identified through the conceptual framework and to refine it further, a case study methodology was developed. October 2019 – February 2020: Based upon the stocktake in *activity 1.2* case study sites were selected across the three countries of study. October 2019 – February 2020: A range of stakeholders were identified for conducting interviews and alongside survey instruments were developed. December 2019 – January 2020: Human ethics proposals were written and submitted to The University of Queensland human ethics committee, and approval was granted by January 2020 (Approval Number: 2019002884). February 2020: The Australian team (involving Lava Yadav and Davina Boyd) joined the Lao Team to conduct stakeholder surveys in the selected case study villages in Northern Laos. February 2020 – August 2020: The data collected from the four case study villages were analysed to develop a draft report for Laos. March 2020 – April 2020: Field activities were planned for Vietnam and Cambodia during these months but were cancelled due to COVID19 related travel restrictions. July 2020 – October 2020: Discussions were held to explore alternative plans for conducting the case studies in Cambodia and Vietnam through our country partners with remote involvement of the Australian team members. These included new budget negotiations as well as the selection of institutions and personnel in the partner countries for conducting the field activities. October 2020: A formal extension request was made to ACIAR, and a six month no-cost extension to 30 June 2021 was approved. October 2020 – November 2020: The originally developed semi-structured survey instruments were updated where the redesigned surveys were more structured. Online training sessions were held with the Cambodian and Vietnamese in-country research teams. November 2020 – January 2021: Field work was undertaken by the country research teams in Cambodia and Vietnam. The completed surveys were translated and sent to the Australian research team for analysis. February 2021 – September 2021: Survey data from the transcripts were first compiled into individual case study reports with extensive details. These reports were then condensed to develop brief overviews of each case study site. A focused analysis of the case study summaries was conducted to produce the study results.
2.2	Identify case study sites across important cattle rearing systems		
2.3	Conduct case studies involving interviews with key stakeholders related to forages and livestock production (for example extension workers, village leaders, traders, agribusinesses, and government officials at the provincial level) along with semi-structured interviews with farming households in each of the selected sites.		
2.4	Illustrate and test key hypotheses identified through the conceptual framework Refine conceptual framework through comparative analysis across the case studies.		

			August 2021: A two-month extension until the 30th of September 2021 was granted on the submission of the ACIAR final report and other deliverables. A working paper on the key study results has been completed and attached with this report as Working Paper Number 3 (Appendix 3) – "Factors contributing to and impeding the adoption of planted forages by smallholder farmers: A comparative analysis across Laos, Cambodia, and Vietnam."

Objective 3: Formulate, verify and communicate strategies for effective forage R&D to ACIAR, partner governments, and the wider livestock R&D community.

No.	Activity	Outputs	Comments
3.1	Synthesis of SRA findings and circulation amongst participating stakeholders for verification and feedback.	Policy briefs for partner governments, final report for ACIAR, and scientific paper synthesising the results of the SRA for journal publication.	August 2021 – September 2021: The results of the study were circulated with country partners for verification and feedback. The key SRA findings and recommendations for partner governments were summarized and developed into a Policy brief, which is attached with this report (Appendix 4). National partners are considering ways of adapting and using this brief for their specific needs.
3.2	Publication of SRA findings and recommendation for ACIAR, partner governments and the broader scientific community.		The SRA findings and recommendations for ACIAR, partner governments, and the broader scientific community have been detailed in Working Paper Number 3 (Appendix 3). This paper will be further reviewed and summarized for a scientific journal publication.

7 Results and Discussion

A summary of the main results and discussions of the SRA are provided below (for more detailed discussions please refer to Working Paper Number 1 and 3). The first part of this section provides an overview of case study sites, highlighting important details related to each site and enabling comparison across sites. This is followed by what the project has termed 'generalizations'; a synthesis of the findings that have broad applicability across partner countries.

7.1 Overview of case study sites

A total of twelve case study sites representing the major agro-ecological zones and cattle production systems within the three countries were selected for this SRA (Figure 3). The case study sites are grouped into their respective agro-ecological zones with brief overviews summarized in tables below.

7.1.1 Extensively farmed uplands

All four case study sites selected within Laos fall under the agro-ecological zone characterized as extensively farmed uplands. The four case study villages demonstrate considerable differences in terms of terrain, demographics, as well as farming systems as can be seen in Table 2 and Table 3.

Table 2: Distribution of farmland types in extensively farmed upland case study villages

Land type	**Phonthong Village** Phonxai District, Luangprabang Province, Laos	**Phatoup Nua Village** Phonxai District, Luangprabang Province, Laos	**Khangphanien Village** Nonghet District,Xiengkhuang Province, Laos	**Ton Nua Village** Pek District, Xiengkhuang Province, Laos
Irrigated paddy lands	-	-	-	-
Rainfed paddy	10%	-	20%	70%
Undulating	60%	-	60%	20%
Steep	30%	100%	20%	10%
Description	Undulating upland with small areas of lowland rice and access to mountainous areas	Located on slopes in a mountainous area	Located in a wide valley with undulating fields and access to sloping land and mountainous areas.	Located on the edge of the Xiengkhuang Plateau with rainfed paddy rice fields in a wide valley leading into the plateau.

Table 3: Comparison of key biophysical and agricultural characteristics across the case study sites in the extensively farmed upland zones.

Case Study Village	Phonthong Village, Laos	Phatoup Nua Village, Laos	Khangphanien Village, Laos	Ton Nua Village, Laos
Demographics and biophysical attributes				
Population	1014	550	1,013	413
District popn. density (people/km20)	14	14	18	66
Ethnicity (proportion)	Khmu (60%) Lao (30%) Hmong (10%)	Hmong (96%) Lao (4%)	Hmong (97%) Lao (3%)	Lao (100%)
Altitude (m)	650	1,050	1,190	1,100
Temperature Range: lowest - highest (C)	8C-41C	8C-41C	3C-30C	5C-30C
Average annual rainfall (mm)	1,000-1,100	1,000-1,100	1,000-1,200	1,200
Agricultural production and farming systems				
Agriculture Contribution to GDP /income (at the district level) (%)	Agriculture (70%) Off-farm (30%)	Agriculture (~100%)	Agriculture (90%) Off-farm (10%)	Agriculture (80%) Off-farm 20%
Agriculture contribution to Employment (at the district level) (%)	80%	80%	85%	40%
Average farm size (ha)	6 ha - 10 ha	12 ha	2 ha - 20 ha	3 ha - 5 ha
Crops grown (in addition to forage)	Lowland rice, sesame, maize, cassava and jatropha	Maize and upland rice	Upland rice and maize	Lowland rice, maize, vegetables (chillies, cucumber, and leafy greens)
Cattle numbers and production systems				
Number of cattle	1,322	698	970	634
Number of buffalo	150	67	59	183
Households with cattle (%)	76%	96%	95%	90%
Average no. of cattle per household	5	11	4 to 5	5 to 6
Popular cattle breeds & reproduction methods	Native Lao	Native Lao	Native Lao	Native Lao
Grazing extent	Almost exclusively grazed on fenced improved or natural pastures and rice straw after harvest. Free grazing restricted	Almost exclusively grazed on fenced improved or natural pastures. Free grazing banned	Grazed natural and improved pasture (private and communal plots) and crop residues and pen feed cut and carried forage and other feed.	Graze private lands (natural pastures, crop residues) and surrounding forest and communal land
Production system	1. Cow-calf (100%)	1. Cow-calf with fattening 2. Cow-calf 3. Strictly fattening (not common)	1. Cow-calf with fattening 2. Cow-calf 3. Strictly fattening	1. Cow-calf (individuals not in cattle fattening group) 2. Cow-calf with fattening 3. Strictly fattening (cattle fattening group)

Table 3: Comparison of key biophysical and agricultural characteristics across the case study sites in the extensively farmed upland zones. (cont.)

