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Final report

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1 Acknowledgments

The research team is indebted to the smallholders who contributed time and energy to the project, providing deep insight into their lives and strategies to improve themselves and the lives of their families.

2 Executive summary

This project explores farmer uptake of agricultural technologies (FUAT). It involved a deep engagement with farmer perceptions and values (**Objective 1**), was followed by engagement with elites who structure farmer practices (**Objective 2**) alongside scientific trial and analysis of 1) existing cassava farming practices and 2) best cassava production practices as documented in the academic literature (**Objective 3**). With identification of a perceived problem of importance to farmers (**outcome of Objective 1**) and available solutions (**outcome of Objective 2 and Objective 3**), the project developed a 'humanised model of extension' (Cook et al 2021) on the topic of Pest and Disease (P&D) management.

Using a 'knowledge exchange' methodology (Cook et al. 2013), which replicated much farmer field school discourse (FFS), an international expert attended engagements with farmers to determine the nature of the perceived problems and existing knowledge of solutions. The day-long engagements involved listening to farmers, answering questions, and a field visit to locate examples of different pests and diseases including expert recommendations on response, all designed to trial and measure the impact of a more humanised (Cook et al. 2021) model of extension (**Objective 4**).

The knowledge exchange involved co-design and generation of a pamphlet on cassava production best practices (here), with emphasis on P&D, which was then produced by a local artist and designer in response to farmers' suggestions and insights. Upon completion of the pamphlet – but delayed due to Covid travel restrictions – the team returned to participants to measure the impacts of the knowledge exchange on Pest and Disease management practices (**outcome of Objective 4**).

An additional impact pathway was added to the project following the mid-project review, which was the translation of the research findings into a theatre production in partnership with Lakhon Komnit. The resulting production wove research findings from Objectives 1, 2, and 3 into a show that confronted the challenges of village life while providing guidance on pest and disease management (recording here). The production was delivered in all 13 participating villages, using a 'thinking theatre' methodology in which audience members commented on the topic and content and were able to 're-write' scenes in order to spark discussion and commentary.

Further, team member Phan – who was supervised by agricultural expert Montgomery in the operation of the demonstration farms and who completed a master's degree on cassava production as part of the project – attended each performance and was available to answer questions following the shows, with a documentary film produced for ACIAR (here) to act as a template and guide for agricultural researchers interested in collaboration with thinking theatres.

The wider scientific contribution sitting overtop of the research questions and guiding the FUAT project is recognition that a more humanized theory of change (ToC) is required for agrarian researchers to contribute to modern rural development in the context of rapid and, often, brutal agrarian change. A central scientific aim of the research, then, was to explore and test a more supportive model of engagement to determine whether such a methodology would be effective.

We found that behaviours resulting from a humanized approach spillover to non-participants and are reapplied in other contexts, thereby demonstrating a theory of change that is: 1) more socially informed and supportive to local circumstances and individual decision making, while also 2) providing diffusion pathways through which large scale impacts can arise without additional inputs from the research team (i.e., diffusion happens as a result of the meaningful engagement).

3 Background

Introduction

Within the Sustainable Development Goals (SDGs) discourse, the uptake of agricultural technologies via agricultural extension is a critically important means for achieving change involving agricultural production-consumption systems. Especially related to SDG2 'End hunger, achieve food security and improve nutrition and promote sustainable agriculture', but also in terms of realising SDGs such as SDG1 'End Poverty' and SDG13 'Climate Action', agricultural extension is portrayed as a mechanism that can prompt change. This prevailing portrayal of agricultural extension tends to render (Li, 2011) human elements from consideration (Cook et al. 2021) while 'black boxing' (Wellstead et al., 2013) the topic of extension. Black boxing describes a process whereby complex issues are simplified and bundled so that they can be set aside in order to advance debates over higher order or related topics.

Black boxing is a common and sometimes necessary move that enables focus. But when a black box is left unopened, conflicting assumptions and values are left unexamined, which undermines the implementation of resulting proposals. In the case of the SDGs, the black boxing of agricultural extension resuscitates the 'diffusion of innovations' (DoI) theory, which decades of research have shown will inevitably fail to prompt the behavioural changes being sought. This black boxing, then, endangers the potential impacts of the SDGs by mischaracterising the potential contributions of agricultural extension. The following project report and review documentation for ASEM/2013/003 Farmer Uptake of Agricultural Technologies (FUAT), outlines the research activities, analyses of farmers' perceptions and practices, and resulting support and collaboration with farmers to identify problem-solution pathways (PSP) for smallholder cassava farmers in Northwest Cambodia. The project represents a 'proof of concept' for humanised agricultural extension, which responds to farmers' expressed wants/needs. As is demonstrated in the subsequent mid-project review of the Next-Gen project, the 'proof of concept' developed through FUAT provides a basis for the interventions to be implemented and compared, as well as for the broadened measurement of impact (see Next Gen component of the review) that will enable comparison of different types of support for farmers.

Context

Agricultural extension, is defined as:

> *"a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations" (Leeuwis, 2013, p. 27).*

This process has, historically, been defined as an act of extending technologies from extensionists to farmers, with technologies defined as:

> *"The means and methods of producing goods and services, **including methods of organisation as well as physical technique**. New technology is 'new' to a particular place or group of farmers, or represents a 'new' use of technology that is already in use within a particular place or amongst a group of farmers" (Loevinsohn et al., 2013, p. 2).*

This extension of technologies is guided by objectives established by donors and global initiatives, such as the SDGs. Those objectives are realised by extensionists (Landini,

2016a; Landini et al., 2017), who attempt to alter on-farm practices, with implementation constrained by farmers' decision making and practices.

The SDGs have been criticised for elevating global priorities over farmers' realities (Cohen, 2019; Covic et al., 2021; Siegel & Lima, 2020; Webb et al., 2020). In response, FUAT offers an account that focuses on farmers' PSPs and agricultural extension as experienced by farmers, emphasising farmers' *perceptions* (i.e., what considerations influence farmer decision making), *practices* (i.e., what do farmers do), *aspirations* (i.e., what do farmers wish for or want to do), and *bounded agency* (i.e., what limitations affect farmers' practices) – these considerations are hereafter explored through farmers' relations or social relations (Bernstein, 2010; Scoones, 2021). This mixed methods research draws on 390 quantitative household surveys, 304 qualitative household interviews with cassava farming households in Northwest Cambodia, interviews with 13 village leaders, data from two demonstration farms, and two implementation pathways (via knowledge exchange and theatre production). The project explores farmer decision making and highlights the types of considerations that shape farmers' collective behaviours, providing a grounded case relative to extension as portrayed within the SDG and agricultural discourses. The emphasis on measurement of impact, including a broadened conceptualisation of learning (Ensor and de Bruin 2021; Baird et al. 2014) coupled with attention to the spillover effects (Nash et al 2017) that result from meaningful relationship building (Cook and Overpeck 2019), is central to assessment of impact.

Extension-adoption: past, present, and persistently past

Reviews of agricultural extension highlight the emergence of the 'diffusion of innovations' (DoI) theory (Rogers, 1962 (1983)) in the post-WWII period (Cieslik & Leeuwis, 2021; Ison et al., 2000; Klerkx, 2020; Landini et al., 2017; Leeuwis, 2013; Leeuwis & Aarts, 2011), with some arguing that it remains the dominant theory of change in practice (Cook et al., 2021; Landini, 2016b; Landini et al., 2017). The DoI theory mirrors debates in disparate fields, including risk (Wynne, 1991), education (Freire, 1968 (1970)), and behavioural economics (Dolan et al., 2012). Common to each of these linear conceptualisations is a series of assumptions concerning change: beginning with the identification of a problem by experts and external creation of technologies to address that problem; this is followed by the one-way transfer of technologies and awareness raising amongst targeted communities; the resulting awareness is presumed to spark understanding that, in turn, prompts behaviours that remedy the expert-determined problem. More advanced than most fields, the agricultural extension literature has coupled this linear conceptualization to the subsequent diffusion to non-participants, a trait that has only recently become prominent in other fields with growing appreciation of 'spillover effects' (Nash et al., 2017) and social networks (Kim et al., 2015). While there are minor differences across these discourses, uniting them is an acceptance that linear models are **ineffective theories of change and that they are also, frus**tratingly, prevailing or dominant in practice.

More specific to the agricultural extension discourse, researchers argue that the failures of the 'diffusion of innovations' theory have prompted its 'replacement' (Leeuwis & Aarts, 2011). Alternatives include participatory empowerment (Chambers, 1983), systems thinking (Röling, 1992), transition processes (Geels & Schot, 2007), 'agricultural advisory services' (Birner et al., 2009), and appreciation for agro-social systems (Leeuwis & Aarts, 2011, p. 2), in which extension-adoption is defined as "a collective process within nested networks of interdependent stakeholders". With this turn towards inclusion of socio-political considerations, the challenges of power, people, and place are centred, with growing appreciation for the extensionists who identify problems, develop technologies, implement interventions, measure the impacts of interventions, and publicize their impacts (Cook et al., 2021; Landini, 2016a; Landini et al., 2017; Nettle et al., 2018; Nettle et al., 2017). Appreciation for the power of extensionists draws attention to differences between agricultural extension 'having impacts' compared to 'having targeted impacts', a difference that underscores ongoing debates over the growing prominence of Randomised Control

Trials (RCTs) (Donovan, 2018) within agrarian studies. Those debates are, themselves, founded on the same critique of agricultural extension as having been unable to 'prove' (Reddy, 2012) that interventions into farmer decision making have resulted in targeted impacts on farmers' practices.

The model of engagement implemented by FUAT applies a farmer-centred approach to the prevailing linear model described above. Rather than pre-determine the problem, **Objective 1** engages with farmers using both qualitative and quantitative approaches to identify and triangulate perceptions of problems (in this case Pest and Disease Management for cassava was identified as a priority as well as transitions to fruit tree production). Rather than accept farmer perceptions divorced from context, **Objective 2** explores problems as perceived by village leaders. Rather than draw only from the academic literature, **Objective 3** trials both expert- and farmer-determined best practices for cassava production in the region; furthermore, rather than de-contextualised generic knowledge of 'yield gaps' (Fermont et al., 2009) and scientific findings, **Objective 3** also undertakes farming *in situ* in order to develop an experience-based understanding of smallholder cassava farmers' practices in the region. Finally, rather than one-way communication of findings, **Objective 4** implements two adoption pathways that both involve elements of co-design, feedback, and farmer commentary on the findings. Together, these Objectives build upon existing understanding of extension while broadening the scope of monitoring and evaluation of impacts arising from Objective 4.

4 Objectives

No.	Activity	Outputs/ milestones	What has been achieved?
PA1	Develop project's Communication strategy and website	Communication strategy prepared & finalised; website running. (Cook)	The communication strategy was prepared at the inception of the project. It has since been revised and updated as the project proceeded, culminating in the Next-Gen communication strategy. This pattern is replicated with Monitoring and Evaluation, which has also evolved as the project has continued, culminating in the Next-Gen M&E strategy.
PA2	Meet with ACIAR project leaders (Cramb, Newby, Tan) to discuss possible data sharing and collaborations.	Identify specific areas of sharing and collaboration. (Cook, Farquharson)	A meeting was held at the University of Queensland (July 2016) between Cook, Cramb, and Newby, including presentations from Newby and Cook to the UQ group. This collaboration resulted in Newby/Cramb sharing the baseline survey instrument used in their ACIAR-funded project in Northeast Cambodia, which was adapted and implemented by FUAT as the baseline survey.
PA3	Establish focus group, participant observation, and interview templates.	The exact questions and methods will be developed by the research team, and tested. (Cook, Milne, Lamb, Rickards, Farquharson)	This discussion implemented the adapted version of the Cramb/Newby survey, which when piloted took nearly 3 hours to complete. The decision to cut the length was taken, though we recognise that this sacrificed the in-built redundancy that allowed triangulation and interrogation of responses. The finalised survey took between 40-80 minutes to complete.
PA4	Develop data collection App	Operational App developed. (Cook)	The data collection and analysis team at the University of Melbourne tested numerous existing data collection software and budgeted construction of a bespoke system. At the time, ACIAR recommended CommCare, which the team decided to use following testing and trials.
PA5	Project inception meeting and training workshop for PRD researchers.	Assemble entire research team in Cambodia for meeting, and initial training session for PRD researchers. (Full research team)	An inception meeting was held in Battambang and Pailin in August 2017.
PA6	Identify case study locations.	Identify 12 villages. (Montgomery, Phan)	The local team (Montgomery, Phan, and Nou) identified 12 villages (plus an additional village in case one dropped out of the project mid-way) that were proximate to the two demonstration farms.
PA7	Identify and lease two 2 ha plots for demonstration farms.	Sign leases for plots. (PRD, Phan, Montgomery)	Land was leased in 2017 for the two demonstration farms.
PA8	Sample soils at demonstration sites	Analyze for pH, available P, exchangeable K, Ca, Mg, total N, soil organic carbon and texture. (Phan, Montgomery)	Soil samples were sent for analysis at the inception of Objective 3, and throughout the demonstration farm activities (see Objective 3). Samples taken from each plot, (184 total) catalogued, air dried and a subsample selected for analysis in Thailand.
PA9	Annual report #1	Project update for ACIAR. (Cook)	See Annual Report 1 (available here)
PA10	Annual report #2	Project update for ACIAR. (Cook)	See Annual Report 2 (available here)
PA11	Annual report #3	Project update for ACIAR. (Cook)	See Annual Report 3 (available here)
PA11B	Annual report #4	Project update for ACIAR. (Cook)	See Annual Report 4 (available here)
PA 11C	Year 3 meeting	Meeting report. (Cook)	
PA11D	Year 4 meeting	Meeting report. (Cook)	
PA12	Final workshops in Battambang and Phnom Penh.	Conduct workshop. (Full research team)	Completed July 2023.

PA13	Final project report	Outline and emphasise outputs and outcomes. (Cook)	This document.

4.1 Objectives from original submission

The aim of this project is to increase adoption of agricultural technologies and best practices. This aim will be achieved through **four** interconnected objectives: **objective 1** will expose and analyse farmer PSPs; **objective 2** will analyse experts' and village leaders' assessments of farmer PSPs to establish whether suitable technologies or best practices exist, whether they are available in North-west Cambodia, and expert perceptions of their benefits and costs; **objective 3** will demonstrate best practices and economic advantages for sustainable cassava production, as well as farmer-desired alternatives (e.g., transition to mango or crop rotations); and **objective 4** will measure whether a PSP-based approach results in increased, expanded, or accelerated adoption of agricultural technologies, with specific emphasis on poor, marginalised, and female-headed households in Battambang and Pailin. The project will partner with a local group (i.e., Lakhon Komnit (LK), who are an arts-based non-profit organisation that works in the participating villages to help farmer households. Specifically, LK uses theatre productions to entertain and inform. The organisation has agreed to produce a 'Farming Village Production', which will cover each of the four main findings of the project (i.e., cassava best practices, transition to fruit trees, pest and disease, and stress-finances). Following the production, a team member will be present to supply any information (e.g., pest and disease pamphlet to any interested farmers, and to collect their contact details so that the project can follow-up and determine whether the production or information resulted in increased awareness, intention, practice change, or sharing with friends family members, or neighbours. 'Increased adoption' will be measured by the number of farmers in the region using the demonstrated best practices or transitions relative to those for whom it is relevant; 'expanded adoption' will be measured by the type of farmers who have adopted (e.g., whether the technology is adopted by female farmers or smallholders); 'accelerated adoption' will be measured by the speed of adoption compared to non-participating neighbouring villages. These forms of adoption will be calculated through comparison of baseline data from focus group meetings and participant observations in year 1 with subsequent years (see Operations), and through comparison with neighbouring non-participating villages.

Each of the four objectives involves sub-research questions, which guide the activity(ies). The project is shaped by these sub-questions, which flow through this proposal to the activities, outputs, outcomes, and budget.

1. Determine farmer PSPs with reference to agricultural technologies and best practices.
    - **Research Question 1**: What problems do farmers perceive, what do farmers think *should* be done, what do farmers think *can* be done by whom (i.e., farmer PSPs)?
    - **Research Question 2**: Which agricultural technologies do farmers identify as part of their PSPs and why?
    - **Research Question 3**: How and why do farmer PSPs differ with regard to sub-groupings (i.e., small, medium, large, poor, marginalised, and female-headed).
    - **Activities**: Focus group meetings, home visits, semi-structured interviews, livelihoods analysis.
2. Determine the feasibility of farmer-preferred PSPs, and the degree of alignment with existing and available agricultural technologies, using expert and village leaders opinion.
    - **Research Question 4**: According to experts and village leaders, how feasible are farmer PSPs and why?

- **Research Question 5**: Which technologies do experts and village leaders believe match farmer PSPs and why?
- **Research Question 6**: Which technologies do experts and village leaders believe are particularly suited to marginalised farmers, with specific attention to technologies designed to support female farmers and female-headed households?
- **Research Question 7**: How do experts and village leaders envision successful extension-adoption of agricultural technologies and best practices amongst different sub-groups of farmers?
- **Activities**: Semi-structured interviews with village leaders, local experts, and national-scale experts.

3. Demonstrate sustainable production of cassava using best practices and, in years 2 – 4, add demonstrations in response to farmer PSPs (Objective 1) using best practices and technologies identified by experts (Objective 2).
   - **Research Question 8**: What are the costs and benefits of sustainable cassava production in Battambang and Pailin?
   - **Research Question 9**: What are the costs and benefits of transitions to other crops identified by farmers and trialled at the demonstration sites?
   - **Activities**: Demonstration sites, following Fermont et al.'s[19] cassava testing methodology, with parallel demonstrations beginning in year 2 in response to farmer perceptions, needs, and questions or suggestions.
4. Measure adoption of agricultural technologies by farmers in Battambang and Pailin to explain why some groups adopt and to identify barriers specific to poor, marginalised, and female-headed households.
   - **Research Question 10**: Which technologies or aspects of technologies do farmers adopt and at what rate?
   - **Research Question 11**: Why do different sub-groups of farmers adopt particular technologies or best practices, between villages and compared with villages that did not participate in the research?
   - **Activity**: Community engagement tour with Lakhon Komnit to visit 26 villages (13 participating plus villages near to the demonstration farms) with accompanying key findings from the research. The productions in 26 villages will focus on the key findings from the research. Following the productions, a team member will interact with any interested farmer or villager, collecting their perceptions and contact details to facilitate follow-up home visits to measure farmer perceptions, intentions to act, any practice change, and/or subsequent social network analysis of any diffusion to friends, family members, or neighbours. Follow-up interviews and home-visits will be undertaken with farmers from each of the villages, ensuring coverage across farmer types (i.e., small, medium, large, male, poor, youths, and female-headed). Additional interviews with farmers from non-participating villages will contextualise the findings.

5 Methodology

5.1 Methodology

The proposed research emphasises farmers' perceptions and experiences, which requires a methodology that can access and analyse perceptions amongst various groups of farmers, but there is also need to situate those perceptions amongst wider political and economic forces. We develop the concept of 'problem-solution pathways' (PSPs) as the basis of our methodology, which builds on the preceding SRA's identification of 'barriers' to adoption of agricultural technologies [39]. PSPs (objective 1) extend the scope of this project past the simple identification of barriers to include: 1) what problems farmers perceive, 2) what they think *should* be done, and 3) what they think *can* be done by whom. Farmer PSPs establish the local and household factors that shape 'farmgate' decision-making.

But farmgate decision-making does not occur independently from wider regional and global factors, such as market variability, foreign traders, costs of labour, and changing cultural expectations. The feasibility of farmer PSPs (objective 2), then, is an integral aspect of adoption and requires understanding *why* farmers make particular decisions. For example, there is no use in determining that farmers perceive 'connection to market' as their primary problem if we do not also explore the 'construction of roads by government' as their preferred solution; furthermore, if the project does not include the views of government officials or the traders operating at nearby markets, then we have simply identified barriers without offering insights into their resolution nor with respect to the capacities or perceptions of the actors with the power to implement a response. In addition to cassava, the farmer PSPs and experts' appraisals of farmer PSPs will identify crops, transitions, or best practices that the farmers desire, which will be demonstrated alongside the cassava demonstrations (objective 3). Finally, we will measure whether engagement with farmers' problems and demonstration of their desired solutions results in more adoption of those crops, transitions, or best practices (objective 4).

5.1.1 Case studies

The project will select 12 villages: 8 in Battambang and 4 in Pailin. At project inception, a field visit will be undertaken to finalise village selection based on the state of the transitioning agriculture, interest amongst farmers, willingness of village leaders and their political representatives, accessibility, and safety (security) for travel and research.

5.1.2 Data collection

Farmer PSPs will be established through focus groups and participant observation, and will be conducted by Partners for Rural Development (PRD) (see research partners), with guidance and involvement from the research team. The PL and members of the research team will run training sessions prior to the first field visits and will oversee early data collection. Alongside multiple interviews with cassava farmer households, two village intensive engagements will be undertaken in order to collect data from different sub-groupings of farmers: males, females, poor and/or marginalised, and youths. Each of the village intensive will involve two-week visits, and will utilise a 'village calendar' method for eliciting farmers' perspectives. The accompanying household interviews amount to 20 days of work per month, resulting in the 12 villages visited per year. These meetings will be run by PRD to ensure consistent methodology, data collection, safety, and the ability to visit multiple households. This amounts to a significant amount of work for PRD, amounting to full time employment for PRD researchers over 4 years (see Budget).

Objective 1: Determine farmer PSPs with reference to agricultural technologies and best practices.

Multiple household interviews will be conducted with farmers in each of the 12 villages – repeated four time with sub-groupings within the villages (i.e., males, females, marginalised, youths) – will engage directly with approximately 480 farmers, repeated 4 times over the 4 years of the project; on average, households in the region are composed of 5 individuals, resulting in regular contact with approximately 2400 individuals from farming families. In the first year of focus group meetings and home visits, we will establish a baseline household survey – which will update data from ASEM-2010-049 [26] – and which will establish current agricultural crops, practices, budgets, and technologies in use, while also establishing household characteristics, livelihoods, and farmer PSPs. A key question for the livelihoods analysis is understanding whole-farm structures, household budgets, and perceptions of the economic returns for different crops in production in North-west Cambodia. The household interviews are used to expose the relationships that influence how knowledge circulates, the individuals who propose or advance best practices, and the peer pressures that shape decision-making.

During the home visits, we will confirm and/or deepen claims made during the village intensive, observe 'real life' situations in which farmers rationalise their practices, and account for the pressures and considerations that shape decision-making. This 'learning with' will also allow for semi-structured interviews to explore specific themes (i.e., from the literature, from experts, or from previous interviews) without constraining the range of possible answers and with less group pressure or bias. Additionally, we will assess the degree of knowledge sharing between neighbours, measuring whether farmers disseminate knowledge from the research or demonstration sites.

The data generated through the village intensives into the data collection app, which can be accessed and analysed by the entire research team. We will use NVivo software for thematic coding and analysis, identifying themes and enabling sub-division of the data by farmer groupings, village, or other defining characteristics that emerge during field visits. The mixed methods will also allow the research team to triangulate findings generated by each method, testing the representativeness of claims made during group meetings or as part of the interviews during participant observation. In establishing a baseline for farmer households, we will record: agricultural crops, practices, and household characteristics. In addition, we will establish farmer PSPs (RQ1), and will identify the technologies and best practices that the farmers are aware of, desire, have considered, or discarded (RQ2). Additionally, we will analyse farmer PSPs according to sub-groupings: small, medium, large, poor, marginalised, and female-headed (RQ3).

Objective 2: Determine the feasibility of farmer-preferred PSPs, and the degree of alignment with existing and available agricultural technologies, using expert and village elite opinion.

Semi-structured interviews will be used to understand the opinions and the knowledge-base of village leaders with regards to the decision-making of poor, marginalised, and female-headed households who currently farm cassava in North-west Cambodia. This will provide the project with appreciation of the views of the elites who shape the wider political-economy and governance of the agricultural sector in which the farmers consider adoption of technologies or best practices. While farmer PSPs provide us with a 'bottom-up' perspective, the interviews will provide a 'top-down' comparison to help contextualise current low adoption of technologies and best practices. Potential alignment between farmer concerns and technologies advocated by experts may identify opportunities for problems and solutions to be reconciled, with adoption the possible result.

The data generated through the interviews will be transcribed and coded using NVivo software. The interviews will be used to discuss farmer PSPs (RQ4), adoption, and their views on the agricultural technologies available in North-west Cambodia suited to the problems expressed by farmers (RQ5). The interviews will explore expert reflections on

the findings and discuss the technologies or best practices that the experts believe are most/best suited to poor, marginalised, and female farmers (RQ6). Finally, we will analyse how experts understand farmer decision making, with emphasis on how the experts think adoption can be prompted and/or improved (RQ7).

Objective 3: Demonstrate sustainable production of cassava using best practices and, in years 2 – 4, add demonstrations in response to farmer PSPs (Objective 1) using best practices and technologies identified by experts (Objective 2).

This project is founded on the contention that farmers are best suited to determine and explain their PSPs. In this way, farmers' priorities and preferences will be exposed, which can then be integrated into on-farm demonstrations. Two demonstration farms will be run as close as possible to the central markets in Battambang and Pailin. These two two-hectare plots will be secured at the inception of the project, and will begin production of cassava in May of 2017. Labourers will be employed by PRD (these costs are included in budget for demonstration farms), with oversight by Phan and Montgomery. The cassava will be harvested and sold, with any profits used to supplement the cost of transitions or demonstrations in subsequent years. Following Fermont et al. [19] cassava production will be demonstrated following: 1) average farmer practice, +2) improved crop establishment using spacing, no intercrop, and timely planting, +3) improved genotype, and +4) fertilizer application. This approach will be modified in response to local circumstances, including soils, availability of technologies and materials, and farmer preferences. Again, following Fermont et al., soil fertility will be measured using composite soil samples (0–20 cm), which will be conducted at both demonstration sites and across each of the four types of cassava production. Soils will be analyzed at each planting and harvest; the samples will be oven-dried, sieved, and analyzed for pH, available P, exchangeable K, Ca, Mg, total N, soil organic carbon and texture [19]. Erosion will be measured through observation [76] on a weekly basis in both demonstration locations; this will be adapted in response to the plot characteristics.

As part of analysing farmer PSPs, a key finding will be the identification of what technologies or transitions the farmers desire and why. In the second year of the project, the two demonstration farms will both be subdivided into two 1 hectare plots in order to demonstrate transitions from cassava to the crop or land use preferred by farmers in that region. One hectare will continue cassava production following Fermont's methodology, while the second 1-hectare plot will be used to respond to farmer PSPs. While the exact demonstration will only be determined following systematic analysis of the farmers' perceptions, the SRA did uncover a desire to transition to mango orchards. As an example of how the demonstration farms will run, if a similar desire for orchards is uncovered, we would begin a full accounting (i.e., economic, social, and environmental costs) of a transition to mango orchards; note, the adaptability of the leased plot will be extremely important in order to ensure that the demonstration sites can respond to farmer preferences. Given that a transition to orchard would take longer than the remaining three years of the project, we would purchase small trees and employ inter-cropping during the transitional period. Our analysis would determine and demonstrate the full costing of this transition, including any period of economic deficit that farmers must undergo for successful transition. Additional emphasis would be on perceptions amongst smallholder, poor, marginalised, and female-headed households concerning the risks associated with such transitions, and the potential responses or adaptations available to those groups.

