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Developing value-chain linkages to improve smallholder cassava production systems in Vietnam and Indonesia

Mid Term Review Summary Report
Dak Lak

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Australian Government
Australian Centre for International Agricultural Research

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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Country Information

Production Statistics

Cassava production in Vietnam increased from around 350,000 tons in 2001 to almost 1.1 million tons in 2016. During the same period, cultivated area roughly doubled, from 292,000 hectares in 2001 to 570,000 hectares in 2016. The significant increase in yield over the same time period is due to the introduction of high-yielding varieties in the early 2000s.

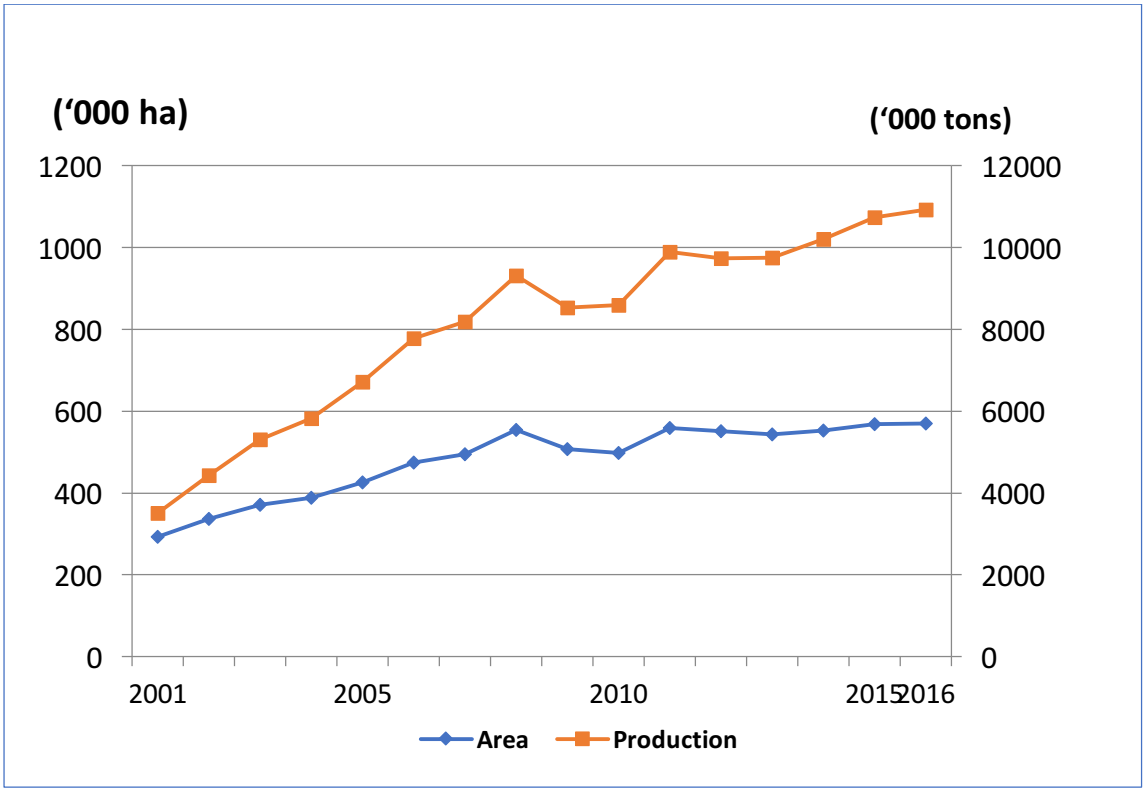

Figure 1: Cassava Cultivated Area and Production in Vietnam 2001-2016

The main cassava producing regions in Vietnam are shown in Table 1. North Central Coast has the highest total production level, but the highest yield among the regions is in South East, at almost 26 tons per hectare.

Table 1: Cassava planted area and production, by region, Vietnam (2016)

Region	Planted Area (ha)	Production (t)
Northern Mountains	117,000	1,485,500
North Central Coast	174,000	3,027,500
Central highlands	149,500	2,542,000
South East	96,000	2,485,000

Processing Statistics

In 2014, there were 94 cassava starch processing factories, producing a total of 2.2 - 2.3 million tons of starch per year. Tay Ninh province alone has 41 starch factories. There 6

ethanol processing plants in the country, but only 3 (Tung Lam, Dai Viet, Nhiên liệu sinh học miền trung) are currently operating. These 3 factories are operating at 50-60 percent of capacity, using 130,000 tons of cassava chips per year.

Trade Statistics

Vietnam exports both fresh roots and starch with a total export value of more than USD1 billion per year. The main market for both starch and chips is China, accounting for more than 85 percent of exports. The remainder is mostly destined for other markets in Asia, including Taiwan, Philippines, Malaysia and Indonesia.

Project Activity Locations

Project activities in Vietnam are being undertaken in two provinces. As shown in Table 2, Son La and Dak Lak both have significant areas of cassava production, and the combined production of the two provinces account for around 10 percent of Vietnam's total cassava production. Differences in agroclimatic conditions, ethnic groupings, value chain linkage levels and the level of commercialization mean that the two provinces have sufficient contrasts to allow very interesting comparisons to be made between value chains in differing locations.

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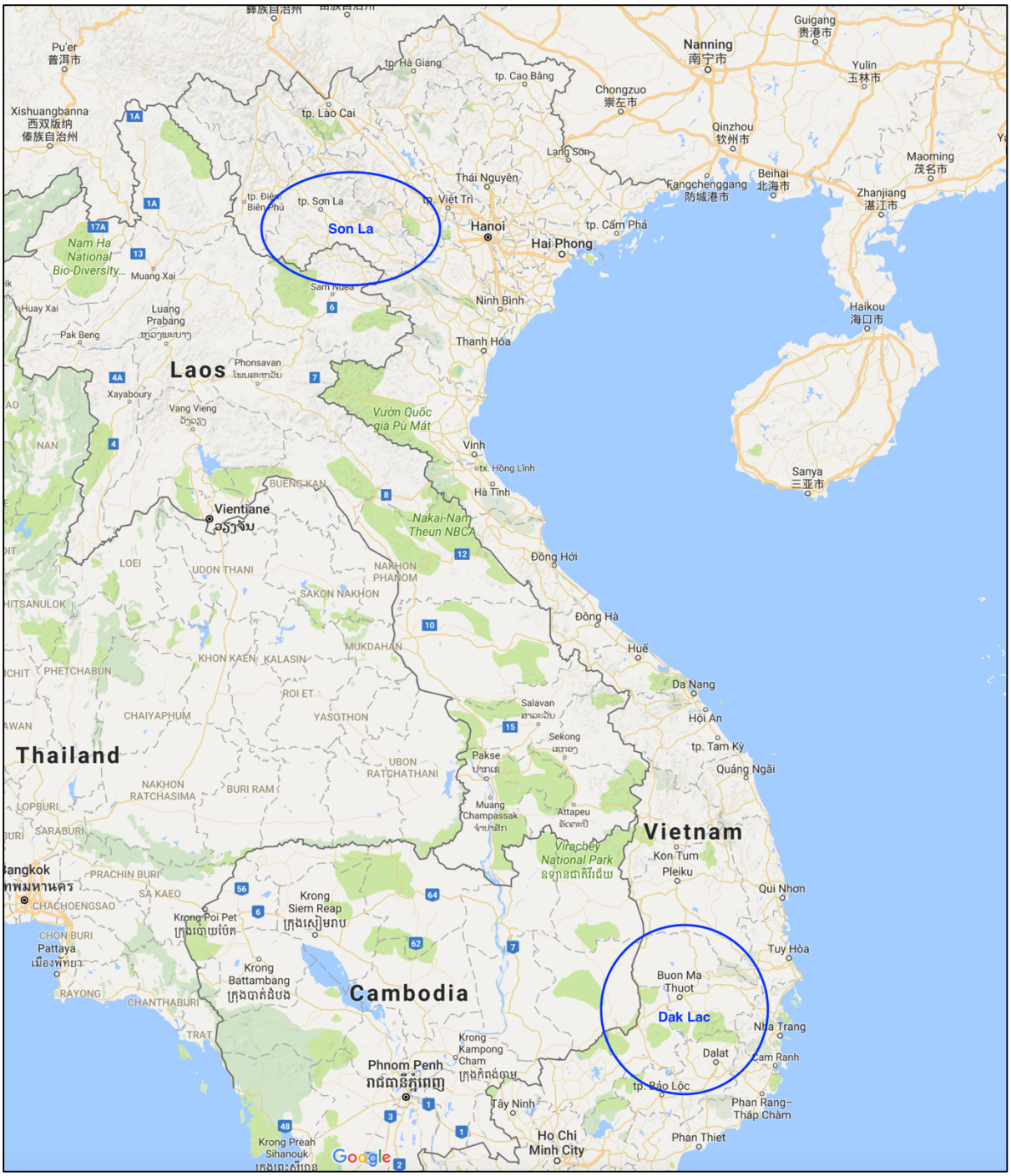

Figure 2: Research Locations, Vietnam

Table 2: Characteristics of cassava production by site, Vietnam (2013)

Province	Area of cassava (ha)	Average fresh yield (t/ha)	Annual Production (t)	Main industries	Number of factories
Dak Lak	25,720	18.4	473,248	Starch, Ethanol Dry chips (industrial)	5 starch 1 ethanol (Dak Nong)
Son La	31,216	11.5	359,485	Starch Dry chips (industrial)	1 starch

Province Information

Production Statistics

Production of cassava in Dak Lak has increased from around 50,000 tons in 2000 to more than 700,000 tons in 2015. Production increases over this period have been almost entirely driven by expansion in the planted area, with yield per hectare remaining relatively static between 2001 and 2015.

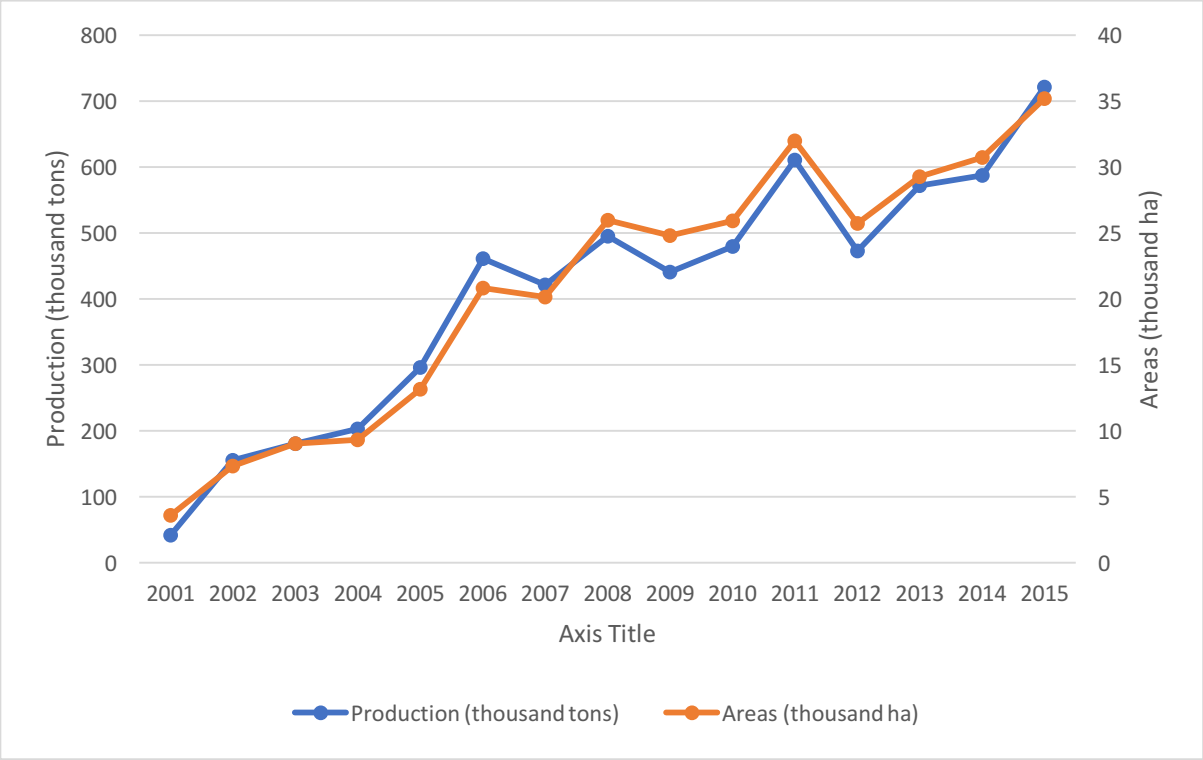

Figure 3: Production and Area of Cassava 2001-2015, Daklak

The project is operating in Krong Bong and Ea Kar districts of Dak Lak, which have the largest (Krong Bong) and third largest (Ea Kar) cassava production and planted area in Dak Lak. Ea Kar has the second highest yield per hectare amongst the districts in Dak Lak.

Table 3: Cassava area, yield and production by district in Daklak (2015)

District	Cassava Area (ha)	Yield (t/ha)	Annual Production (t)
Buon Ma Thuot	725	18.25	13,238
Ea H'leo	4,374	17.61	77,025
Ea Sup	4,729	19.16	90,608
Krong Nang	550	12.44	6,839
Krong Buk	827	8.37	6,918
Buon Don	1,840	11.53	21,217
Cu M'Gar	785	30.00	23,550

Eakar	**5,215**	**24.5**	**127,768**
M'Drak	6,149	23.51	144,580
KrongPak	962	24.97	24,015
Krong Bong	**6,932**	**21.42**	**148,500**
Krong Ana	508	14.06	7,148
Lak	1,411	18.56	26,183
Cu Kuin	120	20.00	2,396
Buon Ho	63	11.92	756
Daklak province	**35,190**	**20.48**	**720,741**

Source: Daklak Official Statistical Book

Processing Statistics

The Krong Bong starch factory purchases about 120,000 tons of fresh roots per year including around 10,000 tons from traders from Phu Yen Province, 30,000 tons from traders in Ea Sup and Buon Don districts and 80,000 tons from farmers in Krong Bong District. Around 40,000 tons of the fresh root from Krong Bong is purchased from 750 farmers in nearby communes who the factory has credit arrangements with. The factory supplies cassava varieties and fertilizer to the farmers and farmers repay at harvest time, either with cash or with cassava. The credit arrangements for not include a fixed price arrangement.

All of the sales of starch and by-products from the Krong Bong factory are handled through the main office of DAKFOCAM and are destined almost entirely for China (Figure 4).

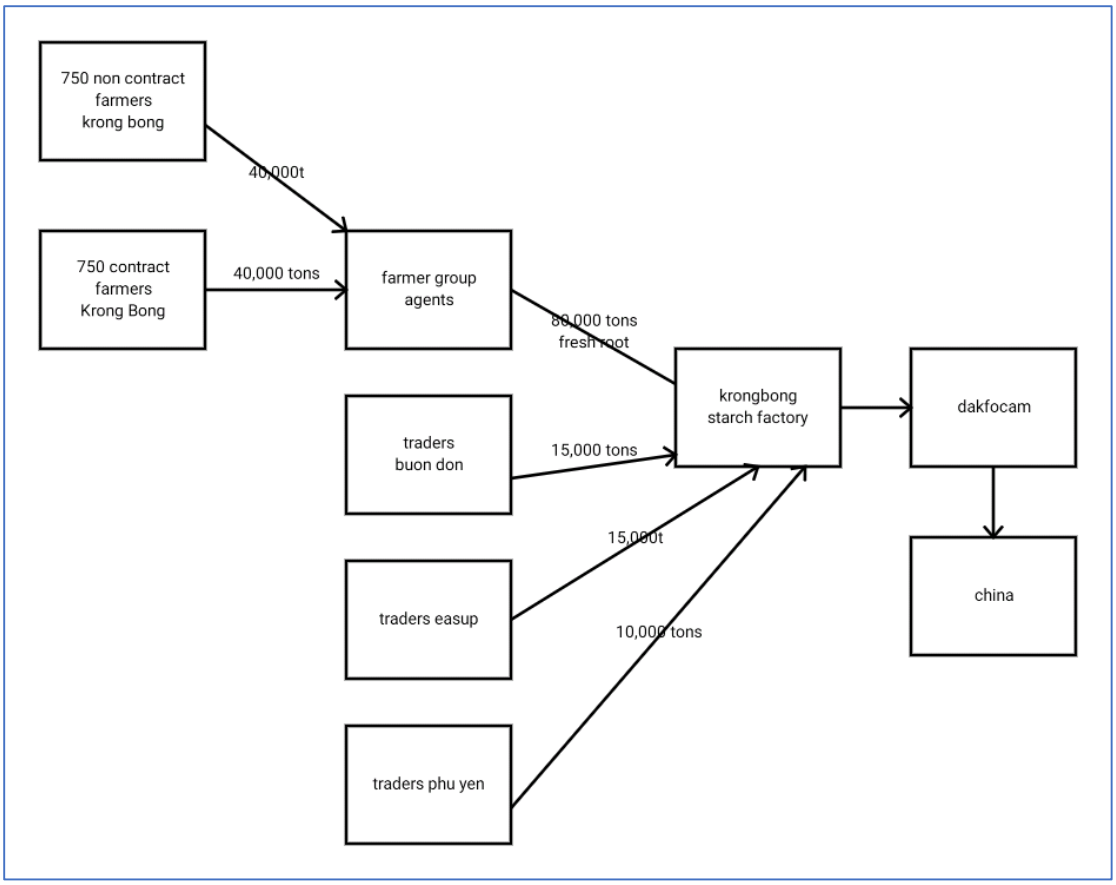

Figure 4: Product Flow map Krong Bong Starch Factory

The majority of fresh roots supplied to the factory are supplied by larger scale traders using 30-40 ton trucks, varying between 60 percent of the total in February to more than 93 percent in the peak supply month of June. The number of farmers and small traders supplying the factory directly peaks in Jan-March with between 360 and 516 farmers and traders supplying up to almost 40 percent of total inputs during those months.

During the early part of the year, the root supplies predominately come from locations within Krong Bong District, with a small minority from other parts of Dak Lak province. The communes close to the factory made up the bulk of supply in March. By May 2016, Krong Bong district was still the main source of roots, but the number of communes supplying large volumes has increased. In addition, the factory is sourcing from a number of other districts within Dak Lak and also from Dak Nong, Phu Yen and Khanh Hoa provinces.

The Ea Kar starch factory sources about 202,000 tons for fresh roots per year, including about 2000 tons from farmer groups covering about 50-100 farmers in nearby communes and 200,000 tons from large and medium traders and from small collectors.

All of the sales of starch from the Ea Kar factory are handled through the main office of DAKFOCAM and are destined to 10 importers from Guangxi and Guangzhou provinces in China. Fibre by-products are sold to animal feed processors in Vietnam.

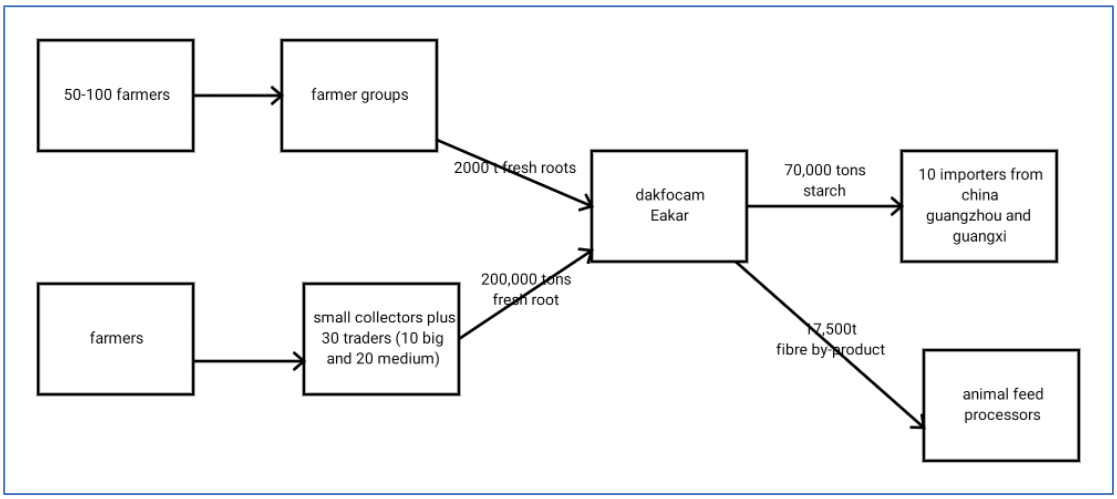

Figure 5: Product Flow map Ea Kar Starch Factory

The majority of fresh roots supplied to the factory are supplied by larger scale traders using 30-40 ton trucks, varying between 89 percent of the total in May to more than 95 percent in the peak supply month of June (**Error! Reference source not found.**). The number of farmers and small traders supplying the factory directly peaks in May with between 63 farmers and traders supplying more than 11 percent of total inputs.

Value Chain Information

Value chains for cassava starch and dry chips in Dak Lak are predominately oriented towards the export market, and in particular towards the Chinese market. The majority of the 600,000t of fresh roots produced in Dak Lak are used by the 5 starch factories operating in the province. More than 260,000t of cassava are produced by smallholders on a total of over 11,000ha in Ea Kar and Krong Bong and much of this production is destined for the 2 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 6. The majority 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 dry chip producers and medium scale dry chip producers.

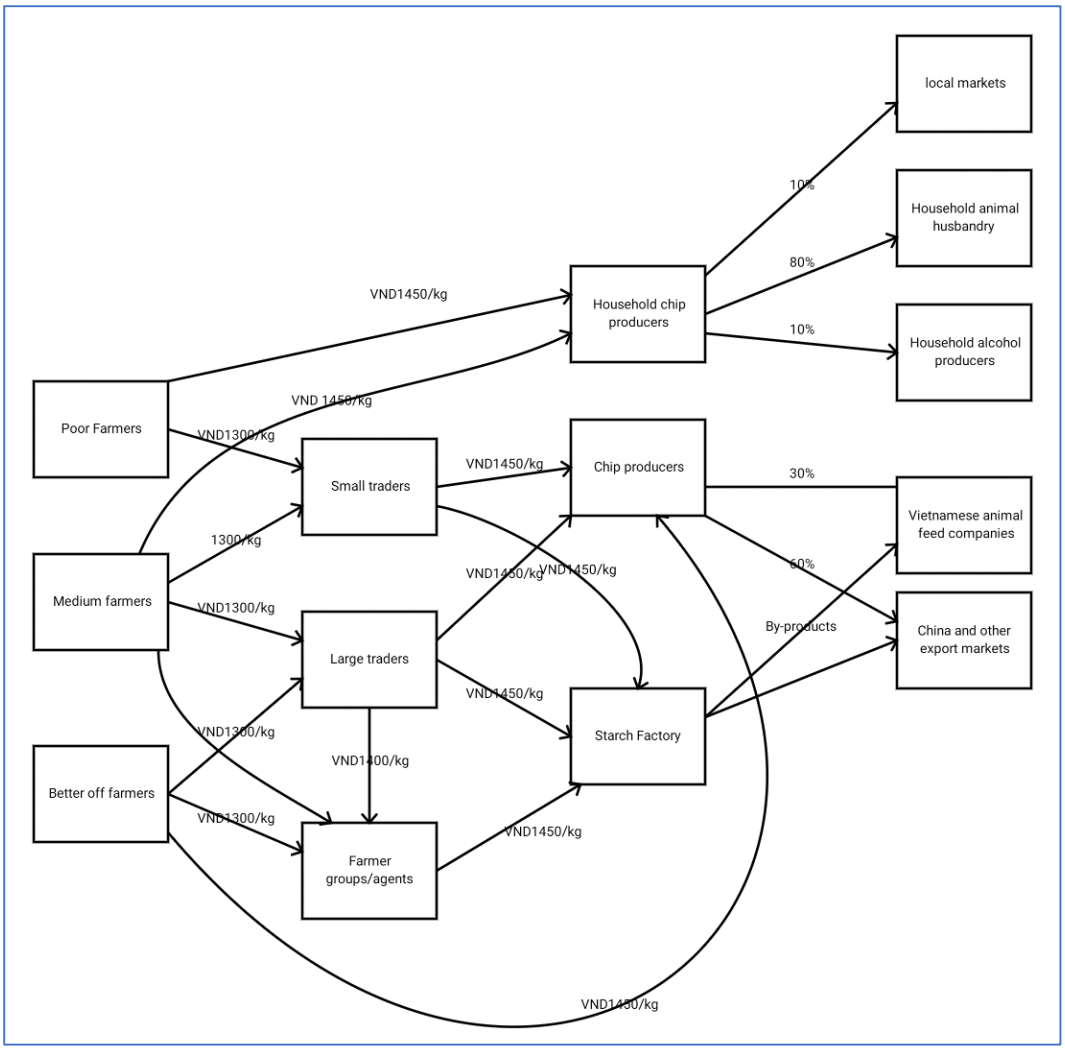

Figure 6: Value Chain Map Krong Bong

Poor farmers sell fresh roots to small traders or directly to household level dry chip producers, while medium farmers sell to small traders, larger traders and also through farmer groups or agents directly to the starch factory. Better off farmers are able to sell to large traders and also through farmer groups or agents directly to the starch factory.

The Krong Bong starch factory has credit arrangements with around 750 farmers from 5 communes close to the factory (Dang Kang, Hoa Thanh, Cu Kty, Hoa Tan and Ea Trul). The factory supplies cassava varieties and fertilizer to the farmers and farmers repay at harvest time, either with cash or with cassava. In 2016, around 26 percent of fresh root sourced by the factory came from farmers which the factory had supported with investment. The credit arrangements for not include a fixed price arrangement.

Small scale chip producers sell to small scale animal husbandry operations and alcohol producers in Dak Lak, while the medium scale chip processors sell though larger traders who sell to animal feed production companies within Vietnam and to export companies for sale

to China. The Krong Bong starch factory sells starch into the Chinese market through the main office of DAKFOCAM.

In Ea Kar, the majority of cassava production is utilized by the DAKFOCAM factory with only a small proportion of fresh roots being used by small-scale chip producers. Poor farmers sell fresh roots to small traders while medium farmers sell to small traders, larger traders and also directly to the starch factory. Better off farmers are able to sell to large traders and also to sell products directly to the factory. Unlike the Krong Bong factory, the DAFOKAM 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.

Small scale chip producers sell to small scale animal husbandry households in Dak Lak and to larger traders who sell to Vietnamese animal feed production companies and for export. The Ea Kar starch factory sells starch into the Chinese market through 10 importers in Guangxi and Guangdong provinces. The starch is transported overland in Vietnam and exported through Mong Cai border gate in Quang Ninh province.

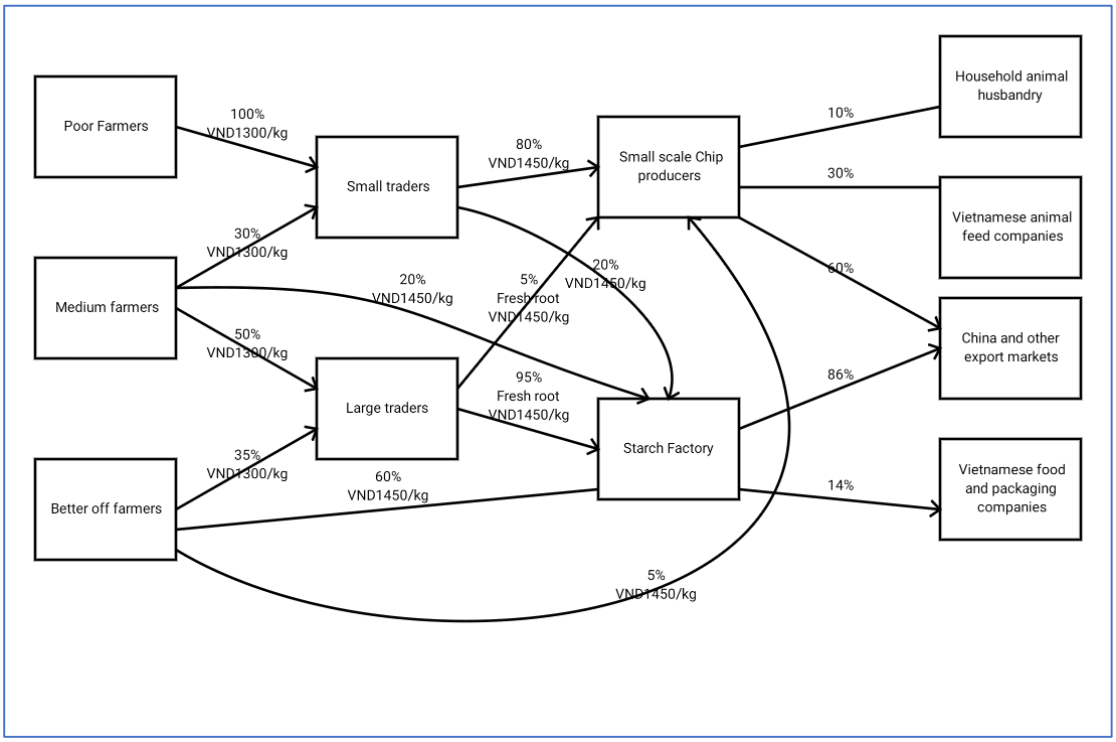

Figure 7: Value Chain Map Ea Kar

The large scale of the starch factories in Krong Bong and Ea Kar means that they are price makers in both districts. Factorygate price in both districts was around VND150/kg higher than farmgate prices. At 2015-2016 prices, this meant that farmgate prices were almost 90 percent of factorygate prices. This is a reflection of the amount of competition between traders to source fresh roots. The fact that many medium and better-off farmers are able to take roots directly to the factory also means that traders must keep margins relatively tight in order to secure product from farmers.

Information Flows

In Ea Kar district the dominant position of the starch factory means that it is effectively a price maker for fresh roots. The factory communicates the base buying price (30 percent starch content) to the large traders and small collectors who supply the factory and this is used as the basis for setting purchase prices for fresh roots sourced from farmers. The basis for price deductions based on starch content and foreign matter are transparent and the information is communicated directly with the traders and included in the receipt given at the time that the sale is made.

The situation in Krong Bong district is similar to that in Ea Kar, with the factory occupying a dominant position and being a price setter for fresh roots in the district. The buying price at Krong Bong factory is more unstable than in the Ea Kar factory, often varying many times per day, but the price transmission to suppliers and the clarity of information about quality deductions is the same as in Ea Kar. Around 25 percent of the supply of the factory in Krong Bong comes from farmers who have received inputs on credit from the factory and who deliver fresh roots as repayment. This credit arrangement does not involve a specified delivery price.

Relationships

Ea Kar Factory has long term relations with traders supplying fresh roots, but there are no formal contracts and price is determined on a spot market basis. The Ea Kar factory has the same type of long-term, non-contract and spot price relations with farmers and farmer groups that supply them with fresh roots.
Krong Bong Factory has long term relations with traders supplying fresh roots, but there are no formal contracts and price is determined on a spot market basis. The Krong Bong factory has the same type of long-term, non-contract and spot price relations with farmer groups that supply them with fresh roots. Farmers with credit from the factory have long-term relations with formalized contracts but price is still determined on a spot market basis.

Location of Project Activities within province

Value Chain Survey Locations

Field research was undertaken in 4 communes in Dak Lak. These were Ea Sar and Ea Pal communes in Ea Kar District, Yang Kang (Dang Kang) commune in Krong Bong District and Ea H'Leo commune in Ea H'Leo district. Ea Kar and Krong Bong districts were chosen for field research as they will be key locations of project activities moving forward.

Ea H'Leo district was selected in order to provide an insight into cassava value chains outside the collection area of DAKFOCAM company (Figure 8).

Figure 8: Research Locations, Dak Lak

Table 4: Area, yield and production of Cassava in surveyed communes, 2016.

Commune	Area (ha)	Yield (tons/ha)	Production (Tons)
Dang Kang	230.00	21.00	4,830
Ea H'leo	1,200.00	16.38	19,650
Ea Sar	537.00	24.50	13,157
Ea Pal	372.00	24.50	9,114

HYV of cassava have been planted in Ea H'Leo commune since 1995, when KM94 was introduced. From 1995 cassava from Ea H'Leo was sold to starch factories in adjoining Gia Lai province until a factory was built in Ea H'Leo district in 2007. Newer varieties with higher yields were introduced in 2010, and the price and yield remained high until 2012. In 2015, cassava production was impacted by mealybug and the general price decline of cassava. In addition, farmers reported that the nearby cassava factory had not been operational since the 2015 season.

HYV of cassava were introduced to Ea Sar commune in 2000. Between 2000 and 2009, farmers used relatively low amounts of fertilizer and the yield declined from 25 tons/ha to around 20 tons/ha. In 2010, higher prices for cassava root prompted farmers to use more fertilizer and the yields increased to between 27 and 30 tons/ha. In 2013 new HYV (KM 419) were introduced, but production has decreased from 2016 due to the low prices received for cassava roots.

HYV of cassava (KM94) were introduced to Ea Pal commune by DAKFOCAM in 2000 and the factory started purchasing from the commune households in 2003. In 2010, the factory introduced a new HYV (KM 140) and in 2013 KM419 was introduced, increasing yields for farmers. In common with other communes, production levels have decreased from 2016 due to the low prices received for cassava roots.

Farmers in Dang Kang have been cultivating cassava since 1990, but the first HYV of cassava (KM94) were introduced by DAKFOCAM in 2003. The yield was initially high (20t/ha) but under low fertilizer management practices the yield declined rapidly to 10t/ha by 2006. In 2010, the factory introduced a new HYV (KM 140) was introduced, increasing yields for farmers. In common with other communes, production levels have decreased from 2016 due to the low prices received for cassava roots.

Household Survey Locations

Livelihood Information

Time of first cultivating cassava

In addition to the significant proportion of the farmers that started cultivating cassava prior to 2000, two distinct "peak" periods for commencing cassava production can be seen. The first peak, in 2007, saw farmers in all communes starting to plant cassava. The most recent last peak years between 2012 and 2016 coincide with the cassava price boom. Farmers in Ea So predominately started growing cassava from 2014 onwards.

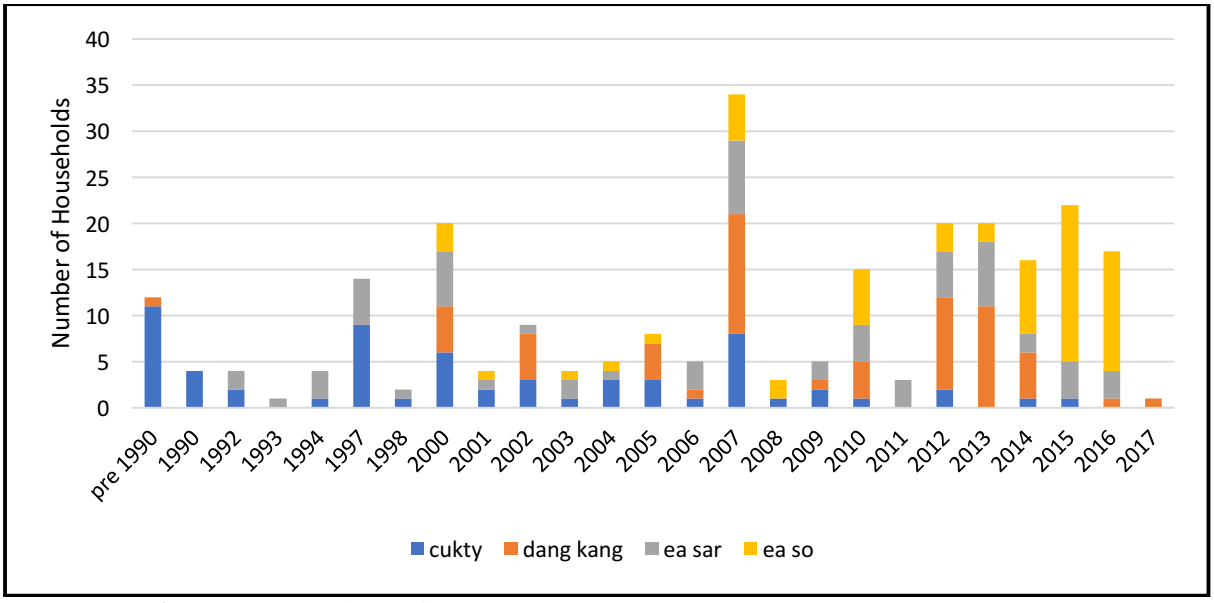

Figure 9: Year of First Cassava Production, by Commune

Importance of Cassava in overall livelihood and in cash income

Table 5: Annual Income from different sources, by commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Total Cassava Income	22,511,269.84	10,641,774.19	26,609,230.77	27,135,793.65	21,806,936.76
Non-Cassava Cropping Income	64,090,700.34	28,437,699.68	10,832,367.15	87,419,389.09	47,479,750.50
Total Livestock Income	11,976,349.21	3,025,967.74	2,384,923.08	20,196,825.40	9,365,770.75
Off-farm Income	33,111,111.11	20,132,580.65	9,040,307.69	25,260,000.00	21,791,383.40

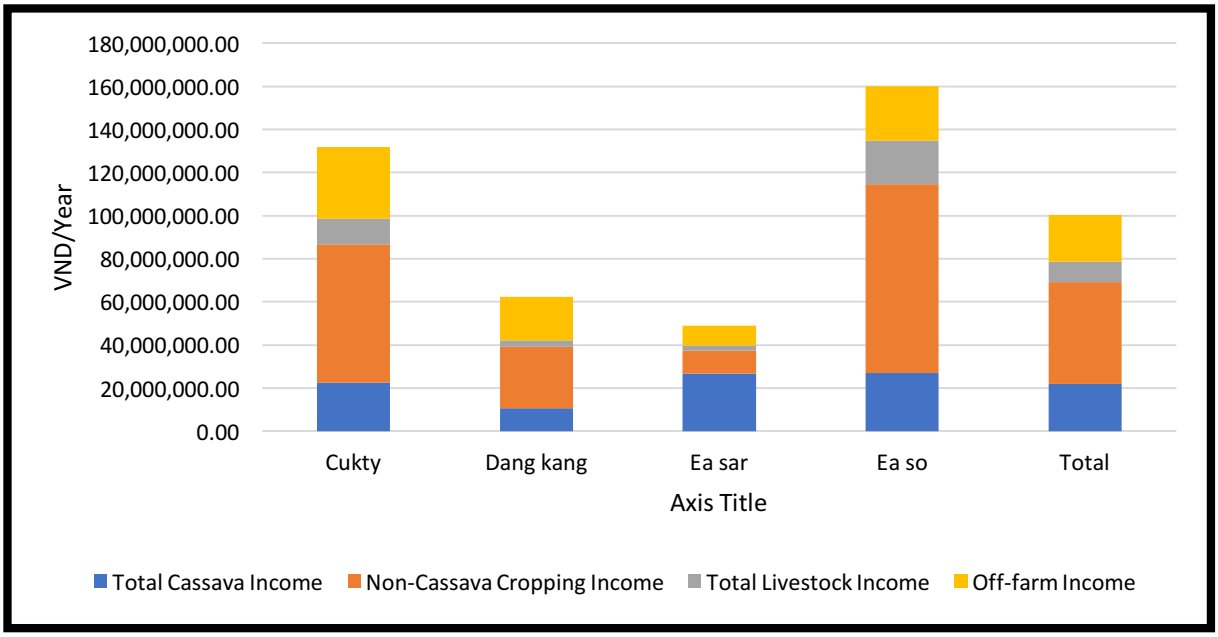

Figure 10: Income Sources, by Commune

Cassava contributes an average of more than 40 percent of overall household livelihood to households in the lowest income quartile and a progressively smaller proportion of livelihood of households in higher income quartiles, to a low of less than 15 percent of livelihood of households in the highest income quartile (Table 6 and Figure 11).

Table 6: Annual Income from different sources, by income quartile

Income Quartile	Q1	Q2	Q3	Q4	Total
Total Cassava Income	9,579,206.35	18,381,093.75	21,742,857.14	37,578,968.25	21,806,936.76
Non-Cassava Cropping Income	4,172,204.21	12,521,548.89	33,787,620.90	139,992,520.18	47,479,750.52
Total Livestock Income	460,476.19	3,229,843.75	7,638,888.89	26,231,269.84	9,365,770.75
Off-farm Income	6,860,000.00	12,872,812.50	24,121,904.76	43,452,380.95	21,791,383.40

Given the smaller average land holdings of households in the lowest income quartile, it is not surprising that off-farm income also contributes an average of more than 15 percent of overall livelihood to this quartile. From quartile 2 up to quartile 4, other crops contribute an increasing proportion of livelihood.

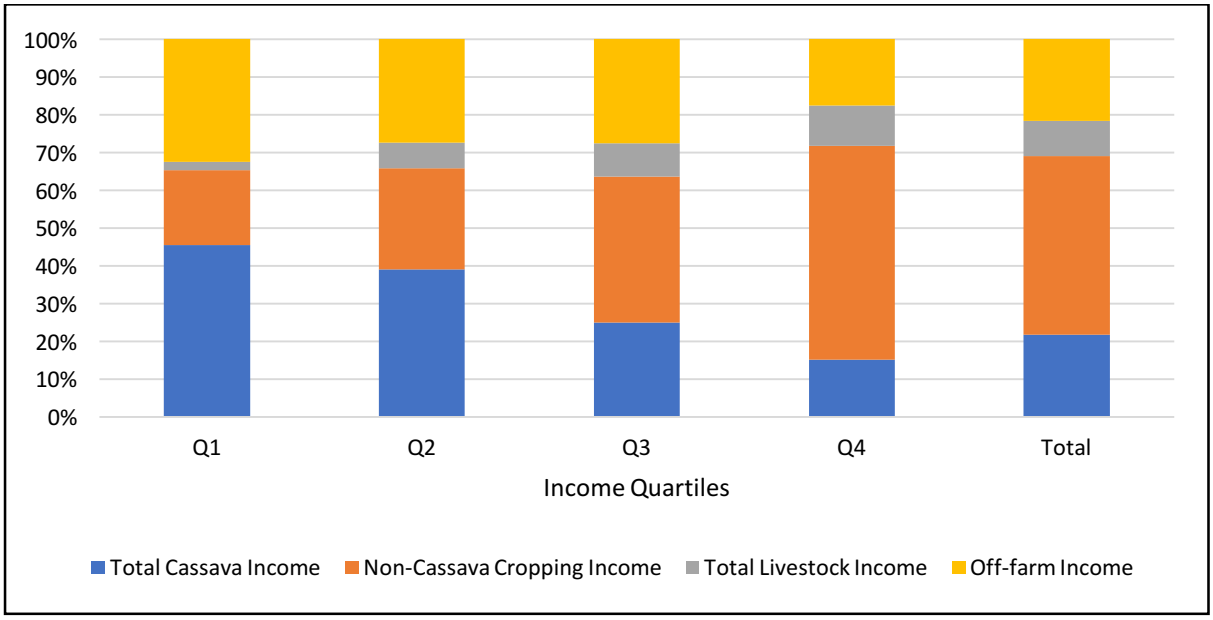

Figure 11: Livelihood sources, by Income Quartile

Figure 12 shows the sources of cash income by income quartile. This is derived by not including the value of paddy rice in the calculation of gross income. Cassava's relative importance to lower income households is shown clearly, with cassava providing on average more than half of the cash income of households in the lowest income quartile, and an average more than 40 percent of income of households in the 2nd income quartile. Cassava provides less than 15 percent of cash income of households in the highest quartile, compared with the more than 70 percent gained from cropping, livestock and off-farm income. More detailed information is presented in Table 43.

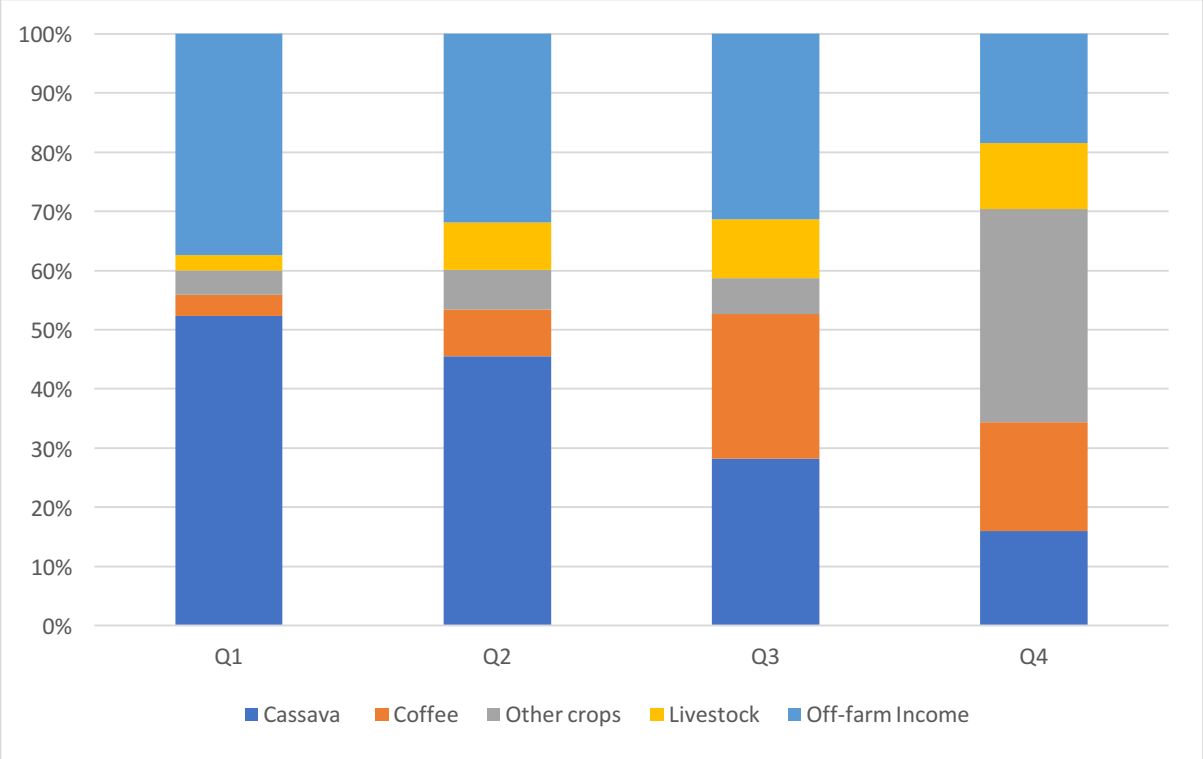

Figure 12: Cash Income sources, by Income Quartile

Labour Force

Average household size was 4.4, with an average of 4.3 members having at least some involvement in agriculture, of which 2.3 on average were employed full-time.

Table 7: number of family members by employment status

	Average Number of Family Members		
Employment status in Agriculture	**Males**	**Females**	**Total**
Full time	1.23	1.11	2.34
Never	0.86	0.88	1.75
Part time	0.12	0.08	0.20
Rarely	0.04	0.08	0.13
Total	2.26	2.15	4.42

Use of labour by gender and household/non-household

There seems to be no specific gender roles in cassava production, with male and female person-days per year for each cassava production related task being relatively even (Figure 13). This is different to the case of paddy rice, where there is significant gender disparity between different production tasks.

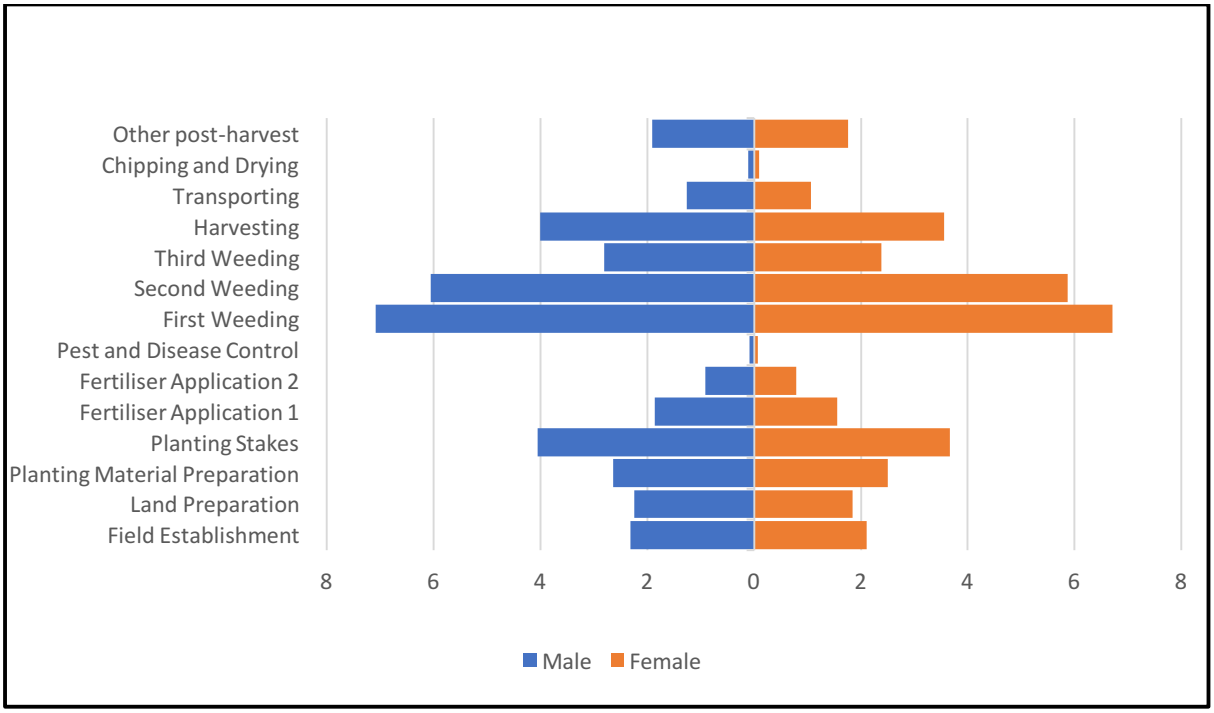

Figure 13: Household Labour Person-Days per hectare, by gender

Land preparation and planting material preparation is predominately carried out manually and this is reflected in the large number of person days dedicated to field establishment, land preparation, planting material preparation and planting of stakes. The relatively small quantities of chemical fertilizer used is reflected in low numbers of person days of labour for fertilizer application.

The predominance of manual weeding mean that a large number of person days of labour is utilised for three separate rounds of weeding. Weeding is the largest activity absorbing household labour.

As shown in Figure 14, while harvesting uses a significant amount of labour, households also utilise an average of more than 25 person days of outside (exchange or hired) labour per hectare for harvesting activities. Detailed labour utilisation and cost figures are shown in Table 44.

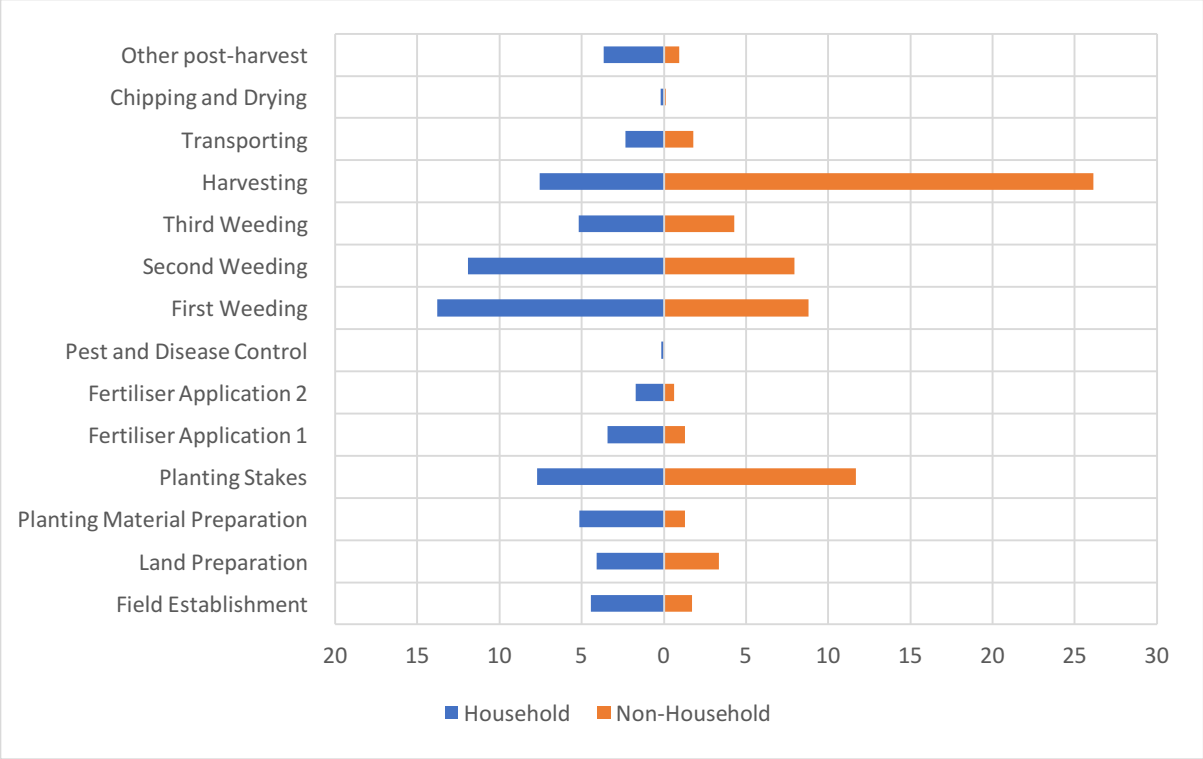

Figure 14: Labour Person Days per hectare, by source

Access to credit

Almost 71 percent of households had taken at least one loan in the past 12 months, with the majority of those only having one loan and no household reporting having more than 3 loans. Quartile 3 reported the highest proportion of households with loans (almost 78 percent), while 63.5 percent of households in the lowest income quartile took a loan in the last 12 months (Table 8).

Table 8: Proportion of households having taken loans

Access to Credit	Q1	Q2	Q3	Q4	Total
Percent of households that received a loan in the past 12 months	63.49%	71.88%	77.78%	69.84%	70.75%
% households with 1 loan	52.38%	56.25%	63.49%	52.38%	56.13%
% households with 2 loans	11.11%	15.63%	14.29%	14.29%	13.83%
% households with 3 loans	0.00%	0.00%	0.00%	3.17%	0.79%
Average value of total loans received (VND)	21,066,666	30,765,625	39,698,412	72,924,761	41,072,964

There were problems around manageability of debt, with more than 58 percent of households reporting at least some concern with their debt level and of those, more than 12 percent reporting that their debt was “unmanageable” or “very unmanageable” (Table 9).

Table 9: Manageability of debt

How manageable is the current level of debt	Frequency	Percent
Very unmanageable	14	6.28%
Unmanageable	13	5.83%
Some concern	104	46.64%
Manageable	89	39.91%
Very manageable	3	1.35%
Total	**223**	**100.%**

The most common source of loans was the Bank for Social Policies, with the second most frequent loan source being from Agribank. Only 14 percent of the loans were from shopkeepers or traders and only 0.5 percent were reported to have come from the starch factory.

Table 10: Loan Sources

Source of Loan	Proportion(%)
Bank for Social Policies	39.8%
Agribank	33.7%
Input supplier/trader	14.8%
Dong A Bank	1.0%
Sacombank	1.0%
ACB	0.5%
Eximbank	0.5%
other bank	4.1%
Womens Union	0.5%
Factory	0.5%
family/friend/neighbor	3.6%

Access to information

Farmers accessed information on agricultural production most frequently from friends and neighbours, from their family or from TV. Traders and cassava processors were noted as a source of information a total of 57 times (Table 11).

Table 11: Sources of Information on agricultural production

Source of Information	Frequency
Friends and neighbours in the village	**241**
Family	**157**
TV	**137**
Friends and neighbours outside the village	**121**
Farmer group	**64**
Cassava Traders	**44**
District government extension	**27**
Province government extension staff	**13**
Cassava processors	**13**
Researchers	**9**
Non government organisation	**7**
Radio	**7**
Other	**5**

Internet	**1**

Farmers accessed information on agricultural markets most frequently from friends and neighbours, TV and from their family. Cassava processors were only noted as a source of information a total of 15 times (Table 12).

Table 12: Sources of Information on agricultural markets

Source of Information	Frequency
Friends and neighbours in the village	245
Family	158
TV	146
Friends and neighbours outside the village	131
Farmer group	65
Cassava Traders	65
District government extension	21
Cassava processors	15
Radio	8
Province government extension staff	5
Other	5
Researchers	2
Non government organisation	0
Internet	0

Group membership

A total of 61 households (24% of all households) indicated that they had a household member participating in a group or a mass organization.

While most of these households were involved with only one organization, some households had memberships for up to five organizations.

Table 13: Household Membership of Groups and Mass Organizations

Name of Organization	Frequency
Women's Union	**31**
Farmers Union	**19**
Ho Chi Minh Youth Union	**4**
Senior Citizens Union	**4**
Veterans Union	**4**
Saving group	**3**
catholic Church	**3**
Communist Party	**2**
Police	**2**
Ethnic minority	**1**
Exercise Group	**1**
Saving group	**1**
Vietnamese Family of Buddhists	**1**
Cultural group	**1**
Village group	**1**

Ownership of assets

Overall, around 82 percent of farmers owned motorbikes. However, only about 68 percent of farmers in the lowest income quartile owned motorbikes. Around 27 percent of farmers owned 2 wheel tractors and more than 12 percent of farmers owned 4 wheel tractors. More than 86 percent of farmers had a mobile phone but only 8.3 percent had a smartphone.

Table 14: Asset Ownership by Income Quartile

Assets	Q1	Q2	Q3	Q4	Total
Truck	0.00%	0.00%	0.00%	0.00%	0.00%
car	0.00%	0.00%	0.00%	0.00%	0.00%
motorbike	**68.25%**	**87.50%**	**82.54%**	**90.48%**	**82.21%**
two wheel tractor	7.94%	21.88%	34.92%	42.86%	26.88%
four wheel tractor	4.76%	7.81%	17.46%	19.05%	12.25%
water_pump	12.70%	26.56%	34.92%	41.27%	28.85%
generator	0.00%	0.00%	1.59%	4.76%	1.58%
mobile phone	74.60%	89.06%	92.06%	90.48%	86.56%
smart phone	3.17%	3.13%	4.76%	22.22%	8.30%
tv	60.32%	73.44%	88.89%	95.24%	79.45%
dvd player	14.29%	18.75%	20.63%	28.57%	20.55%
radio	6.35%	4.69%	7.94%	11.11%	7.51%
refrigerator	0.00%	7.81%	14.29%	31.75%	13.44%

Agronomic Information

Area, production, Current yields and trends

Average cassava production area per household was 1.01 hectares, varying between 0.62 hectares in Dang Kang and 1.21 hectares in Ea So. Average production was 18.26 tons, giving a yield of 17.48 tons per hectare (Table 15). The yield per hectare was higher in Ea Sar and Ea So and lowest in Dang Kang (13.51 tons/ha).

Table 15: Production Characteristics, by Commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Cassava production 2016 (tons)	17.99	8.45	22.84	23.47	18.26
Cassava Harvest Area 2016 (ha)	1.15	0.62	1.07	1.21	1.01
Cassava Yield 2016 (tons/ha)	16.12	13.51	20.45	19.63	17.48

The average highest cassava yield in the past 5 years was 22.1 tons per hectare, while the average lowest yield was 15.7tons per hectare.

Table 16: Highest and Lowest Production in last 5 years, by Commune

	cukty	dang kang	ea sar	ea so	Total
Highest Cassava Production in the last five years (tons)	25.4	11.9	28.2	32.9	24.7
Area Utilized for Highest Cassava Yield in the last five years (ha)	1.2	0.65	1.16	1.33	1.09

Highest Cassava Yield in the last five years (tons/ha)	22.3	17.8	24.0	24.0	22.1
Lowest Cassava Production in the last five years (tons)	17.2	7.1	17.9	23.6	16.5
Area Utilized for Lowest Cassava Yield in the last five years (ha)	1.13	0.64	1.03	1.15	0.99
Lowest Cassava Yield in the last five years (tons/ha)	15.5	11.1	16.2	20.0	15.7

Cassava yields were declining either moderately or rapidly for a majority of farmers in Cu Kty and Ea So and for more than 35 percent of farmers in Dang Kang and Ea Sar. Overall, only 16.6 percent of farmers reported that yield was increasing, while more than 46 percent reported declining yields (Table 15).

Table 17: Cassava Yield Trends, by Commune

Yield Trend	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Increasing rapidly	15.87%	17.74%	15.38%	17.46%	16.60%
Increasing	0.00%	1.61%	0.00%	0.00%	0.40%
fluctuating, but no clear trend	25.40%	32.26%	36.92%	22.22%	29.25%
Relatively constant	1.59%	6.45%	10.77%	3.17%	5.53%
Declining moderately	28.57%	12.90%	7.69%	17.46%	16.60%
Declining rapidly	28.57%	27.42%	29.23%	33.33%	29.64%
Missing	0.00%	1.61%	0.00%	6.35%	1.98%

Plans for growing cassava in the future

More than 54 percent of farmers indicated that they intended to plant cassava into the future, with only 9.5 percent not intending to grow cassava after the current season. The remaining 36 percent were unsure about their future plans for cassava production (Table 18). The proportion of farmers not intending to grow cassava in the future was highest Cu Kty and lowest in Ea So.

Table 18: Future Production Intention, by Commune

Will you grow Cassava in the Future?	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Yes	41.3%	77.4%	78.5%	20.6%	54.5%
No	14.3%	9.7%	9.2%	4.8%	9.5%
Unsure	44.4%	12.9%	12.3%	74.6%	36.0%

Table 19: Future Production Intention, by Income Quartile

Will you grow Cassava in the Future?	Q1	Q2	Q3	Q4	Total
Yes	71.4%	62.5%	44.4%	39.7%	54.5%
No	7.9%	10.9%	4.8%	14.3%	9.5%
Unsure	20.6%	26.6%	50.8%	46.0%	36.0%

Varieties

Farmers reported a large number of names of varieties that they planted (Table 20). Many of these are local names and do not give any information about the actual variety. The most common "variety" reported is Cao San – this means High Yielding Cassava. The most common actual variety name reported was KM 94, which was reported by 15 farmers.

Table 20: Varieties of Cassava used by farmers

Variety Name

	Frequency	Percent	Valid Percent	Cumulative Percent
cao san	65	30.4	30.4	30.4
khong biet	54	25.2	25.2	55.6
khong nho	7	3.3	3.3	58.9
km140	1	.5	.5	59.3
km18	1	.5	.5	59.8
km39	1	.5	.5	60.3
km419	1	.5	.5	60.7
KM48	1	.5	.5	61.2
km92	1	.5	.5	61.7
KM94	15	7.0	7.0	68.7
km9698	1	.5	.5	69.2
lai cu	1	.5	.5	69.6
mi do	1	.5	.5	70.1
mi lai	29	13.6	13.6	83.6
mi thuong	31	14.5	14.5	98.1
n4	1	.5	.5	98.6
nk120	1	.5	.5	99.1
rayong71	1	.5	.5	99.5
tuc nguc	1	.5	.5	100.0
Total	214	100.0	100.0	

Soil Erosion Problems and Control Techniques

Almost 65 percent of farmers viewed soil erosion as a problem, with 19 percent considering it as serious or very serious. Around 16 percent of farmers were aware of erosion control measures but only 1.6 percent had received any training on soil conservation measures in the past. Encouragingly, more than 80 percent of farmers were interested in participating in erosion control measure trials on their land.

Table 21: Soil Erosion Perception, by Commune

Name of commune	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Soil Erosion perceived as a problem	52.4%	67.7%	72.3%	65.1%	64.4%
Very Serious Problem	4.8%	3.2%	4.6%	0.0%	3.2%
Serious Problem	3.2%	17.7%	36.9%	4.8%	15.8%
Medium Problem	30.2%	37.1%	23.1%	42.9%	33.2%

Small Problem	14.3%	9.7%	7.7%	17.5%	12.3%
Are you aware of any measure to reduce soil erosion?	14.3%	14.8%	12.3%	24.2%	16.3%
Have you had any training on any soil conservation measures?	1.6%	0.0%	4.6%	0.0%	1.6%
Are you interested in trialling conservation practices on your land?	65.1%	79.0%	81.5%	95.2%	80.2%

Adoption of intercropping is very low, with only 10.3 percent of farmers ever having grown intercrops with cassava and only 9.1 percent of farmers currently growing intercrops. More than 53 precent of farmers are interested in trialling intercrops, ranging from 42 percent of farmers in Ea Sar to more than 68 percent of farmers in Ea So.

Table 22: Awareness of Intercropping, by Commune

Name of commune	**Cu Kty**	**Dang Kang**	**Ea Sar**	**Ea So**	**Total**
Intercropping					
Have you ever grown intercrops with your cassava?	4.8%	17.7%	13.8%	4.8%	10.3%
Do you currently grow any intercrops with your cassava?	4.8%	14.5%	12.3%	4.8%	9.1%
Are you interested in trialling new intercrops?	44.6%	56.4%	42.1%	68.3%	53.2%

Fertiliser adoption, awareness and correct application

Only 6.3 percent of farmers apply organic fertilizer to their cassava. In contrast, the adoption rate of inorganic fertilizer is relatively high, at more than 85.4 percent. While adoption is high, only around 11 percent of farmers understand what the NPK values on their fertilizer mean (**Error! Reference source not found.**).

Table 23: Fertiliser Practice, by Commune

Name of commune	**Cu Kty**	**Dang Kang**	**Ea Sar**	**Ea So**	**Total**
Do you apply organic fertiliser to your cassava?	15.9%	4.8%	3.1%	1.6%	6.3%
Do you apply inorganic fertiliser to your cassava?	95.2%	69.4%	92.3%	84.1%	85.4%
Do you understand what the NPK values mean on the fertiliser you apply?	20.6%	0.0%	6.2%	19.0%	11.5%
Have you ever seen a fertiliser trial on cassava?	11.1%	4.8%	13.8%	6.3%	9.1%
Are you interested in visiting a fertiliser demonstration trial to see the result on production and returns?	71.4%	80.6%	87.7%	60.3%	75.1%
Are you interested in conducting a trial on your own land?	55.6%	61.3%	69.2%	49.2%	58.9%

The most common fertilizer formulation used by farmers was 16:16:8, a formulation which is not optimal for cassava production. Some farmers did not know what the fertilizer formulation that they utilised was. Clearly there is an opportunity for fertilizer companies to develop more appropriate formulations suitable for cassava production.

Table 24:NPK Formulas Used by Farmers

Formulation	Frequency
13:15	1
15:5:20	2
16:16:8	14
17:17:8	1
Phillip brand	1
Don't know	7

In addition to application of non optimal fertilizer formulations, the average quantity of NPK applied at planting per hectare is relatively low, at around 353kg per hectare

Table 25: Fertiliser Application at planting, by Commune

Commune	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
NPK (kg/ha)	221	550	450	213	353

Weeding and Herbicides

More than 99 percent of farmers indicated that weeds were a problem and that weeds limited the productivity of their cassava crop. This pattern was relatively constant across all communes.

Table 26: Weed Impact Perception, by Commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
large problem	61.3%	75.8%	60.0%	41.3%	59.5%
medium problem	27.4%	21.0%	32.3%	57.1%	34.5%
Small problem	11.3%	1.6%	6.2%	1.6%	5.2%
No	0.0%	1.6%	1.5%	0.0%	0.8%

As almost all farmers indicated that weeds were a significant problem impacting on cassava production, and more than 85 percent of farmers used herbicide on their cassava fields(Table 27).

Table 27: Herbicide Practice, by Commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Do you apply any herbicides?	87.3%	83.9%	84.6%	87.3%	85.8%
Have you received any training on herbicide use?	0.0%	0.0%	3.1%	1.6%	1.2%
Do you use protective clothing when applying herbicide?	69.8%	54.8%	50.8%	66.7%	60.5%

While a majority of farmers use herbicide, almost 100 percent of farmers also practice manual weeding of cassava fields. The most common number of times of weeding over a season is two (Table 28).

Table 28: Manual Weeding Practice, by Commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Do you conduct manual weeding?	98.4%	98.4%	98.5%	98.4%	98.4%
1 weeding	16.1%	4.9%	13.1%	27.4%	15.4%
2 weedings	43.5%	24.6%	45.9%	59.7%	43.5%
3 weedings	35.5%	57.4%	34.4%	9.7%	34.1%
4 weedings	1.6%	9.8%	3.3%	0.0%	3.7%
5 weedings	1.6%	1.6%	1.6%	0.0%	1.2%

Land Preparation

Given the relatively flat topography of cassava fields, it is not surprising that more than 68 percent of farmers cultivate cassava fields using 4 wheel tractors. Only around 2 percent of farmers use buffalo or cattle for ploughing. Almost 18 percent of farmers do at least some manual preparation of land. (Table 29).

Table 29: Land Cultivation Practice, by Commune

	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Tractor	1.6%	0.0%	23.1%	0.0%	6.3%
4 wheel tractor	93.7%	43.5%	50.8%	87.3%	68.8%
Buffalo or cattle	4.8%	0.0%	0.0%	4.8%	2.4%
Manual Tools	0.0%	48.4%	20.0%	3.2%	17.8%
Make Ridges	90.5%	13.3%	19.0%	50.8%	43.8%

Cassava Utilisation

Most farmers sold fresh cassava, accounting for at least 98 percent of farmers in all communes. Less than 1 percent of farmers sold dried chips or used cassava for livestock production (Table 30).

Table 30: Cassava Utilisation, by Commune

Commune	Cu Kty	Dang Kang	Ea Sar	Ea So	Total
Eat	0.00%	0.00%	0.00%	0.00%	0.00%
Use for own livestock	0.00%	0.00%	3.08%	0.00%	0.79%
Cassava Leaf	0.03%	6.45%	1.54%	0.00%	1.98%
Sell fresh cassava	98.41%	98.39%	100.00%	98.41%	98.81%
Sell Dried cassava	1.60%	0.00%	0.00%	1.60%	0.80%

Relationship with Traders

Of farmers that sold cassava to fresh root traders, only around 20 percent described the relationship as strong or very strong. The majority of farmers described the relationship as moderate, and only about 4 percent of farmers claimed that the relationship with traders was weak or very weak. (Table 31).

Table 31: Relationship with Fresh Root Traders, by Income Quartile

Fresh Roots	Q1	Q2	Q3	Q4	Total
very strong	0.0%	0.0%	2.4%	0.0%	0.6%
Strong	22.8%	18.8%	21.4%	14.2%	19.3%
moderate	63.6%	81.2%	76.2%	81.0%	75.6%
weak	9.0%	0.0%	0.0%	4.8%	3.4%
very weak	4.6%	0.0%	0.0%	0.0%	1.1%

Trials 2016-2017

Trials have been established on the basis of findings from the value chain assessment and local soil conditions. A total of nine trials were conducted in the two districts of KrongBong and Ea Kar. Six of the trials are varieties trials and three are fertilizer treatments combined with different planting densities. A participatory approach was adopted in establishment of trials. Farmers, representatives from cassava processing factories and local extension workers were involved in the process including induction trainings and harvest field days.

To evaluate pest and disease resilience and susceptibility of each cassava variety and under different nutrient conditions, pest and disease prevalence were also monitored in all trials.

Variety trials aim to evaluate improved cassava varieties in order to identify the best adapted varieties in order to improve cassava production systems taking into consideration both agronomic and economic factors. The most common soils in KrongBong district are ferrasol soils and acrisol soils, while in Eakar the most common type is sandy acrisol soil.

In KrongBong, variety trials were established in both ferrasol and acrisol soils and in Ea Kar, trials were established on sandy acrisol soil. Cultivation technologies applied in the variety trials followed the standard protocol suggested by Ministry of Agriculture and Rural Development (MARD) and local farmer's practices. Seven varieties were evaluated with randomized complete block design (RCBD) with 3 replicates and 32m^2 each block excluding border rows.

1. KM94 (control)
2. KM140
3. Rayong 9 (KM21-12)
4. KM419
5. HL-S10
6. HL-S11
7. KM505

Fertilizer and density trials were established to study the response of cassava varieties to the application of various combinations of fertilizers (N, P and K) and planting densities in order to find the best and most economic fertilizer rate/density combination to obtain and maintain high cassava yields. In addition, the trials aimed to find out how much soil fertility would be improved by application of bio-fertilizer application in the cassava field. Soil sample analyses were taken before the trials were established and after fertilizer application (30 days before harvesting) for this purpose.

The trials were split-plot designed with 3 replications with 6 fertilizer treatments applied on three density levels and on 2 soil types in Krong Bong (ferrasol soil and acrisol soil) and one soil type (acrisol soil) in Eakar. Four of six fertilizer treatments were based on standard protocols, one was based on farmer's practice and one is no fertilizer. Bio-fertilizers were used for basal application in all four standard fertilizer treatments.

Trial Locations

Trials were established in three communes in Krong Bong district and one commune in Eakar district. Details are shown in Table 32.

This document includes results for variety evaluation trials with standard treatments (trials 1 and 3) and the fertilizer and density trial on acrisols (trial 7) conducted in KrongBong district.

The other six trials will be harvested in the end of January or beginning of February 2018 and analysis will be undertaken during March 2018. Hence the results presented here can be considered to be preliminary.

Table 32: Trial locations

No	TRIALS	Number of varieties	Location	
			Village	Commune
I	**VARIETY TRIALS**			
	KrongBong district			
	Infertile acrisols			
1	- MARD practice	7	Village 5	CuKty
2	- Farmer's practice	6	Village 5	CuKty
	Ferrasols			
3	- MARD practice	7	Cuenam A	Dang Kang
4	- Farmer's practice	6	Ngo B	Hoa Phong
	Eakar district			
	Sandy acrisols			
5	- MARD practice	6	Village 3	Easar
6	- Farmer's practice	6	Village 3	Easar
II	**FERTILISER AND PLANT DENSITY TRIALS**			
	KrongBong district			
7	Infertile acrisols	1	Village 5	CuKty
8	Ferrasols	1	Ngo B	Hoa Phong
	Eakar district			
9	Sandy acrisols	1	Village 3	Easar

Key Activities

Key activities included training of local farmers before establishment of trials, involving farmers and relevant stakeholders in the cassava harvest field days and informing the stakeholders of trial results.

Training of farmers: Four training courses on cassava sustainable cultivation practices including common pest and disease management and information on cassava markets were provided to 350 farmers in three districts of KrongBong, Eakar and M'Drak. The training organized in M'Drak was based on a from M'Drak People's Committee and was covered by the district budget. In addition to farmers, district extension workers and staff from three cassava processing factories located in three districts participated in the training courses.

Trial establishments: Trials were conducted together with farmers and on selected farmers' fields.

Harvest field days: Harvest field days involved farmers, extension workers, 5 cassava starch processing factories in neighbouring districts and one ethanol processing factory in Krongbong and representatives from Daklak Department of Agricultural and Rural Development (DARD). In the harvest field days, cassava yields and starch contents were visually evaluated by participants.

Final results from all trials including cost and benefits analysis have been communicated to relevant stakeholders, including DARD.

Who is involved

Key activities are led by TNU with the participation of farmers, extension workers, cassava traders and processors and representatives from Daklak Department of Agricultural and Rural Development (DARD). In addition, two master students are involved in the trials and used data collected from variety evaluation and fertilizer and density trials in KrongBong district in their dissertations.

Results

Variety trials

Fresh root yield and starch content are the most desired cassava characteristics by farmers, starch processing factories and traders in KrongBong district.

HLS11, HLS10 and KM419 varieties obtained higher starch content and significantly higher fresh root yield than other evaluated varieties in both ferrasol and acrisol soil types. These varieties obtained a yield of 42 – 45 tons/ha in ferrasol and from 30 - 31.8 tons/ha in acrisol. The starch content of these three varieties were higher than that of other varieties in both ferrasol soil and in acrisol soil. The fresh root yield of HLS11, HLS10 and KM419 was also significantly higher than that of other varieties from 18% to 31% in in both ferrasol soil and in acrisol soil. There was no significant difference in starch content and fresh root yield among these three varieties

Yield parameters of all evaluated varieties were observed to be higher in ferrasol soil type than in acrisol soil type except for starch content which was higher in acrisol soil than ferrasol soil for all varieties with the exception of KM94. KM94 (the control variety) was one of the lowest performance varieties in both types of soil in almost parameters. Starch content and fresh root yield performance of KM94 is more than 30% lower than that of three high performance varieties in both types of soil (Table 33).

Table 33: Cassava yield of evaluated varieties on ferrasol and acrisol soil types

Varieties	Ferrasoil					Acrisol				
	Dry matter content (%)	Starch content (%)	Fresh root yield (t/ha)	Dry root yield (t/ha)	Starch yield (t/ha)	Dry matter content (%)	Starch content (%)	Fresh root yield (t/ha)	Dry root yield (t/ha)	Starch yield (t/ha)
KM94 (control)	39,90^{ns}	27,95^{ns}	34,37^{c}	15,37^{b}	9,60^{c}	38,90^{ns}	27,85^{ab}	24,73^{ns}	13,47^{c}	6,89^{ab}
KM140	39,90^{ns}	27,53^{ns}	36,53^{bc}	17,77^{ab}	10,07^{bc}	38,60^{ns}	28,43^{ab}	26,20^{ns}	14,20^{bc}	7,45^{ab}
KM505	41,20^{ns}	25,81^{ns}	38,30^{abc}	18,53^{ab}	9,84^{bc}	40,40^{ns}	26,71^{b}	25,67^{ns}	14,63^{abc}	6,85^{b}
KM419	41,60^{ns}	29,15^{ns}	45,03^{a}	20,97^{a}	13,12^{a}	39,80^{ns}	30,38^{a}	31,73^{ns}	17,90^{a}	9,59^{a}
HLS10	40,20^{ns}	28,06^{ns}	42,07^{ab}	17,60^{ab}	11,82^{ab}	38,70^{ns}	28,96^{ab}	30,00^{ns}	15,70^{abc}	8,69^{ab}
HLS11	42,20^{ns}	29,07^{ns}	45,13^{a}	19,13^{a}	13,12^{a}	40,10^{ns}	30,64^{a}	31,83^{ns}	17,23^{ab}	9,74^{a}
RAYONG9	40,50^{ns}	28,47^{ns}	36,43^{bc}	17,90^{ab}	10,37^{bc}	38,20^{ns}	29,37^{ab}	24,57^{ns}	15,00^{abc}	7,21^{ab}
CV%	3,04	5,36	11,68	10,79	14,14	5,75	5,66	15,29	12,00	17,33

In ferrasol soil, dry root yields were also higher for HLS11 (19.13t/ha), KM419 (20.97t/ha) and KM505 (18.53t/ha). In acrisol soil type, the dry root yield was still high for HLS11, HLS10 and KM419 with 17.23t/ha, 15.7t/ha and 17.9t/ha respectively (Table 33).

The number of roots and the weight of roots per plant are parameters that affect fresh root yield performance. A variety which has a higher number of roots and weight of root per plant will have a higher fresh root yield. In the trials in ferrasol soil, HLS11, HLS10 and KM419 had from 8.87 to 10 roots per plant and a weight of root per plant from 3.37kg to 3.6kg. This was significantly higher than that of other varieties. These three varieties also performed better than other varieties in acrisol soil with number of roots per plant from 7.83 to 8.43 and the weight from 2.8kg – 3.15kg (Table 34).

Due to the higher fresh root yield performance in both ferrasol soil and acrisol soil, the total biomass yield of HLS11, HLS10 and KM419 was higher than that of other varieties despite the low performance in stem and leaf yield. Biomass yield from 63 to 65 tons/ha was obtained with HLS11, HLS10 and KM419 while in acrisol soil a yield from 49 to 52 tons/ha was achieved, reflecting the higher harvest index achieved by these varieties. KM94 and Rayong 9 were the poorest performing varieties in almost biomass yield and root yield parameters (Table 34).

Table 34: Biomass yield and harvest index of evaluated varieties in ferrasol and acrisol soil types

Varieties	Ferrasoil						Acrisol					
	# root per plant (roots)	Weight of root per plant (kg)	Fresh root yield (t/ha)	Stem & leaf yield (t/ha)	Biomass yield (t/ha)	Harvest Index (%)	# root per plant (roots)	Weight of root per plant (kg)	Fresh root yield (t/ha)	Stem & leaf yield (t/ha)	Biomass yield (t/ha)	Harvest Index (%)
KM94 (control)	7.57	2.75	34.37	21.57	55.93	61.44	5.97	2.27	24.73	17.67	42.40	56.66
KM140	8.77	2.92	36.53	21.20	57.73	63.26	6.93	2.51	26.20	18.63	44.83	58.07
KM505	8.00	3.06	38.30	21.53	59.83	63.82	6.67	2.39	25.67	18.77	44.43	59.33
KM419	10.10	3.60	45.03	19.27	64.30	70.04	8.43	3.15	31.73	20.97	52.70	66.67
HLS10	8.87	3.37	42.07	21.20	63.27	66.47	7.87	2.80	30.00	19.30	49.30	60.20
HLS11	9.10	3.61	45.13	20.33	65.47	68.94	7.83	3.01	31.83	20.77	52.60	66.03
RAYONG9	8.70	2.91	36.43	21.97	58.40	62.38	7.37	2.42	24.57	17.80	42.37	57.61

Growth and development.

Emergence of sprouting and sprouting rate are mainly varietal characteristics but also depend on environmental conditions. These parameters influence cassava growth and development and hence yield performance.

Results in Table 35 show that there was no significant difference in emergence of sprouting and the sprouting rate between varieties evaluated in both ferrasol and acrisol soil types as well as between the same varieties planted in different soil types. Emergence of sprouting observed in varieties planted in ferrasol soil varied from 8 to 10 days after planting and from 9 to 11 days after planting in acrisol soil. In both soil types a sprouting rate of at least 97 percent in all evaluated varieties was observed.

Table 35: Growth and development parameters of evaluated varieties in ferrasol and acrisol soil types

Varieties	Ferrasoil					Acrisol				
	Emergence of sprouting (DAP)	Sprouting rate (%)	Plant height (cm)	Branching height (cm)	# of stems per plant (stems)	Emergence of sprouting (DAP)	Sprouting rate (%)	Plant height (cm)	Branching height (cm)	# of stems per plant (stems)
KM94 (control)	8	98,70	248.80	111.11	2.05	9	97,30	233.15	120.67	2.18
KM140	9	97,50	237.40	112.33	2.48	10	98,50	213.27	126.08	2.51
KM505	10	98,65	232.99	131.67	2.46	10	97,90	208.66	131.81	2.56
KM419	8	99,70	239.29	125.29	2.91	9	98,90	215.13	122.22	3.04
HLS10	9	98,10	256.24	110.14	2.60	10	98,90	242.13	102.37	2.84
HLS11	9	98,90	247.68	126.67	2.45	10	97,00	226.86	117.66	2.98
RAYONG9	10	97,00	251.13	108.15	2.30	11	98,00	240.37	120.26	2.33

Plant height, branching height and number of stem per plant are not only varietal characteristics but also depend on environmental conditions. In general, the ideal height of a cassava plant is from 200cm – 250cm. Branching height and number of stems per plant are indicators of the most suitable density for each variety, expected yield and availability of planting material resources for following season.

For all varieties, the plant heights were higher in ferrasol soil than acrisol soil (Table 35). In ferrasoil soil, HLS10 had the highest plant height at 256cm followed by Rayong 9 at 251cm and KM94 at 248cm. Those three varieties also had the highest plant height in acrisol soil, with HLS10 at 241cm, Rayong 9 at 240cm and KM94 at 233cm.

More than 2 stems per plant were observed in all evaluated varieties in both soil types, however, all varieties of cassava planted in acrisol soil had a higher number of stems than the same varieties planted in ferrasol soil type.

Pest and disease resistance and resilience: A higher prevalence of witches broom disease, pink mealybugs and brown leaf spot disease was observed in KM94 than in other varieties. respectively 16%, 10% and 20%. Less than 10% of KM419, HLS11 and HLS10 were infected with those diseases and pink mealybugs (Table 36).

Table 36: Pest and disease prevalence monitored in evaluated varieties

Varieties	Pest and disease prevalence (%)		
	Brown leaf spot	Witches broom disease	Pink mealybugs
KM94 (control)	20	16	10
KM140	15	13	12
KM505	15	11	11
KM419	8	5	6
HLS10	9	6	7
HLS11	10	7	8
RAYONG9	11	10	8

Cost and benefit analysis

Production costs include costs of planting materials, fertilizer, pesticides and labour costs for crop management, planting and harvesting. Production costs were estimated as being the same for all evaluated varieties under the assumption of the same amount of inputs being used and the same price per cultivar for different varieties. The total production cost is estimated at VND27.7 million/ha for all varieties.

The price used to calculate income is 1.9 million VND/ton of fresh roots. This is the market price as at December 2017. Gross and net income estimated for different varieties are shown in Table 37.

Table 37: Possible income gained with evaluated varieties in ferrasol and acrisol soil types

Varieties	Ferrasoil					Acrisol				
	Cassava yield (t/ha)	Starch content (%)	Gross income (mill. VND)	Production costs (mill. VND)	Net income (mill. VND)	Cassava yield (t/ha)	Starch content (%)	Gross income (mill. VND)	Production costs (mill. VND)	Net income (mill. VND)
KM94 (control)	34.37	27.95	65.30	27.70	37.60	24.73	27.85	46.99	27.70	19.29
KM140	36.53	27.53	69.41	27.70	41.71	26.20	28.43	49.78	27.70	22.08
KM505	38.30	25.81	72.77	27.70	45.07	25.67	26.71	48.77	27.70	21.07
KM419	45.03	29.15	85.56	27.70	57.86	31.73	30.38	60.29	27.70	32.59
HLS10	42.07	28.06	79.93	27.70	52.23	30.00	28.96	57.00	27.70	29.30
HLS11	45.13	29.07	85.75	27.70	58.05	31.83	30.64	60.48	27.70	32.78
RAYONG9	36.43	28.47	69.22	27.70	41.52	24.57	29.37	46.68	27.70	18.98

Table 37 shows that all evaluated varieties could provide higher income when planted in ferrasol soil than in acrisol soil. HLS11 could provide the highest net profits when planted in both types in comparison with other varieties.

Fertilizer and density trials

Fresh root yields increased with higher amount of N,P,K applied in all three density levels. With the same amount of fertilizer, KM419 obtained the highest fresh root yields at a density of 10,000 plants/ha and the lowest at 15,625 plants/ha. Yield reduction was from

12% (at the highest fertilizer amount) to 16% (at the lowest fertilizer amount) to fertilizer treatment when density level increase to 56%.

There was no significant difference in fresh root yield between different densities in the no fertilizer trial and farmer practice trial. (Table 38).

Table 38: Fresh root yields in different densities and fertilizer treatments

Fertilizer level	15,625 plants/ha			12,500 plants/ha			10,000 plants/ha		
	# root per plant (roots)	Weight of root/plant (kg)	Fresh root yield (t/ha)	# root per plant (roots)	Weight of root/plant (kg)	Fresh root yield (t/ha)	# root per plant (roots)	Weight of root/plant (kg)	Fresh root yield (t/ha)
90N-60P2O5-90K2O	7,63^{abcd}	2,23^{defg}	34,77^{bc}	7,70^{abc}	3,27^{defg}	40,87^{ab}	8,67^{ab}	4,13^{ab}	41,27^{ab}
99N-66P2O5-99K2O	7,70^{abc}	2,28^{cdefg}	35,67^{abc}	7,97^{ab}	3,23^{bcd}	40,37^{ab}	8,10^{ab}	4,16^{ab}	41,57^{ab}
108N-72P2O5-108K2O	7,70^{abc}	2,43^{cdef}	38,00^{ab}	9,07^{a}	3,25^{bcd}	40,60^{ab}	9,30^{a}	4,42^{a}	44,20^{a}
117N-78P2O5-117K2O	8,40^{ab}	2,52^{cdef}	39,40^{ab}	7,90^{abc}	3,32^{bc}	41,24^{ab}	9,37^{a}	4,48^{a}	44,83^{a}
No fertilizer	5,33^{cde}	1,26^{g}	19,65^{d}	4,16^{e}	2,23^{defg}	20,44^{d}	4,11^{e}	2,08^{efg}	20,81^{d}
Farmers practice	6,15^{bcde}	1,71^{fg}	26,67^{cd}	4,74^{de}	2,85^{cdef}	23,70^{d}	4,15^{e}	2,35^{cdef}	23,49^{d}

Dry matter content and starch content varied insignificantly between different densities with the same fertilizer treatment. Between different fertilizer levels in the same densities dry matter content and starch content are stable and high - around 40% - 41% dry matter content and 30%-31% starch content (Table 39).

Table 39: Starch content, starch yield and dry root yield in different densities and fertilizer amount (ton/ha)

Fertilizer level	15,625 plants/ha				12,500 plants/ha				10,000 plants/ha			
	Dry matter content (%)	Starch content (%)	Starch yield (t/ha)	Dry root yield (t/ha)	Dry matter content (%)	Starch content (%)	Starch yield (t/ha)	Dry root yield (t/ha)	Dry matter content (%)	Starch content (%)	Starch yield (t/ha)	Dry root yield (t/ha)
90N-60P2O5-90K2O	39,07^{ns}	28,45^{ns}	9,89^{bcde}	16,50^{cd}	40,84^{ns}	30,38^{ns}	12,40^{ab}	18,80^{bcd}	40,19^{ns}	30,20^{ns}	12,51^{ab}	18,57^{abc}
99N-66P2O5-99K2O	38,71^{ns}	28,87^{ns}	10,29^{abcd}	16,80^{cd}	41,19^{ns}	30,27^{ns}	12,21^{ab}	19,37^{abc}	39,20^{ns}	30,75^{ns}	12,81^{ab}	18,60^{abc}
108N-72P2O5-108K2O	39,50^{ns}	29,83^{ns}	11,34^{abc}	17,50^{cd}	40,51^{ns}	31,00^{ns}	12,59^{ab}	18,00^{bcd}	41,58^{ns}	30,98^{ns}	13,72^{a}	21,50^{a}
117N-78P2O5-117K2O	39,55^{ns}	29,87^{ns}	11,77^{ab}	17,00^{cd}	41,24^{ns}	31,06^{ns}	12,91^{ab}	19,37^{abc}	43,12^{ns}	31,26^{ns}	14,04^{a}	21,27^{ab}
No fertilizer	40,46^{ns}	27,89^{ns}	5,48^{f}	9,56^{f}	40,82^{ns}	28,95^{ns}	5,90^{f}	10,04^{f}	42,17^{ns}	29,89^{ns}	6,22^{ef}	11,74^{ef}
Farmers practice	40,45^{ns}	28,35^{ns}	7,56^{def}	12,43^{ef}	38,92^{ns}	30,89^{ns}	7,29^{def}	12,36^{ef}	40,86^{ns}	31,25^{ns}	7,40^{def}	14,76^{de}

Starch yields are significantly different between different fertilizer treatments and also significantly different between different planting densities. (Table 39).

Soil Analysis

Soil samples were taken before the trial establishment and 15 days after the final fertilizer application for analysis to evaluate the effect of density and fertilizer application amount (N, P, K) on physical and chemical factors in cassava fields. (Table 40).

Nitrogen content was recorded at 0.12% before planting cassava. Without fertilizer nitrogen content was 0.10% after cassava planting and at 15 days before harvest. Nitrogen content is higher in the highest fertilizer treatment plot.

Soluble phosphate contents varied from 1.29 mg/100g soil to 2.38 mg/100g soil but were not stable in treatments.

Soluble potassium contents were relatively low and varied from 1.29 mg/100g soil to 2.38 mg/100g soil but were not stable in treatments.

Ca^{2+} and Mg^{2+} in different fertilizer treatments varied between 0.44ldl/100g soil to 0.50ldl/100g soil (calcium) and 0.08ldl/100g soil to 0.10/100g soil (magnesium).

Table 40: Effect of density and fertilizer amount on soil physical and chemical factors (thickness 0-30cm)

Treatments	Monitored indicators				
	N_{ts} (%)	P_2O_{5dt} (mg/100g soil)	K_2O_{dt} (mg/100g soil)	Ca^{2+} (ldl/100g soil)	Mg^{2+} (ldl/100g soil)
Before trials	0.12	2.49	8.38	0.73	0.09
90N-60P_2O_5-90K_2O	0.1	1.38	8.45	0.44	0.08
99N-66P2O5-99K2O	0.11	1.46	13.47	0.44	0.09
108N-72P2O5-108K2O	0.11	1.29	10.69	0.44	0.08
117N-78P2O5-117K2O	0.13	1.54	9.28	0.5	0.08
No fertilizer	0.1	1.36	7.23	0.47	0.1
Farmers practice	0.11	1.14	8.24	0.52	0.08

Cost and benefit analysis

The highest production cost (VND31.26 million) was for the treatments with highest fertilizer amount and density level.

The highest net income (VND56.17 million) was obtained at the highest level of fertilizer and lowest level of density (Table 41).

Table 41: Cost and profits analysis of cassava with different treatments of fertilizer and densities

Fertilizer level	15,625 plants/ha				12,500 plants/ha				10,000 plants/ha			
	Fresh root yield (t/ha)	Gross income (mill VND)	Production costs (mill. VND)	Net income (mill.VND)	Fresh root yield (t/ha)	Gross income (mill VND)	Production costs (mill. VND)	Net income (mill.VND)	Fresh root yield (t/ha)	Gross income (mill VND)	Production costs (mill. VND)	Net income (mill.VND)
90N-60P_2O_5-90K_2O	34.77	66.06	28.95	37.11	40.87	77.65	27.7	49.95	41.27	78.41	26.7	51.71
99N-66P_2O_5-99K_2O	35.67	67.77	29.72	38.05	40.37	76.70	28.47	48.23	41.57	78.98	27.47	51.51
108N-72P_2O_5-108K_2O	38	72.20	30.49	41.71	40.6	77.14	29.24	47.90	44.2	83.98	28.24	55.74
117N-78P_2O_5-117K_2O	39.4	74.86	31.26	43.60	41.5	78.85	30.01	48.84	44.83	85.18	29.01	56.17
No fertilizer	19.65	37.34	21.23	16.11	20.44	38.84	20	18.84	20.81	39.54	19	20.54
Farmers practice	26.67	50.67	24.13	26.54	25.72	48.87	22.9	25.97	23.49	44.63	21.9	22.73

Challenges and constraints

Limited farmer's knowledge and willingness to invest in sustainable cassava production due to prolonged unavailability of learnable information is challenging to overcome in the short-term. None of the farmer participants were very interested in learning about cassava fertilizer trials observed in the harvest field days in Krong Bong district.

Access to clean planting materials locally is a constraint. Planting materials are currently shared between farmers while farmer's knowledge on pest and disease identification and management is very limited. KM94, the most popular variety which has been adopted widely for more than ten years is highly susceptible to witches broom disease and pink mealybugs while other improved varieties are not easily accessible to farmers.

Future plans and partnerships

Opportunities and new ideas for 2018

Interest from cassava processing factories in improved technology particularly in new potential varieties can provide a good opportunity for distribution of new varieties and dissemination of appropriate cassava management techniques.

Strong interest from Daklak DARD in improvement of soil fertility of sandy acrisol soil type is an opportunity to improve farmer's knowledge through the extension system which has network at village level.

A new idea for 2018 is to organize a meeting with Daklak PPC and DARD to present research results from trials conducted this year along with policy recommendation. A follow-up meeting can be organized with processing factories and extension agencies, depending on the results of the meeting with PPC and DARD.

Strategy for engagement with value chain stakeholders for adoption

New Varieties

The main entry point/partner for dissemination of new varieties in the value chain in Dak Lak could be the DAKFOCAM Company through their factories in Ea Kar and Krong Bong. DAKFOCAM has an incentive to support farmers to increase the quality/starch content of fresh roots supplied to the factory and to balance supply levels over a longer growing/harvesting season. Interventions could make use of the existing linkages of DAKFOCAM with the small trader/farmer group networks in Ea Kar and through linkages with farmers taking credit from the Krong Bong factory.

More effective fertiliser treatments.

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 investments in facilitation of the adoption of fertiliser for cassava production will be working together with fertiliser companies to develop appropriate formulations based on trial results.

The main entry point/partner for an intervention introducing more effective fertiliser treatments in the cassava value chain in Dak Lak could be fertiliser production companies active in Dak Lak 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 half of cassava producers in The linkages of fertiliser companies to farmers are strong due to their distribution networks through input supply shops down to the local level.

Detailed Tables

Table 42: Average Household Incomes from various Sources (VND/Year), by Commune

Average Household Incomes from various Sources (VND/year)					
Name of commune	**Cukty**	**Dang kang**	**Ea sar**	**Ea so**	**Total**
Total Cassava Income	22,511,269.84	10,641,774.19	26,609,230.77	27,135,793.65	21,806,936.76
Paddy rice production value	13,663,652.72	10,058,538.39	5,387,374.84	2,881,611.31	7,969,013.35
Income from Maize	638,412.70	0.00	1,280,923.08	457,142.86	601,897.23
Income from all other annual crops	53,968.25	349,838.71	887,846.15	81,476,666.67	20,615,928.85
Income from coffee	47,164,285.71	16,892,870.97	1,410,476.92	520,634.92	16,376,241.11
Income from all other tree crops	2,570,380.95	1,136,451.61	1,865,746.15	2,083,333.33	1,916,669.96
Cropping Income	86,601,970.18	39,079,473.87	37,441,597.92	114,555,182.74	69,286,687.26
Non-Cassava Cropping Income	64,090,700.34	28,437,699.68	10,832,367.15	87,419,389.09	47,479,750.50
Cattle Income	2,190,476.19	1,777,419.35	753,846.15	7,230,158.73	2,975,098.81
Buffalo Income	7,111,111.11	354,838.71	1,015,384.62	1,174,603.17	2,411,067.19
Goat Income	0.00	0.00	0.00	0.00	0.00
Pig Income	1,953,174.60	472,580.65	300,000.00	10,126,984.13	3,200,988.14
Chicken Income	272,380.95	421,129.03	291,076.92	871,428.57	462,806.32
Duck Income	449,206.35	0.00	24,615.38	0.00	118,181.82
Other Livestock Income	0.00	0.00	0.00	0.00	0.00
fish Income	0.00	0.00	0.00	793,650.79	197,628.46
Total Livestock Income	11,976,349.21	3,025,967.74	2,384,923.08	20,196,825.40	9,365,770.75
On-farm Income	98,578,319.39	42,105,441.61	39,826,521.00	134,752,008.13	78,652,458.01
Off-farm Wages	8,819,047.62	19,110,000.00	4,776,307.69	13,753,968.25	11,531,146.25
Irregular non-farm income	7,466,666.67	161,290.32	1,893,846.15	1,190,476.19	2,681,818.18
Salary Income	11,126,984.13	458,064.52	2,139,384.62	4,807,619.05	4,629,802.37
NTFP income	0.00	0.00	230,769.23	0.00	59,288.54
Fishing Income	0.00	0.00	0.00	0.00	0.00
Other Income	5,698,412.70	403,225.81	0.00	5,507,936.51	2,889,328.06
Off-farm Income	33,111,111.11	20,132,580.65	9,040,307.69	25,260,000.00	21,791,383.40
Total Income	131,689,430.50	62,238,022.26	48,866,828.69	160,012,008.13	100,443,841.41

Income Quartiles

Table 43: Average Household Incomes from various Sources (VND/Year), by Income Quartile

Average Household Incomes from various Sources (VND/year)					
Income Quartile	**Q1**	**Q2**	**Q3**	**Q4**	**Total**
Total Cassava Income	9,579,206.35	18,381,093.75	21,742,857.14	37,578,968.25	21,806,936.76
Paddy rice production value	2,755,728.03	6,648,275.47	10,307,636.89	12,185,377.12	7,969,013.35
Income from Maize	382,222.22	762,500.00	751,428.57	508,888.89	601,897.23
Income from all other annual crops	224,603.17	1,184,531.25	2,919,047.62	78,443,968.00	20,615,928.79
Income from coffee	661,238.10	3,164,312.50	18,767,222.22	43,121,904.76	16,376,241.11
Income from all other tree crops	148,412.70	761,929.69	1,042,285.71	5,732,380.95	1,916,669.96
Cropping Income	13,751,410.56	30,902,642.64	55,530,478.05	177,571,488.56	69,286,687.31
Non-Cassava Cropping Income	4,172,204.21	12,521,548.89	33,787,620.90	139,992,520.18	47,479,750.52
Cattle Income	365,079.37	2,175,000.00	2,484,126.98	6,888,888.89	2,975,098.81
Buffalo Income	0.00	343,750.00	2,269,841.27	7,063,492.06	2,411,067.19
Goat Income	0.00	0.00	0.00	0.00	0.00
Pig Income	0.00	164,062.50	2,180,158.73	10,507,936.51	3,200,988.14
Chicken Income	95,396.83	125,156.25	684,126.98	951,904.76	462,806.32
Duck Income	0.00	421,875.00	20,634.92	25,396.83	118,181.82
Other Livestock Income	0.00	0.00	0.00	0.00	0.00
fish Income	0.00	0.00	0.00	793,650.79	197,628.46
Total Livestock Income	460,476.19	3,229,843.75	7,638,888.89	26,231,269.84	9,365,770.75
On-farm Income	14,211,886.75	34,132,486.39	63,169,366.94	203,802,758.40	78,652,458.07
Off-farm Wages	6,286,031.75	10,280,625.00	16,274,603.17	13,303,174.60	11,531,146.25
Irregular non-farm income	95,238.10	625,000.00	3,563,492.06	6,476,190.48	2,681,818.18
Salary Income	256,507.94	623,437.50	1,902,857.14	15,800,000.00	4,629,802.37
NTFP income	95,238.10	140,625.00	0.00	0.00	59,288.54
Fishing Income	0.00	0.00	0.00	0.00	0.00
Other Income	126,984.13	1,203,125.00	2,380,952.38	7,873,015.87	2,889,328.06
Off-farm Income	6,860,000.00	12,872,812.50	24,121,904.76	43,452,380.95	21,791,383.40
Total Income	21,071,886.75	47,005,298.84	87,291,271.81	247,255,139.94	100,443,841.62

Table 44: Labour Costs for Various Production Activities (VND/Year), by Commune

Name of commune	Cukty	Dang kang	Ea sar	Ea so	Total
Field Establishment Household Labour	509,121.73	922,079.35	694,273.37	544,993.79	665,809.07
Field Establishment Outside Labour	121,486.93	612,184.74	238,342.64	44,593.25	251,184.89
Land Preparation Household Labour	53,174.60	1,787,031.61	565,214.79	95,815.30	615,612.11
Land Preparation Outside Labour	112,989.58	1,589,760.41	226,622.64	122,158.10	502,064.13
Planting Material Preparation Household Labour	646,368.29	1,018,068.80	797,944.00	646,101.51	775,373.63
Planting Material Preparation Outside Labour	130,433.58	216,312.38	129,379.65	101,139.55	143,626.35
Planting Stakes Household Labour	881,483.45	1,078,373.26	1,718,635.55	950,435.76	1,162,313.45
Planting Stakes Outside Labour	1,737,797.87	2,808,349.83	1,084,953.73	1,389,268.27	1,741,414.68
Fertiliser Application 1 Household Labour	619,448.76	522,928.30	472,414.12	443,773.21	514,240.19
Fertiliser Application 1 Outside Labour	376,206.31	249,959.47	51,565.36	91,389.66	190,705.64
Fertiliser Application 2 Household Labour	443,738.91	261,511.44	34,725.27	291,583.82	256,089.97
Fertiliser Application 2 Outside Labour	181,826.06	159,268.60	0.00	30,257.94	91,574.11
Pest and Disease Control Household Labour	17,857.14	32,786.88	46,242.60	0.00	24,328.45
Pest and Disease Control Outside Labour	2,380.95	16,393.44	0.00	0.00	4,563.49
First Weeding Household Labour	1,347,451.50	1,831,489.80	2,853,266.35	2,237,931.54	2,075,644.14
First Weeding Outside Labour	1,586,604.63	2,707,640.49	437,118.77	612,775.91	1,318,014.93
Second Weeding Household Labour	1,209,644.71	1,759,768.49	2,663,959.40	1,523,364.21	1,796,360.32
Second Weeding Outside Labour	1,253,812.85	2,636,324.50	422,281.57	466,977.82	1,177,277.41
Third Weeding Household Labour	598,723.93	861,547.46	1,427,877.12	218,938.09	781,266.33
Third Weeding Outside Labour	506,507.60	1,862,119.43	96,853.15	11,160.71	605,150.17
Harvesting Household Labour	889,693.40	1,281,453.78	1,681,899.98	688,211.23	1,138,492.74
Harvesting Outside Labour	3,539,136.59	4,684,966.63	4,886,964.86	2,540,436.07	3,914,479.20
Transporting Household Labour	285,291.64	592,541.88	247,133.89	287,188.25	350,297.58
Transporting Outside Labour	237,665.15	492,388.75	197,054.87	142,817.53	265,137.66
Chipping and Drying Household Labour	59,523.81	12,295.08	0.00	47,619.05	29,761.90
Chipping and Drying Outside Labour	23,809.52	36,885.25	0.00	0.00	14,880.95

Other post-harvest Household Labour	477,591.03	499,977.48	684,295.39	544,524.69	553,059.99
Other post-harvest Outside Labour	32,738.10	265,163.93	138,291.77	135,837.33	142,000.86
Total Labour	17,882,508.62	30,799,571.49	21,797,310.78	14,209,292.60	21,100,724.36
Household Labour	8,039,112.92	12,461,853.67	13,887,881.82	8,520,480.49	10,738,649.91
Outside Labour	9,843,395.75	18,337,717.90	7,909,429.00	5,688,812.15	10,362,074.50