Case Study Village	Phonthong Village, Laos	Phatoup Nua Village, Laos	Khangphanien Village, Laos	Ton Nua Village, Laos
Forage production				
Year introduced	2000	1998/ 1999	Early 1990s	1995
Source of introduction	LRC-NAFRI & SIDA	International projects & DAFO, village leader	International projects & DAFO	IFAD
Forage adoption (%) of households with cattle	95%	100%	100%	30%
Forage area (ha) / location	1.6 ha	7 ha to 8 ha	1 ha	1.2 ha to 2 ha
Forage species / types Introduced	Ruzi, Guinea, Stylo, Napier, Mulato	Ruzi, Napier, Guinea, Mulato, Stylo	Ruzi, Brizantha, Mulato I, Camba, Verano, Guinea, Sigman, Stylosanthes	Ruzi, Brizantha, Mulato I, Camba, Guinea, Sigman, Stylosanthes
Forage species / types preferred	Ruzi, Napier	Ruzi, Napier, Guinea	Ruzi, Napier	Ruzi, Napier
Forage market	Yes – Ruzi seeds sold, DAFO staff a major trader of seed & traders collect and sell	Yes – some farmers sell seed	No	No – the village does not produce forage for sale
Forage planting material	Readily available as most farmers grow Ruzi to sell seed	Readily available from farmers selling seed	Readily available (neighbouring village sells Ruzi seed and farmers self-propagate Napier)	Readily available (seed from the market and self-propagation)

Figure 6: Traditional bull fighting in Nonghet District, Xiengkhuang Province, Laos

7.1.2 Intensively farmed uplands

Both Village 4 and Village 3 in Dak Lak Province, Vietnam, fall under the agro-ecological zone characterized as intensively farmed uplands. While the two study sites share many similarities, Xuan Phu commune at a slightly higher altitude consists of more undulating lands while Village 3 in Ea Sar Commune is endowed with more irrigated paddy lands as shown in Table 4. Additional similarities and differences between the two sites are provided in Table 5.

Table 4: Distribution of farmland types for intensively farmed upland case study villages

Land type	Village 4 Xuan Phu Commune, Eakar District, Dak Lak Province, Vietnam	Village 3 Ea Sar Commune, Eakar District, Dak Lak province, Vietnam
Irrigated paddy	10%	30%
Rainfed paddy	-	-
Undulating	90%	70%
Steep	-	-
Description	Rainfed upland with supplementary irrigation. Small areas of communal areas (without land permits) - Bazan red soils with higher soil fertility than Ea Sar.	Rainfed uplands and paddy land with some supplementary canal, river and tubewell irrigation.

Figure 7: Fattening cattle in pens in in Village 4, Xuan Phu Commune, Eakar District, Dak Lak Province, Vietnam

Table 5: Comparison of key biophysical and agricultural characteristics across the case study sites in the intensively farmed upland zones.

Case Study Village	Village 4, Vietnam	Villages 3, Vietnam
Demographics and biophysical attributes		
Population	320	488
District popn. density (people/km2)	139	139
Ethnicity (proportion)	Kinh (99%) Tay (1%)	Tay (57%) Kinh (24%)
Altitude (m)	500	450
Temperature Range: lowest - highest (C)	20 - 39	22 - 39
Average annual rainfall (mm)	1,800-2,000	1,800-2,000
Agricultural production and farming systems		
Agriculture Contribution to GDP /income (at the district level) (%)	Crops (70%), Livestock (30%)	Crops (60%), Livestock (30%), Off-farm (10%)
Agriculture contribution to Employment (at the district level) (%)	66.5	66.5
Average farm size (ha)	1.2	1.1
Crops grown (in addition to forage)	Coffee, pepper, maize, cassava, sugarcane, cashew, rice, fruit trees	Rice, maize, Pepper, cashew, coffee, fruit trees
Cattle numbers and production systems		
Number of cattle	60	145
Number of buffalo	6	17
Households with cattle (%)	~50%	~60%
Average no. of cattle per household	3	2 to 3
Popular cattle breeds & reproduction methods	Exotic (e.g. Lasind, Brahman, BBB) / AI	Exotic (e.g. Lasind, Brahman, BBB) & sm. number of local / AI & some bull service
Grazing extent	Mostly pen fed or tethered in home garden. Some supervised/ tethered grazing of harvested fields and fallow land. No formal free grazing restrictions, but not common	Tethered grazing of cattle on fallow/bare land in the wet season. Tethered grazing of harvested fields in the dry season.
Production system	1. Cow-calf (30-50%), 2. Cow-calf with fattening (40-60%), 3. Fattening purchased calves (5-10%), 4. Fattening purchased thin cattle (10%)	1. Cow-calf (70-90%), 2. Cow-calf with fattening (10-30%), 3. Fattening purchased thin cattle (1 farmer)

Table 5: Comparison of key biophysical and agricultural characteristics across the case study sites in the intensively farmed upland zones. (cont.)

Case Study Village	Village 4, Vietnam	Villages 3, Vietnam
Forage production		
Year introduced	2000	1999/2000
Source of introduction	Dairy company, Programs and Projects, Tay Nguyen University	Department of extension, Tay Nguyen University
Forage adoption (%) of households with cattle	100%	100%
Forage area (ha) / location	Home garden, Pond/ river banks and bunds, Intercropped with tree crops	Home garden; Fallow fields previously used to grow maize and bean
Forage species / types Introduced	Green elephant grass, Purple elephant grass, Guinea Brizantha, VA06, Biomass maize, Giant tea hibiscus, Acacia	VA06, Guinea grass, King grass, Hairy elephant grass, Purple elephant grass, Herb grass, Bean grass, Stylo
Forage species / types preferred	VA06, Elephant grass	VA06
Forage market	Grass – informally between farmers, biomass maize and rice straw – yes	Grass – no, Biomass maize and rice straw – yes
Forage planting material	Readily available (farmers, university, input supply shops)	Readily available (market, self-propagation)

7.1.3 Plains and plateaus

Of the two provinces selected in Cambodia, Takeo Province lies in the southern end of Cambodia sharing a border with Vietnam. Within Takeo province, the case study site of Ruessey Srok Village within Nhaeng Nhong commune, Tram Kak district falls under the agro-ecological zone characterized as Plains and plateaus. As shown below in Table 6, the village is comprised almost exclusively of lowland rainfed areas. While the terrain and farming systems of the village has a lot in common with areas in the Deltas and Tonle Sap agro-ecological zone, the availability of some farmlands in higher altitudes and hence the ability to grow a range of crops appear to place it under the Lowland plains and plateaus zone. Table 7 provides additional information related to Ruessey Srok Village.

Table 6: Distribution of farmland types for the plains and plateaus case study villages

Land type	**Ruessey Srok Village** Nhaeng Nhong commune, Tram Kak District, Takeo Province, Cambodia
Irrigated paddy	-
Rainfed paddy	100%
Undulating	-
Steep	-
Description	Flood prone lowland rainfed (122 ha) Uplands (2 ha) no extensive irrigation - but some HHs have ponds or tubewells that they use to irrigate small specific plots/crops including forages in the dry season.