PRD will act as the focal point for the demonstration sites: they will lease the land for the duration of the project and will contract Sophanara Phan (local government) to run the sites. Responsibility for oversight and monitoring of the demonstration sites will be shared by Phan and Montgomery, with wider advice and consultation provided by Farquharson Nou and Thiele. Throughout the project, we will demonstrate cassava following Fermont et al.. Our aim is to establish 'sustainable cassava production', which we define as an economically and environmentally sustainable system in which profitable yields are consistently delivered without significant detrimental impact on the soils (RQ8). For

example, improved crop establishment might produce profitable yields, but may result in degraded soils; fertilizer may produce profitable yields in a sustainable fashion, but may involve capital investments that farmers cannot afford or feel are too risky. Following completion of the first iteration of focus groups and participant observation (objective 1) in the 12 villages (August 2017, see Gantt chart), we will identify the crop, technology, practice, or transition desired by farmers. Following harvest of the first cassava demonstration, we begin parallel demonstrations of cassava and the farmer-chosen crop, technology, practice, or transition (RQ9), using local (Sophanara, Nou) and international expertise to guide the desired transition or crop (Thiele, Farquharson).

Objective 4: Measure adoption of agricultural technologies by farmers in Battambang and Pailin to explain why some groups adopt and identify barriers specific to poor, marginalised, and female-headed households.

Objective 4 aims to measure and analyse adoption of agricultural technologies by cassava farmers in Northwest Cambodia. The aim is to explain why some groups adopt technologies and to identify any barriers to adoption by poor or marginalised households, especially female-headed households. Lakhon Komnit (LK) is a local 'thinking theatre', which is an organisation that aims to provide entertaining theatre productions on topics of social relevance. Additionally, their model of entertainment involves audience participation and collaboration – in which the audience is able to 're-write' the production as a way of discussing and exploring issues. In our case, the challenges of an agrarian life and the struggles of farmers in Northwest Cambodia will be the topic of the production, with the audience able to comment on problem resolution, which have been identified in the earlier activities of the research. The theatre production will tell the story of a farmer in the region struggling to secure a livelihood for their family, with the underlying issues that they experience including: cassava pest and disease management, cassava best practices, and the transition to fruit tree production and care for fruit trees. LK will deliver 13 theatre performances in the participating villages. Alongside the production, a member of the research team will speak with any of the participants from the research in order to qualitatively measure awareness, intention to act, practice change, and any subsequent diffusion to friends, family, or neighbours, using social network analysis, again with specific attention for gendered findings. Through interviews, we will also measure satisfaction with best practices, the extent of adoption amongst different sub-groupings of farmers, and if the farmers have discussed their experiences with neighbours and if those neighbours have also adopted.

The data generated through follow-up interviews will be translated and transcribed by PRD. The data will be analysed by the research team to measure adoption in three ways (RQ10): 'Increased adoption', which will be measured by the number of farmers in the region using the demonstrated best practices or transitions; 'expanded adoption', which will be measured by the type of farmers who have adopted (e.g., whether the technology is adopted by female farmers or smallholders); and 'accelerated adoption', which will be measured by the speed of adoption compared to neighbouring villages. These measurements will be compared with adoption measurements established during the baseline survey and participant observations in year one and two. The social network analysis will be conducted as part of the final interview (Yr.4 m1-3), using a methodology drawn from Vance-Borland et al (2011)[78] in which farmers' practice change will be mapped and analysed. The adoption measurements will be analysed by sub-grouping to explain why particular crops, technologies, practices, or transitions appeal or are, and are not, adopted by poor, marginalised, and/or female-headed households (RQ11).

6 Achievements against activities and outputs/milestones

6.1 Objective 1: Determine farmer PSPs with reference to agricultural technologies and best practices

No.	Activity	Outputs/ milestones	Completed Date	What has been achieved?
	Focus groups	Run focus groups and participant observations in 12 villages, 6 times over 4 years. (See Gantt)		The research team (led by Lamb with support from Nou, Yin, Kuthea, Sotheara, and Gyorvary) undertook a deep engagement with a local village as a way of collecting group perception data. This engagement followed the quantitative surveys (1.2) and qualitative household interviews (1.3). The team decided that it was preferable to undertake a longer-term and more intensive engagement with a small number of villages rather than numerous short interactions. The project team had extensive understanding of the individual scale of participating farmers but lacked a deep understanding of village dynamics, prompting the changed emphasis and approach. The fieldwork was conducted in 2019, with a research team of two women and two men conducting 38 in-depth interviews in Khmer language (50% men and women). The fieldwork resulted in the publication "From Sapphires to Cassava: the politics of debt in Northwest Cambodia". [**NOTE: the findings of these activities are highly sensitive and are not to be shared beyond review of the project in order to protect the participants.**]

No.	Activity	Outputs/ milestones	Completed Date	What has been achieved?
	Home Visits (quantitative survey)	Conduct participant observations following focus group meetings in 12 villages, 6 times over 4 years.		408 home visits conducted in 13 participating villages proximate to the two project demonstration farms. This resulted in the baseline report (see Objective 1 outputs). The sample was established using each 'village book', which is a list of village members held by the village leader. A random selection of 30 households were identified and engaged with. This represents a problematic reliance on village leaders, but interactions with villagers require permission from the village leader and was therefore a necessary compromise. The mobility challenges, time, and costs of data collection for the proposed number of replications was unreasonable. This was a product of a lack of existing social research in Northwest Cambodia on which to base estimates, as well as inexperience by the project leadership in terms of the under-estimation of time and costs. In general, the costs of the demonstration farms was greater than expected, though highly efficient for what was delivered; this required adaptation of the originally planned data collection.
	Semi-structured interviews			304 The interviews were undertaken in 13 villages surrounding the two demonstration farms, with as many of the 408 cassava farmers who participated in the quantitative survey as possible. These data inform the 'black box' article.

No.	Activity	Outputs/ milestones	Completed Date	What has been achieved?
		Run field days with participants following each village visit in 12 villages, 6 times over 4 years.		Throughout all engagements with smallholder households, the research team promoted the demonstration farms. Locals were offered the opportunity to visit the sites, to witness the activities, and consult with the agricultural experts. There was general appreciation of our activities amongst locals, but the opportunity to visit the site and accompany the agricultural team (I.e., Montgomery, Phan, Wilson) did not appeal or was too unfamiliar for the participating farmers. A field visit day was organised by the team (March 2021) with further such visits cancelled due to Covid travel restrictions (see Objective 3 below).
		Report 1: Establish a baseline survey for farmers in the 12 villages, emphasising agricultural crops, practices, and household characteristics. (Postdoc, Milne & Lamb)		See next line.
		Report Combined into report 1: Identify Farmer PSPs with reference to agricultural technologies. Identify differences amongst sub-groups of farmers or households, with specific attention to the perceptions and experiences of female farmers, female-headed households, the poor, and the marginalised. (Postdoc, Milne & Lamb)		Baseline report
		Report 3: Update trends in farmer perceptions (by sub-groupings). Determine response and perception of demonstration of farmer-identified crop, technology, or practice. (Postdoc, Milne & Lamb)		Delayed due to Covid and subsequently integrated with Report 4.

No.	Activity	Outputs/ milestones	Completed Date	What has been achieved?
		Report 4: Update trends in farmer perceptions (by sub-groupings). Determine response and perception of demonstration of farmer-identified crop, technology, or practice. (Postdoc, Milne & Lamb)		Given the inability to replicate the survey and interviews at the scale of the project, measurement of trends in farmer perceptions could not be answered. As an alternative, the measurement of impacts on farmers' awareness and behaviours was reallocated to follow the development of the Pest and Disease Knowledge Exchange and theatre production undertaken in Q1 2023. See Pest and Disease response and perceptions following Knowledge Exchange in Objective 4. Follow-up engagements have been undertaken, data analysed, and output drafted for submission in Q3 of 2024.
		Publication 1: Paper exploring farmer perceptions of PSPs. (Milne, Lamb, & Farquharson)		A review paper was undertaken to contextualise agricultural extension, titled: 'Humanising agricultural extension: A review'.

PC = partner country, A = Australia

Overview of Objective 1

NOTE: the findings of these activities are highly sensitive and are not to be shared beyond review of the project in order to protect the participants.

Objective 1: Determine farmer PSPs with reference to agricultural technologies and best practices.

Through the combination of data from the baseline survey, household interviews, interviews with village leaders, and the community-based focus groups, FUAT was able to establish farmer Problem-Solution Pathways (PSPs) with reference to the agricultural practices of smallholder cassava farmers in Northwest Cambodia. Details from each of the data collection activities follow:

Figure 1: Presentations of annual calendar and concern/happiness

6.1.1 1.1 Focus Groups

Field Research Report (Gender sub-project)

Research Conducted: December 2019

Team: Ms. Kunthea and Manika, Sabrina, Mr. Kuthea, Sotheara, and Vanessa

No. Interviews Conducted: 38.

Key themes across interviews: Debt (Microfinance lending a big problem), Gender (differences in labour but not necessarily "inequality"), Politics, and the role of the Border.

Three key steps to Research Process.

Step 1: Introduction to village and village calendar (of activities and areas of concern)

On 12 December 2018, we visited Ta Ngaen Leu village to introduce ourselves, and the study. We also thought we could play a game with the community to make it fun. The facilitators and participants (approx. 30) gathered in a circle for a game to introduce ourselves. One of the village leaders, we later interviewed and invited us to visit his farm, told us that that, "We don't want to play a game. We are busy."

As researchers, we were surprised but accepting and proceeded to divide the group for the activity. We broke into 4 groups– 2 male and 2 female only groups –with instructions for each group to draw their yearly calendar of activities (what they plant, what other work they do, harvest). We then asked that they color code the months of the year, pink means more worry or stress, yellow is some stress, and green is happy. Each group presented back to the larger group, allowing time for questions and discussion (see Fig. 1).

Through this activity, the research team was able to understand the general annual calendar for this community and what challenges they face at different parts of the year (as well as happier times). There were differences between men and women in terms of activities listed, but the general calendar was similar, and all 4 groups identified that they experience a lot of hardship and are worried the most in the later part of the year. The findings also showed that months after harvest they are food insecure. The two women's groups did include more indicators for concern overall relative to the male groups. The female groups warmed up to us, but their concerns and their strong links with history underlined that they "don't play games".

Step 2: of the research process was then following up with these farmers individually. We did so over the next 2 weeks, in teams, conducting 38 in-depth interviews, mostly with cassava farmers, but also with some pesticide sellers, microfinance staff, silo managers, and some ex-cassava farmers.

These interviews have been analysed using analytical and descriptive coding. In Appendix 2, in an example interview to show the questions asked, and some interesting findings regarding men's changing roles in the village.

[Please note, this report is not for publication; the research leaders have decided that no identifying information be circulated beyond the project.]

Key findings:

Gender

We discussed gender as a group quite a bit. There was not a clear consensus. Out of the team, half thought that there was no actual difference for men and women in the village. Both men and women had served in the Khmer Rouge regime. Women could have their names on land titles. Women fought alongside men, and today, they farm alongside men. I (i.e., Lamb) argued that while cassava farming is not necessarily "unequal" in terms of gender, that it was still clear that divisions of labour between men and women existed throughout the visit. Women's labour was less valued, and women did more work at home (which was not referred to as "work" or in the participant-produced calendars), and women reported that had overall less free time and more "concerns".

For example, at the farm visit with the deputy village chief, we saw these clear divisions of labor:

-at harvest, men pull the plants and carry the heavy baskets to load into the truck (they are paid more for this task than women, who are paid for their work below. While women can do this work, they are portrayed as just not "strong" enough);

-women separate the large bunches into smaller/singles and put in the baskets (they are paid less for this task);

-The farmers who were free to take us for the afternoon, were men but not their spouses (who were too busy);

-Men do the spraying, not women (unless they are very poor or cannot afford to hire someone else) in such cases women would sometimes help but, in practice, this seemed unheard of;

-This generation of women have it harder than Moms/Daughter's generations (across all interviews). Men were less likely to take this position, (see Appendix 2);

There are differences across the participants with regards to perceptions of gender. Maybe that's the point, rather than "equal" or not? Their work, their daily activity, and thus their connections, are distinct.

For the other themes, there are a few key take-aways:

Debt: nearly every family was in debt to Microfinance banks, some of which are NGOs while some are actual banks, neither are really regulated, Cambodia has only recently issued some regulation, which are not helpful in practice. Some are 2-3 loans deep in debt, and many have lost land because they cannot pay back even small sums ($500US). Positive side: banks (by their own staff reports and by farmers accounts) will not lend to a man without his wife's approval (and vice-versa).

Politics, and the role of the *Border*: this is much more complex, but recent political shifts in Cambodia (to strengthen HS, pre and post July elections (2019)) are not perceived as having benefited the village. Participants feel powerless to do anything for threat of physical and political violence. This was a very sensitive topic and the research team is working to find ways to process this finding, as part of the bigger picture of village life and concerns.

Figure 2: Group Analysis of Key Themes

Analysis

Step 3: As an initial process of analysis and reflection, on the last day of the research trip the team joined for a full day discussion in Battambang City. This was essential to developing the 4 key themes (above) and also to identify steps for action and outputs.

At the start of the morning, we began with key quotes from interviews that held meaning for the team members. Running best quotes:

"'real solidarity' was during the Khmer Rouge".

> *"Silo is like the darkness" [emphasizing how they feel about the current price situation, which is to say 'helpless'].*
> *"This house is built by corn and cassava" [meaning that cassava has been good for some families].*

We also reflected on the research process and were unsure if returning for further interviews would be productive. Some of the interviews took a rather surprising political turn, and it is clear that the community still very much identifies as a last Khmer Rouge stronghold. This means, that in some ways, they are positioned to benefit from these connections in contemporary Cambodia. But it also means that they see themselves as quite separate from other farmers' movements, in Cambodia or in neighboring Thailand. Overall, participants seem to be more well-off than most communities the research team has worked with in Cambodia (i.e., Kratie, along Mekong). However, the participants and village more generally remain very dissatisfied with the current agricultural support from the government, and many are going into debt and losing land and livelihood as a result of the combination of prevailing agricultural practices and debt-fuelled models of industrial agriculture.

Interview Excerpt – Example

Participant 1

Dec 18, 2018

Summary: He's older than 40 years; he built his house here in 2000. He cut the tree to build it himself. It's a nice, wooden home near the road. He arrived to the area earlier in 1996. He's a farmer with 4 ha of cassava (13 km or so away) in a nearby village and around 1 ha of longan near his home, but he also makes wooden tables, a skill he taught himself in Pailin. He sells them for around $100/table. He's surrounded by his family – the two houses across the street are his daughters, he sold them the land.

When we started the interview, Ms K asked if he heard or learned about "gender". He was a bit quiet, then he said, "I just heard of it but didn't really know it much."

Q: What's your regular day like? I wake up at 5-5.30 every morning, and go to get a coffee. Then back by 6-6.30 and off to cassava. I'll be doing weeding or other tending to farm, but mostly weeding. I return from the farm in the evening, we also have longan farm here behind the house to take care of.

Q: Any free time? Sometimes, I go for a coffee at the noodle shop at 11 or 12.

Q: What do you spend most of your time on? Weeding. I can spend the whole day on the farm, doing weeding, tending to crops. It's done mostly by hand but sometimes I spray, sometimes use a machine [grass cutting]. I do this work by myself, I don't hire others.

Q: What if you compare with your wife's day? How different? Well, nowadays my wife cannot help on the farm. She has a problem with her leg. But otherwise, she helped on the farm, just less than I do.

Q: Does she do any other work? She mostly takes care of the housework and the home garden. She washes clothing, but the clothes that are soaked with chemicals after spraying, I wash those myself.

Q: Why? Do you have concerns about pesticide use? I'm concerned but I use because I have to, not by choice. I can protect myself about 60-70% - using the gloves, long sleeves, long pants, and boots, as well as a mask. The seller gave me the long gloves to use.

Q: How many years using pesticides already? It's been a long time [pauses] since the Khmer Rouge soldiers integrated with the government. Back in 1996, I started using pesticides, when I started doing farming.

Before I was a Khmer Rouge soldier based along the border, after I moved here and cleared land like the others, about 5 ha. They stopped providing us with rice, clothes, everything. We only had our bare hands, but we also had small children (now 6 kids, 2 sons, 3 daughters) so we had to work hard to survive.

Q: If we compare, who has a more difficult life, you or your son? My generation had it more difficult. No proper place (home?), no food. My son, he still works on the farm, but he has food and proper place to live.

Q: What if we compare you and your father? My father had a good life. He lived and worked in the Sihanoukville Region Forest. Even though I had 7 siblings (his father had 7 children), life was good; there was no war, we didn't need to flee, and we did not have to pay tax (or had to only pay a little tax).

If you look at my generation, though, it has been a hard life since it began.

Q: During father's time – did he do farming? He did farming but not chamkar just rice farming. He was from Kampong Thom.

Q: When did you learn how to do chamkar then? I learned from Thai people when I lived along the border. During that time of Pol Plot I just "see" it done by the Thais, I didn't do it. I started farming when I get here.

Q: What did you plant? How did you decide? At first it was longbean and soybeans. The Thai company came and said they will buy the product if we plant it. My wife and I discussed, how many hectares can we grow? What should we plant? We talk together.

Q: Finances – who makes the decisions? It seems like we come together to make decisions. For instance, all the money she keeps it, but for spending, we discuss what to buy, how much to spend.

Q: Have you ever heard of a situation where a husband would plant cassava, but the wife doesn't want to? Yes. There are some families. Sometimes, they argue with each other – the husband wants to plant cassava but the wife wants to plant corn. Maybe they just let the wife do what she wants. But after that, if the crop fails, she is blamed – "you didn't listen to me" Other times, the husband has to take action, to do what he wants. They argue each other but at the end – the husband has to take action.

Q: Loans – we've heard many people have. Do you? No, we don't have.

Q: Decisions – What if one wants to take the loan, and the other does not? When decide to get a loan, you have to do it together, the bank does not allow one side to take the loan, they have to agree.

Q: What about other kinds of loans that aren't from the bank, like private ones or from the middle man? Yes, there are some families who take a private loan – when only the wife or husband are taking it. But not many.

Q: Back to farming cassava. Yesterday we visited the farm – we saw men and women work together, but do different roles. Women collect, men lift plants and the baskets. What of the other tasks – like planting, weeding? Not really dividing the role – it depends if the woman can do it. If the women has a big, strong body, she can carry the big basket of cassava, like the men do. She can do. The heavy job, she or he can get much more income. For example, the one who just plants the stems is cheaper (less income) than the one who carries the basket and plants the stem. The basket is heavy, makes more income. If you just plant, make 20,000 riel/day while the basket carry and plant is 25,000 riel/day.

Q: What of other tasks – like weeding? For weeding, we do the same. Even sometimes if women is strong, she can spray. It's heavy, though, so that's rare.

Q: Is there anything that the women can do in farming, that the men can't do?

No [Awt Mean]. Mostly is focused on strength. We rarely see the woman carrying a big bag of corn, for instance, but sometimes she can do.

Q: As a man in this village, any other challenges (pen ha) that we should know about? A challenge we face is about income generation for the family, we earn a little, spend a lot. I can say it's the same for many men here in this village. We spend most on food and other household consumption, and also my children's education.

Q: Ever go to anyone – government or in the village – to ask for help? I used to discuss with the village chief, how to make my crop products or another person's crops get a good price. But the discussion is only, no action.

Q: Last question: Thank you and any questions for us. No questions, but I want you to find someone or a company to help buy my or others' product; to get a good price.

[We explain I'm a researcher can't sell products but can make recommendations]

6.1.2 1.2 Home Visits (Quantitative Surveys)

Report 1: Establish a baseline survey for farmers in the 13 villages, emphasising agricultural crops, practices, and household characteristics

Report by Dr. Brian Cook, Dr. Nicholas Read

The full report can be found (here). Below include the gender analysis, the PSP analysis, and conclusions.

Gender

A key analytical objective of the research is to explore whether, and ideally how, farmer perceptions and experiences are gendered. This objective is explored in multiple ways, both with regards to the specific – and potentially different – responses from female-headed households, as well as through responses that allocate responsibilities according to gender. We are therefore interested in the characteristics of female head-of-households (HoH) and whether their conditions differ significantly from those of male HoH. In general, we see that female head-of-households (HoH) make up a disproportionate amount of the single and widowed HoHs. Additionally with regards to family composition, household size exhibits more complicated findings. Female HoH farms were proportionally more common amongst smaller household sizes, such as 2 or 3 members, as well as amongst large household sizes, such as 8 and 9. Note that there are relatively few farms with 8-9 members, only 20 farms recorded more than 8 members.

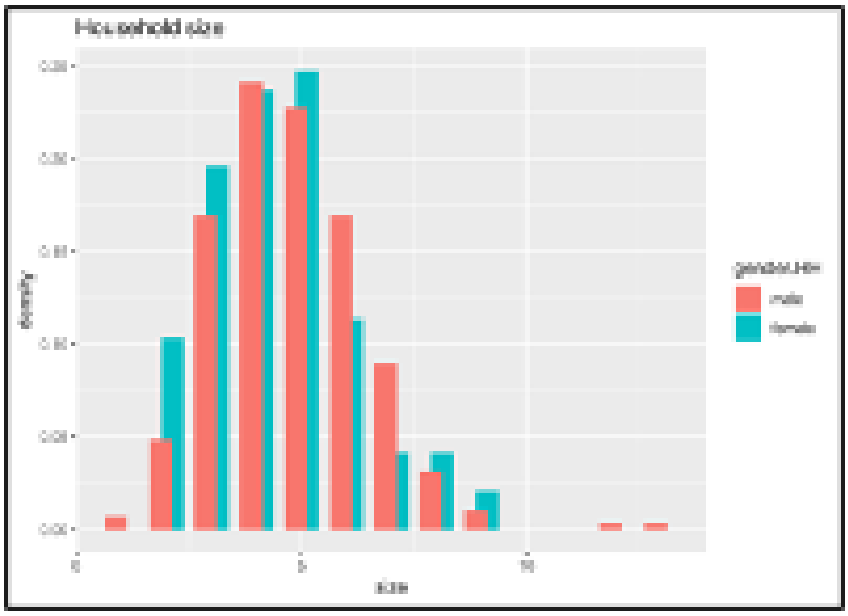


Figure 3: Household size by gender of HoH (note two tails – unknown causes)

Incomes are often presumed to be substantially different between female and male headed households, which is confirmed by the data – but with the caution (from above) in terms of the challenges associated with income data.

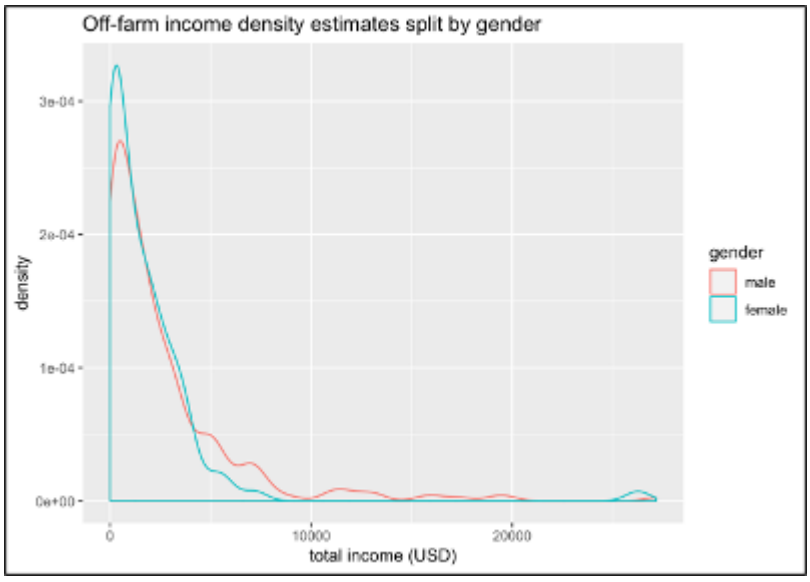
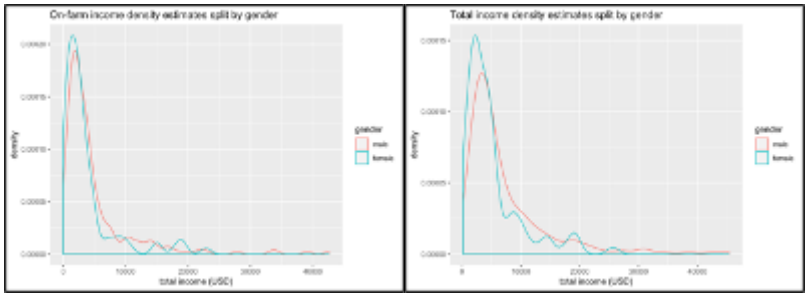


Figure 4: Income by gender, including on/off farm experiences – all suggest female HoH receive less income



Similar to income, the area of land managed by female HoH farms tends to be lower than that of male HoH farms.

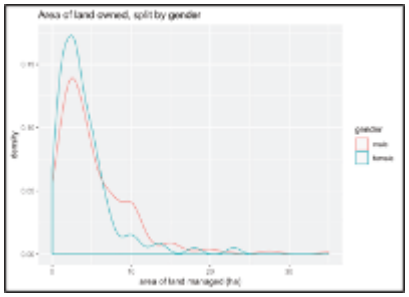
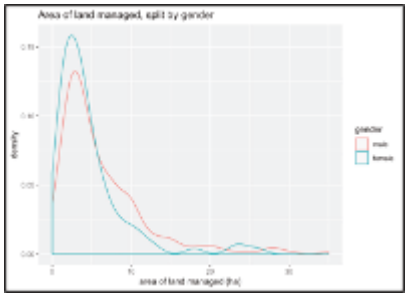


Figure 5: Land and are by gender



Future outlook (Problem-Solution Pathways)

There was a brief section towards the end of the survey that asked respondents about their thoughts on the future. It asked:

- What one change would most improve your life (or your family's life)?
- How might this change happen?
- Who has the power to make this change?

Respondents generally answered these questions, with only 8 missing answers for the first question, 28 for the second question and 11 for the third question. The responses to all three questions were worded, and we went through classifying responses into broader categories. For all questions the majority of respondents gave a single answer, but some gave two or three. In this analysis we have grouped all these responses together, no weighting was given to respondents that gave multiple answers. In this sense, respondents who gave multiple answers have a larger influence on the results.

What one change would most improve your life?

The first question asked about which single change would most improve the respondents life. Some 10.2% of respondents gave more than one response. The most common response to give was about growing or continuing to grow tree crops, indeed 58.1% of respondents included this answer. It was also common to include responses about high prices (9.2%), growing vegetables (8.2%), opening or maintaining a home business (5.4%) and raising livestock (5.1%). Cumulatively 9% of respondents gave answers about business, or off-farm work while 2% wanted machinery (tractor, truck, or motorbike).

If we break farm households into income brackets, we see that the desire to grow tree crops increases with income (this is also true for total off-farm income). We get similar results if we look at the area of land managed. This is not too surprising, tree crops are a big investment and require time before they produce income. Families need to be able to

farm some of the land, or have strong sources of income to support them while they wait for the fruit trees to mature. These differences are supported by a simple test: a Wilcoxon-Mann-Whitney U-test indicates that there is a statistically significant difference in the mean income and mean area of land managed for those who answer “tree crops” compared with those that did not.

How might this change happen?

The second question asked about “how might this change happen?” Some 10.2% of respondents gave more than one response to this question. Most respondents took personal responsibility, 60.1% included “hard work” as a response. Another popular response was “save money”, with 16.6% including it as a response.

Who has the power to make this change?

The third question asked who has the power to make the proposed change. A large number of respondents, 30.4%, gave multiple answers to this question, but most of them were variations on “family”. We created the categories to be as fine as possible, but 80.8% of respondents included one or more of “myself”, “head of household”, “family”, “children”, “grandchildren”, “husband/wife” or “parents”. Only 14.1% of respondents gave answers that included external bodies. There was no significant difference in income or land managed between those who gave a family type response to the third question and those that gave an external body type response.

Conclusion

The data and analysis included in this report is a random sampling of 409 quantitative surveys undertaken in 13 villages in Northwest Cambodia between mid-2017 to late-2017. While the data is, in places, problematic, this is a reflection of the challenges associated with data collection in a very challenging location and of the sensitive nature of the some of the themes.

Key findings

- Farmers indicate that, if given the opportunity, they would transition from cassava production to fruit tree production;
- There is extreme variability in the reported price paid to farmers for cassava – with multiple possible explanations, including: massive variability of prices; and lack of knowledge of prices received; confusion in questioning and response;
- Pest and Disease (P&D) management was the issue that most farmers requested support for;
- There is a relationship between the amount and security of land title and the willingness to plant tree crops;
- The data appears to show two trends amongst farmers transitioning to fruit tree production: 1) those still waiting for their trees to mature, and 2) those receiving income from their fruit trees;
- Income is significantly gendered amongst cassava farming households, both in terms of on-farm and off-farm sources;
- Land assets are significantly gendered amongst cassava farming households;
- Farmers take personal responsibility for their lives and livelihoods, with proposed solutions almost entirely at the individual scale.

Returning to the research questions that guide objective 1 and the baseline survey, the findings of the household survey provide clear answers. With regard to **RQ 1**: "What problems do farmers perceive, what do farmers think *should* be done, what do farmers think *can* be done by whom (i.e., farmer PSPs)?" the issue of pest and disease (P&D) was the most requested. The farmers communicated to the research team that they were unsure about the types of P&D common to their farms and what, if anything, might be done in response. We expected debt and indebtedness to be a possible problem, and were surprised that the majority of farmers indicated that their levels of debt were manageable – something the project will explore in greater detail using qualitative methods.

With regards to **RQ 2**: "Which agricultural technologies do farmers identify as part of their PSPs and why?" the single change that farmers believe would most help them is the transition to fruit tree production, which was, by far, the most identified choice. While this finding is not surprising the scale of this shared objective is striking. The vast majority of elite and wealthy farmers are undertaking this transition and many agricultural experts in the area recommend the transition as superior to cassava. Furthermore, there is a rationality to this desired transition, as fruit trees are more sustainable and, like cassava, require relatively less labour once established when compared to traditional maize-bean rotations.

The findings also suggest that perceived and preferred solutions to the problems experienced by farmers are 'ideally' addressed at the individual scale via household actions, with only 15 mentioning government – the same proportion of respondents who believe 'nothing' can be done to affect change. Specifically, the problems most identified by farmers concern pest and disease, especially the uncertainty with regards to identification and response.

6.1.3 1.3 Semi-structured Interviews

Qualitative Interview Data: the assemblage of agricultural practices

Approximately one year after completion of the quantitative surveys, Cambodian members of the research team returned to participating villages to reconnect with farmers and their households using a qualitative household interview. The themes of the survey were replicated but revised in order to include findings from the farmers' 'future outlooks' determined in the surveys. If the surveys is understood to describe 'what' households were and were doing, then the qualitative interviews explore 'why' and 'how' these households were navigating the challenges of agrarian change, with attention towards agricultural extension. The 'future outlook' conclusion of the survey spawned additional themes for the interviews: transitioning to fruit tree production, pest and disease management, isolation, and mobility. The interviews lasted between 30 and 90 minutes, with the discussions translated and transcribed by Cambodian members of the research team.

Why did you begin planting cassava?

The overwhelming majority of cassava farmers describe the process of transitioning to cassava production as the outcome of multiple relations, many occurring simultaneously. In general, the farmers first become aware of a possible technology through their social networks. For the sampled farmers, this was overwhelmingly their neighbours. In many instances, this neighbourly relation also had ties with Thailand or Vietnam, or with the traders who visit rural Cambodia to purchase directly from farmers. When asked "What made you start planting cassava?", most farmers described a successful neighbour who had already implemented the transition.

> *"I: At first, I planted rice. Then after rice, I planted sesame. Then I planted mung bean as everyone was planting mung bean. Then I*

planted corn because everyone was planting corn. I started planting cassava because all of my neighbours were planting it.
F: So, will you stop planting cassava when your fruit trees grow big?
I: Yes.
F: What made you change from cassava to fruit tree?
I: I'm following the other farmers. I'm planting mangos" (OR02 02.12.19).

"I: Farmers followed each other. So, when one planted, another one started to follow" (OS02 28.05.19).

"I: I used to plant sesame but when I saw other farmers doing cassava, I followed them.
F: Why did you follow them?
I: I saw they received very good yield in the first year, so I wanted to try also. Our soil nutrition is depleting so I cannot plant every year on the same soil" (OS03 28.05.19)

"I: Here we just followed each other. When we saw one planted, others started to follow no matter if it was corn or cassava" (AP02 26.06.19).

What is made evident by the farmers' accounts is that, running parallel to awareness of a possible transition, farmers who transition tend to also have a trusted individual who has already successfully implemented the change. This relation is often a neighbour or member of their extended family and, in many instances, provides the farmer with planting materials for free or at a discount.

"I: My father planted cassava and got a good yield. So, I planted cassava also" (KT02 30.07.19).

"I: I saw other farmers planted cassava. I wanted to change from corn, so I asked for planting materials from them and started planting cassava as well" (AP10 26.06.19).

"I: I followed my mother. Besides, cassava is lower maintenance and cost less than corn. Also, it's easier to find labour for cassava than corn" (AP24 11.07.19).

In addition to neighbourly observations and familial relations, a small number of participants also mentioned specific attention directed towards elite villagers. Elites are distinguishable because of the relatively large amount of land owned or for their relative wealth. The village leader was a key elite observed by farmers, with many indicating that a transition to cassava was a result of the village leader first implementing the change and being successful. With regard to elites, this 'copycat' approach that was evident with regard to neighbours is again evident.

"F: What reason will make you stop planting cassava?
I: It's because the price drops cheap.
F: What will you plant instead of cassava?
I: I will see what the rich farmers do. I will plant whatever they plant" (OK20 07.12.19).

By recounting how they came to farm cassava, many of the farmers describe a process of near-continuous trials and attempted transitions – amongst a large majority, trials of

different crops are continuous. In many cases, they describe a sequence of transitions, which includes sesame, peanut, maize/corn, soybean, rice, and mungbean. These findings help to explain the boom/bust cycles that have affected the region (Diepart & Dupuis, 2014; Diepart & Sem, 2018; Mahanty & Milne, 2016), as well as a pattern whereby the majority of farmers rapidly convert to a new technology. As noted in the 'future outlook' of the survey, the transition to fruit tree production was at the time of engagement, by a wide margin, the most prominent transition being discussed, planned, and implemented.

Overall, the farmers are shown to be extremely adaptive, trialling many transitions while observing the attempts of neighbours and hearing from family members who are attempting transitions elsewhere. Rather than 'laggards' (Rogers, 2010), these farmers are: willing and able experimenters, connected through social networks (Dolinska & d'Aquino, 2016; Teodoro et al., 2022; Wood et al., 2014; Zhang et al., 2020), aware of available alternatives through relations that stretch across village, province, and regions, and connected with global chains that reach into Thailand via traders. Contrary to assumptions within the SDGs, the farmers do not appear to require awareness raising or prompting: they are already aware and continuously undertaking experimental agrarian transitions (Thompson & Scoones, 1994). Agricultural extension as experienced, in this assemblage of nested relations shaping practices, is not associated with a single technology, but is a continuous process of socially informed practices (Cofré-Bravo et al., 2019; Dolinska & d'Aquino, 2016; Teodoro et al., 2022). This relational understanding of agricultural extension as experienced was made even more evident when the farmers were asked how they informed themselves.

Where do farmers get their information or ideas about farming practices?

The interviews demonstrate that agricultural extension is not a top-down activity involving experts, the State, or donors. Instead, agricultural extension is an assemblage of local, social practices that are almost entirely informal and, for the most part, are not-for-profit. In order to understand agricultural extension as experienced, farmers were asked "Did you ask for help/advice from anyone regarding the problems facing growing cassava?" This question was designed to identify who was trusted and which relations the farmers drew upon when in need. It is important to appreciate that when smallholder cassava farmers are responding to challenges, they are acting on potentially life and death decisions that can result in destitution and, increasingly in Cambodia, bondage to debt collectors (Green & Estes, 2019; Natarajan et al., 2021). The overwhelming majority of the participants indicated that they consulted with their neighbours and extended family, though a large proportion of these consultations were deemed futile because those individuals were experiencing similar problems without evident solutions.

> *"F: Did you ask for help/advice from anyone regarding to the problems facing growing cassava?*
> *I: I asked my neighbours as they used to face the same problem as me.*
> *F: Did you ask anyone else besides your neighbour?*
> *I: I asked the pesticide seller. They are just small-scale sellers. They don't really have good knowledge on it.*
> *F: Was there anyone from agriculture district office coming to raise awareness on cassava?*
> *I: Yes, there was. But I couldn't follow their precise practice. They taught us how to prepare the land, plant, and use pesticide. I don't have money to follow all the steps" (AP04 25.06.19).*

> *"I: I didn't ask anyone because everyone had the same problem" (AP15 26.06.19).*

> *"I: I saw other farmers sprayed pesticide but not effective. So, I didn't do anything. Then the farmer whose farm got infected with red mite tried cutting the leaves and then the red mites were gone.*
> *F: Were there anyone from PDA [Pailin Department of Agriculture] coming to raise awareness on cassava?*
> *I: No there weren't" (SPK10 23.11.19).*

A near universal finding is that farmers engaged with one another, and that trustworthy external support was non-existent (see perceptions of the pesticide vendors below). Farmers' consultations within their social networks, then, confirmed that those challenges were endemic and without implementable solutions. This type of collective consultation stretched throughout farmers' social networks (Cofré-Bravo et al., 2019; Dolinska & d'Aquino, 2016; Teodoro et al., 2022), suggesting that if there were a solution that was successfully deployed by a trusted individual, it would 'diffuse' rapidly and be adopted. That such solutions were not circulating confirmed to the farmers that no such solution existed and that investments in responses were unlikely to succeed. Such assessments were common to the interviews, with many farmers decrying the futility of the situation. Confirming the isolation and self-reliant framing that was evident in the 'future outlook' portion of the survey, during interviews, farmers were clear when they described situations in which no help was available. This was especially evident with regard to seeking advice.

> *"F: Did you ask for help/advice from anyone regarding to the problems facing growing cassava?*
> *I: I only asked my farmer neighbours. They didn't know what to do either.*
> *F: Did you only ask your neighbour?*
> *I: Some people were driving past to Battambang and told me that my farm still had some cassava left, but for them, nothing left from their 1-2ha farms. All the stakes were dead.*
> *F: Did you ask anyone else?*
> *I: No.*
> *F: Not even the pesticide seller?*
> *I: They just told us to use the herbicide or liquid fertilizer, but it wouldn't work.*
> *F: Did you do any research or watch the news on TV about it?*
> *I: I like watching the news, but my children don't. They like watching entertainment show so they always change the channel.*
> *F: So, you never receive help from anyone with these problems?*
> *I: No, never" (OS23 04.06.19).*

> *"I: I've never asked anyone except for my neighbour farmers but it's not really effective.*
> *F: Are there anyone else or the specialist from agriculture department come to raise awareness on that?*
> *I: No there aren't any" (DT23 20.05.19).*

Across the interviews there is a contradiction between feelings of isolation and the universal presence of the pesticide vendor. As mentioned in the preceding excerpts, the pesticide vendor is a constant non-family social relation and, in most cases, the only 'formal extensionist' with whom the farmers have direct contact, acting as a type of 'innovation broker' (Klerkx & Leeuwis, 2009) but not one who is trusted or embedded in farmers' decision-making. This finding is relatively unsurprising, as the commercial sector has been promoted as part of wider efforts to transition agricultural extension to a 'for profit' business model (Castilla et al., 2020; Chen et al., 2018; Nettle et al., 2018; Prager

et al., 2016; Sutherland et al., 2013). What is surprising is the monopoly that vendors appear to have with regard to technical advice. In the vast majority of instances, the pesticide vendor was the only social relation that farmers had with anyone from the agricultural sector – outside of traders.

> *"F: Did you ask for help/advice from anyone regarding to the problems facing growing cassava?*
> *I: I just asked the pesticide seller if they know what to do or spray.*
> *F: Why didn't you ask the agriculture officers?*
> *I: I don't have connection with them. I don't know.*
> *F: Did they ever come to teach here?*
> *I: They probably came but I never got to attend" (AP05 25.06.19).*
>
> *"I: I never asked anyone. I don't know who to ask. I just bought pesticide to spray" (AP22 11.07.19).*

Unsurprisingly, the farmers struggled with the vestedness of the pesticide vendor's dual roles as both advisor and profiteer. Given this situation, as well as the quantitative survey indicating that the majority of the farmers have only primary school-level education and literacy, farmers relied heavily on their neighbours' experiences to judge the effectiveness of chemical inputs and practices. In this way, the farmers exhibited a simultaneously extensive network of social relations that they drew upon to form collective assessments (Dolinska & d'Aquino, 2016; Kaynakçı & Boz, 2019; Teodoro et al., 2022; Zhang et al., 2020), which was also a very limited network in terms of the diversity of individuals with whom they are directly connected.

> *"F: Did you ask for help/advice from anyone regarding to the problems facing growing cassava?*
> *I: I just asked the pesticide sellers for their recommendation.*
> *F: Why did you go to the pesticide seller?*
> *I: I asked my neighbour, and they recommended me to go to the pesticide seller.*
> *F: Do you think the pesticide seller can help you?*
> *I: Yes sometimes" (AP21 11.07.19).*
>
> *"I: I used to ask my neighbour and they recommended me to spray pesticide.*
> *F: Why did you ask your neighbour?*
> *I: They had more knowledge and experience than me" (AP18 11.07.19).*

Throughout discussions concerning chemical inputs and vendors, the nature of the relationship was viewed by farmers as problematic. Empathising with the farmer, it is clear that they face an extremely challenging situation: they are desperate for solutions, they have limited literacy to understand the labels and chemicals available to them, they are isolated and therefore reliant on a small number of vendors who are often affiliated with specific traders or silos with whom the farmers must maintain productive relations, farmers have anecdotal reports of chemicals being counterfeit or ineffective, there are warnings about the health harms associated with the application of the chemicals, and they tend to purchase the inputs on credit with high interest rates. Given these overlapping concerns and uncertainties, it is unsurprising that most participants report 'do nothing' as their response to pest and disease outbreaks and to other challenges. Critically, these complex calculations are, for the most part, poorly understood within the extension discourse (Bylander, 2015; Leeuwis, 2013; Leeuwis & Aarts, 2011; Leeuwis et al., 1990; Remoundou et al., 2014; Wilson et al., 2009), and entirely absent from black boxed extension within the SDG discourse.

While much of the SDG and related discourses have embraced commercialisation and profit as a central delivery mechanism of agricultural extension (Eisenmenger et al., 2020; McMichael, 2013), the farmers' experiences show how such relations are vulnerable to doubt. Repeatedly, when asked if they received any support from anyone outside of their neighbours and families, farmers dismissed the advice of vendors as simply promoting their products.

> *"F: Did you ask the pesticide seller?*
> *I: Yes, but the pesticide is only temporarily working. It won't get rid of the mealy bugs.*
> *F: Are there anyone else or the specialist from agriculture department come to raise awareness on that?*
> *I: No. Only the fertilizer company came to promote their products" (DT7 08.05.19).*

> *"I: There used to be companies came to promote their pesticide, but it was not effective. I tried to call them but couldn't be reached. They were cheaters!*
> *F: Were there government officers with them?*
> *I: No. But I saw a fertilizer company came to promote every year and gave us a sample to try. That was good" (AP03 25.06.19).*

With more direct follow-up questions, there was an approximately even split amongst the participants in terms of trust in the pesticide vendors.

> *"I: I've only asked my neighbours what to spray. Sometimes it worked, sometimes it didn't.*
> *F: Did you ever ask the pesticide seller?*
> *I: Yes, I did. Sometimes it worked on the first time. And when I used for the second time, it didn't work.*
> *F: Did you trust the pesticide seller?*
> *I: Yes sometimes. Because I didn't know anything, so I think the pesticide sellers knows more than me. And the pesticide also helped a little bit about 20 out of 50. When the rain came, the cassava became good again" (DT27 21.05.19).*

> *"I: I only asked the pesticide seller because there's no one to ask. They then would give me pesticide to spray but it's not really working.*
> *F: Did you trust the pesticide seller?*
> *I: Not really. Some didn't have good knowledge about it" (OS25 05.06.19).*

> *"I: I asked the pesticide seller but it's not effective.*
> *F: Why didn't you ask the specialist from agriculture department?*
> *I: I don't know where and who to ask.*
> *F: So, do you trust the pesticide seller?*
> *I: Sometimes. The pesticide they gave me for other crops worked but the one on cassava didn't" (SP12 12.06.19).*

> *"I: No, I didn't. I didn't know who to ask. I just went to buy pesticide from the pesticide seller.*
> *F: Why did you think the pesticide seller can help you?*
> *I: Because I didn't know where I can get help besides going to buy pesticide from the pesticide seller.*
> *F: Did you trust the pesticide seller?*

I: At first I did. That's why I went to buy pesticide but since the pesticide didn't work, I lost trust in them.
F: Now you didn't buy pesticide anymore?
I: No, I didn't. I only sprayed booster now" (TN23 19.07.19).

Seen as a collective, these excerpts are representative of the interviews, demonstrating an intensely difficult livelihood in which isolated individuals rely on social relations to inform themselves while commercial interests offer 'solutions' that may or may not work, but which will certainly add to their debts (Green, 2020a). Readers, at this point, might wonder 'why smallholder farmers continue to farm cassava?' in light of the uncertainties and challenges. Unfortunately, relative to available alternatives, it remains the least awful livelihood (Natarajan et al., 2021), leading to creative adaptations that farmers undertake to lower their risk while maintaining the slight chance that they will produce a large crop before oversupply saturates the market.

What considerations shape/influence/determine farmers' behaviours?

Having established the origins of the transition to cassava production and the relations that farmers draw upon for support, the research focus turned to the adaptations that farmers implement in response to the often brutal social, environmental, and economic relations that they face. A key finding from these discussions is the term 'Ngeay Sruol', which translates to 'easy' but which our local team interpreted as 'convenient' to describe the multiplicity of intentions underlying farmers' accounts. Convenient was mentioned by more than 20% of participants as part of their multi-layered reasoning for continued cassava production. Importantly, the topics and the underlying rationalities communicated within discussions of 'convenience' were nearly universal, suggesting that the logics were shared across the majority of participants, many of whom did not use the specific word but who described the same considerations. The term is used in this section as a way of consolidating the perceptions and rationalisations that farmers' describe in the context of agrarian change and agricultural extension for cassava farmers in Northwest Cambodia.

Convenience often referred to the workload needed to produce different crops. As mentioned above, farmers and their social relations have attempted numerous crops, meaning that their production of cassava is informed by relative comparisons with other available crops and practices, including the experiences of their trusted relations. Many farmers explain that cassava is convenient because the workload is concentrated at specific times, and that those specific times tend to fall outside of the rainy season when roads can be impassable and labour in short supply. This temporal focus enables short and medium term migration for wage labour to supplement household needs (Bylander, 2014, 2015).

"F: What made you start planting cassava?
I: Because cassava is more convenient than corn. Corn is difficult to transport when harvested in rainy season.
F: How about cassava?
I: It's harvested in dry season (November-December). So, no problem for the transportation" (AP11 26.06.19).

"F: Will you plant cassava next year/season?
I: Yes, because cassava is more convenient than corn. Moreover, my husband is never home so it's easier for me to plant cassava" (AP12 26.06.19).

> *"I: I followed my neighbours. Moreover, cassava is low maintenance. So, I changed from peanut to cassava" (AP28 12.07.19).*

Associated with workload is the need to hire labourers to help families plant and harvest cassava. Farmers reported that labourers were most often paid per day, but that pay-per-tonnage was an emergent form of compensation chosen to limit inefficient harvesting. Farmers also mentioned that labour costs had increased substantially in recent years, with many able-bodied community members choosing to migrate to Thailand or urban centres for wage labour (Bylander, 2014, 2015). The shortage of available labour represented a very serious worry for farmers, who might be unable to harvest their crops, leaving them destitute. Convenience, then, included consideration of the overall workload needed to produce a crop as well as the availability of labourers at planting and harvest. The ability to rely on labourers being available, then, is a convenience that shapes the decision to farm cassava; in many cases, this form of convenience was a central consideration in the context of agrarian change: farmers would not consider alternative crops or practices because of fear that they would be unable to secure the labour needed to plant, maintain, or harvest.

> *"I: It's hard work being a farmer. It's hard to find labour to help with the planting and harvesting" (AP08 25.06.19).*

> *"I: I was told that planting cassava is easier and low maintenance.*
> *F: Who told you?*
> *I: My neighbour. They said I wouldn't need much labour. I could do it myself" (AP16 26.06.19).*

> *"I: Yes, I will continue to plant cassava since it's a convenient crop and doesn't require many labourers" (OS11 29.05.19).*

As a result of labour concerns, farmers had recently begun selling their cassava crops as 'standing', which means that the transporters bring labourers with them and include harvest and transport as part of a packaged sale. This increasingly common practice fits within discussions of 'convenience' as it addresses a significant risk as perceived by farmers.

> *"I: Corn and mung bean are difficult to find labour. Cassava is more convenient and provides better yield than those crops. It's easier to harvest and I can sell stand crop" (KT07 30.07.19).*

> *"I sold stand crop. I received 1.6 or 1.7 baht per kg, and they took care of the rest.*
> *F: So, for your last harvest, did you sell standing crop?*
> *I: Yes, I did.*
> *F: Why did you sell standing crop?*
> *I: Because it's hard to find transportation and labour" (AP14 26.06.19).*

Importantly, farmers were well-aware of the costs associated with their desire for convenience. Selling their crops 'standing' lowered their potential profits, though the lowered risk of labour shortages and transportation challenges appeared to be tempting and worthwhile. This cost-benefit calculation was evident throughout the discussions, for example with farmers acknowledging the unsustainability of cassava production due to soil erosion but still concluding that it was an optimal crop in terms of balancing risk-reward.

> *"I: It's not hard work planting cassava. I think it's the most convenient crop. The only problem is with the low price and the degradation of the soil" (OS13 29.05.19).*

As in the preceding excerpt, unsurprisingly, the price of cassava was a prominent point of discussion during the interviews. Woven into discussions of cassava as a 'convenient crop' are many economic considerations, especially the ability to find a market for their products. Equally prominent was the complaint that cassava prices were highly variable and that the prices plummet at harvest. Newby et al (2018) has explored the volatility of cassava, demonstrating that it is, arguably, the most variable crop in the region. Farmers' rationalisations and discussions of their decision making, then, demonstrated a great deal of worry over price, market, and the unpredictability of returns on their investments. Like the commodity, the farmers were highly variable in terms of their characterisations of cassava. Even within the same conversation, farmers would note that cassava was both 'easy to sell' as well as being prone to price collapses that would bankrupt them, leaving them in precarious debt relations and in danger of losing their land.

> *"I: it's a convenient crop and it's easy to sell too" (KT13 31.07.19).*

> *"I: As long as there is market for cassava, I will still plant cassava since it's a convenient crop and I could earn more than with corn" (KT18 01.08.19).*

> *"F: Will you plant cassava next year/season?*
> *I: Yes, I will. Cassava is more convenience and lower maintenance than corn.*
> *F: Will you plant cassava in the next five years?*
> *I: I'm not sure yet. I might plant other crops instead.*
> *F: Are you planting fruit trees now?*
> *I: I want to plant mango, but I haven't done it yet.*
> *F: Will you plant mango in the future?*
> *I: Yes, I will. However, I'm worried about the market demand in the future" (OR14 03.12.19).*

> *"I: I don't think I will stop planting cassava no matter what the price is. Cassava is a convenience and low maintenance crop" (KT24 02.08.19).*

> *"I: At first, I planted sesame and soybean, but it was not good and there was small market demand also. Then I changed to corn, but I kept getting loss. Then I saw my neighbour planted cassava and got good yield. So, I followed him and started planting cassava also since it was more convenience.*
> *F: What reason that will make you stop planting cassava?*
> *I: I will stop when there is no more market demand. I will plant whatever crop that have good market price and demand" (OR10 02.12.19).*

6.2 Objective 2: Determine the feasibility of farmer-preferred PSPs, and the degree of alignment with existing and available agricultural technologies, using expert opinion

6.2.1 Objective 2 Outputs Table

No.	Activity	Outputs/ milestones		What has been achieved?
2.1, 2.2, 2.3 and 2,4: Interviews with: 1) cassava farmer households, village leaders, in Cambodia		Identify experts and enlist in interviews. Conduct interviews with village leaders (n=13).		All 13 village leaders were interviewed by our Cambodian team.
		Report 5: Identification of the technologies that experts associate with farmer PSPs. Specific attention to female farmer PSPs and those of poor and marginalised. (Cook & Lamb).		The baseline quantitative survey (including the 'future outlook' component), the household interviews, and the village leader interviews were analysed to identify farmer priorities and PSPs. We identified 'Pest and Disease management' and 'Transitioning to Fruit tree production' as the two primary farmer PSPs.
		Follow-up survey of experts with conclusions.		The follow-up engagements with village leaders were cancelled due to Covid travel restrictions.
		Report 6: Describe how experts envision extension or adoption of the technologies associated with farmer PSPs. Identify the availability of technologies in Battambang and Pailin according to experts and the cost of the individual technologies for farmers. (Cook & Rickards).		The follow-up engagements with village leaders were cancelled due to Covid travel restrictions. As a way of adapting to the Covid lockdown, we produced expert-informed videos on cassava production best practices as key output associated with the farmer PSP 'Pest and Disease' on topics that they noted as priorities (videos here).
		Interview experts to establish their final views on farmer PSPs and views on Agricultural sector in NW Cambodia.		The follow-up engagements with village leaders were cancelled due to Covid travel restrictions.
		Publication 2: Comparison of expert and farmer PSPs. (Cook & Rickards)		Due to the inability to re-engage with village leaders, it was decided that we would draw on the Sustainable Development Goals literature as the basis of comparison of 'elite perceptions' (i.e., the SDGs) and farmers' perceptions (i.e., established through Objective 1).

6.2.2 Interviews with Village Leaders

Cambodia village leader interviews

Margot Wilson and Brian Cook

Introduction

This report outlines and compares findings from a series of 13 interviews conducted by facilitators from Partners for Rural Development (PRD), who interviewed village chiefs from 13 villages in Battambang and Pailin provinces in northwest Cambodia. The interviews were conducted in November 2018 and cover topics of village population, leadership structure, language and culture, weather and climate, household characteristics, education, economics and farming, healthcare, infrastructure, assets, and problem-solution pathways. Common concerns raised by village leaders include increasing weather variability and intensity of rains and droughts causing lower yield for farmers, unstable market prices for crops, and associated problems of debt and starvation. The interviews reveal a wide variety of potential and current methods to solve these problems.

Village description

Village populations range from 483-1949. Age structures of these populations are unknown. In terms of gender, some villages have uneven sex ratios. In Ou Sngout, 44% of the population is female, 47% in Kompong Touk, 45% in Krochab, 46% in Tanorn, and 48% in Toek Phos. On the other hand, the population of Doun Troet is 52% female and that of Ou Russey Krom is 55% female. All others are approximately 50% each. None of the interviews address the reasons for these imbalances, though many villages have gendered differences in labour demand and abilities –which I discuss below– and these may shape the gendered population proportions.

The villages differ in terms of the distance villagers must travel to reach the nearest big city. In Tangen Loeu, Soun Ampov Lech, and Ou Sngout it takes residents only 5-10 minutes by car or motorbike to travel to the nearest city centre. The travel time for most other villages ranges between 15-30 minutes. For residents in Doun Troet and Tanorn it takes up to 60 minutes to travel to the nearest city centre, with village leaders of both villages explaining that this is due to poor road quality.

In almost all villages, a significant majority of land is used for agricultural purposes. On the other hand, Tangen Loeu has only 9% agricultural land and Soun Ampov Lech does not have any agricultural land because all the agricultural land used by its farmers and labourers is located in neighbouring villages. The proportion of land used for agriculture in Ou Sngout is unknown.

Village leadership structure

Village leadership positions are male-dominated in almost all villages. Some women are deputy leaders or village members, but rarely village leaders. Mrs. Kong Srey in Au Roel and Mrs. Prak Khoeum of Doun Troet are notable exceptions. Many people in village leadership positions are former Khmer Rouge soldiers, or held other positions in the Khmer Rouge such as transportation workers or nurses. Other than that, most leaders come from civil servant or farming backgrounds. In Tanorn, the interviewee explains their desire to train younger people to become part of the village leadership structure in the future, but that young people generally do not want to do this because they want freedom to go anywhere –presumably beyond the village– to earn money. No other interviews discuss future leadership plans or prospects.

Language and culture

All villagers speak predominantly –and often only– Khmer, though some residents in Ampeb also speak Muslim –Arabic?– in their household while also speaking Khmer in public. All villages have a Buddhist population, though none provide numeric statistics on how many Buddhist families or households. Some villages also have some Muslims and/or Christian households. The only village which is recognised to have ethnic minorities is Doun Troet, which has 10 native Por and Kuoy families. These families all work as farmers.

Weather and climate

None of the villages surveyed are reported to have any data on weather and climate. They all have 2 seasons: rainy season and dry season. All village leaders report a greater variability and intensity of weather, including (i) heavier, harder, longer-lasting rain, and (ii) hotter, dryer temperatures. In Toek Phos, for example, the village leader explains that in April and May of previous years it had been dry, but this year it rained nonstop. This increased intensity and decreased predictability of future weather patterns have been blamed by village leaders for destroying crops and affecting crop yields.

Flooding occurred in almost all villages interviewed, particularly during the months June-October. This flooding damaged and destroyed a significant portion of cassava crops. For example, root rot and other flood-related factors –including washing away seeds and plants– damaged or destroyed 30% of cassava in Ampeb, 90% in Kompong Touk, 50% in Krochab, 80% in Ou Sngout, 50% in Sre Chipov, 40% in Tangen Loeu, 90% in Doun Troet, 50% in Toek Phos, and an unknown but reportedly significant amount in Ampov Lech.

As well as cassava, flooding destroyed significant percentages of corn, fruit trees, rubber, and other crops. It also damaged roads in Toek Phos, making harvesting far more difficult, and caused sewers in Ou Russey Krom to become blocked.

In villages where flooding was not reported to have occurred, heavy or hard rain was recognised to make lowland farms very wet. For example, while it did not flood in Au Roel, lowland farms became very wet from July to August and destroyed an estimated 40% of each cassava and corn crops. It is unclear how interviewees distinguish ‘very wet’ conditions from ‘flooding’.

Farmers’ crop yields were also impacted by hard rain. In Ampov Lech, hard rain from July-September destroyed a significant but unknown percentage of cassava, as well as 50% of corn. In Ampov Kuet, 2 months of hard rain from July-August destroyed 30% of each cassava and corn, and 70% of cassava in Tanorn. Once again, it is difficult to distinguish between the effects of flooding versus hard rain, as the effects are often closely related.

Within the villages, lowland areas and farms located along waterways were disproportionately impacted by flooding and wet conditions. On the other hand, farms on higher land tended to be more negatively impacted by droughts.

Following the floods and heavy rain, most villages experienced droughts in November. The dry season is generally identified to occur from January to May, so the incidence of droughts in November suggests that dry seasons are getting longer. These recent November droughts were generally reported to be more severe (hotter and dryer) than in dry seasons of previous years, and that this negatively impacted crop yields. In Tanorn, droughts caused corn not to seed and to die, while in Au Roel, drought destroyed a reported 90% of farmers’ crops, with some having to replant multiple times. In Sre Chipov, November droughts destroyed 20% of cassava that had just been planted and corn that

had just begun to flower. Drought began even earlier in Ou Sngout, in mid-October, and destroyed 70% of cassava. Notably, the drought impacted people differently based not only on their farms' elevation and distance from waterways, but also the time at which farmers decide to plant and harvest.

Strong winds were identified as a problem in several villages, though consequences specific to these strong winds were not expanded upon. Two villages, Ou Russey Krom and Toek Phos, were also reported to have been negatively impacted by the disease 'Kra'. In Toek Phos, the interviewee expressed difficulty for farmers in identifying Kra disease until it was too late, and struggled to distinguish between Kra and rot. The main way they eventually knew it was Kra was because it was impacting crops even in highland areas that had not flooded. Kra was not mentioned in the other 11 interviews.

Farmers in the villages have attempted to navigate these issues of increasing weather variability and intensity by replanting seeds after a heavy inundation of rain, planting seeds earlier or later, or harvesting crops earlier. However, these were not discussed in great detail in any of the interviews.

Household characteristics

The average household size in each village ranges from 4-7, and often includes several generations of a family. In the past 10 years, most villages have seen efforts to introduce residents' awareness of birth-spacing methods. Several interviews mention that this project was run by Village Health Volunteer (VHV), though most other interviews do not mention which organisation or entity was responsible for running the program. The program educated women and men about spacing out having children, whereas in the past most villagers were having children by chance and without fore-planning. Some discernible changes from this program are that women in Au Roel are less shy talking about their reproductive health and as a result are more informed. In Tanorn and Doun Troet, the number of children being born has reduced since the introduction of the program: while they previously had 4-5 and 5-6 children per family respectively, this has since decreased to 2-3 and 3 respectively. The interviewee suggests that the reduction in births is specifically due to the program. Other interviews do not give specific details about how the program has influenced household size, but they do say it increased women's knowledge and thus their abilities to decide for themselves their desired family size.

The year at which people started living in each village varies from 1979-2004, and the first families to move into each area were usually Khmer Rouge soldiers and their families.

Education

Access to schools varies across villages. Most villages have access to at least one school, usually a primary school. In Ampeb and Tangen Loeu, there are no schools so children have to travel to nearby villages. Some villages have access to secondary schools, though for most villages, children are required to travel to nearby villages to continue their studies. The average level of school completion is grade 6 for all villages except Ou Sngout where the average level of completion is grade 12. This may be partially due to the fact that the village has both a secondary and high school.

Reasons for children discontinuing their studies before grade 6 and grade 12 are quite similar across villages, and relate to difficulties in accessing transport to get to school, low economic status of parents making them unable to pay for tuition or supplies, and parents pulling their children from school so that they can assist with farm labour. In Au Roel and Sre Chipov, children are reported to leave school because parents are busy working on farms and therefore these parents "did not care about their children's study" or their "commitment is weak". In Doun Troet, some children dropped out because the road quality was poor, and when the road flooded they could not access school and therefore

became too far behind their classmates to continue studying. Lastly, in Tanorn, some children choose to discontinue their studies so that they can get paid employment – usually by selling their labour– and gain financial independence.

Several interviews mention a gendered difference in school attendance. In Tanorn, there are more boys than girls in school, but boys are also more likely to drop out of school because their parents want to use their labour on the farm to increase household income. The village leader does not provide details about the proportion of boys and girls who complete their studies.

In terms of literacy levels, a general trend across all villages is that literacy levels are disproportionately low among women, particularly women aged 50 and over. Most village leaders do not provide an explanation for this, though village leaders in Sre Chipov and Ou Russey Krom recognise that it is because women growing up under the Khmer Rouge often did not study. Village leaders in Kompong Touk, Doun Troet, and Soun Ampov Lech explain that literacy programs have been conducted to improve literacy levels, particularly of older women and of children who discontinued their studies. However, attendance is often low and so the programs are discontinued. The reasons for low attendance vary. While in Kompong Touk and Soun Ampov Lech people do not attend literacy classes because it means they are not spending the time at work and are therefore sacrificing their income, in Doun Troet people stopped attending “since they’ve mostly learnt a lot”.

Economics and farming

The average daily wage for labourers across each village ranges from 20,000-35,000 riel. This figure varies according to types of labour performed, the equipment that labourers can access, and the demand or urgency for each type of work in a given area. In Au Roel, for example, weed sprayers’ wages depend on whether they have access to mechanised equipment or whether they have to work manually, and on the location of the work and density of weeds.

The primary occupation in most villages is farming, and there are also many civil servants and soldiers. Many villagers supplement their income by selling their labour both within and outside the country. The most common sources of work outside of the village are construction work in Thailand and Phnom Penh, and garment factories in Phnom Penh. Some women in Au Roel and Tangen Loeu also work in casinos, though interviewees do not give details about where these casinos are located.

As I have alluded to above, there are several factors shaping the differences in income between men and women villagers, and these vary across villages. In Ampeb, Kompong Touk, Ou Sngout, Soun Ampov Kuet, Sre Chipov, Ou Russey Krom, and Tanorn, men earn more money than women. Village leaders explain that this is due to two key reasons. First, men are able to do more intense physical labour, which is often the type of work in high demand. Second, men have fewer household responsibilities than women, such as preparing food and providing care, which means that men have the time each day to travel further away to find better paying work. On the other hand, in Au Roel women earn significantly more than men because many women work in casinos where they are paid a regular salary, compared to men who work on farms where income is insecure and volatile. In Tangen Loeu and Toek Phos women can reportedly earn more than men because they are more willing to sell their labour or do certain jobs than men, though no further explanation is given here. Ultimately, men generally tend to earn more than women in most of the 13 villages but there are several factors shaping –and sometimes reversing– this trend.

The most common crops produced by farmers for the purpose of selling are cassava, corn, longan, soybean, cashew, and mango. In addition, several farmers in Ampeb also grows mung bean, rubber, turmeric, and galangal, while some farmers in Krochab and Tanorn produce pumpkin alongside the common cash crops. Farmers sell their products

at a variety of locations to a variety of sellers, and this depends on the crop type. Most frequently, farmers go to silos to sell their crops, or sell at their farms or homes. Most crops are sold to middle men/women who then export the crops to Phnom Penh, Thailand, or Vietnam.

At the time of the interviews, the average price at which farmers sell cassava ranged between 2.10baht/kg to 2.5baht/kg. Leaders in Sre Chipov, Tanorn, and Ou Sngout say that the price at the start of the year was 2.70baht/kg but that this has fallen throughout the year. They did not give a reason for this. Importantly, these prices vary not only across time and village, but also differ for farmers within each village. As the leader in Ou Russey Krom explains, different buyers offer different prices to farmers. Therefore, these averages are not the same for each farmer within each village.

Cassava yields in most villages are sinking. In some cases village leaders explain that this is due to heavy rain, flooding, and disease, but other leaders do not give reasons for sinking yields. Another issue highlighted is that several years of planting cassava in the same spot is causing nutrients to be depleted from the soil. In Krochab, the yield is flat rather than sinking because farmers are adopting better farming techniques and learning how to use fertilisers. In Toek Phos, yield is flat despite the heavy rain and diseases, because farmers replanted their crops after rain damaged them.

Recognising the many issues causing lowering yields, some farmers are adopting different farming methods including shifting from cassava to other crops, rotating cassava with corn, or intercropping cassava and corn with fruit trees. In Au Roel, Ampeb, Krochab, Soun Ampov Kuet, Tanorn, Doun Troet, Ou Russey Krom, and Toek Phos, farmers rotate between cassava and corn to increase soil nutrient quality, as the Au Roel leader notices “the yield drop every year” when planting only cassava. Most village leaders also notice an increase in the number of farmers intercropping cassava and corn with fruit trees, which they explain is because fruit trees do not require as intense labour and mangos. This is particularly important for ageing farmers who are less able to engage in difficult physical labour than in the past. The village leader in Tanorn recognises this motivation, explaining that fruit trees are a “long term plant”. Additionally, mango trees are increasingly appealing because mangos are stronger in the market than cassava and corn and are less subject to price fluctuations. For those farmers who are shifting from cassava to fruit trees, they often intercrop for a couple of years while there is still space between the trees before they grow too large, because this is a more efficient use of their land. Once the trees grow large, usually after several years, farmers discontinue intercropping with cassava and corn, and instead plant these crops elsewhere or stop planting them altogether. Conversely, some farmers are not adopting these methods. In Kompong Touk, a small percentage of farmers rotate cassava with corn or intercrop with fruit trees, but most do not have the financial capital or time to invest in new seeds, equipment, and farming methods. In Sre Chipov, some farmers are hesitant to shift from cassava to other crops despite sinking yields because cassava is a short-term plant that can be harvested within one year, while fruit trees require three years before they yield any produce which can be sold. Moreover, in Kompong Touk, the leader explains that farmers do not shift from cassava to other crops because they have already invested in expensive stakes. Ultimately, there are various reasons involved in whether farmers shift, including available capital, farmers’ ages and physical abilities, and desires to improve soil quality and earn more money.

Healthcare

In terms of villagers’ access to healthcare, several villages have an economic divide whereby richer villagers attend better-equipped and often further away private clinics, while poorer villagers attend poorly-equipped but closer and more affordable public health centres. This divide is evident in Ou Sngout, Soun Ampov Lech, Tangen Loeu, Tanorn, and Ou Russey Krom.

In most villages, there is some support available for poorer women who are pregnant or giving birth. Support is provided by a range of sources, including governments, village chiefs, pagoda, Commune Equity Funds, and women's affairs groups. These groups provide cash payments, cover the costs of check-ups and other services, or provide transportation allowances to cover costs of the journey to health clinics. Supports such as food and materials for the baby are also available to women in Soun Ampov Kuet. No specific support is currently available for pregnant women or new mothers in Ampeb or Kompong Touk.

Villages differ in terms of distances residents must travel to access the nearest trained doctor. For most villages, there is a trained doctor within 10 minutes. For Ampeb and Tanorn, it takes 15 minutes, and in Doun Troet it takes 30-40 minutes. There are no trained doctors in Toek Phos, and no estimated travel time was given during the interview. In terms of the nearest hospital, it takes residents of approximately half the villages surveyed approximately 2 hours by car or motorbike, while the other half must travel only 5-30 minutes.

Infrastructure

Most villages' roads are described in interviews as "pave road and good quality". Kompong Touk and Tanorn are described as "laterite road and good quality", Ou Russey Krom and Toek Phos as "laterite road and ok quality", and Doun Troet as a bad quality dirt road.

Electricity access at homes in villages also varies. 100% of homes have reliable access to electricity in Ampeb, Au Roel, Soun Ampov Lech, and Tangen Loeu. In most other villages, over half of the homes have electricity with a small percentage of the most remote villagers relying on solar power, generators, and batteries. In Doun Troet and Kompong Touk, no homes have access to electricity, and they are instead entirely dependent on solar power, generators, or batteries.

Assets

Mobile phone ownership is 100% in most villages, though it is unclear if this percentage refers to every adult, every person, or every household. For those which are not at 100%, Ampeb is 90%, Krochab 80%, Sre Chipov 99%, and Ou Russey Krom above 90%, with the village leader explaining that all people except some elderly people use mobile phones.

Tablet and computer ownership varies across the villages but is very low in all. There are none in Doun Troet and Russey Krom, and under 10% ownership in all others, except perhaps Ampeb, Soun Ampov Lech, and Tangen Loeu where ownership is unknown. In most cases, it is only schools and civil servants who use tablets or computers.

Car ownership also varies across villages, but is generally low. There are 20 or fewer cars in all villages except for Soun Ampov Lech, where there are 30 cars, 5 trucks, and 2 taxis.

Motorcycle ownership is very high in about half of the villages surveyed, with 100% ownership in Soun Ampov Keut, Soun Ampov Lech, and Tangen Loeu and 95% ownership in Ampeb. Ownership is slightly lower in the other villages, though over 50% of households own motorbikes in all villages surveyed.

In terms of tractor and kor yun ownership, very few households own tractors, while kor yun ownership is generally more common. A significant number of households in Ampeb, Ou Sngout, and Doun Troet own a kor yun. For households which own neither a tractor nor a kor yun, it is not explained in the interviews whether farmers plant and harvest their crops manually, or whether they rent or borrow equipment.

NGOs

All villages except for Tangen Loeu, Toek Phos and Soun Ampov Keut receive some assistance from NGOs in terms of agricultural development. The key categories of assistance include the clearing of landmines, education, water filtering, and providing assistance and knowledge about growing vegetables and raising chickens.

Problem-solution pathways

Most village leaders indicated the exact same four significant costs faced by households within their villages: family daily food consumption, health, agriculture production costs (chemicals, fertiliser, seeds), and children's education. The village leader in Kompong Touk does not recognise education as a significant cost, but does recognise the other three.

The most significant problems faced by villagers vary across villages, though some common concerns according to village leaders are farmer debt, economic poverty, and starvation. In Ampeb, 70% of households are in debt. In Au Roel and Krochab, debt is at 90% of households. This issue is also significant in Kompong Touk, Ou Sngout, Soun Ampov Lech, Sre Chipov, Tangen Loeu, Tanorn, Doun Troet, Toek Phos. This is due primarily to farmers' inabilities to repay micro-finance loans they took out to grow crops, as eventual yields were far lower than expected returns due to droughts destroying crops. In Toek Phos, the debt is regarded as being largely due to the fluctuations in market price of crops, whereby "the price changes every day. Sometimes two times a day", so farmers are unable to accurately predict how much they can safely borrow and therefore end up trapped in debt cycles.

Poverty and starvation are identified by many interviewees as separate issues to each other and to the above-mentioned issue of debt, but when these issues are discussed further, it is revealed that they are heavily interrelated. One way in which these issues are closely linked is that a primary reason for all of these issues crop failures and the low market prices of crops, and other insecurities and volatilities associated with farm work. In Soun Ampov Keut, many villagers are in precarious economic situations and cannot provide food for their families because there is a shortage of demand for labour between July-October, so landless labourers cannot secure an income to feed families or pay off debts. Thus, the issues of debt, poverty, and starvation are closely linked.

Another related issue identified by many village leaders, including those in Ou Sngout, Tanorn, and Doun Troet, is that many villagers are unable to afford necessary healthcare. In Doun Troet, this inability for many people to afford healthcare is recognised by the village leader as closely related to issues of debt, whereby not having money to start up a business or pay for healthcare and debts then leaves families unable to escape existing issues of debt and poor health.

To combat these issues, the primary intervention that village leaders explain would help is stabilising or fixing crop prices, or at the very least finding a more secure and reliable market for farmers to sell these crops. This was explicitly mentioned by village leaders of Soun Ampov Keut, Soun Ampov Lech, Sre Chipov, Ou Russey Krom, Toek Phos. It is hoped that this greater stability and economic security would reduce vulnerability to debt traps by increasing farmers' ability to plan around potential future income. In most cases, there is no concrete plan to actually implement this solution, though the leader of Soun Ampov Lech explains that they have heard that the governor is actively working on finding a good market for farmers' crops.

Another solution which was discussed by village leaders in Sre Chipov, Ou Russey Krom, and Ou Sngout is food assistance, usually rice, to families who are starving. This is recognised as absolutely crucial for the survival of families which are starving. However, it is also a short-term fix and does not directly address the root causes of the problem, including extreme weather and crop price volatility.

Another key set of issues faced by many households in some villages surveyed are that some villagers struggle with their gambling and drinking habits. Gambling is identified as an issue in Au Roel, while drinking is identified as an issue in Krochab, and both are identified as issues in Kompong Touk. Moreover, in Krochab and Kompong Touk, these issues are understood to directly lead to an increase in domestic violence. Additionally, in Kompong Touk, problem gamblers and drinkers are generally from the same households which struggle with starvation and poverty, showing how various types of vulnerability intersect for these households.

To combat these issues, village leaders have a variety of approaches. In Au Roel, the leader does not mention any potential solutions to the gambling issue. In Krochab, the leader explains that authorities raise awareness of the issue of domestic violence at meetings, and that this helps to curb the issue slightly. Notably, they do not explain how raising awareness helps or who is involved in the meetings, or the methods by which they are measuring whether the incidence of domestic violence has decreased. Moreover, the leader remarks that “we can’t stop people from drinking alcohol”. In Kompong Touk, the village leader also raises the issue of domestic violence caused by alcohol and gambling during meetings, but they explain that no action is taken, and that the “law of the safety village and commune does not help because the duty department not active”. While there is sometimes action taken by law enforcement in response to complains of domestic violence, there are no further steps or plans in place to prevent these issues from occurring in the future. In terms of infrastructure, two key issues are highlighted: lack of irrigation and poor road quality. In Krochab, there is no irrigation system, and this negatively impacts many farmers’ abilities to grow certain crops during dry season, including asparagus. A reported 2 out of 5 families attempting to grow asparagus have already given up. There is currently nothing in place to navigate this issue and improve the irrigation in the village, though the village leader is planning to create a vegetable growing association in partnership with the Buddhist for Development NGO in hopes that this will help. No further detail on this plan is given. The village also struggles with poor road quality, and some planning by the government is currently underway to improve road quality and in turn improve farmers’ livelihoods.

Poor road quality is also an issue faced by villagers in Doun Troet, Ou Russey Krom, and Toek Phos. In Doun Troet, there is a budget allocated to help build the road but no other details such as a timeline are given on this solution, and no further support for village development is being provided or planned. In Ou Russey Krom, the issue with the roads is that they are extremely dusty due to being made of laterite. The governor plans to help fix this issue by making bigger road, though funding is not discussed. In Toek Phos, poor road quality is identified as a key reason why some children drop out of school, because the journey from home to school is too difficult. However, there is little incentive for governments to address and fix this issue because the bad roads impact only a few families.

Notably, while some villages are reported to have poor or unreliable access to electricity, no village leaders mention this as a key problem needing to be solved.

In Ou Russey Krom and Soun Ampov Lech, the village leaders express concerns that some poor residents are emigrating to Thailand. In Soun Ampov Lech, planned future investment from Chinese and Korean companies into agricultural products throughout the Pailin district are viewed as a potential way to improve the livelihoods of farmers and thus reduce this emigration. No further information is given about these migrations or how to address them.

Several village leaders explain that the problems faced by farmers in their villages are or could be navigated by increasing farmers’ agricultural skills and resources. In Sre Chipov, the leader explains that this year the government will provide some agricultural materials including plastic to cover the land in order to ease with growing certain vegetables, namely cucumber and cabbages. In Soun Ampov Keut, Soun Ampov Lech, and Tanorn, leaders believe that teaching farmers proper techniques to grow vegetables or

encouraging them to raise chickens will help increase their resilience to economic shocks and their abilities to provide food for their families. Efforts to raise awareness of this potential solution are currently underway in Soun Ampov Lech. In Soun Ampov Keut, officers of the agricultural department meet farmers and provide technical assistance on growing cassava and corn upon farmers' request, though there is no broader assistance underway for farmers who do not explicitly request it. In Tanorn, there are no such efforts currently underway beyond encouragement from the village leader for farmers to raise chickens and grow their own vegetables. There is a commune budget package in Tanorn, but the leader is unsure how and to whom this will be allocated. The leader nevertheless explains that encouraging farmers to make these on-farm shifts to growing vegetables and raising chickens is crucial, because farmers currently have the land to grow vegetables and raise chickens but instead they grow cash crops and buy all of their own food from the mobile grocery, which increases their vulnerability to market shocks. Notably, the village leader of Tanorn was the only interviewee who expressed the importance of finding what villagers themselves want to do and what their real needs are. No large-scale plans have so far been implemented to gather feedback from villagers, though the leader recognises the importance of doing so. By contrast, the village leader in Ou Russey Krom explains the difficulty and complications in engaging with villagers in terms of their issues because "it is endless. All these small problems add up", seemingly inferring that the wide variety and large scale of problems faced by villagers threaten to overwhelm and complicate any potential efforts to improve farmer livelihoods. This comparison reveals that village leaders have different and even contradictory approaches to improving farmer livelihoods.

In Tangen Loeu, little is being done to improve farmer livelihoods. The leader explains that they make requests to upper levels for food assistance, but receive very little: only enough food to support 1-2 families. They also explain that the government is rarely seen coming to the village to help improve farmer livelihoods.

To summarise, this analysis reveals that many of the problems faced by villages are similar, though proposed solutions and actions to implement these solutions often diverge. Solutions range from awareness campaigns, short-term food and monetary aid, to longer-term resilience-building by increasing farmers' abilities to grow crops and sell them at sustainable prices. At present, the effectiveness of each solution is not yet known.

6.3 Objective 3: Demonstrate sustainable production of cassava using best practices and, in years 2 – 4, add demonstrations in response to farmer PSPs (Objective 1) using best practices and technologies identified by experts (Objective 2)

6.3.1 Objective 3 Outputs Table

No.	Activity	Outputs/ milestones	Date Completed	What has been achieved?

3.1	Trial of cassava best practices in Battambang and Pailin.	• Soil samples of demonstration sites. • Plant first cassava crop • Harvest cassava • Soil sample and analysis. • Plant year 2 cassava. • **Briefing notes 1**: Monitoring and evaluation update on cassava demonstration for ACIAR and partners. (Sophanara & Montgomery) • **Pamphlets 1**: In Khmer and pictorially, publicise the full economic costs of sustainable cassava production. (Sophanara & Postdoc) • Harvest cassava • Soil sample and analysis. • Plant year 3 cassava • **Publication 3**: Establish the full costs and benefits (social, economic, and environmental) of sustainable cassava production? (Farquharson & Thiele) • **Pamphlets 2**: In Khmer and pictorially, publicise the full economic costs of sustainable cassava production. (Sophanara & Postdoc) • Harvest cassava • Soil sample and analysis.		Samples taken from each plot, (184 total) catalogued, air dried and a subsample selected for analysis in Thailand. Yr. 2 as above for new site Pailin (92 samples) Took a transect of soil samples across the transition 1ha sites and analysed by themselves for pH, colour, structure and presence of Phytophthora root rot (Montgomery and Wilson). 4 small plot replicated agronomy trials were sown at each site. They include: optimal plant density; planting method (horizontal or vertical, no-till vs, min till or farmer practice of ploughing and hilling up); time of sowing; cassava alone or intercropped with mungbean or peanut. The extra transition ha on each site was planted to cassava as per farmer practice so the transition would be realistic. Cassava trials were grown for 10 months and managed according to best bet agronomic practices by Montgomery, Phan and Wilson. The in-country research team – lead by Montgomery and Phan – successfully harvested the first planting of cassava. Dry matter samples and extra measurements were taken. Analysis is underway. The second planting of cassava is complete on both demonstration farms. The same trials were planted again to give a history of results.

3.2	Trial of farmer-chosen transitions or agricultural technology(ies).	• Identify and plan for farmer chosen demonstration. • Soil sample and analysis. • Implement farmer chosen demonstration • Harvest farmer chosen demonstration.		Design extra 2 ha's for transition to fruit tree orchards includes measuring and mapping site, plan for tree type, quantity, orchard BMP, irrigation set up, water source and access (Montgomery and Wilson) Plan irrigation layout, source reliable company to provide good quality equipment, install and provide support; implement micro sprinkler irrigation to each tree, with head control and pump from farmer's dam. Only Samlout is irrigated; Pailin is demonstrating transition to rainfed mango production. Montgomery and Wilson have begun planting durian, mangosteen, mango and longan at the Samlout site; awaiting remaining trees from slow suppliers. Pailin site is awaiting further grafted mango trees. Trees already First intercrop planted in June at Samlout consisted of mungbean, peanut and corn. Mungbean is seed increase of Australian variety CMB-3 for sister ACIAR project CSE/2015/044 for proposed release in Cambodia. Intercrop planted at Pailin consisting of peanut, soybean and corn received will be planted in early August.
	Outputs			
		• **Briefing notes 2**: Monitoring and evaluation update on farmer-chosen demonstration for ACIAR and partners. (Sophanara & Postdoc)		See Briefing notes (below).
		• **Pamphlets 3**: In Khmer and pictorially, publicise the full economic costs of the farmer-chosen crop, technology, or practices. (Sophanara & Postdoc)		These data informed and were consolidated into the development of the 'Taking Care of Cassava' pamphlet produced as part of the knowledge exchange (see Objective 4)
		• **Publication 4:** establish the full costs and benefits (social, economic, and environmental) of farmer-chosen technology? (Farquharson & Thiele)		See "The effect of planting time on cassava yield and the risk of crop failure in Northwest Cambodia".

		• **Pamphlets 4**: In Khmer and pictorially, publicise the full economic costs of the farmer-chosen crop, technology, or practices. (Sophanara & Postdoc)		These data informed and were consolidated into the development of the 'Taking Care of Cassava' pamphlet produced as part of the knowledge exchange (see Objective 4)

6.3.2 Objective 3: Demonstrate sustainable production of cassava using best practices and, in years 2 – 4, add demonstrations in response to farmer PSPs (Objective 1) using best practices and technologies identified by experts (Objective 2).

The field research component consisted of two sites of 2 ha each; 1 ha allocated to cassava agronomy trials and the other hectare for the transition demonstrations. The rationale for having two research sites was so that one site was located in each of the two districts (Pailin District and Samlout District) the project was working in, so farmers from the 13 focus villages had the potential to access a site in their district. Although this means for some farmers the sites are still quite far away (up to 40 km) due to the large district size, the project did not have the resources (staff or budget) to manage more than two sites. Additionally, the sites needed to be large enough to investigate sustainable cassava agronomy options as well as farmer requested transition options and therefore required a high level of management and maintenance over the course of the project.

The original plan was to begin cassava demonstrations during the first year of the project, and to allow the social science research to identify farmer PSPs with the goal of understanding what the farmers would like to do with their land. The pilot research suggested that many of the farmers indicated a desire to transition from cassava to fruit tree production, so the team decided to implement demonstrations around this farming system shift. This finding was relatively expected, as it aligns with existing trends amongst more wealthy farmers, and is supported by anecdotal belief that such products will easily market to China, especially Durian. Broadly, the findings are logical and expected, though the research team had to question whether 'we found what we expected'. As the survey data continued to be analysed, the planning and preparation for the demonstration farms to implement multiple transitions to fruit tree production was instigated. The survey analysis took longer than anticipated and planning for a farming system paradigm shift takes time, hence the agronomy team could not afford to wait until all surveys were analysed, otherwise they would have lost another year of implementation.

In Pailin province, the trial site was conducted in Teuk Phos village for the first year in 2017-18, which was located approximately 15 km east of Pailin town and was 157 m above sea level (a.s.l.) with GPS co-ordinates of 12 53'38.12"N, 102 37'50.74"E (Fig. 5.1.1). In 2018-19 this trial site needed to be moved to Pich Kiri village, which is approximately 3 km away from the original site and was situated 149 m a.s.l. with GPS co-ordinates of 12 58'41.57"N, 102 39'52.63"E. It was necessary to conduct the second and third years of experiments at this alternative location due to the farm owner rescinding the leasing arrangements and ongoing theft problems at the original site.

The trial site in Battambang province was conducted in Kompong Touk village, Samlout District, at an elevation of 111 m a.s.l. with GPS location of 12 42'58.56"N 102 46'28.16"E. This site remained constant for the three year duration of the research trials. The land is owned by the Commune Chief, which along with its' proximity to the main road, was the main reason why it was specifically chosen for our trial site. Land belonging to the

Commune Chief is safer from theft then general farming land and as was proven in Pailin, theft from trial sites is often a problem for our projects.

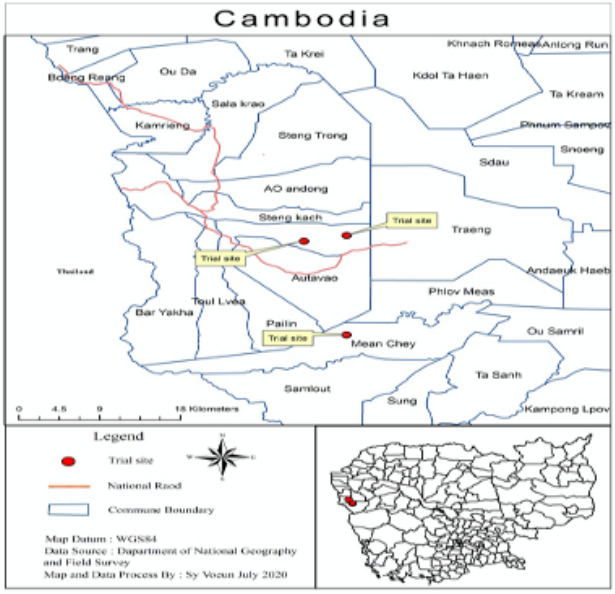


Figure 5.1.1 Location of the experimental sites at Samlout district and Pailin Province (Source: (Phan S, 2020)

Soil type at the Samlout site was characterised as a red brown silty clay and is indicative of the district (Table 5.1.1). Soil at the first Pailin site ranged from a red sandy clay on the upper slope through to a brown clay on the lower slope. Soil from the second site was heavier sandy clay of dark brown colour and together with the first Pailin soil type are common in the region. Samples were taken across all sites and analysed in the laboratory at Suranaree University of Technology, Thailand.

Table 5.1.1 The chemical and physical properties of soil at all sites, Samlout and Pailin districts

Properties	Samlout	Pailin 2017-18	Pailin 2018-19
pH water	6.73	7.83	7.80
EC(mS/cm)	0.199	0.1766	0.234
OM (%)*	3.662	3.018	3.474
Avai.P(mg/kg)	10.390	9.082	7.94
Exc.K(mg/kg)	106.4	63	84.34
Exc.Ca(mg/kg)	4564	2698.4	9211.4
Exc.Mg(mg/kg)	188.6	916.6	1364.4
Texture	Silty clay	Sandy clay	Sandy clay
Miner. N(mg/kg)	76.48	62.24	73.5

The sites were managed by the field research leader, Dr Stephanie Montgomery and the project agronomist, Mr Phan Sophanara. From October 2017 to June 2019, the agronomy team also had part time assistance from Eric Wilson, an Australian tropical agronomist who helped out on all aspects of the site management but particularly with the implementation of the transition demonstrations and the economics of all the experiments. The sites required a lot of management and maintenance, so casual labour from the nearby villages were employed as required. These labourers all had farms of their own and were within our focus villages. Employing them to manage the trial sites, meant they were learning by doing and enabled them to query and discuss the trials in real time.

Automatic tipping rain gauges (Davis Instruments, Model No. 7852M) containing USB data loggers were installed at each trial site to record daily rainfall. Paired with this was a temperature and relative humidity logger, set to record hourly measurements (Lascar Electronics, Model No. EL-USB2+) per trial site. The mean annual rainfall for the three years of field research indicated that there was more rainfall at Samlout than at Pailin site.

At Samlout site (Fig. 5.1.2) in 2017-18, there was 1829 mm with 392 mm, 1110 mm and 327 mm falling in the pre-monsoon, monsoon and post-monsoon periods. At the same site in 2018-19, there was 1379 mm with 401 mm, 836 mm and 142 mm falling in the pre-monsoon, monsoon and post-monsoon periods. At the same site in 2019-20, there was 1640 mm with 214 mm, 1109 mm and 317 mm falling in the pre-monsoon, monsoon and post-monsoon periods. At the Pailin site (Fig. 5.1.3) in 2017-18, there was 1256 mm with 392 mm, 760 mm and 104 mm falling in the pre-monsoon, monsoon and post-monsoon periods. At the Pailin site in 2018-19, there was 1145 mm with 358 mm, 686 mm and 101 mm falling in the pre-monsoon, monsoon and post-monsoon periods. At the same site in 2019-20, there was 1332 mm with 237 mm, 888 mm and 102 mm falling in the pre-monsoon, monsoon and post-monsoon periods.

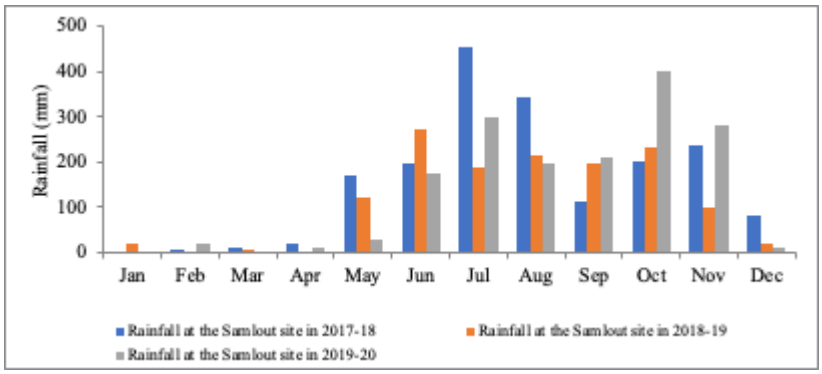


Figure 5.1.2 Rainfall at the Samlout site for 3 years (Source; trial site)

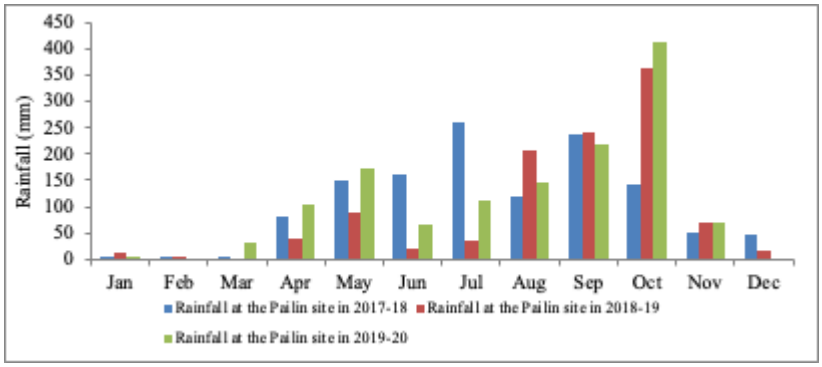


Figure 5.1.3 Rainfall at the Pailin site for 3 years (Source; trial site)

The mean daily temperature was 28ºC at the Samlout site, with a maximum temperature of 41ºC in the pre-monsoon period and a minimum temperature of 14ºC in the post-monsoon period, consistent for the two-year period. The mean humidity level was 76% which ranged from 24% to 99%.

The mean daily temperature was 28ºC at the Pailin site in 2017-18, with a maximum temperature of 43ºC in the pre-monsoon period and a minimum temperature of 14ºC in the post-monsoon period. The mean humidity levels and ranges for both Pailin sites were the same as for Samlout. The mean daily temperature was 28ºC at the Pailin site in 2018-19, with a maximum temperature of 44ºC in the pre-monsoon period and a minimum temperature of 14ºC in the post-monsoon period.

Table 5.1.2 Summary of mean climate data during the research period from 2017 to 2019, Pailin and Samlout

Site	Variable	Pre-monsoon Mar-June	Monsoon July-Oct	Post-monsoon Nov-Feb	Annual Total
Samlout 2017-18	Mean Rainfall (mm)	392	1110	327	1829
	Mean Daily Temperature (ºC)	29	28	30	29
	Temperature Range (ºC)	21-39	20-37	21-41	14-41
	Mean Relative Humidity (%)	65	80	70	72
	Relative Humidity Range (%)	26-98	45-98	24-97	24-98
Pailin site 2017-18	Mean Rainfall (mm)	392	760	104	1256
	Mean Daily Temperature (ºC)	30	28	30	29
	Temperature Range (ºC)	24-32	27-30	21-43	21-43
	Mean Relative Humidity (%)	25	78	70	57
	Relative Humidity Range (%)	25-88	44-99	29-98	25-99
Samlout 2018-19	Mean Rainfall (mm)	401	836	142	1379
	Mean Daily Temperature (^{0}C)	29	28	30	29
	Temperature Range (ºC)	21-39	20-37	21-42	14-42
	Mean Relative Humidity (%)	65	80	70	72
	Relative Humidity Range (%)	26-96	45-99	24-97	24-99
Pailin site 2018-19	Mean Rainfall (mm)	147.9	844.5	101.6	1094
	Mean Daily Temperature (ºC)	30	28	30	29
	Temperature Range (ºC)	24-32	27-30	21-44	21-44
	Mean Relative Humidity (%)	25	78	70	57
	Relative Humidity Range (%)	25-88	44-99	29-98	25-99
	Mean Rainfall (mm)	214	1109	317	1640

Samlout 2019-20	Mean Daily Temperature (^{0}C)	28	28	29	28
	Temperature Range (^{o}C)	21-36	20-31	21-34	21-36
	Mean Relative Humidity (%)	65	80	70	72
	Relative Humidity Range (%)	26-96	45-99	24-97	24-99
Pailin site 2019-20	Mean Rainfall (mm)	237	888	102	1227
	Mean Daily Temperature (^{o}C)	30	28	30	29
	Temperature Range (^{o}C)	24-32	27-30	21-43	21-43
	Mean Relative Humidity (%)	25	78	70	57
	Relative Humidity Range (%)	25-88	44-99	29-98	25-99

Cassava agronomy trials

Eight cassava experiments investigating improved agronomic practices for growing cassava on NW sloping lands commenced from April 2017. Four experiments were sown at each of the sites, which included intercropping options, time of planting, vertical/horizontal planting method, and plant density. Table 5.1.3 provides information related to each of the cassava trials.

Figure 5.1.4. The three cassava demonstration sites – clockwise from above left: Pailin site 1 - 2017, Pailin site 2, Samlout site showing planting method trial at planting and in early vegetative growth, 2017.

The 2019-20 experimentation year saw a slight change in experiments in response to previous years results and the identification of further research required. The intercropping trials were not continued and instead were replaced by expanding the time of planting trial

to include also time of harvesting, which meant doubling the size of the original time of planting trial and increasing plot numbers from 24 to 72. Plot size was reduced in order to fit 72 plots in to the space which previously held 48 plots. The need to more accurately identify the optimal growing season length as well as time of planting was highlighted by farmers in the northwest increasingly cutting short the number of months their cassava crops are in the ground. The new trial design investigated whether 8, 10 or 12 months was the ideal length of time to grow cassava to optimise yield and market. These harvest dates were implemented for each of the 3 times of planting with the aim of establishing optimal planting and harvesting windows for the northwest region. Due to Covid-19 delays, the 12 month harvest time was extended to be 13 months.

Table 5.1.3 Experiment details for field sites at Pailin and Samlout

Year	Trial	Design	Objectives
2017-18 2018-19	Time of planting (TOP)	6 treatments x 4 replicates 2 main: conventional hill, no till 3 split: April, may June	Determine suitable planting time for cassava in NW Cambodia in order to maximise yield and profitability; compare yield and profit of no-till vs conventionally tilled cassava at different planting times.
2019-20	Time of planting, time of harvest (TOPTOH)	18 treatments (2 main plots x 3 split x 3 split-split) x 4 reps as above but with a further split-split plot of 3 harvest times	As above but with the added factor of optimal harvest timing (8, 10 or 12 months)
2017-18 2018-19 2019-20	Planting method	6 treatments x 4 replicates 3 main: conventional hill conventional flat, no till 2 split: vertical/horizontal	Investigate alternative planting methods of reduced tillage and horizontal stem planting for cassava compared to usual farmer practice in NW Cambodia of ploughing and hilling up vertical stem planted cassava.
2017-18 2018-19 2019-20	Plant population	5 treatments x 4 replicates densities of 5000, 7500, 10000, 12500, 15000	Determine optimal plant populations for cassava in NW Cambodia to maximise yield.
2017-18 2018-19	Intercropping	6 treatments x 4 replicates 3 main: cassava only, cass/mungbean, cass/peanut 2 split: cassava density 5000 and 10000	Determine if intercropping cassava with legumes will reduce soil degradation, increase yield and total profitability per hectare

Land preparation

Land preparation involved initially ploughing the whole trial site by four-wheel tractor as the field had come out of conventional cassava with hills when we leased the site. Then hills were pulled up for the conventional hill treatment only, as there was no requirement to hill up for minimum till and no till treatment in the relative trials (Fig. 5.1.5). In the two trials where land preparation was not a treatment, all plots received the same preparation. The plant density trial was totally no-till for 3 consecutive years; whilst the intercropping trial was conventionally hilled up for the two years it was conducted to simulate intercropping in farmer fields. In the second year, only the conventional hill and convention flat treatments were ploughed. No-till was not mechanically disturbed, only sprayed for weed control.

Planting method

For the planting method trial, there were two different planting methods as treatments (Fig. 5.1.5). Planting method 1 was vertical planting where stakes were planted upright into the soil (traditional practice in NW Cambodia). Planting method 2 was horizontal planting where stakes were planted horizontally in the soil (common practice in Eastern Cambodia, and the method for machine planting). Horizontal and vertical planting methods were the split plot treatment applied under the main plots of land preparation. For all other trials, the common practice of vertical planting method was applied.

Figure 5.1.5. Cassava land preparation and planting method treatments - top to bottom, left to right: conventional hilled up vertical stake, conventional hill horizontal stake, minimum till vertical, min till horizontal, no till vertical, no till horizontal.

In crop management

Cassava variety 89 (CMR 89) was cultivated in all experiments under rain-fed production systems. N and P fertiliser were applied next to the planting row at planting time with a combination of Urea (46-0-0) and DAP (18-46-0). Urea was applied at a rate of 50 kg/ha

which equated to 23 kg/ha of N; DAP at 100 kg/ha which provided 18 kg/ha of N and 20 kg/ha of P (46% P_20_5). Further to this Potassium chloride (0-0-60) was applied as 2 split applications of K of 50 kg/ha at 1 and 3 months after sowing.

Weed pressure was constant and as there are no safe reliable herbicides registered for weed management in cassava in Cambodia, we hand weeded all trials 3-4 times over the 10 month period. Farmer practice is to spray glyphosate and 2,4-D in the interrow of the crop and then return with paraquat. These chemicals are not registered for use in cassava and are also damaging to the plant. This is not a practice recommended by our project.

Integrated pest management (IPM) was implemented throughout the growing seasons to monitor insect pest/beneficials and any disease issues that arose. Insect pests and diseases found in the trials included low levels of Bacterial Blight and Brown Leaf Spot, which occurred as a black spot on the leaves during times of rain and high humidity. Cassava Witches Broom disease and some rotten plants were present in the trials in low levels. No CMD was found in any of the trials until the final day of harvest, when two plants were found in the planting method trial at Pailin. Insect pests such as red spider mites and some mealy bugs were present during hot, dry weather periods and mainly on the edge of the field having moved in from the bamboo.

Harvest

The final years' harvest finished in early July 2020 after a 5 week delay, due to shutting down field activities from late March to avoid potential exposure/spread of Covid-19 during harvesting activities. All harvest work was done with appropriate PPE and using a social distancing protocol between the farm labour group (who live together in Samlout or Pailin) and the project staff from Battambang to reduce the risk of transmission between communities. Harvest is a manual operation done by hand-pulling up the plants, aided by lifters, which is the most common farmer practice method (Fig. 5.1.6). Shovels and a crowbar were used for digging tubers broken off underground to ensure all yield was captured. Plant and biomass data was collected at harvest and cassava was sold to a nearby silo for the daily fresh tuber price.

Figure 5.1.6. Vertical stake planted harvest which lifts easily out of the ground (left) vs horizontal stake planted cassava (right). Tubers resulting from horizontal planted stakes often send a thick taproot tuber straight down which makes the plant impossible to remove without digging.

Data analysis

Each trial and crop was independently analysed and is reported on separately. Data was analysed using R for Mac version 3.6.0, Statistix9 programme and Microsoft Excel. Initially the analyses compared mean values in each trial by creating mixed linear models using the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & Team, 2015) to account for the nesting structure of all the trials (except for the plant density trials). Where overall significant differences were found, simple pairwise comparisons of treatments were made via the general linear hypothesis (Tukey's) approach (Hothorn, Bretz, & Westfall, 2008). The above model was subsequently extended to conduct multiple comparisons against the compound effect (ie planting method and time of planting effect on yield), using the same nesting structure. Tukey's multiple range tests and the significant differences were tested at P-value < 0.05.

Transition demonstrations

The surveys reported that over 90% of the farmers interviewed wanted to transition from their current cash crop farming system to semi-permanent fruit trees. Project staff have observed that the lower to middle income class of small holder farmers often start by transitioning to non-irrigated mango because they can't afford the set-up costs of irrigation, and other fruit trees have a higher requirement for water.

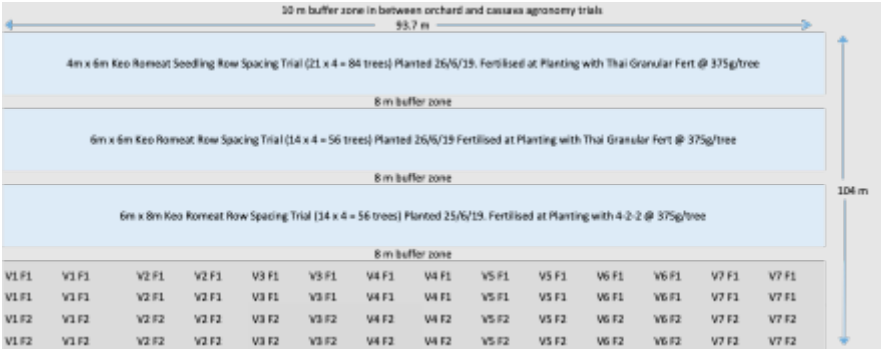
Pailin rainfed site

Based on the survey results and the teams' observations it was proposed to establish the Pailin site as a rainfed mango orchard with a series of research questions around water use efficiency. This included such treatments as plant density (row spacing), nutrition, and evaluation of alternative varieties for drought tolerance (see Table and Figure 5.2.1 below). When the project took over the site it had been ploughed after a corn crop. The friable Kompong Siem soil type was very exposed to erosion from the wet season rains, especially as it had no ground cover and was on sloping ground (Fig. 5.2.2). To combat this threat, the site was planted to blocks of corn, peanut and soybean in July/August 2018, whilst we designed the trial site and constructed plans to implement the transition orchard. After soybean harvest in early November, that area was broadcast with the legume cover crop, Sunn hemp (*Crotolaria juncea*), for added ground cover, weed suppression and soil amelioration. By the time the corn was harvested in early December it was too dry to plant Sunn hemp but the corn stover maintained a high level of ground cover on the soil surface for weed suppression and erosion protection.

The nutrition x mango variety trial was sown whilst the corn and soybean were actively growing in late August/September 2018. The larger row spacing trial was sown the next year in June to ensure the orchard established at the beginning of the wet season to take full advantage of the plant available water for establishment before the dry season set in. The whole 1 ha site was intercropped with forage grasses at the same time in June 2019. The northern half of the site was sown to *Panicum Mombasa* and the southern half to Mulatto II (*Brachiaria ruziziensis x B. brizantha x B. decumbens) which are both quick to achieve full ground cover and are highly palatable cattle feed (Fig. 5.2.2). The forages were established using no till farming techniques, which included spraying weeds before broadcasting the seed and fertiliser, and following behind with roller to ensure optimum seed-soil contact. Grasses were planted at 8 kg/ha and DAP and MOP applied at 40 and 20 kg/ha each respectively.*

Table 5.2.1 Mango varieties included in the variety x nutrition demonstration, Pailin

Key	Variety	Planting Date	Type
V1	Nam Doc Mai	20/6/19	grafted
V2	Taiwan	20/9/18	grafted
V3	Akakoung	20/6/19	seedling
V4	Keo Romeat	20/6/19	seedling
V5	Keo Romeat	29/8/18	seedling
V6	Svai Yiet	29/8/18	grafted
V7	Keo Savoy	29/8/18	grafted



NB: F1 is a slow release fertiliser treatment. 375g/tree is applied at planting and then twice per year in the following years; F2 is a quick release fertiliser treatment which is usually used by farmers in the area. 100g/tree 15-15-15 is applied at planting then twice/year in the following years

Figure 5.2.1 Pailin orchard field layout including row spacing demonstrations (upper blue blocks) and variety x nutrition demo (lower grey block)

Figure 5.2.2 The orchard demonstration site at Pailin – mango intercropped with high quality forage grasses (left); soil erosion and top soil loss on the same site before the grass was sown (right)

Samlout irrigated site

To compliment the rainfed site, an irrigated site was established on the Samlout lease area where a small pond was made available to our project to irrigate from. The 1 ha area was square in shape with relatively even labansiek soil type across it, which allowed for

ease of planning for the orchard layout. The design included variety evaluations for mangosteen, durian, mango and longan trees (see Table 5.2.2 and Figure 5.2.3 below) and included best practice methods for planting durian on mounds for Phytophthora root rot prevention, and the longan and mango demonstrations included a comparison of seed germinated seedlings to grafted rootstock.

The lease began on the 1 ha demo site in April 2017, at which time we prepared the land and planted traditional farmer practice cassava to simulate a realistic transition from cassava to fruit trees. The cassava was harvested in March 2018, at which time the hills were flattened and the site ploughed and harrowed to create an even soil surface to install the irrigation system.

Irrigation design, site layout and pumping requirements were calculated and drafted (Figure 5.2.4) in consultation with local irrigation company, Angkor Green, who specialise in implementation of orchard irrigation systems in Cambodia using high quality Rivulus manufactured equipment imported from Australia. The idea was to display to local farmers thinking about transitioning to irrigated fruit trees, alternative high quality longer lasting products to the locally used blue PVC piping which starts to disintegrate in approximately 2 years, sending micro-plastics out into the environment.

Whilst installing the mainlines for the irrigation system underground, by digging small trenches, the work was interrupted by a violent storm (early wet season sporadic storms in May) which resulted in significant downslope soil erosion wash and exposed the mainline we had just buried. We already knew the ground cover would be paramount in our orchards and was a focus of the demo's but this storm really emphasised the urgency to stabilise the exposed soil. Three weeks later in early June cover crops of peanut, mungbean and corn were sown (Figs. 5.2.5-6). The legumes were planted over the whole irrigation area and the corn on a small area of dryland on the end. Legumes were chosen to promote quick ground cover stabilisation and their N-fixing ability.

The focus at this site was on variety evaluation under irrigated conditions for the different species. Sourcing grafted trees proved to be difficult as most mango trees are planted from seed and longan from cuttings. The point of a variety trial is to compare different varieties that may be suited to a particular region and/or conditions, to evaluate them under the same parameters. The team searched thoroughly all around NW Cambodia and also in Phnom Penh and Siem Reap to find suitable trees for testing. This took a lot more time than anticipated and meant that trees were planted from June to August 2018 and then more trees were planted the following June 2019 and some durian in October also. This later planting was in some instances trees that weren't available the year before and in other cases, replacement trees for losses due to plant deaths.

The whole 1 ha site was intercropped with forages in June 2019. The mangosteen and durian area was sown to Panicum Mombasa and the mango and longan areas to Mulatto II (Brachiaria ruziziensis x B. brizantha x B. decumbens). The dryland area on the end or the orchard was sown to Stylo hamata at 10 kg/ha. The forages were established using no till farming techniques, which included spraying weeds before broadcasting the seed and fertiliser. In this instance the roller could not be used after sowing due to heavy rain the night before and also rain on the day of sowing, which meant the mud and seed would have stuck to the roller. Grasses were planted at 8 kg/ha and DAP and MOP applied at 40 and 20 kg/ha each respectively.

The irrigated demonstration site at Samlout required more management than the rainfed site at Pailin. The young trees often needed watering every 3 days or at least once per week in cooler periods. Eric closely monitored the irrigation requirements; however he could not get to the field as often as sometimes the irrigation required, due to the 3-hour round trip from Battambang and other commitments (50%FTE). To solve this issue, the project employed a nearby farmer to assist with the irrigation and maintenance of trees and forage (more information in section 7.2.1).

Table 5.2.2 Crop species and varieties planned for Samlout transition orchard

Species	Variety	Number	Total	Tree Spacing (m)	Tree density (/ha)
Longan	Cutting	40	80	5 x 6	333
	Grafted	40			
Mango	Akakoung seedling	15	80	5 x 6	333
	Keo Romeat seedling	25			
	Keo Savoy	10			
	Nam Doc Mai grafted	10			
	Svai Pomme	10			
	Svai Yiet	5			
	Taiwan	5			
Durian	Don Ta/ Manthong	15	39	7 x 7	204
	Manthong/Manthong	6			
	Musang King	3			
	Don Ta/Kradum thong	3			
	Don Ta/Pou Malis	3			
	Don Ta/Don Ta	3			
	Don Ta/Ouch Kach	3			
	Don Ta/Noch Yiep	3			
Mangosteen	Small Fruit	9	24	8 x 6	208

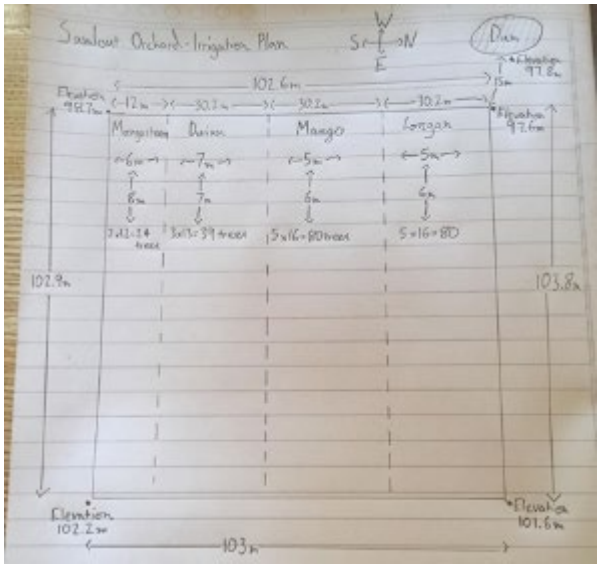


Figure 5.2.3 Samlout orchard field layout including tree species, variety evaluation and cutting vs grafting techniques for optimal production

6.3.3 Results

The results of this study for two years at Samlout, demonstrated that the current farmer practice of planting cassava in April, which is the driest and hottest month in this area, resulted in lower yields than cassava planted in May and June under conventional hill and no till farming practices. The soil moisture measurements clearly illustrated the impact of low soil moisture at planting on establishment. The results demonstrated that, shifting planting times back to cooler months with more reliable rainfall and some stored soil moisture, is successful for cassava in Northwest Cambodia. Hence, planting cassava in May and June can be used as the basis for recommendations for alternative planting windows for reduction of crop failure and improvements to cassava production in the region.

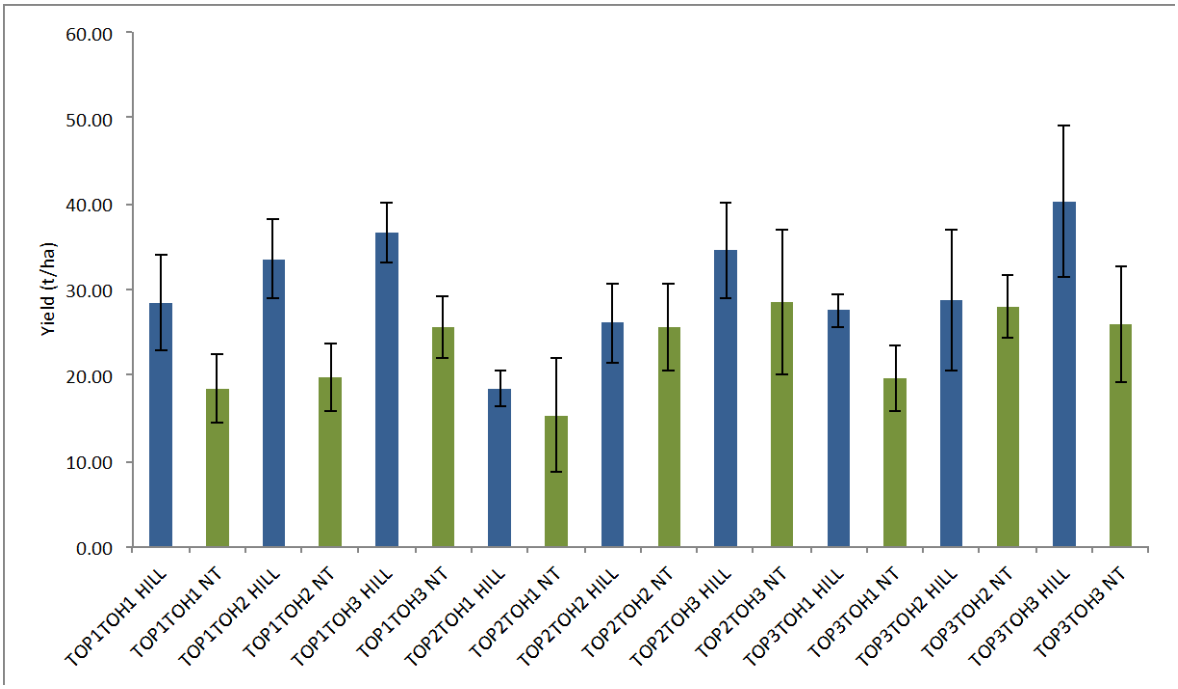
The same trend that emerged from the planting method trials was also evident at Samlout, where hilled up treatments tended to yield higher than no till methods. Furthermore, selection of good quality, healthy planting stakes is of critical importance to achieving high yields. Stakes for planting should be stored in the shed to avoid stem deterioration and loss of vigour before planting, and not kept for longer than one month. The absence of good quality stakes at Pailin in the final year meant the yield trend evident at Samlout was

reversed with April plantings yielding higher than June due to sub-optimal plant densities in June.

6.3.4 Time of Planting Time of Harvest (TOPTOH) trial, Samlout 2019-20

The experimental programme was adjusted in the 2019-20 in response to previous years results and the identification of further research required. The time of planting trial expanded to include also time of harvesting, which meant doubling the size of the original time of planting trial and increasing plot numbers from 24 to 72. Plot size was reduced in order to fit 72 plots in to the space which previously held 48 plots. The need to more accurately identify the optimal growing season length as well as time of planting was highlighted by farmers in the northwest increasingly cutting short the number of months their cassava crops are in the ground. The new trial design investigated whether 8, 10 or 12 months was the ideal length of time to grow cassava to optimise yield and market. These harvest dates were implemented for each of the 3 times of planting with the aim of establishing optimal planting and harvesting windows for the northwest region. Due to Covid delays, the 12 month harvest time was extended to be 13 months.

The three-way comparison of time of planting (TOP) x time of harvest (TOH) x planting method (conventional hill or no-till) did not produce significant interactions between factors ($P>0.05$; Fig. 7.1.11). However across all treatments, no-till yielded significantly lower (23 t/ha) than conventional hill planting method (30.5t t/ha; $P<0.05$); and TOH1 (21 t/ha) was significantly lower yielding than TOH3 (32 t/ha), however TOH2 (27 t/ha) was not different to either of them. Furthermore, the only interaction between planting method and harvest timing occurred with conventional hilled treatments at TOH2 and TOH3 yielding significantly higher than no-till at TOH1 ($P<0.05$). Analysis of starch subsamples failed to find any differences between treatments ($P>0.05$).



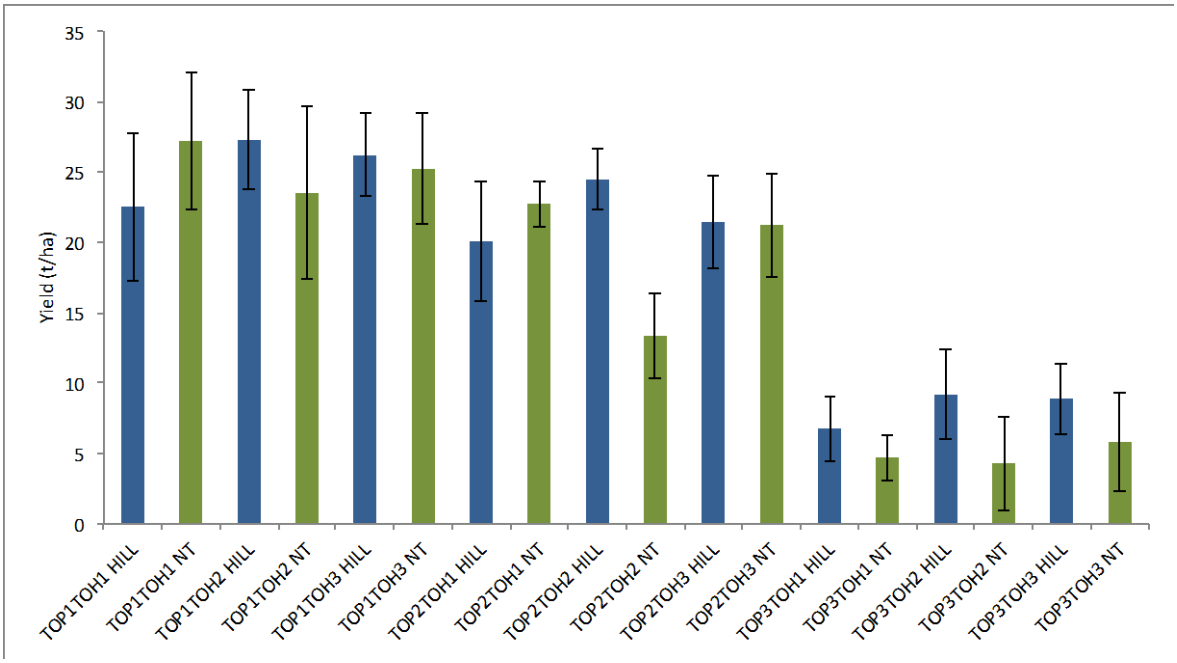
NB: TOP = Time of Planting - April, May, June; TOH = Time of Harvest – 8, 10, 13 months

Figure 7.1.11 The effect time of planting (TOP) and time of harvest (TOH) on cassava yield, Samlout 2019-20

6.3.5 Time of Planting Time of Harvest (TOPTOH) trial, Pailin 2019-20

This trial was the same design as for the Samlout experiment and they were planted and harvested on the same days. The three-way comparison of time of planting (TOP) x time of harvest (TOH) x planting method (conventional hill or no-till) did not produce significant interactions between factors ($P>0.05$; Fig. 7.1.12). In contrast to the same trial at Samlout,

across all treatments, there was no significant differences in yields between conventional hill (18.5t t/ha) and no-till planting methods (16.5 t/ha, P>0.05); and in this trial it was the TOP that demonstrated statistical differences not the TOH like at Samlout. Planting time 1 (April) yielded 25.3 t/ha which was significantly higher than TOP2 in May which produced 20.5 t/ha, which was also statistically different to TOP3, yielding only 6.6 t/ha from the June planting (P<0.05). As for yield, plant height also decreased with each progressive TOP (P<0.05). Starch subsamples were not a full data set due to the silo closing all starch testing facilities during TOPH3, so whilst analysis was conducted on the results, it was deemed to have too many missing values to be a rigorous dataset; hence results are not included in this report.



NB: TOP = Time of Planting - April, May, June; TOH = Time of Harvest – 8, 10, 13 months

Figure 7.1.12 The effect time of planting (TOP) and time of harvest (TOH) on cassava yield, Pailin 2019-20

Conclusions for all TOPTOH trials

This set of trials produced varying results at the two different sites, which has perhaps created more questions than answers. The trial was expanded from the original time of planting trials and thus there was only time to conduct it over one season. It is recommended to continue these trials for 2 more years to see if more definite results emerge. The Samlout site produced significant differences between the planting methods of no till and conventional hilled treatments, which follows the common trend from several of the time of planting and planting method trials conducted at the same sites. It appears that no till cassava is slower to establish and often suffers a yield penalty in this region.

The Samlout results also suggest that the trend of farmers harvesting earlier than previously is causing yield decline. This was illustrated by TOH1, which is eight months after planting and the new norm for Samlout farmers, yielding significantly lower than TOH3 (12 months), but not significantly different to TOH2 (10 months after planting and the usual harvest time). Whilst it would be ideal to have more years of data, this preview suggests that farmers should stick to harvesting 10 months after planting for the compromise between optimal yield and cropping intensity.

In contrast to this, the Pailin data did not show a difference between planting methods nor harvest times. However there was statistical significance between planting times. Some of these conflicting results may be due to the different soil types at each site and varying climatic conditions. It would be best to run further trials for more concrete results.

6.3.6 Plant density trials - all sites, all years

The aim of these trials was to determine the optimal plant populations for cassava in NW Cambodia to maximise yield. Altering plant densities per hectare is a simple agronomic practice, which can be easily implemented by farmers if found to have a significant impact on yield and profitability. Unfortunately, our plant density trials conducted at both sites for 3 years, did not draw firm conclusions on the optimal plant populations for cassava in labansiek and kompong siem soils. There was a trend of increasing yield with increasing plant population; however we were unable to confirm this statistically (Table 7.1.17). Several environmental facts impacted on yield confounding the results by a wide spread in the range of yields across the 4 replicates for each treatment.

Factors that impacted the yields included spray drift from the neighbouring field of maize in the first year at Samlout and variable stake quality in the second year of both trials. Drought in the early growth stages impacted the final year of the trial at Pailin; however Samlout produced the most rigorous results in the final year with a significant difference in yield between the lowest (5000 plants/ha) and the highest (15000 plants/ha) treatments ($P<0.05$). The 2018 year at Samlout also produced statistical differences between the lowest yielding 5000 plants and all other treatments ($P<0.05$). The only significant results to be produced at Pailin was in 2018 when the 15000 plants/ha treatment yielded 2-3 times higher than the 7500 and 5000 plants treatments ($P<0.05$).

Table 7.1.17 Yield results (t/ha) for cassava plant density trials, NW Cambodia 2017-2020

Plants/ha	5000	7500	10000	12500	15000
Samlout 2017-18	5.8	8.3	8.0	10.5	12.0
Samlout 2018-19	10.7[a]	11.6[b]	11.7[b]	17.1[b]	14.0[b]
Samlout 2019-20	20.4 [a]	27.5 [ab]	25.1 [ab]	24.9 [ab]	30.2 [b]
Pailin 2017-18	8.6	15.4	12.9	14.3	16.4
Pailin 2018-19	3.8 [a]	6.4 [a]	8.2 [ab]	10.4 [ab]	13.2 [b]
Pailin 2019-20	1.5	1.9	1.9	3.6	2.5

NB: no significant letters superscripted equates to no statistical differences in results of that trial

Conclusions

We believe that planting at 5000 plants/ha density is likely to be a constraint to production in most years and that it increases the risk of low yields especially if establishment is patchy. However, from these results we cannot confirm that there is any statistical difference from planting 7500 plant/ha and higher.

6.3.7 Intercropping cassava with legumes

The plant architecture of cassava is such that it provides very little ground cover and hence leaves the soil exposed to the weather. In NW Cambodia, the pre-dominant soil types are labansiek (red dermosol) and kompong siem (grey vertosol), which are well structured but highly friable soils, which are highly erosive on undulating topography when subjected to tropical rainfall. The objective of this trial was to determine if intercropping cassava with legumes would reduce soil degradation whilst simultaneously increasing yield and total profitability per hectare. Furthermore, we looked to investigate whether intercropping reduces the risk of total crop failure in smallholder farming systems.

Intercropping peanut and mungbean with cassava was not convincingly successful during the two year trial period. The high fertility soils (majority types for the region) resulted in high biomass production of the intercropped legume and the cassava lacked ability to compete with peanut and mungbean. Often cassava is grown in other areas and countries

on lower fertility, constrained soils which in turn produces less intercrop biomass, allowing the cassava to grow unchecked. In this scenario, the intercrop provides nutrient to the cassava, stimulating production of higher yields. This was not the case in the highly productive soils of NW Cambodia, where the intercrop hindered the yield potential of the cassava.

As a general trend the cassava monoculture treatments yielded higher than all other treatments. When results were analysed, statistical significances concluded that cassava only treatments at both populations yielded higher than all low intercrop treatments in 2017-18 ($P<0.05$, Table 7.1.18). This significant difference was expanded upon in 2018-19 to include both cassava monoculture treatments yielding higher than all treatments except mungbean at the high cassava population (Samlout, $P<0.05$); and at Pailin the high population of cassava monoculture yielded significantly higher than all intercrop treatments ($P<0.05$) but not different to cassava monoculture low population, which was not different to any of the treatments.

Table 7.1.18 Yield results (t/ha) for cassava intercropping trials, NW Cambodia 2017-2019

Treatment	Cass5	Cass10	CassMung5	CassMung10	CassPnut5	CassPnut10
Samlout1718	23.3^{bc}	27.7^{c}	10.3^{a}	17.1^{ac}	10.2^{a}	13.5^{ab}
Samlout1819	20.9^{c}	19.5^{bc}	10.7^{ab}	17.6^{bc}	6.9^{a}	8.0^{a}
Pailin1819	6.1^{ab}	9.5^{b}	1.0^{a}	1.7^{a}	1.7^{a}	2.3^{a}

NB: Pailin intercrop trial failed in 2017-18 and was not harvested

Conclusions

From these experiments, we conclude that on the high fertility soils of NW Cambodia, in the moderate to high rainfall zone, intercropping cassava with legumes such as mungbean or peanut is not a viable option to improve the productivity of the farming system. There is however the potential for a cover crop to be grown in between crops for soil amelioration and ground cover; however it may be difficult to achieve appropriate timing. It is recommended that future research look at such options.

6.4 Transition demonstrations

When the idea of the transition demonstrations to fruit tree orchards was initially discussed, the agronomy team made sure the social science team was fully aware and agreeable with the fact that there would be very little tangible results possible due to the short timeframe of the project and the lag time that it takes from planting to first fruit for these trees (minimum 3 years). The agronomy team needed to wait for the initial survey to be conducted and analysed to find out the farmer's priorities in term of what they wanted their farming system to look like. This would have worked well as the sites needed to grow one crop of cassava first, before the transition was implemented, in order to transition out of a farmer practice field that had been uniformly treated. The orchard planning required several months in order to design, mark out and source appropriate varieties and quality of trees, so the team had to decide by January 2018 (9 months into the project), in order to be ready to plant in the wet season that year (June), otherwise they would lose another year of production. The surveys were not fully analysed at that time but it was clear from the pilot that transition to fruit tree was the overwhelming response from farmers, so the team settled on that option.

The idea to have one rainfed site and one irrigated site initially came from the difficulty in finding two irrigated sites within our budget with high security water and a uniform area for the orchard and cassava trials. After exhausting the options for irrigated land and in trying to find a way to have two project sites (ensure access for farmers in each Province and mitigates crop risk failure through geographic diversification), the team realised that

actually having one rainfed site and one irrigated would better simulate the fruit tree scenarios that farmers in the region are implementing.

6.4.1 Pailin rainfed site

The Pailin orchard site is 1 ha of fairly uniform Kompong Siem (grey-black Vertosol) with a mean pH of 7.33 and situated on a slight slope, which at the end of the orchard slopes more steeply down into a creek bed. It is a good representation of topography in the region and is surrounded by some other farms in similar states of transition out of cassava and corn and into trees such as mango and cashew, which are also rainfed and on similar soil type. When the team took over the site, the soil had been ploughed after a corn crop and was exposed to downslope erosion during any rainfall event, due to the undulating nature of the terrain and the friable, fragile structure of the soil. Rill erosion was evident within the orchard area and quickly became deep gully erosion (>1 m deep in parts) just outside of the orchard boundary, where the slope was steeper leading down to the creek. This amount of rill and gully erosion is commonplace in the region due to the plough based farming practices on undulating topography.

Even though it would be logical to think that transitioning to semi-permanent tree plantings would lead to reduced erosion and better protection of the natural resource base, it is apparent that this is not the case. In fact, farmers continue to plough the interrow area between the trees and plant cash crops of cassava or corn, which don't assist in stabilising the soil surface and erosion issues continue to predominate. Whilst our demonstration sites couldn't produce fruit yields in the 2.5 year window from planting to end of the project, we were able to establish forage grasses in the interrow area, which effectively halted the erosion completely within 6 weeks of planting. This beneficial practice was shared with over 120 farmers at field walks held with farmers at both sites (November 2019). Out of all the farming system activities discussed and observed at the field days, farmers from Pailin were most engaged and passionate about the planting of forages in their orchard. This was a new concept for the majority of farmers present, but they were motivated to learn more about it and instigate on their own farms for the dual purpose reasons of extra income as cattle feed and reduction of soil loss every year.

From this point forward the idea of the demo site being a community managed forage site turned into a reality. The forage had been sown in June 2019 and 6 weeks later was ready for its first cut. It was difficult to source famers willing to cut the forage to a maintenance height and several fruit trees were whipper snippered due to the fast growth of the grasses during the wet season and lack of care from the labour. The farmers weren't so interested in the forage from July to October whilst there was a lot of roadside feed available from the rains, so it was difficult for the team to engage them in visiting the site of their own accord and cut and carrying forage home. They preferred to use roadside vegetation closer to their cattle. However, the coincidence of the field day and the start of the dry season, captured their interest and from that point forward up to 10 farmers would visit the site (some daily, some weekly) to cut and carry forage for their cows. This arrangement was mutually beneficial as the farmers received good quality feed for free and in one location which made cutting it fast; and it kept the forage under control so that casual labour was not required to maintain the forage over the dry season.

The impact of having a community managed forage site is that a number of farmers have gone on to plant their own forage areas on their farms after seeing, and being able to first test the forage from our sites with feeding their animals, before outlaying the expense of planting themselves. Our teams' technical guidance has also given them the confidence to establish their own fields. We conducted 4 farmer home visits to assist them with site selection and agronomic recommendations during their establishment phase. These key farmers were being keenly observed by other farmers in their respective villages, who said if they were successful they would also implement forages on their farms.

Meanwhile the mango trees continue to grow and if the team manages them well they should begin bearing fruit after 3 years of growth for the grafted varieties. This means that

if the demonstrations are continued as planned, fruit yields and other production components could be measured by the beginning of the follow-on ACIAR project.

6.4.2 Samlout irrigated site

The Samlout site was positioned on sloping land on a relatively even area of the most common soil type in the area, labansiek (ferrosol). This meant that the two demo sites were positioned one each on the two most common soil types in the Samlout/Pailin regions, labansiek and kompong siem soils. The comments above in relation to the Pailin results and discussion (7.2.1) are also applicable to the Samlout site, so won't be repeated here.

The Samlout site required more intensive management than the Pailin site, due to the water management needed, repairs and maintenance to the irrigation structures and fittings, continual high weed burden, and more intensive planting methods. The young seedlings especially the mangosteen suffered leaf burn when watered even though irrigation was usually done in the morning. To combat this we built shade cloth structures for each mangosteen and durian plant. All trees were well mulched with rice straw at the beginning of the dry season and again part way through when necessary.

Managing an irrigated site becomes quite challenging when a 3 hour round trip is involved just to travel to the site and back. We decided to try and engage the local farmers more. Just paying them to do casual labour on the site as needed was not achieving buy-in to the research or active engagement. So our Plan B was to contract hire a husband and wife team, Narrl and Srey Pean, to manage the irrigated demo fruit tree site and the forage intercrop. They lived approximately 3 km from the site, which was convenient for regular visits. We negotiated to pay them a monthly salary and that they would work autonomously to achieve all the outputs required per month, with a weekly visit from our team. They agreed and contracts were signed.

Despite having clear timelines for activities that needed to be done and constant communication between the project team and the farm staff, the outcomes were disappointing. Due to the late cutting of forage because they chose not to work over the holiday period, a dominoes effect of extra work required and damage sustained to the trees and irrigation structures ensued. The forage was growing rapidly with the rain and they were supposed to cut it once per month to maintain it at a reasonable height. However they didn't cut it before Pchum Ben holiday (10 days in September). The information the team received was that they had cut the forage in the mangosteen and durian area, but when the Field Research Leader arrived in the last week of September, only about 25 m x 25 m area had been cut. The remaining 0.7 ha consisted of forage over 2 m high in places as there had been a lot of rain. Promises were made to cut it asap.

On the 2nd October, the trees were due to be fertilised so we arrived at the site ready for action, but we couldn't apply any nutrients as they were still cutting the forage and hadn't weeded around the tree bases where the fertiliser was to be placed. Again they promised to finish asap and weed around the trees. Finally on our visit on 10th October the forage had all been cut and looked good (except for stylo area). Tree bases were still not weeded. Hence Steph and two other labour weeded and fertilised the mangosteen and durian survivors (some trees cut off by the whipper snipper) with 1 kg of prilled bat/seafood fertiliser. Srey Pean promised to finish the weeding that day so that the mango and longan trees could be fertilised.

Paying her and Narrl a monthly salary up front did not invoke the work ethic and loyalty we were hoping for. Unfortunately neither of them had any motivation to do the required work. Narll was chasing cash in Battambang building houses even though he was only paid on the days he worked (a lot of down time due to heavy rains); so Srey Pean sub-contracted out the work to other farm labour and then complained about losing money. It quickly became evident they lacked the capacity to maintain a household income budget and couldn't see the value of a guaranteed salary per month, which was a generous amount if

they kept on top of the work. Instead they delayed the work in favour of drinking or working in the building trade, and then the farm work became a large task due to high biomass forages and damage to irrigation.

The following journal log, from the Field Research Leader, outlines the work undertaken during the last 6 weeks of the irrigated site lease. All of this work was essentially borne out of the labours' decision to delay doing the original forage maintenance cut by one month.

16-17/10/19	Replanted in spots where trees had died which included 11 mangosteen and 11 durian. Srey Pean still hadn't finished the weeding. Common theme since paying her in salary, is that she would come to field with me for maximum 2 hours in the morning then find an excuse to leave and not come back.
	Narrl still hasn't fixed the irrigation and I need to water the new trees.
24/10/19	Planted mango varieties Akakoung and Keo Romeat. Fixed irrigation pipe, lines and sprinklers that had been cut by the whipper snipping. A snowball effect was created due to Srey Pean's apathy to hire labour to cut the grass and left it until the grass was 2 m tall. Consequently she lost 100,000 riel of her monthly salary due to the size of the job; labour couldn't see the pipe or sprinklers and damaged a significant number of them, which took 2 of us (Neil and I) 4 days to fix all the damage they caused
28/10/19	Continue to fix irrigation. Started it and watered durian and mangosteen for 3 hours and mango for 1 hour. Found the grass cutters had hacked through the submain line at Valve 2 (longan). Not possible to replace this so tried to patch it. Different hired labour was recutting the grass everywhere except the mango whilst it is still under control. Orchard looks good.
30/10/19	Fix irrigation sub main line and mulch durian and mango not done already. Farmer from the village came to ask if he could cut forage for his cows! He has 10 head and asked to come everyday. He will also cut from along our road and buffers. Community buy in!!!
31/10/19	Fix irrigation sub main line (cut out damaged pipe and heat fused it to main line, put bracket on) and mulch longan- got half way. Farmer from the village started cutting the forage. Srey Pean advised they would no longer work for salary and stop to work at the site from now.
4/11/19	Must have been rain yesterday so trees were all nice and moist but we irrigated the mangosteen/durian for approximately 1 hour anyhow. I cleaned out 3 blocked sprinkler heads and fixed spray angles. Finish mulching longan trees (for all used rice straw from Tahen). Tested irrigation but submain line leaking, did further repairs with silicon so can't test for 24 hours. Another sub-sub mainline cut but fixed that ok.
12/11/19	Found odd borer in tops of some mango trees. Submain still leaking so redid silicone, this time with the nozzle. Watered durian/ mangosteen 3 hours and weeded all; mango watered 1 hour.
19/11/19	leaking less but still too much. Also some longan nozzles blocked, tried to clean but didn't fix. Might have to replace. Field day on site today, attended by 40 farmers. Great engagement. Impressed with cassava trials and the tubers growing. Lots of discussion. Think our methods not practical as too expensive to use labour for hand weeding now and hard to find so have to spray (agree just explain we do that so as not to affect the trial with spray drift etc). Farmers very interested in the fruit tree management and forage production. Lots of questions, especially good interaction with Vannara (guest speaker – key farmer from Kantout Village) who spoke about the

	importance of rotation and having multiple crops in your farming system, not all eggs in one basket. Also PRR management and durian production.
26/11/19	fixed longan valve by putting in a new seal and fitting for the sub main hurdle. Now it only leaks a tiny bit and seems fine to work for now. Will keep an eye on it. Watered durian/mangosteens for 2 hours and longan for 1 hour. Pressure not enough to reach the top 4 rows of trees. Not sure why. Need to clean out filter in main head valve perhaps.

Earlier in November the Field Research Leader fielded the idea of handing over the Samlout orchard demo site early to the owners. There were several reasons for this, many of which stemmed from the issues in regards to water access, which has been a continual problem since the irrigation system was installed. The original contract made with the Commune Chief (land owner) was that our project would have full access to the pond for irrigation and also they would help us to pump water from the river into the dam using their equipment when required and we would pay for labour and diesel.

During the third week of November Steph re-contracted our original labour to do one more month irrigation and orchard maintenance at our site - even though they have proven to be very unreliable, the team were unable to contract anyone else in the vicinity. I asked Srey Pean to pump water from the river to the dam (which we then irrigate from) asap as the dam level was getting low and we can't afford not to have water to irrigate with. It was the dry season now and the soil was very dry at the site, so the trees need watering twice a week for durian and mangosteen and once per week for longan and mango. She promised to do this and stick to the irrigation schedule.

As usual she did not do as previously agreed and didn't pump water that day. However on Friday (22nd) and Sunday (24th) she did try to pump water, only to be refused access to the pump and the river by the owners (Ming). On November 27th, Sophanara met with Ming and Srey Pean at Samlout and tried to negotiate continuing access to Ming's pump, piping and the river. However, a resolution was not achieved, with Ming firmly stating her pump is too busy as she is irrigating every day her papaya, cucumber and longan. Even though we always pay for the use of the pump and we provide our own labour, she still did not agree.

She stated that she would allow us access to the river but we had to use our own pump, buy 200 m (or maybe more) worth of pipes and pay for the extra labour it will take to manage this system. However, this is not actually viable for us, as our current pump was bought to pump a short distance from the pond to the irrigated field; it does not have the capacity to pump long distances with the lift required from the steep descent to the river and up the neighbouring sloping field. Hence we would have had to buy another pump for this exercise. All in all, I estimated the costs to comply with Ming's new conditions to be in excess of $3000USD (could be more depending on the cost of increased horsepower engine) just for set up, not factoring in the extra labour costs this new irrigation method would incur.

The agronomy team didn’t consider this to be a sensible use of project funds when the lease on this land expired in only 4 months time. We felt it was unlikely that they would renew the lease for a further 6 months to the end of the project. This family are always difficult to deal with, and cost Phanara and Steph a lot of time just trying to implement fundamental project activities; yet this elevated the difficulties to a whole new level. In light of all of this and the other work commitments the team had within the project, a proposal was put forward to end the lease of the 1 ha orchard area immediately, and hand back the running of the orchard to the owners. The major reason being insuperable differences in regards to irrigation of the orchard. We only had enough water left in the dam to water 1-2 times more, which meant the decision needed to be finalised and actioned before the end of that week, otherwise trees would begin to die.

We proposed to hand back the orchard land without asking for a rebate on the lease, but instead requested to extend the lease on the cassava trial area (1 ha) a further 3 months for free, which enabled us to finish harvest of all trials in June. The orchard handover took place in early December 2019; due to a break down in water sharing relations we were no longer able to water the trees without spending several thousand dollars on new equipment, which was not deemed feasible with only 4 months remaining on the lease.

We had thought that we would be able to continue to observe how the owners embrace the new technology orchard, and the decisions they make over the next year of production. This was not the case however, as unfortunately, the owner did not continue to irrigate the land but rather removed our pump to use it in another location and allowed the durian, mangosteen and longan trees to die, only keeping the mango trees as a rainfed orchard. The forage was ploughed and cassava planted, with no ground cover on sloping land. It appears that after almost 4 years of collaboration, the owners adopted nothing from this transition demonstration and reverted straight back to their previous farming practices of ploughing on sloping land and leaving soil exposed with no ground cover, vulnerable to further erosion and land degradation. The owner is the Commune Chief, which does not bode well, as a key figure in the community not willing to test and implement more sustainable farming practices but rather continue habitual practices, destructive to the natural resource base and limited in profitability.

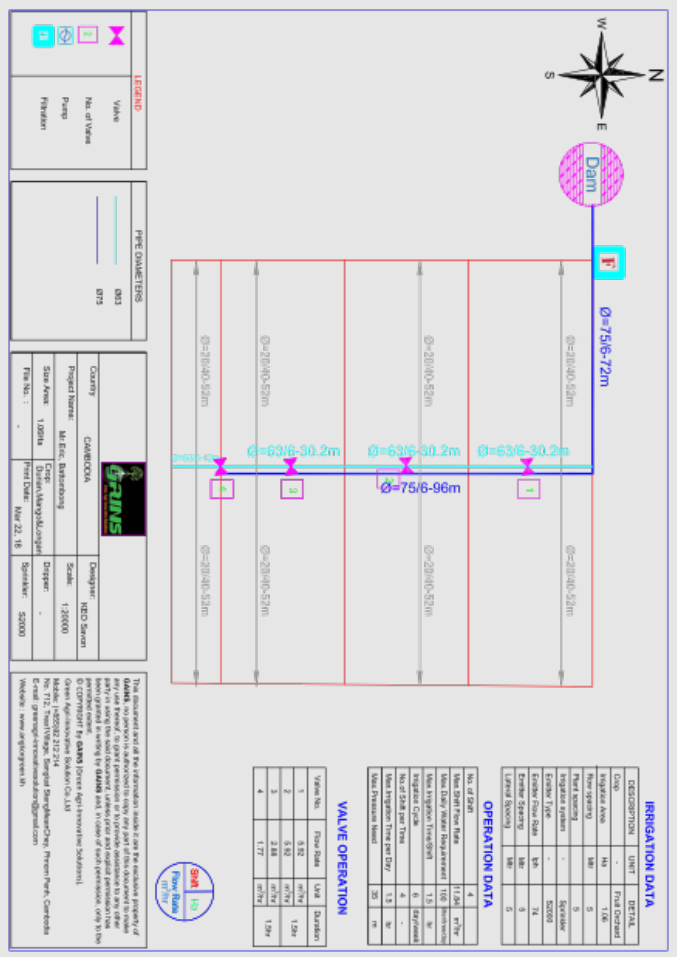


Figure 5.2.4 Irrigation layout and design for Samlout orchard (Source: Angkor Green)

Figure 5.2.5 Soil sediment runoff from the Samlout orchard site before planting of cover crops (left); Freshly planted young durian seedling surrounded by mungbean cover crop (right)

Figure 5.2.6. Young mango about to be planted amidst peanut intercrop (micro-spray irrigation droppers evident) left; irrigation head controller (right)

6.5 Objective 4: Measure adoption of agricultural technologies by farmers in Battambang and Pailin to explain why some groups adopt technologies and how organisations can align future efforts to improve adoption amongst different farmer sub-groups

6.5.1 Objective 4 Outputs Table

No.	Activity	Outputs/ milestones	Date Completed	What has been achieved?
4.1	Follow-up interviews with farmers from each of the villages, ensuring coverage across farmer types (i.e., small, medium, large, poor, and female-headed).	Conduct follow-up interviews alongside theatre production.		Engagements following productions completed; analysis is underway; follow-up engagements with participants to occur 12 months following theatre. Additional follow-up engagements undertaken with participants from the knowledge exchange, in order to measure and compare the impacts of the two impact pathways.
		Publication 5: The economics of cassava and alternatives for farmers in NW Cambodia (Farquharson & Rickards)		This publication has evolved away from pure economic analysis towards an analysis of 'Climate smart agriculture' as perceived and enacted by smallholder cassava farmers in Northwest Cambodia. The data is analysed and will be drafted and submitted in the second half of 2024.
		Publication 6: The perceptions and experiences of poor, marginalised, and female households in the context of agriculture in NW Cambodia. (Lamb & Milne)		"From Sapphires to Cassava: the politics of debt in Northwest Cambodia" (here).

		Publication 7: Measure whether PSP-based approach to extension-adoption improves adoption; measured using the speed of any adoption or partial adoption, amendments or adaptations to technologies, satisfaction with technologies, and the extent of adoption amongst different groups (small, medium, and large-scale farmers, poor marginalised, and female-headed households). (Cook & Milne)		A paper on the experiences of elderly women in cassava farming households was submitted for review at the Journal of Agriculture and Human Values.
		Report 7: Final full project report. (Cook)		To be completed and submitted to ACIAR in March of 2024.
4.2	Presentation in 13 villages (13 participating~~)~~ by Lakhon Komnit (LK)	Village performance on topics of: 1) pest and disease; 2) cassava production best practices; 3) debt and happiness; 4) transition to fruit tree production.		Completed. There is a video version of the theatre production (here) as well as a documentary that has been made in collaboration with Lakhon Komnit as a guide for researchers looking to partner with thinking theatres as part of research impact pathways (here).
4.3	Follow-up interviews with attendees of the village presentations	**Report on**: awareness, intention, practice change, and sharing with friends, family, and/or neighbours. Academic publication on village theatre presentations as a method for awareness raising.		Data collection for this publication completed in Q1 and Q2 of 2023, with interviews with participants from the Knowledge Exchange and with attendees of the Thinking Theatre. The interviews have now been translated, transcribed, and analysis has begun. A publication will be drafted and submitted in the second half of 2024. A report and analysis of the learning resulting from the theatre production is underway. An academic output will be drafted and submitted in Q3&4 of 2024.
4.4	Knowledge exchange (KE) with Provincial Departments of Agriculture	Run a knowledge exchange with Pailin Department of Agriculture and Battambang Department of Agriculture		To be completed in Q4 of 2024.

7 Key results and discussion

The aim of the project was to increase the adoption of agricultural technologies and best practices, focusing on smallholder cassava farmers in Northwest Cambodia. Adoption is entwined with agricultural extension, which has received extensive critique over recent decades. Despite these critiques, extension in Northwest Cambodia had remained (and continues) within a 'diffusion of innovations' (DoI) framing, requiring analysis, engagement, and exploration of alternatives. In order to establish a foundation on which our research could be based, we undertook a review of the agricultural extension discourse (see Cook et al. 2021). This highly-cited review established that agricultural extension, despite decades of critique, was 'booming' in terms of the number of publications and that it remained a salient topic for many researchers – though it has been abandoned by critical social scientists. With abandonment by segments of the social sciences, the review demonstrated that the existing discourse had come to render social and political considerations, which has had the effect of excluding the human factors recognized as critical to the success of extension and wider efforts to support on-farm practice change through adoption of agricultural (and other) technologies. The argument emerging from the review is that researchers who criticised historic agricultural extension have abandoned the term, leaving it in the hands of researchers who are unfamiliar, or openly antagonistic towards, inclusion of socio-political considerations. This situation, effectively, returns the field to its origins (i.e., DoI), resurfacing many of the classic challenges of attempting to support farmers while excluding the social, political, power, and economic factors that shape farmer decision-making. This publication establishes the basis for the remainder of the research outputs and impacts.

Activity 1: Determine farmer PSPs with reference to agricultural technologies and best practices

With establishment of the contemporary state of agricultural extension, the project began an effort to understand smallholder cassava farmers' lives and livelihoods. **Activity 1** engaged with smallholders using a variety of methods, including a quantitative household survey, a qualitative household interview, focus groups, and engagements with village leaders. These data have been integrated, coded, and analysed to inform subsequent activities (i.e., Activity 3 and 4) and to inform the publication of results.

Following the household survey a small portion of the research team undertook focus groups in two villages in Northwest Cambodia. Through group discussions, the topic of debt and village-scale power-relations emerged as central to an understanding of on-farm practices, especially the persistence of cassava production. The output (Gyorvary and Lamb 2021) exposes the impacts of debt on village governance, eroding the capacity of villagers to build the solidarity necessary to address problems arising from agrarian change. In simple terms, debt is an 'individualizing' force that limits social connectedness, care, and support, leaving smallholders in a precarious position and unable to do more than survive. The research highlighted the control of local elites – tying these power-relations to the Khmer Rouge and the residual impacts of the peace agreement that ended hostilities in 1991.

A follow-on analysis arising from Activity 1 data includes exploration of the experiences of elderly women (Cook et al. at JoAHV) in the participating villages. This output demonstrates how informal caring responsibilities continue to be excluded from consideration and that these ageing women are experiencing a mundane – and largely overlooked – form of dispossession. These women are shown to be extremely reliant on hired labour, which is becoming more scarce in rural villages in Northwest Cambodia; as a result, labour costs have 'squeezed' the already precarious livelihoods of ageing women, who have turned to sacrificing food and their assets (e.g., jewellery, land) as they gradually succumb to debt-driven agricultural production and highly variable returns on cassava production. In this analysis, in the shadows of cassava production-consumption

systems, ageing women describe the challenges of age-related loss of physical capabilities combined with, and amplified by, wider challenges associated with cassava production. The participants explain that pride at not wanting to ask for help, their gender for not wanting to add burden to their families, and a history of bearing hardship in silence all combine to exacerbate the everyday struggles of cassava farming. These women are losing autonomy and agency, which is described as the most distressing aspect of their experience with agrarian change (as opposed to 'losing' a very difficult livelihood, but one that was none-the-less within their control). The participants describe a natural erosion of capacity associated with progression of age, but one amplified and shrouded for ageing women in the context of cassava production.

Summarising the entirety of data from Activity 1 – and positioning these data in the context of the Sustainable Development Goals (SDGs) and SDG2 specifically – the research has attempted to explain the impediments to SDG2: analysing the decision-making that smallholder cassava farmers apply when they consider on-farm practice change (Cook et al. in review at SD), a process labelled 'prefiguring' by recent publications (see Henfrey et al. 2023). During analysis of the household interviews, a recurrent term arose when farmers described the appeal of cassava or the factors that guide their decision making: 'convenience'. This term in Khmer is '*ngeay sruol*', which translates directly to 'easy' but which our local team interpreted as a composite of 'convenient', 'practical', and 'possible' to describe the logic prefiguring smallholder decision-making. While the words 'Ngeay Sruol' were mentioned by more than 20% of participants, the underlying values were nearly universal, suggesting a communal framing across the participants. Importantly, 'convenience' is not a negative aspersion. It describes smallholder rationality, helping them to explain their decision-making as they seek sustainable livelihoods in the context of extreme precarity, uncertainty, and risk. Ngeay Sruol included reference to the time, attention, labour, and workload needed to produce different crops. 'Ngeay sruol' is the mindset shaping farmer decision making and uptake of agricultural technologies. It is in no way a reflection of laziness or unwillingness to alter their practices, but rather, exposes a composite of *low-input and low-cost decision-making guided by extreme risk-aversion*. Ngeay sruol is extremely rational while also being extremely incompatible with contemporary SDG2 efforts to increase production and productivity. While production and productivity have long been attacked as a top-down imposition, it remains central to SDG2, most notably Goal 2.3 which seeks "By 2030, double the agricultural productivity and incomes of small-scale food producers" and Goal 2.4 "By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production".

Research Question 1: What problems do farmers perceive, what do farmers think *should* be done, what do farmers think *can* be done by whom (i.e., farmer PSPs)?

- At its most simple, 'ngeay sruol' answers this question. Farmers understand their problem-solutions through a framing founded on a desire for *low-input and low-cost farming guided by extreme risk-aversion*. Critically, as demonstrated in the baseline survey and confirmed in the household interviews and focus groups, the farmers do not seek external aid or support to help them overcome their problems. For example, the final question of the baseline survey asked who has the power to make the preferred change. The vast majority of answers were variations on 'family'. While the categorisation of the data attempted to capture as much breadth as possible, 81% of respondents included one or more of 'myself, 'head of household', 'family', 'children', 'grandchildren', 'husband/wife', or 'parents'. Only 14% of respondents gave answers that included external actors or organisations.

Research Question 2: Which agricultural technologies do farmers identify as part of their PSPs and why?

- The farmers' accounts and perceptions differ from the framing of this research question as conceived by the research team. The data show that farmers are relatively indifferent

to the specific technologies and are more concerned with the risks associated with any transition and/or adoption of a new livelihood. By recounting how they came to farm cassava, farmers are shown to be extremely adaptive, trialling many alternatives while observing the attempts of neighbours and hearing from family members who are attempting and observing transitions elsewhere. Rather than 'laggards' or in need of education or awareness raising, these farmers are willing and able experimenters, connected through social networks that span the region. Farmers are not seeking technologies but systems/relations that allow prediction and a reasonable amount of reliability on which to found their livelihoods. In this light, farmers were explicit in that they would be willing to undertake almost any crop or practice if it could provide them with the predictability and consistent returns that they need for a sustainable livelihood.

- Despite this broader answer to RQ2, pest and disease management was a common challenge facing farmers. As such, good pest and disease (P&D) management technologies were widely welcomed, which led to the development of the knowledge exchange/farmer field school, P&D pamphlet, and theatre production on the topic.

Research Question 3: How and why do farmer PSPs differ with regard to sub-groupings (i.e., small, medium, large, poor, marginalised, and female-headed).

- The findings of the engagements with smallholders demonstrate that, at a general level, 'ngeay sruol' apply describes a shared perspective with regard to how farmers understand their problem-solutions and pathways for change. As an aside, even discussions with middle class and elite farmers demonstrated this view: with many explaining that the unpredictability of markets and environment made any investment in agriculture a high-risk decision. Farmers were still investing but all were limiting their levels of investment with the aim of reducing their exposure to compounding socio-economic-environmental variabilities. Broadly, the opportunity costs of cassava production were too high to warrant the investment in raised production and/or productivity, with most following 'ngeay sruol' combined with wage labour in urban regions.
- The output focusing on ageing women does confirm that sub-groupings of the data experience agrarian change and precarity in different ways. Specifically, the risks of agricultural livelihoods are amplified by caring responsibilities (i.e., for their grandchildren and for their parents), which in turn limits the time that they can spend on agriculture and, more generally, leads to expressions of extreme fatigue – possibly amplified by the poorest of these participants reporting regularly having to go without food.

Activity 2: Determine the feasibility of farmer-preferred PSPs, and the degree of alignment with existing and available agricultural technologies, using expert and village leaders opinion.

The focus group fieldwork (see Gyorvary and Lamb 2021) exposed a disconcerting amount of extreme bullying and exploitative relations within villages. While a certain level of such relations is to be expected, participants requested that their specific stories and descriptions not be used, describing extreme worry of possible repercussions. This presented the research team with concerns, not wanting to exacerbate or worsen the lives of participants. As such, in Variation 1, we reduced the planned levels of engagement with village leaders; we retained a basic – respectable – level of engagement in order to show appease the individuals with the power to deny access to villages, while also accepting that their accounts would likely be highly biased towards existing power-relations, which from the focus groups, are founded on dispossessive relations. Interviews with the village leaders were undertaken, but these data have been used, predominantly, to inform the research activities – as opposed to treating them as data within publications.

The village analysis identified the same four significant costs faced by households within their villages: family daily food consumption, health, agriculture production costs (chemicals, fertiliser, seeds), and children's education. These are relatively expected

opinions; importantly, they also confirm the rendering process explored in the review article, exhibiting a refusal to blame anyone other than individual farmers for the processes that impoverish smallholders. Village leaders identified farmer debt, economic poverty, and starvation, in some cases describing up to 70-90% of households in their villages as 'in debt'. The framing of debt was individualistic: with blame attributed to farmers' inability to repay micro-finance loans used to grow their crops. For some of the village leaders a further 'rendering of political processes is described' as debt is regarded as being due to the unpredictable fluctuations in market price of crops, whereby "the price changes every day. Sometimes two times a day." This more forgiving account, though, portrayed smallholders as unable to accurately predict how much they can safely borrow and therefore end up trapped in debt cycles. These accounts justify with the 'ngeay sruol' mindset as well as the findings from the baseline survey.

Continuing the individualized and 'self-reliant' framing, village leaders described the primary reason for smallholder hardship as crop failures (due to environmental and pest and disease) and to low market prices of crops at harvest combined with unpredictability. A key aspect of the village leaders' views is their inability to alter the economic relations in which smallholders are engaged. As such, the proposed 'solutions' are highly abstract and, often, impossible: a common response being intervention in stabilising or fixing crop prices. Greater stability and economic security is advanced as a way to reduce vulnerability to 'debt traps' and 'debt juggling' by increasing farmers' ability to plan around potential future income but, for these village leaders, there is no concrete plan or ability to do more than ask Government to act. Whereas the ageing women analysis uncovered the amplification of hardships experienced by females, the village leaders commonly described the impacts of gambling and alcohol as the basis for much hardship in the villages. For example, gambling is identified as an issue in Au Roel, while drinking is identified as an issue in Krochab, and both are identified as issues in Kompong Touk. These issues – or combined issue – are understood to lead to increased domestic violence and poverty. For the village leaders, problem gamblers and drinkers are often from the same households, which struggle with starvation and poverty, showing how various types of vulnerabilities intersect for these households.

As a result of the challenges of rural life in Cambodia's Northwest, the village leaders describe an exodus of younger residents in search of wage labour. While understood as a coping mechanism, and with recognition that farming is an extremely difficult livelihood, the large-scale removal of able-bodied residents is described as raising significant challenges for the villages. The leaders express concern that some poor residents are emigrating to Thailand and are there exploited. No leader provided insight into how these migrations might be addressed in a way that benefits both villagers and villages.

To summarise, the village leaders describe relatively uniform problems across the villages, though proposed solutions and actions to implement these solutions are predominantly abstract, vague, or 'wish-casting', reflective of the relative lack of capacity and resources available to these individuals. Solutions range from awareness campaigns, short-term food and monetary aid, to longer-term resilience-building by increasing farmers' abilities to grow crops and sell them at sustainable prices but with little discussion or substance in terms of implementation. When combined and contrasted with the baseline survey and household interviews, we reconfirm the *ngeay sruol* framing – a near-complete fixation on loss aversion and reducing risk exposure. As is discussed in reference to the research questions 4-7, smallholders' framing fundamentally contradicts the questions as originally conceived (i.e., improvement, success, alignment versus ngeay sruol).

Research Question 4: According to experts and village leaders, how feasible are farmer PSPs and why?

- In general, the findings demonstrate that the farmer PSP is ngeay sruol, which is a framing shared across all participants. Ngeay sruol, though, is more of a coping strategy for withstanding the forces of agrarian change and the risks that arise with cassava production, rather than a feasible, positive framing for improved livelihood.

In this regard, village leaders share the smallholders' PSP, but do not endorse or recommend the pathway because it does not align with an evident and endemic assumption that improved livelihoods result from improved production and productivity (note: there is a contradiction in this position (i.e., *Ngeay sruol* implies less investment while improved livelihood is assumed to result from improved on-farm practices through investment of resources). In this light, the contradiction is an accurate representation of the uncertainty and lack of options available to cassava farmers, especially smallholders, women, and those locked into debt-relations.

Research Question 5: Which technologies do experts and village leaders believe match farmer PSPs and why?

- See RQ4. In general, there is no single technology thought to satisfy farmers' needs and circumstances. That no 'silver bullet' exists is unsurprising. The village leaders do note the potential benefits of training and skill development, while also acknowledging that able bodied villagers are choosing to migrate in search of wage labour, leaving older farmers in the villages and growing general reliance on scarce labourers. It is worth asking whether skill development would facilitate an exodus of labour as the individuals may view themselves are more 'hireable'.
- Despite the lack of a consistent match perceived by village leaders, pest and disease management was regularly positioned as core to the negative relations that result in destitution: borrowing to invest in agriculture that fails (due to environmental, social, or economic variabilities) leaving smallholders in extreme desperation in which they sell their capital or begin 'debt juggling' between multiple micro-finance institutions (MFIs) or with local lenders). As such, pest and disease management was identified as an area where positive skill development could be provided in Activity 4, but also recognizing that there is no 'one size fits all' solution available to smallholder cassava farmers in the region.

Research Question 6: Which technologies do experts and village leaders believe are particularly suited to marginalised farmers, with specific attention to technologies designed to support female farmers and female-headed households?

- When developing the proposal, this question was emphasised by the internal review and was gladly included in the analysis. It is a critical question. Unfortunately, the findings indicate that nearly all smallholder cassava farmers are, relatively, marginalized and are subject to exploitative relations that are harmful to their economic and social wellbeing. To parse individuals in this group will distinguish levels of marginalisation, but as a group they are all very marginalized. The findings – especially the output on the experiences of ageing women – describe a group who are significantly harmed by their present livelihoods. In reflecting on the data and the accounts of the smallholders, the answer implied by the findings is: 'any technology that allows the smallholders to exit cassava production'. Unfortunately, like an addiction and those unable to escape toxic relations, the smallholder – especially the ageing women – are locked into debt, which locks them into cassava, which limits their options, which (likely) dooms them to ultimately sell their remaining capital over time. In the context of gambling, there is a saying that 'the house always wins' which describes the unequal odds that cassinos enjoy over time; the smallholders describe something similar to this situation, especially in terms of their frustration and despondence with appreciation that nothing they can do will enable escape. The village leaders recognize this imbalanced relationship but lack any ability to alter the system.

Research Question 7: How do experts and village leaders envision successful extension-adoption of agricultural technologies and best practices amongst different sub-groups of farmers?

- They don't. Summarising all sources of data – including the demonstration farms and our experiences farming alongside other farmers – there is a clear preference towards loss reduction. Within psychology, Kahneman and Tversky (1979) coined the term 'loss aversion' to describe the tendency of individuals to significantly prefer avoiding loss to securing gain. Across this research, it is estimated that loss aversion is roughly twice as powerful than the prospects of gain; this would mean that people are motivated to, roughly the same degree, by their desire not to lose $200 as they are by a desire to gain $100. This shorthand for risk-aversion within the agrarian change discourse is evident within all the data: the lives of the smallholders and their mindsets (i.e., ngeay sruol) do not seek success or improvement, but are a near-constant search for loss avoidance.

Activity 3: Demonstrate sustainable production of cassava using best practices and, in years 2 – 4, add demonstrations in response to farmer PSPs (Objective 1) using best practices and technologies identified by experts (Objective 2).

Activity 3 consisted of two sites of 2 ha each; 1 ha allocated to cassava agronomy trials and the other hectare for the transition demonstrations. The rationale for having two research sites was so that one site was located in each of the two districts (Pailin District and Samlout District) in which the project was working. Ideally, farmers from the 13 focus villages had access to a demonstration site in their district. Additionally, the sites needed to be large enough to investigate sustainable cassava agronomy options as well as farmer requested transition options and therefore required a high level of management and maintenance over the course of the project.

The original plan was to begin cassava demonstrations during the first year of the project, and to allow the social science research to identify farmer PSPs with the goal of understanding what the farmers would like to do with their land. The pilot research suggested that many of the farmers indicated a desire to transition from cassava to fruit tree production, so the team decided to implement demonstrations around this farming system shift. This finding was relatively expected, as it aligns with existing trends amongst more wealthy farmers, and is supported by anecdotal belief that such products will easily market to China, especially Durian.

Broadly, the findings are logical and expected, though the research team had to question whether 'we found what we expected'. As the survey data continued to be analysed, the planning and preparation for the demonstration farms to implement multiple transitions to fruit tree production was instigated.

In Pailin province, the trial site was conducted in Teuk Phos village for the first year in 2017-18, which was located approximately 15 km east of Pailin town and was 157 m above sea level (a.s.l.) with GPS co-ordinates of 12 53'38.12"N, 102 37'50.74"E (Fig. 5.1.1). In 2018-19 this trial site needed to be moved to Pich Kiri village, which is approximately 3 km away from the original site and was situated 149 m a.s.l. with GPS co-ordinates of 12 58'41.57"N, 102 39'52.63"E. It was necessary to conduct the second and third years of experiments at this alternative location due to the farm owner rescinding the leasing arrangements and ongoing theft problems at the original site.

The trial site in Battambang province was conducted in Kompong Touk village, Samlout District, at an elevation of 111 m a.s.l. with GPS location of 12 42'58.56"N 102 46'28.16"E. This site remained constant for the three year duration of the research trials. The land is owned by the Commune Chief, which along with its' proximity to the main road, was the main reason why it was chosen for our trial site. Land belonging to the Commune Chief is safer from theft than general farming land and as was proven in Pailin, theft from trial sites is often a problem for our projects.

This set of trials produced varying results at the two different sites, which has perhaps created more questions than answers. The trial was expanded from the original time of planting trials and thus there was only time to conduct it over one season. It is

recommended to continue these trials for 2 more years to see if more definite results emerge. The Samlout site produced significant differences between the planting methods of no till and conventional hilled treatments, which follows the common trend from several of the time of planting and planting method trials conducted at the same sites. It appears that no till cassava is slower to establish and often suffers a yield penalty in this region.

The Samlout results also suggest that the trend of farmers harvesting earlier than previously is causing yield decline. This was illustrated by TOH1, which is eight months after planting and the new norm for Samlout farmers, yielding significantly lower than TOH3 (12 months), but not significantly different to TOH2 (10 months after planting and the usual harvest time). Whilst it would be ideal to have more years of data, this preview suggests that farmers should stick to harvesting 10 months after planting for the compromise between optimal yield and cropping intensity.

In contrast to this, the Pailin data did not show a difference between planting methods nor harvest times. However there was statistical significance between planting times. Some of these conflicting results may be due to the different soil types at each site and varying climatic conditions. It would be best to run further trials for more concrete results.

We believe that planting at 5000 plants/ha density is likely to be a constraint to production in most years and that it increases the risk of low yields especially if establishment is patchy. However, from these results we cannot confirm that there is any statistical difference from planting 7500 plant/ha and higher (Phan et al. 2021).

We had thought that we would be able to continue to observe how the owners embrace the new technology orchard, and the decisions they make over the next year of production. This was not the case however, as unfortunately, the owner did not continue to irrigate the land but rather removed our pump to use it in another location and allowed the durian, mangosteen and longan trees to die, only keeping the mango trees as a rainfed orchard. The forage was ploughed and cassava planted, with no ground cover on sloping land. It appears that after almost 4 years of collaboration, the owners adopted nothing from this transition demonstration and reverted straight back to their previous farming practices of ploughing on sloping land and leaving soil exposed with no ground cover, vulnerable to further erosion and land degradation. The owner is the Commune Chief, which does not bode well, as a key figure in the community not willing to test and implement more sustainable farming practices but rather continue habitual practices, destructive to the natural resource base and limited in profitability.

Research Question 8: What are the costs and benefits of sustainable cassava production in Battambang and Pailin?

- It is unclear from the data that there is a sustainable model for cassava production in the area without access to irrigation, though such access would make the choice of cassava production foolish.

Research Question 9: What are the costs and benefits of transitions to other crops identified by farmers and trialled at the demonstration sites?

- As noted above, the cost/benefit calculations of the demonstration sites were contradictory and, seemingly, unpredictable. This aligns with the experiences described by farmers in the context of social-environmental-economic variability, with risk aversion suited to the context.
- Interestingly but anecdotally, the transition to fruit tree production continues at a rapid pace in the region, with diversification underway beyond mangoes. Despite this, the commune chief whose land was rented for the trials immediately ploughed and planted our demonstration site with cassava. A disappointing outcome for the agricultural team, it confirms that cassava remains powerful as a practice and that change – even with significant subsidy – does not guarantee the outcome that the agricultural team would prefer.

Activity 4: Measure adoption of agricultural technologies by farmers in Battambang and Pailin to explain why some groups adopt and to identify barriers specific to poor, marginalised, and female-headed households.

The final activity as proposed by the project was to measure the adoption of selected technologies, with attention to the differentiated uptake amongst different groups. This Activity undertook two pathways, both exploring pest and disease management (P&D). P&D was chosen due to: the prevalence of the issue with participants, with village leaders, and due to our efforts on the demonstration farm. The choice was reinforced because of the portrayal of P&D as one of the 'root causes' of the extreme precarity that all the smallholders described, and which the female farmers were especially vulnerable to because of their dependence on male labour to implement most P&D practices (i.e., spraying). P&D was also chosen because of its relatively straightforward solution pathway, and because of the project leader's acquaintance with Dr. Tin Aye, who is a world-leading cassava P&D expert working in the region.

The **first pathway** was a knowledge exchange (KE) designed to create a learning environment on the topic of P&D management. The approach borrows the farmer field school methodology (FFSs); the term FFS was not used due to past efforts in the area and associations with the approach. Efforts to support smallholders have recently evolved from traditional top-down, training and visit (T&V) approaches towards more participatory collaborations, with 'Farmer Field Schools' (FFS) key to farmer-centred efforts from the 1980s onwards. Recent reviews of FFSs have concluded that the emancipatory promise has fallen short of expectations, with some concluding that FFSs have become little more than T&V in disguise. In Northwest Cambodia, a learning-centred FFS – labelled a 'knowledge exchange to avoid the preconceptions now associated with FFSs – was implemented in partnership with two small groups of interested smallholders on the topic of pest and disease management for cassava. The research evaluated the impacts of these partnerships using Baird et al.'s (2014) learning typology and Truelove et al.'s (2014) development of spillover effects. This analytic is used to broaden conceptualization of impacts and to explain how impacts linked to the P&D partnerships diffuse through local relations.

In addition to substantial cognitive learning (i.e., the awareness of P&D best practices), participants describe normative learning (i.e., an alteration to their norms and values) that affected their worldviews and their on-farm pest and disease management. Through follow-up interviews more than 3 years following the FFS (this delay due to the need to wait for a farming cycle to pass and then extended because of Covid and international lockdowns), normative learning and on-farm practices were described as having affected relational learning (i.e., the building of relationships with non-participants) that reinforced normative learning (e.g., altered esteem, confidence, and gender relations), which spilled over into the behaviours of non-participants. While this small, learning-centred effort with motivated individuals warrants cautious reflection, the findings demonstrate the impacts of FFS that push past communications and awareness raising. Most importantly, the spillover effects associated with the FFSs suggest that substantial positive impacts may presently be going unmeasured, which may help to revitalize the FFS movement through demonstration of wide-ranging and wide-spreading impacts.

Qualitatively, evidence of normative learning was most pronounced and compelling as a result of the follow-up engagements – they demonstrates the impacts of the FFS most persuasively – though in complicated socio-human terms and explanations. As with FFSs, 'learning' is shown to be central to positive, lasting impacts on farmers, their households, and their social networks. Despite this clear finding, learning is not simply content/cognitive acquisition or recall. Instead, it is clear from the qualitative accounts that it is the normative learning that enables behaviour change and spillover effects to occur. Whether content is a necessary but insufficient component is unclear from this case study. What is evident is that cognitive learning combined with normative learning appears to facilitate behaviour change that spills over to affect non-participants (i.e., diffusion).

Accounts of this diffusion describe social interactions over time founded, primarily on observation of on-farm practices and outcomes, as the mechanism for enquiry, diffusion of learning, and (likely) uptake of practice change.

The findings demonstrate that transformational change of smallholder practices will require explicit focus on facilitating the conditions that enable normative learning, likely alongside cognitive learning on a topic of expressed need. Our assessment is that present stakeholder's fixation on the content of FFSs and the expertise of the facilitator distract from the group dynamics and principles of engagement needed for normative learning to occur. These findings are being written for an output in the latter half of 2024.

The **second pathway** involved a community engagement tour with Lakhon Komnit to visit the 13 participating to present a theatre play based on the findings from the research. The productions in 26 villages will focus on the key findings from the research. Following the productions, a team member interviewed any interested farmer or villager, collecting their perceptions and contact details to facilitate follow-up home visits to measure farmer perceptions, intentions to act, any practice change, and/or subsequent social network analysis of any diffusion to friends, family members, or neighbours[1]. Follow-up interviews and home-visits will be undertaken with farmers from each of the villages, ensuring coverage across farmer types (i.e., small, medium, large, male, poor, youths, and female-headed).

Research Question 10: Which technologies or aspects of technologies do farmers adopt and at what rate?

- The preliminary findings of the follow-up engagements with participants from the KE cannot not provide any statistical results due to the engagement being small-scale with 23 participants. The aim was to understand whether a 'humanized' approach top extension could generate learning and inform a 'learning-behaviour-spillover' theory of change (ToC). The engagements generated positive responses from participants related to the knowledge exchange five years following its delivery. Further, the follow-up engagements have provided interesting and meaningful insight into farmer experiences and the ways that participants of agricultural interventions navigate decisions about whether to adopt new technology. The analysis of these 23 interviews gives depth to questions in the literature which remain challenging to analyse such as to spillover effects (Galizzi et al., 2019) and the ways in which knowledge can be meaningfully adopted, measured, and employed to catalyse wider learning across social networks (Ensor & de Bruin, 2022). The clear linkages between Farmer A and Farmer B cohorts are evident despite the small sample size, suggesting general but clear indication of social learning occurring throughout the villages despite disruption to the project due to COVID-19 and the resulting long periods of no contact between researchers and participants. This sustained adoption may signify that meaningful collaboration to address participant concerns may confirm the ToC and provide a 'depth over breadth' approach to agricultural extension that can supplant existing, DoI-based methods.

[1] *These follow-up engagements are to take place one year following the productions, with transcription, translation, and analysis due to be completed by Q42024.*

Research Question 11: Why do different sub-groups of farmers adopt particular technologies or best practices, between villages and compared with villages that did not participate in the research?

- With regard to the KE, the data and sampling that extended beyond participants is unreliable, which resulted due to the extensive delays caused by Covid and lockdowns. The comparison is therefore impossible in a rigorous manner. For example, when 'tracing' a participant's social connections, our team was referred to people who had had no discussion about P&D, leading us to conclude that too much time had passed.
- In terms of the theatre production, we have undertaken initial engagements and will follow-up with those individuals in the second half of 2024 so that an entire growing cycle can have passed to enable any learning to be applied.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Sitting overtop of the research questions and guiding the FUAT project is recognition that a more social/humanized theory of change (ToC) is required for agrarian researchers to contribute to modern rural development in the context of rapid and, often, brutal agrarian change. A central scientific aim of the research, then, was to explore and test a more supportive model of engagement to determine whether such a methodology would be effective.

In this context, all of the engagements implemented by FUAT adapted form of 'active processing' developed by Broockman and Kalla (2016) in which participants are asked to actively consider the experiences of others. We hypothesise that reflection focused on identity and personal experience offers theory of change that is more likely to produce lasting adoption of on-farm technologies and practices; equally importantly, we hypothesise that behaviours resulting from this approach may spillover to non-participants and be reapplied in other contexts, thereby demonstrating a theory of change that is: 1) more socially informed and supportive to local circumstances and individual decision making, while also 2) providing diffusion pathways through which large scale impacts can arise without additional inputs from the research team (i.e., diffusion happens as a result of the meaningful nature of the engagement).

In order to conceptualize impacts, **Activity 4** analyses learning and behaviour change resulting from the KE and the theatre production. To do so, we adopted Baird et al.'s (2014) learning typology, which defines: cognitive learning as the acquisition of knowledge (i.e., awareness raising; change in what a participant knows), normative learning as changes in norms or values (i.e., change in mindset – meaning a change in attitudes and values; change in worldview – or a change in overarching conceptions of the world itself), and relational learning as changes in how interactions with others are understood (i.e., change in beliefs about how interactions with others matter) (Armitage et al., 2018; Baird et al., 2014). Broadly, this conceptualization represents the learning-behaviour-spillover ToC hypothesis, which is the foundational conceptualization of the NextGen Extension project ($4.5 project that has engaged with 3,200 households), is the ToC for Cook's research on flood risk adaptation in Melbourne ($1.8 million dollar project that has engaged with 2,000), is the ToC at the core of a $2.3 grant presently under review on heatwave and smoke risk in Australia, and informs ongoing research in collaboration with Surf Life Saving Australia on drowning prevention.

8.2 Capacity impacts – now and in 5 years

Partners for Rural Development

At the time of the project development and proposal (i.e., 2012-13), there was a complete absence of capacity in Northwest Cambodia in the context of social science and community engagement. While Non-Governmental Organizations (NGOs) have long operated in the area, these entities did not undertake engagements in ways that would allow for data collection and analysis. This posed significant challenges for conducting research in the area, with the need to draw on groups from Phnom Penh (e.g., CARDI) or elsewhere; this was sub-optimal due to the desire to have the research team be culturally and locally-expert.

At the time of project development, MJP (a local NGO funded by the Maddox Jolie-Pitt foundation) was dissolving. The original vision of the organization was to employ local people and to, gradually, devolve responsibility and ownership to the local team. At this time, the foundation was reticent of devolving power, leading to the departure of the NGO

in-country leader, who approached the project lead as part of an effort to create a locally-owned and locally-expert NGO who could work at the intersection of education, agriculture, and health – with a commitment to gender equity and a mission to provide rural and isolated women and girls with access to education and training to build secure and sustainable livelihoods. As a result, Partners for Rural Development (PRD) was created. It was agreed that the Uptake of farmer technologies project would be the first partner for PRD, allowing the NGO years of predictable funding, training, and opportunities to grown their enterprise.

As of 2024, PRD continues to operate in Northwest Cambodia, growing its operations and expanding the number of activities and partners with whom the NGO partners. There are now 10 partners who contribute to five main projects that cover themes of Education, Conservation, Agriculture, Gender Empowerment, and Health. PRD's activities remain focused on some of the most disadvantaged communities in Northwest Cambodia, continuing to work with 18 villages over this period – 13 of which were originally chosen as part of FUAT.

With the NextGen Extension project, PRD has diversified its roles, providing training and accounting/booking services for a much larger project (e.g., hiring, training, and overseeing 10 researchers).

Broadly, the FUAT project helped to establish PRD, which used this initial opportunity to develop its skillset and the services offered. It continues to operate to present, positively contributing to critical issues amongst some of the most marginalized communities in a highly marginalized part of SE Asia.

Five years into the future

At present, it is reasonable to envision continued operation of PRD for the next 5 years. They have demonstrated reliable, ethical, and transparent operations. They have nurtured their network of partners and continuously seek further funding. Furthermore, there remains limited capacity in the region for organisations focused on females and the marginalised, as well as a near-complete absence of organisations that can rigorously assess the impacts of their activities.

Sophanara Phan

As originally proposed, Activity 3 was an ambitious effort at transdisciplinary research. As is typical, agricultural science is an extremely expensive and labour intensive activity, which is normally supplemented with social science and/or 'comms' to diffuse or disseminate the findings. FUAT attempted to invert this approach, leading with a social science engagement project that would also undertake agricultural science in order to inform and create opportunities for synergies and understanding to cross the typical disciplinary divide.

The labour needed for the demonstration farms was extreme, requiring a significant proportion of the budget and demanding Montgomery's full attention despite her .5 position. To help with the labour needs, Sophanara Phan was seconded from the Pailin Department of Agriculture. He was employed full-time on the project, and given the responsibility of operations on both demonstration farms. Mr Sophanara Phan is Chief of Agronomy at the Agricultural Land Improvement Office, Department of Agriculture, Forestry and Fisheries, Pailin Province. He has extensive practical knowledge of rural development and implementing field research based on agricultural research priorities for upland farming systems. As a result of the project, Mr Phan has provided technical advice and co-ordinated monitoring and evaluation of project activities relating to enterprise development, household income, community development social welfare work and vocational skills. These skills have then been incorporated into his involvement in surveys, research studies, and training/market need assessment and the preparation of resource materials on elements of crop-cattle production systems including production of English/Khmer technical manuals, factsheets, and farmer flip charts for the FUAT project.

As part of his FUAT responsibilities, Sophanara was responsible for monitoring the sites, data collection, upkeep of methods, and oversight of the labour hired to weed and work on the farms. In this context, it was decided that Sophanara was, effectively, undertaking sufficient research to constitute a Masters degree, with the research team deciding that this would represent a good investment. Unfortunately, there was no budget for this degree – which would be undertaken at Suranaree University of Technology due to the expertise available. Fortunately, the cassava trails operated by the project produced sufficient surplus to cover the costs of the degree (the research team was unsure whether there would be profits from cassava production and had not allocated such funds in the original proposal).

Five years into the future

Sophanara is now seconded into the NextGen Extension project while also continuing his role with the Pailin Department of Agriculture (PDA). This ensures continuous collaboration with the Government of Cambodia and communication with individuals working in extension and uptake. Sophanara's role is ongoing, meaning that the training and skills developed as part of his involvement in FUAT will continue to influence practices in Pailin and Battambang for the foreseeable future.

8.3 Community impacts – now and in 5 years

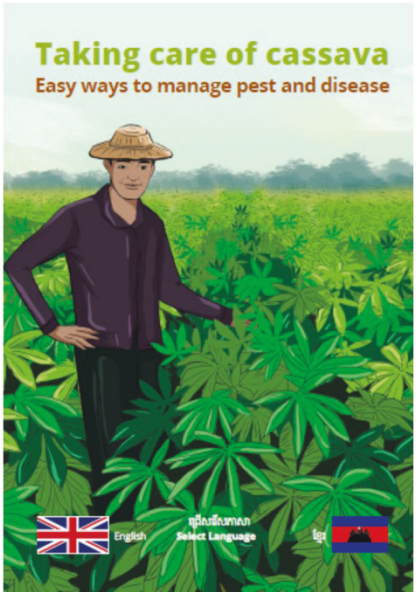
8.3.1 Economic impacts

The economic impacts of the FUAT project are extremely difficult to calculate and, given the time that passed during Covid and lockdowns, would be of dubious quality.

The use of the ToC developed in FUAT and applied in the NextGen project will allow for much more rigorous economic calculations to determine the value of the approach.

8.3.2 Social impacts

As part of the Knowledge Exchange (KE), the FUAT team hired a designer to help us produce a 'good practices' guide based on the P&D lesson and the learning that participants thought valuable. The pamphlet was produced in consultation with participants and has since been used as a way of 'closing the learning loop' in which the research team delivered a copy of the pamphlet when we undertook the follow-up engagements. This was a way to demonstrate that the project took farmer contributions seriously, that their voices were incorporated into the outputs, and that their suggestions were being shared well beyond their village.



The result was the "Taking Care of Cassava: Easy ways to manage pests and disease" as an interactive PDF in English and Khmer. The pamphlet has been downloaded several hundred times from the project website, as well as 200 copies being distributed in the participating villages as part of our efforts to reconnect with participants post-lockdowns.

Building on learning from development of the pamphlet – and to provide work for the Cambodian research team while locked down – Sophanara was made responsible for the development of tutorial videos. These videos were produced by the local team and uploaded to Youtube. The resulting playlist has resulted in more than 2,000 views. This effort has also provided the Cambodian team members (PRD and Sophanara) with video development skills.

8.3.3 Environmental impacts

In terms of environmental impacts, participants in the KE reported having altered their cassava production practices and 'spilled over' to non-participants, typically other villagers but also friends and family members through social media. These self-reported impacts are likely to be locally focused and difficult to associate with any wider environmental impacts.

8.4 Communication and dissemination activities

The primary communication and dissemination activities have been through the website, pamphlet, videos, and theatre production, which was viewed by more than 1,000 villagers, – as well as more traditional academic presentations and outputs.

9 Conclusions and recommendations

The most significant finding arising from FUAT is confirmation that the learning-behaviour-spillover ToC is evident and results in significant, lasting behaviour changes amongst participants, which spillover to non-participants. In broad terms, contemporary efforts to support farmers relies on 'comms' and other forms of one-way communication of information as the basis for 'up-scaling'; this project has demonstrated a proof-of-concept for a more humanized model of agricultural extension that results in learning and uptake, with preliminary indications of spillovers through social relations.

9.1 Conclusions

By exploring the circulation of learning arising from a knowledge exchange and theatre production, FUAT has trialled a model of engagement founded on support that may, if replicable at larger scale and more diverse types of extension activities, represent a viable alternative to 'DoI-like' methodologies. To date, this 'sharing' or 'circulating' has fixated on the content of 'what is circulating', whereas we focused on learning in order to explain 'why a participant would circulate something and whether that resulted in altered behaviours by a non-participant'. In this way the 'diffusion' element of DoI remains central while the 'of innovations' element is replaced by normative learning – that is, attention towards the feelings and socio-cultural context in which learning happens, the way(s) learning is nurtured, and whether this learning-based approach can generate the widespread change needed in the context of rapid agrarian change.

More specific to the findings, identification of ngeay sruol answers the majority of the research questions while tying to the wider development of the learning-behaviour-spillover ToC. At its most simple, the initial review of the extension discourse demonstrated a rendering of socio-political factors, reaffirming the long-standing argument that those human elements are critical-yet-overlooked aspects of understanding the uptake of agricultural technologies by smallholder farmers. Ngeay sruol adds depth to this position, explaining the decision-making that characterises smallholder cassava farmers. Ngeay sruol is a composition of the humanized considerations that shape uptake, with the KE and theatre production impacts demonstrating that impacts and change occur, but through the prism of ngeay sruol considerations. The loss and risk aversion that, undeniably, dominates smallholder decision-making contradicts prevailing understanding of extension-adoption, which presumes participants as maximisers and profit driven.

Ngeay sruol and the ToC uncovered with the engagement approach are already informing the NextGen research, which has the capacity, scale, and team to more rigorously expand the analysis of a humanized approach to agricultural extension.

9.2 Recommendations

In order to provide a balanced perspective on the FUAT project, there is need to reflect openly on the challenges and weaknesses of the project.

Funding for transdisciplinary research

- When the full scope of the research is considered, running two demonstration farms and having the full post-doctoral budget allocated to someone only involved in the agricultural research was necessary, but significantly limited the capacity for the collaborative research. When coupled with undertaking multiple rounds of 400 engagements using surveys and interviews, the data collection was overly-optimistic. The post-doc (Montgomery) was a .5 position and was immeasurably successful to be able to operate two demonstration farms with such a small operating budget, but this left too much of the project to the project leader.

Teaching and research leaders

- I am unsure whether ACIAR takes a position on teaching responsibilities and their grants, but there are many ARC grants (DECRA, Future Fellowships, Laureates) that demand teaching relief from the host university. ACIAR grants are often much larger than those of the ARC and I would encourage some teaching relief to be part of the in-kind contributions in the contracting. My own experience with a full load and large classes to teach is that my teaching consumed 5 months a year. In many cases, project operations would grind to a halt during my teaching term, with significant delays and waste associated with restarting things once the teaching term was over.

Pandemics

- I will not go into great detail, but the pandemic and lockdowns significantly affected this project, effectively removing 2 years in the middle of the project. This was not entirely due to the 'on-the-ground' situation, but also included the impacts on team members. The project lead was responsible for teaching and learning for their school, which resulted in burn-out post-lockdown. Alternately, members of the research team moved to other positions or simply lost capacity during this period, leaving much to the project lead. While the outputs and impacts will continue to be written and assessed, there were significant challenges that arose as a result of Covid.

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10.2 List of publications produced by project

Accepted

PHAN, S., SODCHOL, W. & MONTGOMERY, S. 2021. The effect of planting time on cassava yield and the risk of crop failure in Northwest Cambodia. Asian Journal of Agricultural and Environmental Safety, 1, 11.

GYORVARY, S. & LAMB, V. 2021. From Sapphires to Cassava: The Politics of Debt in Northwestern Cambodia. ACME: An International E-Journal for Critical Geographies, 20.

COOK, B. R., SATIZÁBAL, P. & CURNOW, J. 2021. Humanising agricultural extension: A review. *World Development,* 140**,** 105337.

In review

COOK, B., SATIZABAL, P., FINLAYSON, C. & TOUCH, V. In review. Ageing in debt: The struggles of elderly women cassava farmers in Northwest Cambodia. *Agriculture and human values*.

COOK, B., FINLAYSON, C., TOUCH, V., BANNAN, L.-A. & TRAN, T. A. In Review. Smallholder decision-making and SGD2: cassava smallholders and the search for 'ngeay sruol'. *Sustainable Development*.

For submission in Q3-4 2024

COOK, B., BANNAN, L.-A., FINLAYSON, C., TOUCH, V. & TRAN, T. A. Pest and disease management: the impacts and spillovers of knowledge co-production *The Journal of Agricultural Education and Extension*

COOK, B., BANNAN, L.-A., FINLAYSON, C., TOUCH, V., TRAN, T. A. & COOMBE, B. Thinking theatre productions and audience responses: the case of cassava disease management in Northwest Cambodia. People and Nature.

Non-peer reviewed outputs

Pamphlet: A pamphlet based on the knowledge exchange was produced to be used in future work with farmers.

Download the pamphlet "Taking Care of Cassava: Easy ways to manage pests and disease" as an interactive PDF in English and Khmer (6.1MB). *PLEASE NOTE: You will need to download and open the pamphlet in Adobe Acrobat (not in an Internet Browser) to be able to select your language.*

Videos: A series of videos was developed by Sophanara Phan, Chief of Agronomy, Pailin Department of Agriculture, Forestry and Fisheries which cover the 'key messages' developed through the knowledge exchange.

11 Appendixes

11.1 Appendix 1: