Developing value-chain linkages to improve smallholder cassava production in Southeast Asia

Paper presented to symposium on "Smallholder participation in global value chains: Implications for inclusive and sustainable agricultural development," at the International Tropical Agriculture Conference, Brisbane, 20-22 November 2017.

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Introduction

The recent boom in the global market for cassava has created livelihood opportunities for many smallholders in Southeast Asia. Research over many years by public agencies has generated an abundance of technologies that could enhance the productivity and sustainability of these cassava producers. While national government policies have not prioritised the dissemination of these technologies, we hypothesise that, in particular contexts, private-sector value-chain actors have incentives to invest in the promotion of suitable varieties, fertiliser regimes, pest control methods, and other production practices. In other contexts, however, there is little incentive for private-sector involvement, and support from public-sector or non-government actors will be required. In this paper we briefly analyse the drivers behind the recent boom and provide an overview of smallholder cassava production in the region. We then present a framework to analyse the incentives for private value-chain actors to invest in the promotion of different technologies, taking into account (1) the characteristics of the technology, (2) the nature of the production system, and (3) the features of the value chain, including the ability of value-chain actors to capture the benefits of any investment in technology dissemination. We test this framework through a preliminary analysis of three contrasting case studies: (1) a value chain centred on a large starch factory with a wide catchment area of smallholder suppliers in Dak Lak Province, Vietnam; (2) a cross-border value chain linking smallholders in Kratie Province, Cambodia, to starch factories in Vietnam; and (3) a local value chain for cassava as a food crop in Nusa Tenggara Timur Province, Indonesia.

Smallholder Cassava Production in Southeast Asia

The rapid spread of commercial cassava cultivation has been one of the major land-use changes in recent decades in the Southeast Asian region (De Koninck and Rousseau 2012, Lefroy 2014). Globally, cassava is the world's seventh most important food crop in terms of area planted, but is ranked third in the tropics. While traditionally a subsistence crop, cassava has become a very important cash crop in Southeast Asia in terms of smallholder income and rural livelihoods, with significant contributions to regional and national economies. The global trade in cassava products (starch and dried cassava) has increased substantially in recent years and is now valued at around USD 3.79 billion annually. Both production and consumption of traded cassava are concentrated in Asia, which accounts for over 95 per cent of global exports.

The market outlook for cassava remains strong, but is now coupled to the volatile energy market, with biofuel mandates changing regional market dynamics. This coupling has increased the connections to other commodity markets, notably for maize and sugarcane, where cassava is a substitute in both production (competing for land) and in a range of starch and feed commodity markets. Thus the future of the regional cassava market is heavily influenced by external factors, including agricultural policies for a wide range of commodities, especially Chinese policies impacting on the domestic maize sector. Unlike carbohydrates grown for direct consumption, cassava in Asia is a 'normal economic good' with a positive income elasticity of demand. As such, there has been a rapid increase in demand linked to the consumption of starch-based products (including sweeteners, paper and cardboard, and processed foods).

Vietnam currently grows over 500,000 ha of cassava, generating over USD 1 billion per year in export earnings, making it the world's second largest exporter of cassava products (starch and dried chips). Indonesia, on the other hand, cultivates over 1,000,000 ha of cassava but remains the second largest importer of cassava starch. Both countries feature several different agroecological zones with significant variations in climate, impacting on both production and marketing opportunities. However, there is now limited opportunity for further expansion in these countries, with the industry turning to Laos and Cambodia.

The area of cassava in Cambodia has increased by 15 times in the past 10 years. In Laos the increase has been more recent, with a five-fold increase in the past 5 years. Unlike in Vietnam and Indonesia, the current growth in Laos and Cambodia has been partly driven by domestic and foreign companies receiving concessions to establish processing facilities and estates, with smallholders delivering varying amounts of feedstock under different market linkages and/or contractual arrangements (Zola 2008, Wright 2009, Manoram, Hall et al. 2011).

The increase in demand for feedstock has also seen production move into more fragile landscapes, typically without the adoption of best management practices. This is leading to concern regarding the environmental impact of the cassava boom, particularly in Vietnam. Thus the Government of Vietnam is seeking to maintain or reduce the current production area, while investing in research and development efforts toward productivity gains. In Indonesia there is also a strong focus on increasing productivity. With cultivated area in decline in the traditional production zones in Java, expansion into new areas (including the eastern province of Nusa Tenggara Timor (NTT)) is considered possible but presents a range of trade-offs in terms of food security and environmental outcomes.

The cultivation of cassava offers a profitable livelihood activity for smallholders, provided it is managed sustainably and farmers are adequately linked to input and output markets and to appropriate technologies. Various on-farm technologies have been developed to address the issues facing the crop, including improved varieties for industrial end-uses, better soil fertility management, integrated pest management, intercropping systems, and clean-seed approaches. However, adoption has been very uneven. Understanding the incentives for and constraints to adoption is critical to developing a sustainable smallholder sector. Hence new impact pathways need to be explored, where feasible incorporating the private sector, to ensure research outputs lead to development outcomes and impacts. Developing improved value-chain linkages, nuanced to suit local conditions, has the potential to increase the adoption of cassava technologies and thereby enhance smallholder livelihoods.

Methodological Framework

Technologies that can increase the productivity and profitability of cassava smallholders have been available for a number of decades through research at CIAT and other research centres, institutes, and universities worldwide. Nevertheless, the process of translating these research results into widespread adoption by farmers has been far less successful (Röling 2009, Klerkx, van Mierlo et al. 2012). Many projects have demonstrated significant levels of adoption and positive impacts on livelihoods in intervention sites during the life of the project, but in most cases this is not sustainable after the project finishes. This has prompted a focus on planning the 'impact pathways' of agricultural research. For improved technology to be utilised sustainably by farmers requires careful consideration of who are the 'next users' of the research outputs and which actors have an incentive to promote the adoption of improved technology by 'end-users'.

Yet current thinking about impact pathways often lacks a nuanced understanding of the incentives for value-chain actors (including direct actors such as the private sector and indirect actors such as local governments and non-government organisations) to act as vehicles for transferring technology to farmers. In addition, while there has been some progress towards developing typologies of farm-households and of value-chain actors, there is still a lack of appreciation that not all value-chain actors will be interested in all technologies or have an incentive to transfer technologies to farmers.

The transfer-of-technology framework has been superseded in recent years by systemic approaches to 'research for development', including the Agricultural Knowledge and Information Systems (AKIS) approach (Engel 1995) and, more recently, the Agricultural Innovation Systems (AIS) approach (Hounkonnou, Kossou et al. 2012). These approaches view research, dissemination, and adoption as a joint effort between researchers, extension personnel, farmers, and other value-chain actors within an overall system, rather than simply a one-way transfer of technologies from public-sector researchers to farmers. Taking such a systemic approach, the interest of a particular value-chain actor in engaging with and disseminating innovations, and of farmers in adapting and utilising them, is hypothesised to depend on the characteristics of (1) the technology (Rogers 1995), (2) the production system, and (3) the value chain and the value-chain actor in question (Schut, Rodenburg et al. 2014).

In this paper we expand on existing adoption/diffusion frameworks (for example the Smallholder Adoption and Diffusion Outcome Prediction Tool (Brown, Nidumolu et al. 2016)) to incorporate features, not only of the technology and the production system, but of the value chain and value-chain actors. We use this expanded three-dimensional framework to examine the potential level of engagement of value-chain actors with the development and diffusion of smallholder cassava technologies.

Technology: The *intrinsic characteristics of the technology* include the learnability of the technology and the relative advantage of the technology. Key elements of the *learnability characteristics* include (1) the observability of the technology itself and/or of the results of using it; (2) the complexity of the technology; and (3) the ease of trialling the technology. These variables contribute to the potential scale of diffusion of a technology. For a given commodity, the learnability characteristics of a technology would remain relatively constant across different communities. The key variables for the *relative advantage* of a technology include the upfront cost, the degree of reversibility, the profitability of the technology now and in the future, the costs and benefits to the community and their timeframe, the associated risks, and the ease and convenience of applying the technology.

Production System: The *production system characteristics* that influence the potential scale of diffusion of a given technology and the engagement of value chain actors include (1) agronomic characteristics; (2) socio-economic characteristics; and (3) political characteristics.

Value-Chain: The potential scale of diffusion of a given technology is influenced by the *value-chain characteristics*. The scope of linkages between actors in the value chain, the presence of well-functioning external support services, and high levels of existing skills and knowledge among value chain actors lead to an increased level of cohesiveness of value chains and effective transmission of information. These combine with the level of awareness of innovations within the value chain and the learnability characteristics of the technology to affect the scale of its diffusion among farmers. The *incentive for a value-chain actor* to engage with the technology is influenced by the actor's profit orientation and risk orientation, the degree of competition faced, the scale of the enterprise, the management horizon, and any short-term constraints.

Using this three-dimensional framework for analysing engagement and diffusion through value chains will enable better targeting of support interventions. An analysis of the different characteristics can assist in decision making around which technologies have potential, which value-chain actors could be potential partners, and where investments could be made to enhance engagement, diffusion, and adoption.

This framework is used here to analyse the incentives for private value-chain actors to invest in the promotion of different technologies in three contrasting cassava value chains. These value chains have been chosen out of a total of seven (Table 1) that are the subject of research underway in two interrelated ACIAR-funded projects (ASEM/2014/053 - *Developing cassava production and marketing systems to enhance smallholder livelihoods in Cambodia and Laos* and AGB/2012/078 - *Developing value-chain linkages to improve smallholder cassava production systems in Vietnam and Indonesia*). These two projects are analysing the socio-economic conditions under which improved technology and market booms in commercial crops such as cassava can be harnessed to increase the profitability and sustainability of smallholder farming systems in Southeast Asia and thereby contribute to poverty reduction.

Table 1: Overview of Value Chains (ranked from most commercialised to least commercialised)

Value Chain	Study Location	Key Features
North Sumatra, Indonesia	Bandar Haluan Sub District, Hatonduhan Sub District and Dolok Panribuan Sub District, Simalungun Regency	Highly commercialised production system currently dominated by PT Bumi Sari Prima and a small number of other processors, each with a well-developed network of traders/agents.
Dak Lak, Vietnam	Krong Bong and Ea Kar Districts	Highly commercialised production system currently dominated by DAKFOCAM and including a small number of other processors. DAKFOCAM operates a well-developed network of traders and collectors and enjoys a near-monopoly position in the districts of Krong Bong and Ea Kar
Son La, Vietnam	Thuan Chau and Mai Son Districts	Value chain for starch processing and chip production relatively well developed and efficient. Starch factory has good links with multiple traders, but limited direct links with farmers.
Kratie, Cambodia	Prek Thaham village, Kbal Trach Village and Chror Va Koh Dach Village	Production linked to export markets in Vietnam. Well-developed network of collectors and traders selling through brokers to traders in Vietnam. Construction of a new starch factory in Kratie could have a positive influence on smallholder livelihoods.
Xayabouly, Lao PDR	Kenthao and Paklai districts	Production linked to export markets in Thailand and China. Local small scale processors and traders are active. Some production is undertaken on marginal land, which will likely not continue if cassava price remains low.
Bolikhamxay, Lao PDR	Bolikhan and Viengthong districts	Production linked to export markets in Vietnam and Thailand. Local processors may not have sustainable business models. Some production is undertaken on marginal land with relatively low yields.
Nusa Tenggara Timur, Indonesia	Nita Sub District, Mego Sub District and Waigete Sub District, Sikka Regency	Production of sweet varieties, largely for in-home consumption. Relatively few links to national or international starch markets.

Technology Characteristics

The available production technologies to support improved livelihoods for cassava smallholders fall into four major categories:

- **Improved varieties** specifically bred for desirable characteristics including increased root production, high starch content of roots, drought resistance, pest and disease resistance. Improved varieties of sweet cassava have been bred for desirable characteristics including increased root production and improved palatability. The adoption of new varieties and improved practices has markedly contributed to the increase in average yields of cassava in Southeast Asia from about 12 t/ha in 1984 to 21 t/ha in 2013 (Howeler and Aye 2014).
- **Fertility Management** including effective use of fertiliser to enhance production and profitability. Fertilisers are predominately inorganic, but treatments may include some use of manure. Balanced application of N, P, and K mineral fertilizers has increased root yields by 50 to 100 per cent in many areas and even more in very poor soils. The root starch content has also increased with the application of increased N, P, and K, but most markedly with additional K application.(Howeler and Aye 2014)
- **Soil Management** including intercropping and conservation agriculture techniques.
- **Pest and disease management** including methods for prevention and treatment. This can include biological control, "clean seed" protocols and control using pesticides.

Each of these major technology types has different learnability characteristics and relative advantage (Table 2). With the exception of some small differences, the learnability and relative advantage of each type of technology remains relatively constant across different countries and sites. As shown in Table 2, improved varieties and fertility management have relatively high learnability and relative advantage, while soil management and pest/disease management have longer timeframes to impact, less private benefits, and lower learnability.

Table 2: Learnability characteristics and relative advantage of main technology types

Technology	Learnability characteristics	Relative advantage
Improved varieties	Easy to trial given access to stakes Low complexity – little change in farm practices Observability high at each stage but main evaluation at harvest. Observing starch content more difficult	Upfront cost low; farmers subsequently use own stakes through vegetative propagation High reversibility Impacts realised from first year of use No community benefit Relatively low risk; may have higher susceptibility to some pests and diseases No change in level of convenience
Fertility management	Moderately easy to trial – however there is low awareness of NPK fertilisers and appropriate rates. Moderately complex – fertilizer application depends on type of fertilizer, timing, and location. Observability is good at different stages, but main evaluation at harvest. Observing starch content more difficult.	Moderate upfront costs. Relatively good rate of return. Immediate impact can be high; long-term impact unclear. No community benefits – potential negative environmental externalities. More exposure to risk. Less convenient than no fertility management.
Soil management	Difficult to trial as may be long lag between implementation and observable impacts. Complex – many options including intercropping, soil conservation techniques. Low observability until critical threshold reached.	High labour input in initial years. Some benefits in first year of intercropping. Other impacts have long time horizon. Positive community benefits. Less convenient that no soil management.
Pest and disease management	Difficult to trial due to externalities requiring collective action (e.g., cannot treat one field if surrounding fields not treated). Complexity can be high. Observability may be low as often difficult to connect pest/disease control with yield; no 'with' and 'without' cases to observe.	Moderate upfront cost. Uncertain private benefits in first year. High community benefits if community-based treatment undertaken.

Characteristics of Cassava Value Chains in Three Sites

Dak Lak Value Chain

Value chains for cassava starch and dry chips in Dak Lak Province are predominately oriented towards the export market, in particular, China. The majority of the 600,000 tons of fresh roots produced in Dak Lak are used by the five starch factories operating in the province. More than 260,000 tons of cassava are produced by smallholders on a total of over 11,000 ha in Ea Kar and Krong Bong Districts, and much of this production is destined for the two factories in these districts owned by the DAKFOCAM Company.

A stylized representation of the value chain map for cassava in Krong Bong is shown in Figure 1. Most of the 150,000 tons of cassava produced in the district are used by the DAKFOCAM starch factory in Dang Kang Commune, with a small proportion being utilized by household-scale and medium-scale dry-chip producers. In Ea Kar, most cassava production is utilized by the local DAKFOCAM factory, with only a small proportion of fresh roots used by small-scale chip producers. Poor farmers sell fresh roots to small traders while medium-scale farmers sell to small traders, larger traders, and directly to the starch factory. Better-off /larger-scale farmers are able to sell to large traders and also to sell products directly to the factory. Unlike the Krong Bong factory, the factory in Ea Kar does not enter into credit arrangements or have supply contracts with farmers or traders and buys on a spot market basis.

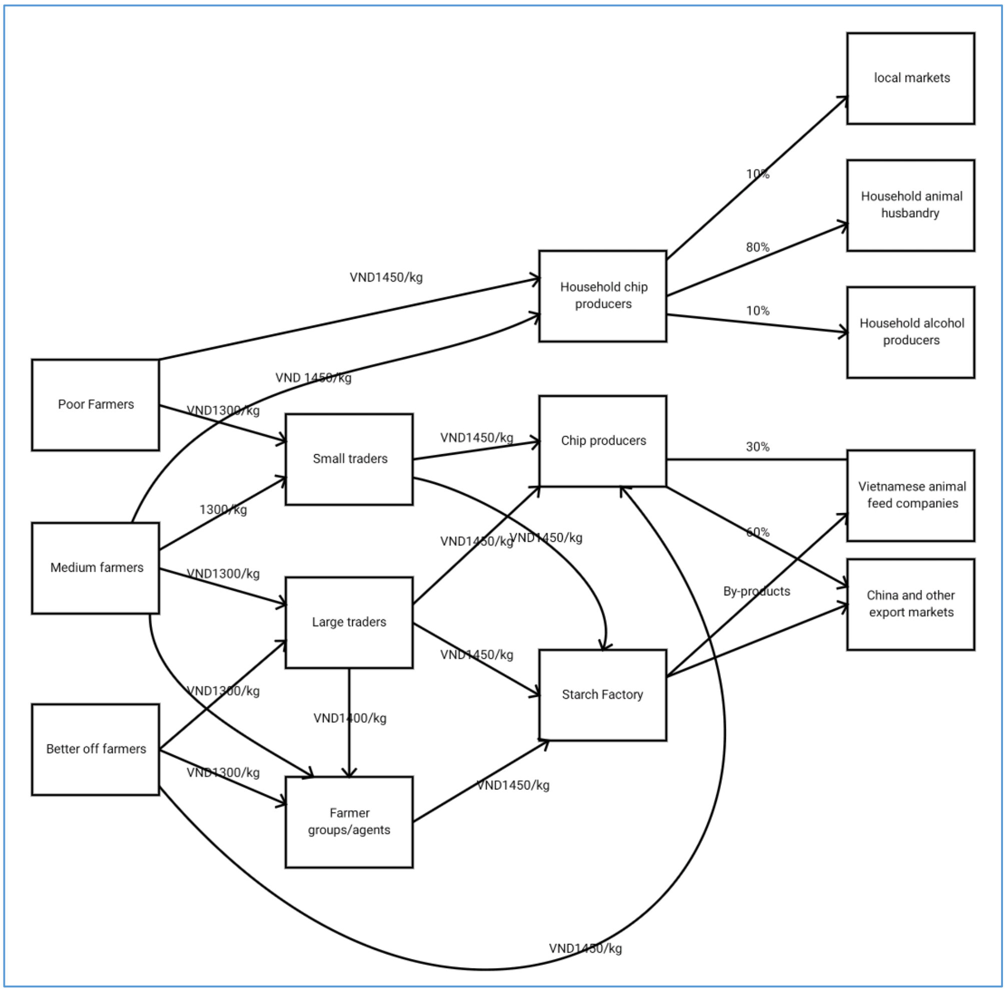

Figure 1: Value Chain Map Krong Bong District

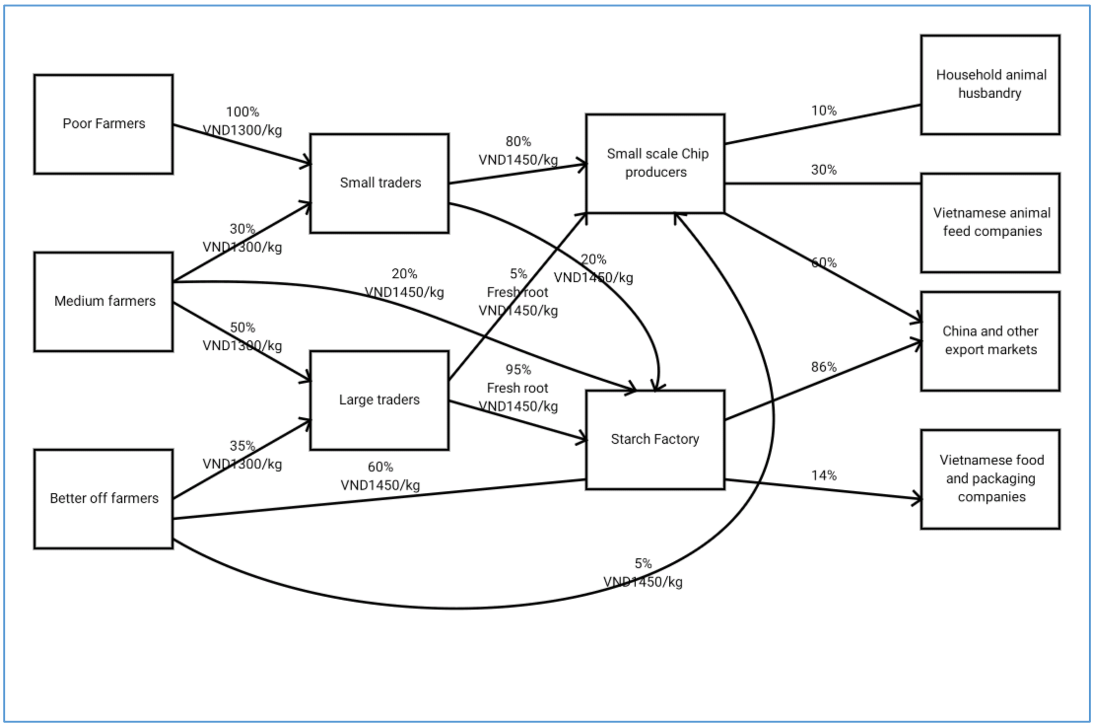

Figure 2: Value Chain Map Ea Kar District

Based on the analysis of the value chain, the framework leads us to predict that the main partner for the evaluation, introduction, and dissemination of improved cassava varieties in Dak Lak would be the DAKFOCAM Company through its factories in Ea Kar and Krong Bong. DAKFOCAM has an incentive to support farmers to increase the starch content of fresh roots supplied to the factory and to balance supply levels over a longer harvesting season. Interventions could make use of the existing linkages of DAKFOCAM with the small trader and farmer group networks in Ea Kar and through linkages with farmers taking credit from the Krong Bong factory. The large scale of the starch factories in Krong Bong and Ea Kar means that they occupy a dominant position in the value chain, with almost all cassava roots produced in the two districts being processed within their facilities. This means that DAKFOCAM has a significant incentive to invest in dissemination of improved varieties as any increase in production from technological improvement would lead to an increase in processing volumes in their factories.

The potential level of adoption of fertiliser is currently low due to the non-availability of appropriate formulations of fertiliser for cassava production. One of the key interventions for the adoption of fertiliser for cassava production will involve working together with fertiliser companies to develop appropriate formulations based on trial results. The framework predicts that the main partner for an intervention introducing more effective fertiliser treatments in the cassava value chain in Dak Lak would be the fertiliser production companies active in Dak Lak[1] and their associated networks of agricultural input supply shops. There is a significant profit incentive for fertiliser companies to promote the widespread dissemination and adoption of fertiliser for cassava production as less than

[1] Potential partners include the Binh Dien company, based in Ho Chi Minh City, but very active across the central highlands with a high market share (especially for fertilizer for coffee) - Công ty Cổ Phần Phân Bón Bình Điền (http://binhdien.com) . A local potential partner is the HUCO Tay Nguyen company, based in Buon Me Thuot (http://huco.com.vn).

half of cassava producers use adequate fertiliser. The linkages of fertiliser companies to farmers are strong due to their distribution networks through input supply shops down to the local level.

Kratie Value Chain

Given the proximity of Kratie Province to one of the major cassava-processing provinces in Vietnam (Tay Ninh), it is hardly surprising that export-oriented value chains predominate. The fresh cassava root value chain from Kratie is predominately oriented towards exports to processing factories in Tay Ninh, with only some small-scale starch processing undertaken near Memot (in neighbouring Tbong Khmum Province) which accounts for a very small proportion of the fresh roots from Kratie.

Small-scale farmers producing cassava in the relatively densely populated regions close to Kratie Town mostly sell fresh roots to large-scale traders through a network of agents operating at village level. The agents pay farmers upon delivery of fresh roots to small collection points inside the village and then organize for a large trader to collect the roots and transfer them to larger collection points or directly to the border.

In the less densely populated areas to the south-east of Kratie Town and in Snoul District, small-scale farmers sell cassava directly in their fields to small-scale collectors, who also supply labour to load cassava onto trucks. These smaller scale collectors then transport fresh roots to a network of collection points owned by large traders. The collection points are located along the major roads within the province, especially on Road 7 between Kratie and Snoul.

Larger-scale farmers generally transport fresh roots directly to the collection points using their own labour and transportation, or contract smaller traders to undertake loading, transport, and unloading at collection points. Under this arrangement, the small traders do not take ownership of the cassava. Large traders from both Kratie (including Kratie Town and Snoul District) and Memot town of Tbong Khmum Province are involved in the fresh cassava value chain from Kratie. They use 40-ton trucks to transport fresh roots from the collection points to the Vietnamese border at Chang Riec border gate.

The trade at the border is facilitated by brokers. These brokers operate in the ‘no-man’s land’ between the Cambodian and Vietnamese customs points. The brokers normally speak both Khmer and Vietnamese, and their function is to link Cambodian sellers and Vietnamese buyers. The brokers do not take ownership of the product but only facilitate an agreement between buyer and seller. Once such an agreement is reached, the Cambodian seller will come to Cambodian customs and pay the necessary fees and the Vietnamese buyer will do the same with Vietnamese customs. At the border, the fresh roots need to be offloaded from the Cambodian trucks and reloaded onto Vietnamese trucks.

Cassava roots are either purchased by Vietnamese traders who then transport and sell to factories within Tay Ninh, or directly by factories who maintain collection points and staff at the border gate. Transportation from the border to factories is generally undertaken utilizing 30-ton trucks. A representation of this value chain is shown in Figure 3.

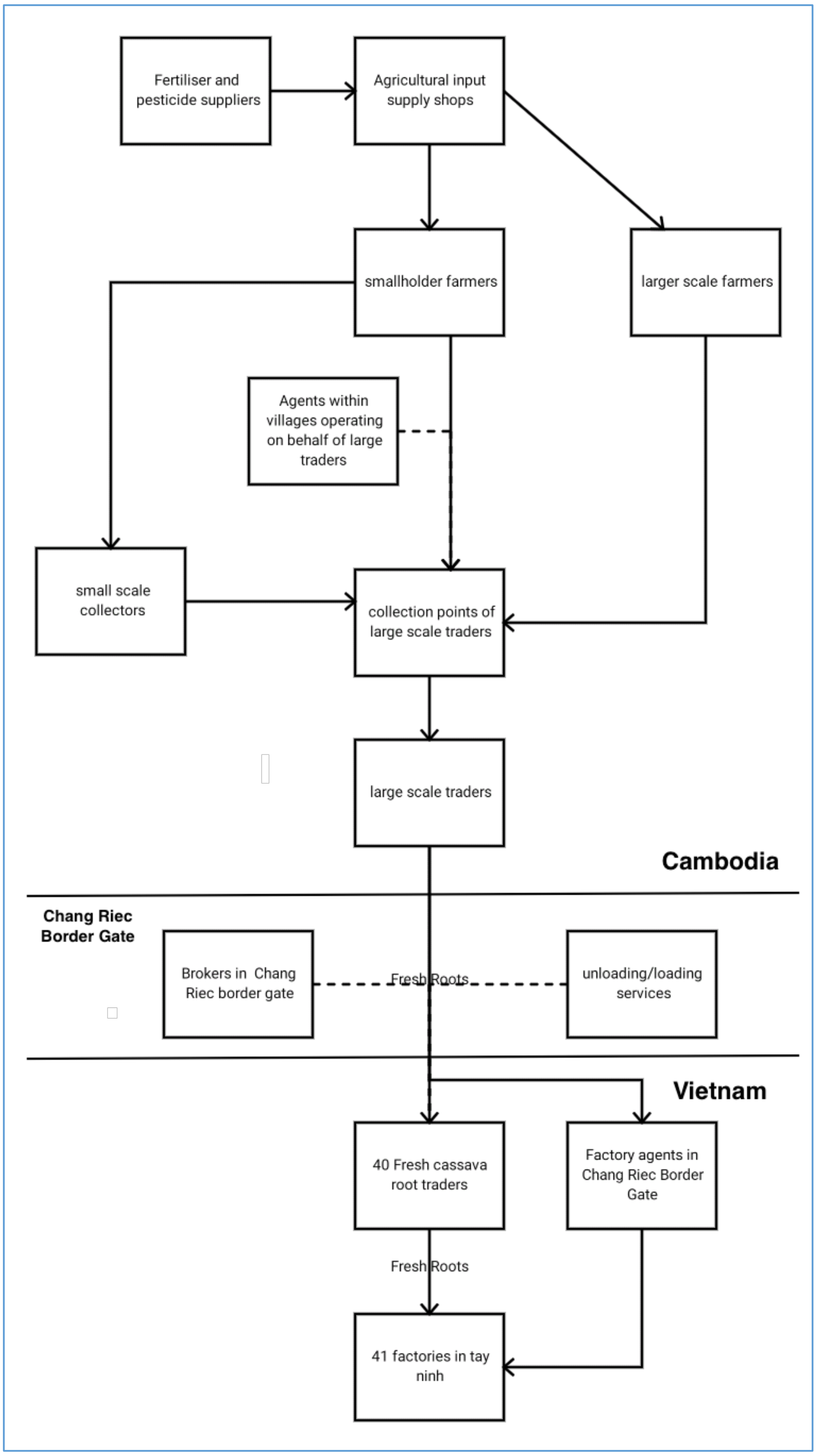

Figure 3: Representation of fresh cassava root value chain from Kratie province

With regard to the incentives for value-chain actors to be involved in technology dissemination, the large starch factories in Vietnam that are the final destination for cassava roots produced in Kratie have very little incentive to invest in disseminating higher-yielding varieties in Kratie as they have no direct relationship with Cambodian farmers, collectors, or traders due to the characteristics of the cross-border trade. On the other hand, medium-scale traders/collectors who collect the majority of cassava roots within Kratie have an incentive to disseminate higher-yielding varieties as they face little competition and could reap the benefits of increased production as a result of higher cassava yields. If a proposed new starch factory opens in Kratie then it may be a good focal point to work with, in addition to working with traders who currently export to Vietnam and will start to work with the new starch factory. The starch factory would have an incentive to develop strong relationships in order to secure supply of input material for new starch factory.

The main partner in the cassava value chain for an intervention to introduce more effective fertiliser application could be the fertiliser production companies active in Kratie and their associated networks of agricultural input supply shops. There is a significant profit incentive for fertiliser companies to promote the widespread dissemination and adoption of fertiliser for cassava production to increase fertiliser use from its currently low level. At present less than half of cassava producers in Kratie use any fertiliser. The potential linkages of fertiliser companies to future fertiliser users are strong due to their distribution networks through input supply shops down to the local level.

There is an urgent need to control cassava pests and diseases, which are widespread in Kratie. Witches Broom, mealybug, and Cassava Mosaic Virus have potential to cause serious damage to the cassava crop, with a major impact on smallholder livelihoods. The private incentive to control pests and diseases is relatively low, due to the presence of significant externalities – treating one field is not effective if other farmers do not also treat their fields. There is thus a case for the involvement of the many donor and NGO programs working on cassava and livelihoods in the province to support the efforts to control pests and diseases in order to ensure smallholder livelihoods and food security.

Nusa Tenggara Timur Value Chain

The sweet cassava value chain accounts for at least 90-95 per cent of the cassava produced in Sikka Regency in Nusa Tenggara Timur – a reflection of the place of cassava as a staple food crop for much of the population. A small amount of bitter cassava is produced in the coastal plain close to Maumere as an input to small-scale processing of modified cassava flour (MOCAF) and *tiwul*, a local food. This bitter cassava value chain is likely to remain small in the absence of further investments in MOCAF and *tiwul* processing or the construction of a starch processing factory.

The value chain for sweet cassava that currently exists in Sikka can be classified as closed and self-sufficient. Cassava production is predominately undertaken within mixed farming systems in the mountainous sub-districts in the south, east, and west of the regency (above ~300 masl) by smallholders with around 1 ha per household. The households undertake a wide variety of activities to support their livelihoods, including production and fermentation of cacao, production of cashew, coconuts, maize, peanuts, cloves, candlenuts, and livestock-rearing, including goats and pigs. Cassava is grown both for consumption and sale in local markets – both direct to consumers and to traders. Rice is increasing in importance as a staple food, especially among younger people, implying that an increasing proportion of cassava is being marketed by farmers in order to get money to buy rice.

Much of the cassava produced in the hilly zone stays in the hilly zone. Based on farmer focus groups and key informant interviews, we estimate that 25 per cent of production is consumed within the cassava farming household for food and a further 5 per cent is used by the household for feeding livestock and producing *gaplek* (dried cassava). In addition, a further 30 per cent of production is sold to rural consumers, either directly by farmers in local markets or through traders in local markets. In all, around 60 per cent of the production is utilized within the hilly rural areas, with approximately 40 per cent being traded into the coastal, more urban zones, in particular into Maumere.

The main customers for fresh cassava roots in the urban markets are households. An estimated 35 per cent of production is accounted for by this channel. The remaining 5 per cent is sold as inputs to the small-scale processing industry for crackers (*kripik*) and cookies that is operating predominately in Maumere and adjacent districts (Figure 4).

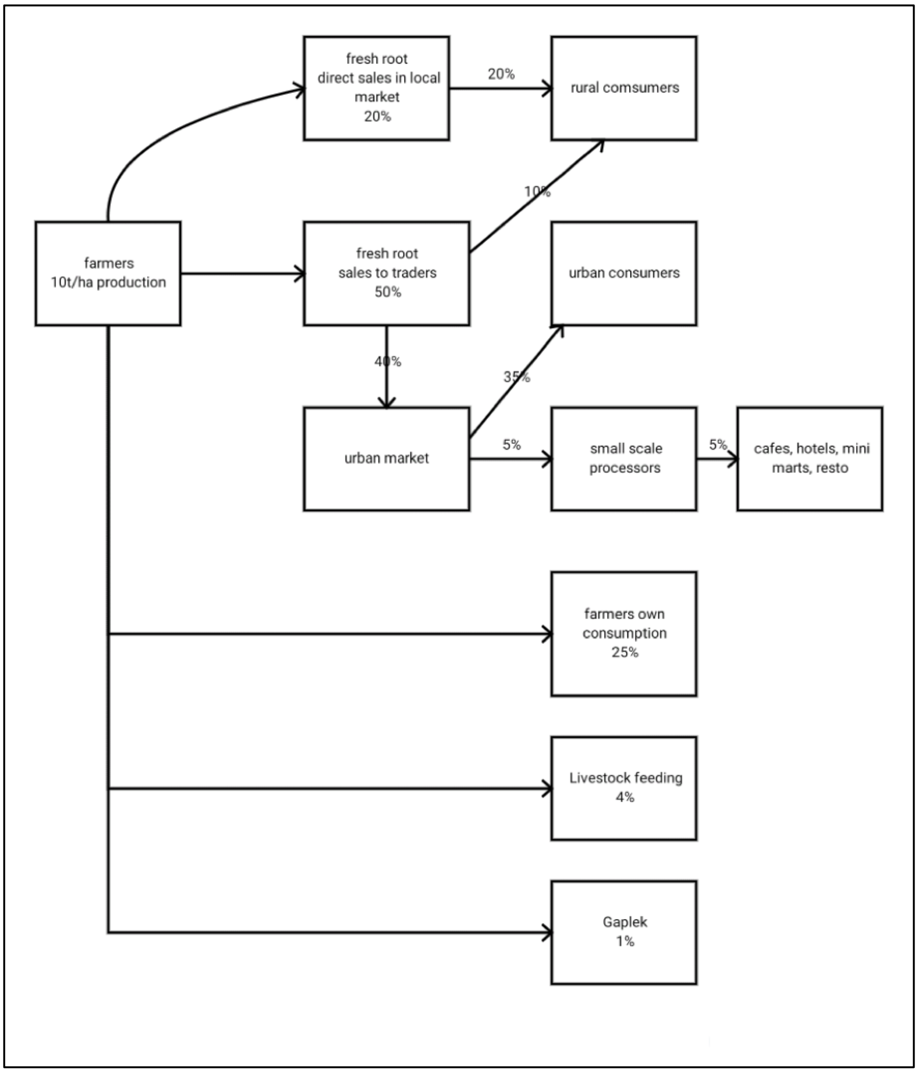

Figure 4: Sweet Cassava Value Chain, Nusa Tenggara Timur

At least three types of trader in the urban markets can be identified: (1) Farmer/traders take their own produce and produce procured from other farmers at the farm-gate or in rural markets and bring to urban marketplaces for sale. These traders often bring a variety of products for sale, including fresh cassava roots, taro, chayote, and sweet potatoes, and stay 2 or 3 days until all products are sold. (2) Multiple-market traders operate in more than one market, depending on the day of the week. For example, traders would buy products in a rural market and then bring to Pasar Alok (the major market in Maumere) for sale on Tuesday (the main market day) and also buy products in Pasar Alok to bring to the rural market for sale. (3) Fixed market vendors buy products from farmer/traders and multiple-market traders and sell them in a fixed stall at the urban marketplace. Within the value chain, the first two types of trader are the most mobile and connected actors.

The processing sector is extremely small in terms of the volume of production, the number of actors involved, and the scale of individual actors. Processed products made from cassava in these micro-industries include *kripik* (fried cassava crisps), *tiwul*, modified cassava flour, and cookies/cakes. At present, none of these industries exceeds the scale of 10 tons of fresh cassava root input per year and it is unlikely that the processing sector as a whole absorbs any more than 50- 60 tons of fresh cassava roots per year.

The predominant form of relationship in the value chain appears to be spot or ad-hoc relationships – farmers sell cassava when they need cash and likely do not generally cultivate long-term or contractual relationships with the consumers or traders to whom they sell. At the other end of the value chain, processors also indicate that they will buy from multiple traders in the market and generally do not form long-term or contractual relationships with their suppliers.

In terms of developing a more commercialized, industrial cassava production system with higher yielding bitter varieties, it is not realistic or desirable to develop such a system within the existing upland production systems. The current systems provide a diversified source of livelihood for upland farmers and help to minimize risk and increase the sustainability of production. Other interventions would potentially have much more significant positive impact for upland farmers – for example, some introduction of higher-yielding sweet cassava varieties, pre-emptive control of mealybug, and a step-by-step process of replacing the older (15-20 years), less-productive cashew and cacao trees.

However, there is a public-good case to intervene for the control of mealybug, which is in evidence in many fields. If mealybug becomes more widespread in Nusa Tenggara Timur, it has the potential to devastate the cassava crop and have a serious impact on smallholder livelihoods and food security. The private incentive to control mealybug is relatively low, due to the presence of significant externalities (treating one field is not useful if other farmers do not also treat). In the absence of a sizable private sector in the cassava industry in Sikka, there is a case for the involvement of local government and local and international NGOs, all of whom have a strong incentive to control pests and diseases to benefit smallholder livelihoods and food security in the uplands of Nusa Tenggara Timur.

In this case, therefore, rather than relying on a private-sector partner, an appropriate partner for project interventions may well be a local or international NGO with a focus on sustainable livelihood improvements. Local and international NGOs have a strong incentive to promote higher-yielding sweet varieties of cassava as it is a key component of smallholder livelihoods and food security in the uplands of Nusa Tenggara Timur.

Conclusions

A flexible approach needs to be taken when proposing linking with private sector to achieve development results. While the private sector is undoubtedly an engine of growth and a vital partner in development efforts (DFAT 2014), the methodology of linking with the private sector needs to be tailor-made to match the situation and incentives of the private value-chain actor as influenced by the complex interrelationship between technology characteristics, production system characteristics, and value-chain characteristics. We have identified the potential for cassava processors to be involved in disseminating improved varieties to smallholders in their catchment area in Dak Lak, Vietnam, and for farm input suppliers to promote the use of more balanced fertilisers by smallholders in Kratie, Cambodia. However, it is also important to note that there are many situations and development challenges where technology, production systems, and value-chain characteristics combine to make the private sector an inappropriate partner for technology diffusion, such as in Sikka, Indonesia. In these instances, it may be more appropriate to rely on the 'traditional' methods of delivering improved technologies, through government-to-government support or linking with local or international NGOs.

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