Table 7: Key biophysical and agricultural characteristics related to the case study site in the plains and plateau zone.

Case Study Village	Ruessey Srok Village, Cambodia
Demographics and biophysical attributes	
Population	839
District popn. density (people/km2)	305
Ethnicity (Proportions)	Khmer (100%)
Altitude (m)	10 to 45
Temperature Range: lowest - highest (C)	21 - 37
Average annual rainfall (mm)	1,370
Agricultural production and farming systems	
Agriculture Contribution to GDP /income (at the district level) (%)	1. Off-farm, 2. Livestock, 3. Crops (peanuts)
Agriculture contribution to Employment (at the district level) (%)	60 to 70
Average farm size (ha)	0.72
Crops grown (in addition to forage)	Rice, peanuts, vegetables (e.g., cucumber), fruit trees, maize, mungbean, watermelon, cowpea
Cattle numbers and production systems	
Number of cattle	320
Number of buffalo	0
Households with cattle (%)	90
Average no. of cattle per household	2
Popular cattle breeds & reproduction methods	Crossbreeds (Brahman, Simbra, Haryana and Indo-Brazil) & sm. number of local / Bull service
Grazing extent	Mostly pen fed. Supervised/tethered grazing. No formal free grazing restrictions, but very limited
Production system	1. Cow-calf (100%)
Forage production	
Year introduced	2007
Source of introduction	GDAHP / ACIAR project
Forage adoption (%) of households with cattle	20%
Forage area (ha) / location	Fields previously used for other crops (rice, maize, vegetables)
Forage species / types Introduced	Paspalum, Guinea grass, Mulato II, Stylo
Forage species / types preferred	Paspalum, Mulato II, Elephant grass
Forage market	Yes – trucks selling paragrass
Forage planting material	Available (champion farmer locally and via Facebook)

7.1.4 Coastal Lowlands

Thanh Hoa Province, the second province selected in Vietnam for conducting the case studies is located in northern Vietnam, south of Hanoi City. With its proximity to the coast, both the case study villages of Tan Phuc village in Tho Lam commune, Tho Xuan District, and Village 10 in Quy Loc commune, Yen Dinh distrct fall under the agro-ecological zone characterized as Coastal Lowlands. The two case study sites are quite similar with a mix of irrigated paddy lands, rainfed paddy and uplands (Table 8). Both villages are situated next to rivers and consist of small areas of forested hills; although these areas are slightly larger and higher in Tho Lam Commune. Table 9 provides additional information related to the two villages.

Table 8: Distribution of farmland types for the coastal lowland case study villages

Land type	**Tan Phuc Village,** Tho Lam Commune, Tho Xuan District, Thanh Hoa Province, Vietnam	**Village 10,** Quy Loc Commune, Yen Dinh District, Thanh Hoa Province, Vietnam
Irrigated paddy	10%	45%
Rainfed paddy	20%	30%
Undulating	35%	25%
Steep	35%	-
Description	Mix of steep and undulating uplands, and rainfed and irrigated paddy land. The village is bordering the Song Chu river and a hilly area.	Delta along the Ma river with mostly irrigated and rainfed paddy land, and undulating uplands. 8 km from a market, but not on a through road.

Figure 8: Cows grazing along the dyke bank in Tan Phuc Village, Tho Lam Commune, Tho Xuan District, Thanh Hoa Province, Vietnam

Table 9: Comparison of key biophysical and agricultural characteristics across the case study sites in the coastal lowlands zone

Case Study Village	Tan Phuc Village, Vietnam	Village 10, Vietnam
Demographics and biophysical attributes		
Population	410	2,805
District population density (people/km2)	655	741
Ethnicity (proportion)	Kinh (100%)	Kinh (99.9%)
Altitude (m)	20-50	20-130
Temperature Range: lowest – highest (C)	16 - 31	15 - 32
Average annual rainfall (mm)	1,800-1,900	1,600-1,800
Agricultural production and farming systems		
Agriculture Contribution to GDP /income (at the district level) (%)	Livestock (50%), Crops (45%), Off-farm (5%)	Crops (60%), Livestock (26%), Off-farm (14%)
Agriculture contribution to Employment (at the district level) (%)	38.2	40.9
Average farm size (ha)	0.2	1.5
Crops grown (in addition to forage)	Rice, maize, elephant grass, cassava, fruit trees, acacia, sugarcane, peanut	Rice, maize, peanuts, sesame, soybean, vegetables, fruit trees, sugarcane, chilli

Figure 9: A buffalo keeper in Village 10, Quy Loc Commune, Yen Dinh District, Thanh Hoa Province, Vietnam

Table 9: Comparison of key biophysical and agricultural characteristics across the case study sites in the coastal lowlands zone. (cont.)

Case Study Village	Tan Phuc Village, Vietnam	Village 10, Vietnam
Cattle numbers and production systems		
Number of cattle	150	950
Number of buffalo	200	200
Households with cattle (%)	~100%	~80%
Average no. of cattle per household	3 (including 1-2 buffaloes)	2 cattle (and or 1 buffalo)
Popular cattle breeds & reproduction methods	Exotic (e.g. Lasind, Brahman, BBB)/ AI & bull service	Exotic (e.g. Lasind, Brahman, BBB) / bull service & AI
Grazing extent	Mostly pen fed. Some tethered/ supervised of harvested fields in the dry season. No sanctioned free grazing	Mostly pen fed. Limited supervised grazing of harvested fields and fallow land. Grazing restrictions managed by village cooperative
Production system	1. Cow-calf (50-60%), 2. Fattening purchased calves (30%), 3. Fattening purchased thin cattle (10%)	1. Cow-calf (50-80%), 2. Cow-calf with fattening (30%), 3. Fattening purchased calves (10-20%), 4. Fattening purchased thin cattle (3%)
Forage production		
Year introduced	2004	2000 & 2015
Source of introduction	Farmers, Dairy company, NIAS	Projects, Local cooperative, NIAS, Champion farmer, Traders
Forage adoption (%) of households with cattle	95%	90%
Forage area (ha) / location	Flood plains, Fields previously used for rice/ maize, Ditches, river banks, and bunds	Rainfed flood plains, Fields previously used for rice/ maize, Ditches, river banks and bunds
Forage species / types Introduced	Elephant grass, Vao grass, Maize and sugarcane, VA06, Guinea	Biomass maize, Elephant grass, Guinea, VA06
Forage species / types preferred	Elephant grass	Biomass maize, Elephant grass
Forage market	Grass, sugarcane tops and maize stover – informally between farmers	Grass – informally between farmers, biomass maize and rice straw - yes
Forage planting material	Readily available (trader, farmers)	Readily available (nurseries, district ag. centres)

7.1.5 Deltas and Tonle Sap

The two case study villages in Kampong Cham province (Trapeang Reang village in Trapeang Preah commune, Prey Chhor district and Praek Preah Ang Village in Prek Bak commune, Stueng Trang district) and Prey Chheu Teal village in Prey Phdau commune, Prey Kabbas district fall under the agro-ecological zone characterized as Deltas and Tonle Sap (Table 10). There were more similarities between the two villages within Kampong Cham with both comprising of about 80% rainfed paddy lands. Prey Chheu Teal village on the other hand had slightly greater access to irrigation with about 20% irrigated paddy lands. However, being located in the deltas, an abundance of flood prone lowlands is a feature shared by all three sites. Table 11 provides additional information on the three villages.

Table 10: Distribution of farmland types for the deltas and Tonle Sap case study villages

Land type	**Trapeang Reang Village,** Trapeang Preah commune, Prey Chhor District, Kampong Cham Province, Cambodia	**Preaek Preah Ang Village**, Preaek Bak commune, Stueng Trang District, Kampong Cham Province, Cambodia	**Prey Chheu Teal Village,** Prey Phdau commune, Prey Kabbas District, Takeo Province, Cambodia
Irrigated paddy	10%	-	20%
Rainfed paddy	80%	80%	80%
Undulating	10%	20%	-
Steep	-	-	-
Description	Flood prone lowland, mostly rainfed, although some farmers have ponds and tubewells to irrigate small areas. Some HHs also have small parcels of non-flooded areas near their house	Located along the Mekong and including an island (Koh Takae). Rainfed upland and rainfed and irrigated lowland paddy.	Rainfed lowlands located near a large lake. An estimated 20% of lowland areas have access to irrigation.

Figure 10: A farmer selling forages by the road in Prey Chhey Teal Village, Prey Phdau commune, Prey Kabbas District, Takeo Province, Cambodia

Table 11: Comparison of key biophysical and agricultural characteristics across the case study sites in the Deltas and Tonle Sap zone.

Case Study Village	Trapeang Reang Village, Cambodia	Preaek Preah Ang Village, Cambodia	Prey Chheu Teal Village, Cambodia
Demographics and biophysical attributes			
Population	500	2676	840
District popn. density (people/km2)	300	367	366
Ethnicity (proportion)	Khmer (100%)	Khmer (100%)	Khmer (100%)
Altitude (m)	24 to 80	13 to 20	7 to 12
Temperature Range: lowest - highest (C)	26 - 38	21 - 35	22-39
Average annual rainfall (mm)	1,160	1,150	1,125
Agricultural production and farming systems			
Agriculture Contribution to GDP /income (at the district level) (%)	Crops (50%), Livestock (30%), Off-farm (20%)	1. Cash crops (cashew), 2. Livestock, 3. Off-farm	1. Crops (rice and forage), 2. Silk weaving, 3. Off-farm, 4. Livestock
Agriculture contribution to Employment (at the district level) (%)	NA	NA	NA
Average farm size (ha)	1	1.5	0.55
Crops grown (in addition to forage)	Rice, cassava, fruit trees, sweet bamboo shoots	Rice, cashew, yam, yam bean, maize, cucumber, tobacco, date palm, longan, mango and rice	Rice (WS & DS), vegetables (radish, cucumber), coconut, cassava
Cattle numbers and production systems			
Number of cattle	190	691	78
Number of buffalo	0	0	0
Households with cattle (%)	36	15	23
Average no. of cattle per household	3 to 4	7	2 to 3
Popular cattle breeds & reproduction methods	Crossbreeds (Haryana & Brahman) / Bull service & limited AI	Crossbreeds (white) / Bull service and rarely AI	Crossbreeds (Brahman & Haryana) / sm. Number of local / Natural or bull service
Grazing extent	Mostly pen fed. Limited supervised/tethered grazing typically on own fields to retain manure. No formal free grazing restrictions, but very limited	Pen fed. Supervised/tethered grazing of harvested fields and natural grasses – cashew plantation / around rice fields (mostly DS). Grazing restrictions require farmers to supervise grazing activities	Mostly pen fed (WS). Mostly tethered in the fields (DS). No formal free grazing restrictions, but very limited
Production system	1. Cow-calf system with fattening (80-90%), 2. Cow-calf selling calves (common), 3. Fattening, buying thin cattle (4-5 HHs)	1. Cow-calf system (majority), 2. Cow-calf with fattening (farmers on Koh Takae), 3. Fattening purchased thin cattle (one HH)	1. Cow-calf (100%) 2. Cow-calf with fattening (3-5 HH), 3. Fattening purchased thin cattle (2-3 HH)

Table 11: Comparison of key biophysical and agricultural characteristics across the case study sites in the Deltas and Tonle Sap zone. (cont.)

Forage production			
Year introduced	1997	2016	2010 & 2015
Source of introduction	GDAHP, PDAFF, CIAT, ACIAR	District livestock offers	Farmers, GDAHP
Forage adoption (%) of households with cattle	25%	30%	30%
Forage area (ha) / location	Uncultivated uplands, Filled in paddy fields, Fields previously used for other crops, Intercropped with fruit trees	Koh Takae, Fields (lowland /upland) previously used for other crops	Fields previously used for other crops (wet season rice and vegetables)
Forage species / types Introduced	Mulato II, Stylo 184, Stylo scabra, Guinea grass, Paspalum, Ruzi, King grass	King grass, Elephant grass, Mulato II	Paragrass
Forage species / types preferred		King grass, Elephant grass, Mulato II	Paragrass
Forage market	No	No	Yes – grass collecting trucks and individuals sell paragrass
Forage planting material	Available (District Livestock Officer – sole forage seller)	Available (Chief of AHAP Kampong Siem District / other provinces or neighbours)	Readily available (farmers, self-propagation, grass group)

Figure 11: Koh (island) Takae in Prek Preah Ang Village, Prek Bak commune, Stueng Trang District, Kampong Cham Province, Cambodia

7.2 Generalizations

The main findings of the study are grouped into four overarching themes below. Under the first theme A. '*Agro-economic context of forage adoption',* we detail factors relating to the context that have contributed to increased forage demand and supply. *B. 'Nature of forage interventions'* highlights elements of forage interventions that have promoted and shaped forage adoption pathways. *C. 'Farm-household characteristics influencing adoption of forages'* examines the influence of various farm and household characteristics on both the nature of forage uptake as well as cattle production systems adopted. Finally, *D. 'Subsequent outcomes of forage adoption'* provides a discussion on subsequent developments that have been found to evolve from forage introductions and in turn often stimulate adoption further.

7.2.1 A. Agro-economic context of forage adoption

A1. Consistently high farm-gate prices for beef have induced farmers with a tradition of cattle-raising (primarily for draught) to breed, grow, and fatten cattle for sale, increasing the demand for more productive sources of feed.

The 'livestock revolution' as coined by Delgado et al (1999) is associated with an increase in demand for meat and dairy products resulting in higher market prices. Many farmers across the region have responded to these incentives by intensifying their cattle production activity, which in turn has resulted in higher demand for planted forages.

A2. Reduced profitability and the greater riskiness of many traditional agricultural activities have increased the relative advantage of raising cattle, resulting in higher demand for planted forages.

Forage adoption has been encouraged not only by the high and relatively stable prices of beef cattle (and in some cases of forage and forage seed), but by reduced yields, declining profitability, and greater riskiness of other crop and livestock activities. Examples of such push factors include reduced profitability from maize due to falling market prices, reduced yields of pepper crop due to footrot, and the higher production risk of pigs with the advent of the African Swine Fever.

A3. Higher farm-gate prices for larger animals combined with the availability of AI services have increased farmers' preference for exotic cross-breeds and hence their need for more and better-quality feed.

Farmers are attracted by the higher prices offered for larger cattle and have expressed a strong demand for exotic breeds. This was particularly the case in the Vietnam sites, where the long established Laisind cross is widely used, as well as *Bos indicus* breeds such as the Brahman, Simbrah, and Indo-Brazilian, and *Bos taurus* breeds such as the Belgian Blue (BBB). A well-organised artificial insemination (AI) service is available to farmers in Vietnam, giving them ready access to exotic breeds. A switch to heavier cross-breeds increases the demand for feed, even if cattle numbers remain unchanged.

A4. Widespread mechanisation of land preparation has reduced the need for draught animals, altering farmers' preferences for cattle versus buffaloes.

With the expansion of mechanization throughout MSEA countries, the purpose of keeping large ruminants have changed from draught power to beef production. This has also resulted in many farmers switching from raising buffaloes to raising cattle. The reasons given for this included the higher reproduction rate of cattle, the relative ease of raising them, their higher growth rates, and the greater potential for increasing productivity through cross-breeding. Hence, while buffaloes are considered superior draught animals in the paddy environment, cattle are better suited to a commercial beef enterprise. Given that

cattle need less fibrous feed sources than buffaloes, the change to cattle has increased the demand for more productive forages.

A5. Long-term expansion and intensification of cropping have reduced areas of common and fallow land available for open grazing, inducing farmers to rear cattle in farmyards or stalls with a cut-and-carry system of feed supply.

Traditionally large ruminants were allowed to graze freely on harvested rice paddies and on grass- and forest-lands held in common by the village community. However, several decades of high population growth and increased market demand have led to the expansion of cropping areas, eating into the common reserves of forestland and limiting the area of fallow lands available for grazing. These trends have induced some farmers in the lowland sites and the intensively-farmed uplands to keep their cattle and buffaloes in farmyards or stalls close to the home, necessitating a cut-and-carry system of feed supply, which has further increased the demand for planted forages.

A6. The reduction in land area available for grazing or producing native grasses for cut-and-carry has created a need for planted forages with increased land productivity.

While the expansion and intensification of cropping can increase the supply of crop residues, as for example in the coastal lowland sites in Vietnam, this has been offset by a reduction in the availability of native grasses for livestock feed. This has resulted in increased specialization where some farmers have turned into specialized cattle producers while others have abandoned cattle raising altogether and specialized in cropping. With a decline in grazing areas, but also the reduced availability of natural feed sources, those specializing in cattle production have planted forages in more productive farmlands.

A7. The steadily increasing opportunity cost of household labour has increased the cost of traditional feed sources, inducing farmers to plant forages with increased labour productivity.

Increased competition from off-farm sources have resulted in reduced household capacity both to manage grazing and to cut and carry feed (native grasses and crop residues) to stall-fed animals. Planted forages address this constraint by lowering unit labour costs. This is because they can be planted close to the cattle stall, reducing the time spent transporting feed, and also provide high production per unit area, reducing the time required to harvest a given quantity of feed.

Figure 12: Cattle grazing on harvested rice fields in Village 10, Quy Loc Commune, Yen Dinh District, Thanh Hoa Province, Vietnam

7.2.2 B. Nature of forage interventions

B1. Interventions to promote forage adoption in a given location may result from broader government policies to reduce poverty or promote cattle production.

Government policies in the case-study countries have been found to influence decisions regarding the type and location of forage interventions. For example, in Laos, the government's poverty alleviation policy prioritised agricultural (particularly cattle) development as a pathway for improving livelihoods and reducing the reliance on shifting cultivation practices in the northern provinces. This helped enable early forage R&D in the area, which eventually became increasingly adopted into livestock and rural development projects. However, forage interventions were independent of government policies in Cambodia where they have been driven by R&D partners and their networks.

B2. Initial adoption of planted forages in a village requires intervention from trusted actors such as a lead farmer, extension worker, or cattle trader.

Trusted actors are found to be an essential part of the forage adoption story in most of the case studies. Such actors include government extension personnel, village leaders, farmers, and forage traders who operate as knowledge brokers providing access to technical support and inputs. Especially given the limited agricultural extension facilities that have constrained forage adoption, entrepreneurial or champion farmers have stepped in to bridge such gaps by aiding in the technology dissemination process or even by filling missing markets by supplying planting materials or linking forage growers to broader forage markets.

B3. Widespread adoption of planted forages requires a reliable, ongoing source of suitable seed/planting material.

Easy and reliable access to forage seeds and/or planting material are a prerequisite for widespread forage adoption. Where there was adoption in the case-study sites, planting material had been made available as part of an initial intervention. Although several forage varieties were initially distributed by projects, a much smaller number of varieties are currently grown. The selection of preferred species was based on a number of factors including whether a species requires continual replanting, ease of management, and productivity, but continued access to the planting material was prioritized most.

B4. Initial interventions to promote specific forages and forage systems set in train an adaptive process in which farmers progressively modify their preferred species and management regimes (subject to the constraints noted in B2).

The nature of an initial intervention has also been observed to constrain subsequent adaptation by farmers. Despite a preference for forage varieties other than those introduced, generally with limited access to planting materials or challenges related to propagating preferred varieties, farmers have been found to adapt to the initially introduced varieties.

As farmers have become increasingly linked to markets and gained further experience, their contexts have changed, resulting in a shift in the adoption pathway. For example, in Northern Laos farmers have switched to a grazing system due to its labour-saving properties. Similarly, in several case-study sites in Vietnam, farmers were found to feed forages to calves prior to sale to increase their sale weight. These adaptations reflect the increased market orientation of livestock farmers.

B5. The low "learnability" of forage technology means that the spread of forage adoption is initially high within villages where there has been an effective intervention or demonstration, but low between villages.

Forage adoptions tend to be concentrated in particular districts and in particular villages within districts. This concentration of adoption and limited diffusion or spill over into neighbouring villages or districts seems to be linked to the low learnability of forage technology. The learnability of a technology encompasses its complexity, observability, and the ease of testing it on the farm (trialability). Forage technology is still new to many people where cultivation as well as its incorporation into cattle feed is not easily communicated to farmers via the extension system.

Figure 13: Cattle feeding on chopped forages and banana stems mixed with rice bran in the village leader's house in Trapeang Raeng Village, Trapeang Preah commune, Prey Chhor District, Kampong Cham Province, Cambodia

7.2.3 C. Farm-household characteristics influencing adoption of forages

C1. Households with limited access to good-quality land face greater difficulty adopting forages.

Limited access to land is generally one of the key challenges farmers face in terms of forage adoption. Particularly in lowland rainfed and irrigated areas where land sizes are smaller, the opportunity cost of replacing other food and cash crops is higher. In addition to land size, other land characteristics such as the availability of irrigation, soil fertility, and terrain are also key factors constraining forage adoption.

C2. The availability of different categories of farm-household labour and the labour demands of different agricultural and non-agricultural pursuits influence forage adoption.

The high labour inputs associated with cultivating and feeding forages to animals were found to discourage forage adoption in settings where farmers still had access to traditional feed sources and/or had small herd sizes. However, for farmers with limited access to such feed sources, growing forages has come to be associated with higher labour efficiency.

The type of labour availability also determined the likelihood of forage adoption. For example, in some of the case-study sites in North Central Coastal Vietnam, households with elderly farmers who were unable to participate in active farm or non-farm work were more likely to tend to their grazing animals, resulting in reduced forage adoption. In contrast, households with younger farmers were likely to be actively growing forages to support cut-and-carry feeding as this gave them more time to engage in other activities.

C3. High upfront capital requirements for establishing and expanding cattle production systems constrain the shift to commercial cattle production and forage adoption.

Relative to small ruminants, pigs, and poultry, raising cattle is associated with substantial upfront costs. Large sums are required to purchase cattle (young animals, breeding animals, or thin animals to fatten). Beyond the costs associated with acquiring cattle, farmers also face substantial upfront costs to convert land for growing forages. For example, in Northern Laos, converting previously unused fallow land into plots for growing forages involves hiring tractors and labourers for ploughing and preparing the land. However, a major expense in this setting arises from the need to fence the forage plots to restrict grazing to the farmer's own animals. As limited access to capital is a reality for most smallholders, it poses a major barrier to expanding forages and cattle production.

C4. The choice of cattle production system and the associated forage system involves a series of trade-offs, the outcomes of which depend on each farm-household's initial endowment of land, labour, and capital.

The choice of cattle production system was found to be influenced by the household's endowment of land, labour, and capital. For example, the adopters of a cow-calf system in Tan Phuc Village in North Central Coastal Vietnam were likely to have access to additional land, deemed necessary to ensure good health of the newly-born calves. At the same time, they were likely to have additional labour for supervised grazing of the calves. Access to capital was also a key requirement for farmers who wished to adopt a cow-calf system by purchasing a good quality breeding cow. Farmers employing a cow-calf system with fattening had access to sufficient green feed and were generally not in debt, enabling them to fatten young animals and wait to sell only when the animals were ready for slaughter. In contrast, farmers with debts and/or immediate expenses such as children's school fees were likely to sell their calves without growing or fattening them. Farmers who could not afford a breeding cow and were looking for a quick turnover tended to buy calves to grow and fatten for an early sale.

In terms of forage systems, cattle feeding methods in Luangprabang had evolved to a controlled grazing system of planted forages where farmers were able to eliminate the labour-intensive task of cutting and carrying forages altogether and conserve labour, which was relatively scarce. On the contrary, for farmers in Ton Nua Village with smaller land areas and less fertile soils, it was more economic to fertilise and fence small plots than to adopt an extensive grazing system.

Figure 14: A more commercial cattle enterprise with cattle feeding on supplementary feed purchased from the market in Trapeang Raeng Village, Trapeang Preah commune, Prey Chhor District, Kampong Cham Province, Cambodia

7.2.4 D Subsequent outcomes of forage adoption

D1. Farmer attitudes towards forages and the level of inputs invested in growing them change with increased experience of forage production.

The extent of forage adoption and the range of forage cultivation practices varied widely, partly due to different attitudes related to growing forages. Such attitudes and hence management practices gradually evolve as farmers gain more experience. In the absence of a market for fresh forages or forage seed, forages only have value as an intermediate good, which is a less tangible output. With a traditional view that considers them to be an unproductive or low value output, they have generally been given low priority. They are usually assigned to marginal farmlands with low productivity and their cultivation practices are associated with minimal inputs. However, as farmers become more market linked and their understanding of the value of forages improve, they are found to employ improved cultivation practices including regular application of fertilizers, regular weeding, and occasional irrigation of forage.

D2. Local demand for planted forages generates demand for a local seed supply, inducing (i) some farmers/villages to specialise in seed production and distribution and (ii) some traders/livestock officers/farmers to trade in forage seed.

Where formal sources of seed supply are lacking, increased demands have been found to promote alternate sources of supply. In Northern Laos, Ruzi seed production have become a dominant agricultural activity which has resulted from its high demand. However, the gap in technology dissemination and also links to output markets were developed through the efforts of a local livestock officer who took on the role of a forage trader. Similar initiatives were also found to develop in Cambodia where formal sources of seed supply are limited but local livestock officers have been involved in a private capacity for establishing links with forage markets.

D3. Growth in demand for feed and forages eventually leads to the emergence of a market for feed/forages, inducing some farmers to specialise in forage production for sale.

With a growing beef cattle sector, the rising demand for fresh forages has also encouraged farmers to grow forages for sale where markets have been developed. For example, in the Takeo sites in Cambodia, the production of Para grass for sale has become a dominant cropping activity and hence a reliable source of income for households. The attractive prices has encouraged even farmers that do not have cattle to grow them. Similarly, with the high demand of forages from the dairy sector, several farmers in Vietnam were found to specialize in biomass maize production to sell to dairy companies. Fodder markets are likely to continue to grow in importance as some farmers expand beef production and are no longer able to produce all of their own feed.

D4. Increased privatisation of farm land is reducing access to common feed resources, giving farmers more control over their own feed resources and inducing them to grow forages and improve pastures, while contributing to other farmers abandoning cattle production.

The value of feed resources have been steadily rising with the increasing commercialisation of beef cattle production. The increased competition for feed sources have resulted in a gradual shift towards privatization. For example in Northern Laos, grazing practices have evolved from communal free grazing to grazing animals within privately fenced forage plots. Similarly, across all case study sites, crop residues, stubble, grass on bunds, and other sources of feed are increasingly seen as private rather than communal feed resources. At the same time, cattle have been increasingly confined and their movement controlled, which has enabled farmers to plant crops and forages without fear that these will be eaten or destroyed by cattle of other animals. As a result, depending upon the circumstances of each household, there has been a trend towards specialized cattle production or specialization in other activities while reducing or abandoning cattle raising altogether.

D5. Increased forage production increases farmers' capacity to raise and fatten larger cross-bred animals, increasing the demand for exotic breeds and AI services.

Commercial cattle farmers have shown a strong preference for cross-breeding their local cattle with larger Zebu or European breeds, whether through natural mating or AI. However, the substantially higher feed requirements of these cross-bred animals is a constraint to increasing their numbers if farmers are still dependent on native grasses and crop residues. With the establishment of high-yielding forages and improved forage management, farmers' capacity to upgrade their herds with exotic breeds is enhanced.

Figure 15: Cattle tethered in the shade in Koh Takae Island, Prek Preah Ang Village, Prek Bak commune, Stueng Trang District, Kampong Cham Province, Cambodia

8 Implications and Conclusions

This study of forage dissemination and adoption in Vietnam, Laos, and Cambodia has shown that planted forages have come to be highly valued and widely used by farmers in diverse agro-ecological settings as they intensify and commercialise their cattle production systems in response to the economic transformation underway in the Southeast Asian region. Given the differing goals and circumstances of cattle producers, forages have been incorporated in a range of feed production systems, from grazing to intensive cut-and-carry to specialised forage production for sale in local markets. It is projected that these systems will continue to evolve, with greater differentiation and specialisation among farm households. The overall implication is that we need to tailor our recommendations for future R&D and scaling-out efforts to the different contexts in which forages can contribute to rural livelihoods.

8.1 Scenarios for Smallholder Forage and Cattle Production Systems

Forage production plays an essential role in improving the incomes of cattle-producing households in all agro-ecological zones, but not all households have the interest or capability to make forage and cattle production a major component of their farming system. We identify four likely scenarios:

Scenario 1 *Households with only very small areas of land suitable for growing forages (<0.1 ha).* These households have limited scope to increase cattle production but may be able to improve their incomes from cattle production through better feeding. Examples include the deltaic areas in Cambodia with poor flood control and very small farms with limited scope to increase crop and cattle production in all agro-ecological zones.

Scenario 2 *Households with small- to medium-sized land suitable for growing forages (>0.1 ha).* These households are typically engaging in intensive forage production for pen-fed cattle (cut-and-carry systems) and have the potential to make forage and cattle production a major part of their mixed crop-livestock farms. They constitute the majority of farms in the region, found in the coastal lowlands, lowland plains and plateaus, and the intensively-farmed uplands, as well as in limited areas of the deltaic zone and the extensively-farmed uplands.

Scenario 3 *Households with larger areas of land suitable for growing forages (several ha) that are grazing their animals on improved pastures.* These households are practising grazing systems and have the potential to improve pasture and cattle productivity. They have emerged in the extensively-farmed uplands of Northern Laos, but cattle grazing may also be an option for farmers with larger forage areas in other agro-ecological zones.

Scenario 4 *Small-scale commercial cattle fattening*. Only a few examples of this kind of system were encountered in the study, involving 15-30 cattle kept in pens and fed forages, crop residues, and supplements. The cases encountered were predominantly of young, entrepreneurial farmers with professional livestock experience. However, this type of operation is likely to increase in importance as some farmers with sufficient access to capital and expertise specialise in cattle fattening operations, drawing on animals produced in surrounding cow-calf systems.

Mixed scenarios consisting of both grazing and cut-and-carry systems are also likely to emerge, although only a few examples were encountered in the study. For example, farmers in Northern Laos may continue to graze the majority of their cattle on improved

pastures but place selected cattle in pens for conditioning or fattening prior to sale to maximise returns. Similarly, farmers in other agro-ecological zones may also prefer to graze some of their cattle while keeping others in pens.

8.2 Targeting Future R&D for Forage Production

Previous forage R&D projects in Southeast Asia have been highly participatory, offering farmers a choice of forage species and working with them to select and develop suitable forage systems. Future R&D should continue this participatory approach but be more targeted, focusing on areas where many farmers fit Scenarios 2 and 3 and, within these, on farms with adequate land, labour, and capital resources and an interest to further develop forage-based cattle production. While this risks leaving resource-poor farmers and farmers in areas with lower potential behind, once R&D projects begin to bear fruit an effective scaling-out program (see below) can extend the resultant technologies to farmers in less-advantageous circumstances.

Younger farmers who are focused on farming rather than off- or non-farm work and who are motivated to pursue more commercial cattle production systems should be especially targeted for R&D projects. In several case-study sites, older farmers with limited help within the household were found to be less interested in expanding their cattle herd and increasing forage production.

For Scenario 2, it may be important to focus on farmers with access to some form of irrigation during the dry season as this increases the benefits of forages, and for Scenario 3, on farmers with the ability to provide fencing and access to water for their cattle.

Forage adoption was found to be high in areas with few alternative crop options and at some distance from large population centres offering non-farm employment opportunities that compete with farm labour. This situation increases the relative advantage of forage-based livestock systems and hence the likelihood of good farmer participation in R&D.

It should be noted that there is now a very sophisticated though limited capacity within government R&D agencies that was not there several decades ago, largely as a by-product of ACIAR and other bilateral project and training support. There are also many sites where farmers have responded to forage interventions and developed forage technologies to suit their circumstances. There can be a benefit in building on and sustaining these capacities, while also developing strategies for scaling out to new sites.

The role of policy in formulating and supporting forage interventions was an important finding of the case studies. Hence research results also need to be targeted at key officials in government departments concerned with agricultural policy, development projects, and livestock extension so that the results can be integrated in national development initiatives from an early stage.

8.3 Forage Production R&D Opportunities by Scenario

For Scenario 1, suitable forage technologies exist but are not easily accessible. It is recommended that no new R&D be undertaken for this type of farmer but that the emphasis should be on improving access to established best-practice technologies and to appropriate seed and/or planting material.

For Scenario 2, the challenge for R&D is to improve the productivity and diversity of forage and fodder species in intensive production systems for the farmer's own use and for sale, and to improve effective use of available feeds to maximise cattle productivity.

There is scope to make use of a wider range of potentially suitable forages for on-farm evaluation. Researchers could identify productive forage and fodder species and varieties for specific situations and increase the number of suitable species available to farmers. Past research identified robust forage varieties that could be grown in most situations, but these

may not be the most productive or suitable species for specific situations. There is thus potential to identify better species and varieties for different soils (e.g., sandy soils, clay soils), field types (e.g., paddy fields with varying water management capability; dry land with irrigation), and seasons (e.g., drought-tolerant varieties), and to increase farmers' choices of suitable species.

Research on improved fertiliser and water management is critical for ensuring the sustainability of cut-and-carry systems and to enable the integration of forages into cropping rotations. This could include obtaining a better understanding of where to plant forages in the landscape to make use of available soil moisture.

Research can also identify and evaluate labour-saving devices for planting, harvesting, and feeding of forages, and explore private-sector service provision for farmers who have larger-scale operations.

As well as these production-oriented research initiatives, there is scope for research to improve the utilisation of forages, providing the knowledge and tools to formulate forage-based diets and year-round feed budgets that better integrate forages with available crop residues, crop by-products, and supplements.

Given the demand for measures to overcome seasonal feed shortages, research is needed to investigate options for forage conservation such as baling of straw and grass hay and making of small-bag silage. These could be used to meet on-farm needs as well as for sale to neighbouring farmers and beyond. As these activities are likely to be beyond the capacity of most smallholders, collaborative research with private-sector service providers is recommended.

For Scenario 3, the focus should be on overcoming dry-season feed shortages and improving pasture sustainability. This will involve the identification of additional forage species for grazed pastures with good dry-season performance and improving access to suitable species.

Research is also needed on cattle and pasture management to improve the productivity and sustainability of pastures, including grazing management, fertilisation, and weed control.

The identification of labour-saving devices for planting and management of forages will also be important for this type of farmer, whether for own use or through the development of service provision options for those who require a larger scale of operation.

Service provision options should also be investigated for the conservation of forage, as discussed for Scenario 2. Similarly, researchers could also partner with the private sector to improve the returns from forage seed production. Ruzi and other suitable forage species could form the basis of increased commercial seed production. This is a complex area for entrepreneurs as it needs specialised production knowledge, facilities for drying, cleaning to remove weeds, packaging, and storage, and marketing channels. Hence collaboration with research agencies will be mutually beneficial.

Research priorities for Scenario 4 overlap substantially with those for Scenario 2, with a particular focus on improving intensive forage production, developing seasonal feed budgeting, and incorporating forages in diet formulation.

Table 12: Forage production R&D needs and opportunities by farming scenario

Forage production R&D needs and opportunities	**Scenario 1**: Low potential (pen feeding)	**Scenario 2:** Potential with small farm size (pen feeding)	**Scenario 3:** Potential with large farm size (grazed	**Scenario 4:** Small-scale commercial (pen feeding)
Improve access to a range of suitable forage seeds (i.e. development of a well-functioning forage seed market)	X	XXX	XXX	X
Identify additional productive forage and fodder species/varieties for specific situations to increase the range of forage options available to farmers		XXX[1]	XXX[2]	X[1]
Improve nutrient/fertiliser management		XXX	X	XXX
Improve cutting/grazing management		X	XXX	X
Improve feeding/use of forages: Knowledge and tools to formulate forage-based diets and feed budgeting		XXX	X	XXX
Identify labour-saving devices for planting, harvesting and feeding of forages and develop service provision for those that require scale		XX	XX	X
Develop service provision options for conservation of forage (hay and silage) such as baling of straw and grass hay, and making of small-bag silage to overcome seasonal feed shortages on-farm and for sale		XXX	X	XXX
Improve returns from forage seed production in Laos, including additional forages for sale[3]		XXX	XXX	

1 Highly productive forage and fodder species/varieties suited for cut & carry management.
2 Forages for grazed pastures with good dry/winter season performance.
3 Recognising that this is a complex area as it needs special production knowledge as well as facilities for processing and storage (drying, cleaning to remove weeds, packaging, storage) and marketing channels. Strong opportunities for private sector partnerships. Particularly suitable for intensive and extensive upland agro-ecoregions.

8.4 Scaling-Out Forage Technologies

The success of forage-based interventions in the case-study sites and beyond demonstrates that technologies developed through participatory R&D have the potential to be scaled-out to farmers in other similar sites. However, the low “learnability” of forage technologies and the limited supply chains for seed or planting material have limited the extent of diffusion beyond project sites. The evidence from the case studies is that successful scaling out has a number of essential requirements.

Widespread adoption of forages is only feasible if it is supported by government policy and investment. This includes targeting of provinces and districts that have been designated as priority areas for beef cattle production. However, extension services tend to prefer simple, standardised, and thus measurable technology packages that may not suit the wide range of evolving situations. For example, in Vietnam, the extension service offered VA06, partly because it is high yielding but also because it can be propagated easily from cuttings and hence easily distributed to farmers, giving a ready indicator of "achievement". Governments need to be prepared to invest in promoting a basket of technologies in the expectation that farmers will pick and choose those that fit with their circumstances.

It is important to build on existing, high-potential sites of forage adoption for scaling out, rather than starting again in totally new locations, as these provide opportunities for learning from the forage-based cattle production systems that farmers have already developed and adapted. There is a tendency for farmers merely to copy the first successful system in a given site, giving rise to a high degree of uniformity within villages. However, a range of suitable sites can be selected as potential nodes of diffusion to new sites.

Because systems are at different stages of development and subject to different limiting factors, it is even more essential than in the past to conduct careful diagnostic analysis before new projects are undertaken. This is to ensure we are not merely rolling out previous technologies that fail to fit the current situation or alleviate new critical constraints. In long-established sites, new entry points may be relevant, such as support for fertilisation of forages to sustain productivity, improved access to superior planting materials (e.g., Mulato II in Northern Laos), or support for fencing (including maintenance), which has become both an essential component of improved pasture management and the largest cost item.

There is clear evidence of the importance of influential local actors ("champions" or "knowledge brokers"), including agricultural extension staff and leading farmers, in overcoming initial barriers to forage adoption. There is an opportunity to better identify and support these actors and to enlist a larger number of them in parallel to enable more rapid scaling out. Such local actors are not to be regarded as "model farmers", receiving material support beyond that which most farmers could expect to draw on. Rather, they are key to a process of farmer-to-farmer learning, which was found to be an essential ingredient in forage promotion and adoption. This learning has typically occurred within existing social networks, such as within a given village, but for widespread scaling out projects need to find ways to join up networks, using an adoption site as a node of diffusion to other sites through investing in systematic, facilitated cross-site visits and farmer field days.

Improving access to seed and/or planting materials is critical for scaling out. Limited access to a wider range of suitable forages has been identified as a constraint at all study sites. An efficient forage seed market is thus essential for widespread and sustained forage development. There are currently few suppliers of suitable forage seeds, almost exclusively located in Northeast Thailand. Development of a forage seed industry in Laos and Cambodia would broaden the supply base as well as provide additional income opportunities for farmers.

The increasing role of capital in developing commercial, forage-based cattle production systems was clearly identified in the study sites. However, banks and other credit institutions do not appear to provide credit for forage development (which may include expenses for land preparation, seed, planting, fencing, fertilising, and harvesting). The reasons for this constraint on lending need to be investigated, given that profitable outcomes can be observed. Models involving partnerships between lending agencies, technology providers, and farmer groups could be trialled in scaling-out projects.

8.5 Researchable Issues Related to Scaling Out

While the evidence from the study has clear implications for the nature of forage interventions, additional socioeconomic research is needed to fully understand the scaling

out process for this kind of technology. As noted above, forage technologies are characterised by low learnability (because of their complexity, low observability, and the relative difficulty of trialling them on-farm). In addition, adoption is constrained because of missing markets for key inputs (seed and credit). An action research program could be undertaken in conjunction with scaling-out efforts to address these key constraints to forage adoption (and, indirectly, of other similar technologies).

It is argued above that the learnability constraint can be addressed by recognising the role of, and better utilising local actors as nodes of diffusion in farmer-to-farmer extension. While alternative extension approaches have been the topic of much research, the effectiveness of this type of diffusion (planned and unplanned) needs detailed investigation. Relatedly, there is evidence from the study sites that farmers are increasingly accessing information about forages through the internet and social media. While this cannot substitute for farmer-to-farmer learning, the role of information technology in raising awareness of forage options should be researched.

Research is also needed on the forage value chain, both upstream and downstream from forage producers. Despite the current popularity of private-sector-led development, this has not eventuated for smallholder forage and cattle production. There is a need to identify constraints to the emergence and growth of markets for forage seed and planting material and to explore the opportunities for improving fodder markets, including the potential to produce and sell not only fresh forage (as occurs already on a limited scale) but also hay and silage. It is likely that the latter will be contingent on the emergence of service providers for the baling of straw and grass hay and making small-bag silage products, as discussed above under production issues. Institutional innovations for extending credit to forage and cattle producers should also be explored.

8.6 Conclusions:

The introduction of planted forages to a range of farming systems in Mainland Southeast Asia, despite being initially met with a limited response and largely confined to particular project sites, has provided the basis for the dramatic growth of commercial cattle production over subsequent decades. There is now clear evidence for the growing importance of forages in mixed-farming systems from the lowland plains to the extensively-farmed uplands, and for the potential for further research in support of more productive and sustainable forage systems and more widespread and rapid scaling out.

This research needs to be diagnostic, well-targeted, and nuanced to be able to respond to the opportunities and constraints of the various systems that are emerging, and to go beyond the farm to include the value chains with which forage and cattle producers are engaged. The priorities for research are:

- Identify additional forage and fodder species and improve access to a range of suitable forage seeds and planting material;
- Improve the sustainability of forages through better management, including fertilisation, irrigation, and grazing management;
- Investigate ways to address dry-season feed shortages, including suitable varieties, better forage management, and forage conservation;
- Document key lessons regarding the role of local actors, farmer-to-farmer learning, and other diffusion strategies (e.g., use of social media) in addressing obstacles to scaling out forage technologies;
- Develop and evaluate service provision options to improve fodder markets, implement forage conservation, alleviate labour constraints through labour-saving technologies, and alleviate capital constraints through appropriate credit schemes.

9 References cited in report

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10 Appendixes

10.1 Appendix 1: Working Paper Number 1:

Huyen, L.T.T., Phengsavanh, P., Sophal, L., San, S., and Stur, W. (2021). *"Status of forage development in Cambodia, Lao PDR, and Vietnam.*" Working Paper Number 1 on the Australian Centre for International Agricultural Research (ACIAR) supported project LS/2018/186 Forages – taking stock and identifying research needs

10.2 Appendix 2: Working Paper Number 2:

Yadav, L.P., Cramb, R., Boyd, D., and Stur, W. (2021). "*Changes in large ruminant production and the uptake of planted forages in Mainland Southeast Asia: a review."* Working Paper Number 2 on the Australian Centre for International Agricultural Research (ACIAR) supported project LS/2018/186 Forages – taking stock and identifying research needs

10.3 Appendix 3: Working Paper Number 3:

Yadav, L.P., Boyd, D., Cramb, R., Stur, W., Huyen, L.T.T., Phengsavanh, P., Sophal, L., Sareth, C., Phengvilaisouk, A., Chittavong, M. (2021). *"Factors contributing to and impeding the adoption of planted forages by smallholder farmers: A comparative analysis across Laos, Cambodia, and Vietnam."* Working Paper Number 3 on the Australian Centre for International Agricultural Research (ACIAR) supported project LS/2018/186 Forages – taking stock and identifying research needs

10.4 Appendix 4: Policy Brief: