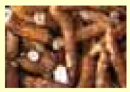
Cassava Starch Processing at Small-Scale in North Vietnam

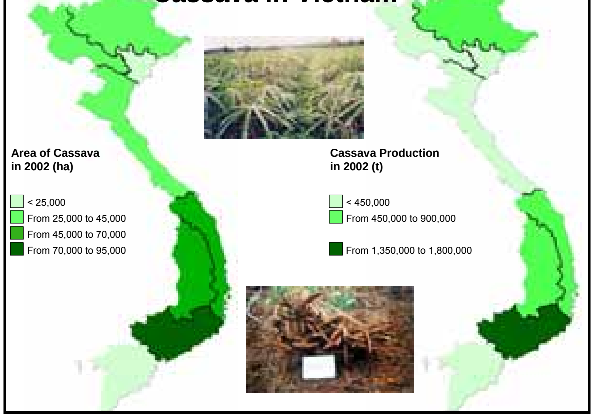
Impact of technology on efficiency and effluent management.



Hoai Duc district, Ha Tay Province

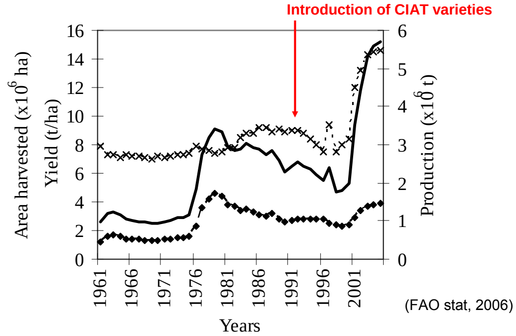
Da, G ; Dufour, D; Marouzé, C; Le Thanh Mai; Maréchal, P.A.; Trinh Thi Phuong Loan

Cassava in Vietnam



Cassava in Vietnam (cont)

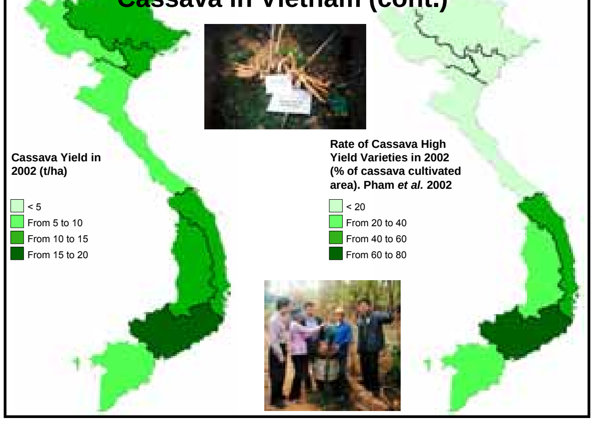
Last benchmark study in 1994 (Howeler *et al.* 1996)



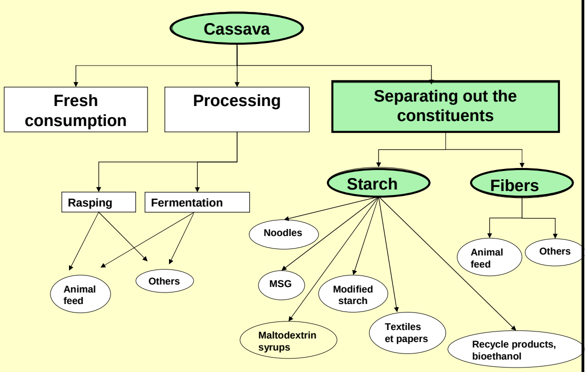
(FAO stat, 2006)

Production (–), Area harvested (-♦-), Yield (-×-).

Cassava in Vietnam (cont.)



Cassava valorization



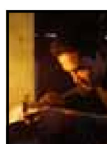
Cassava starch production in Vietnam

- Rapid market growth (+ export) since the *Doi Moi* (opening) in the late 80's
- Cassava production used in starch production: 24% (IFPRI, 1998) in 1998 (131,000 tons) versus 50% in 2004 (450,000 tons).

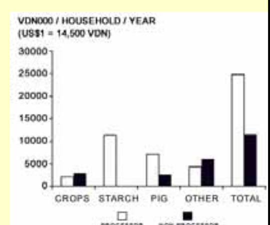
- Industry structure including **different production scales** :
  - Large scales: 42 factories in 2005 (imported equipment: Thailand, China)
  - **70% of the processing units at small scale** (about 4,000 units producing up to 1 ton of starch/day) including the "**craft villages**" (**CIVs**) from the Red River Delta => complex cassava value chain (ADB, 2005)

The Craft and Industrial villages (CIVs) in the Red River Delta (Northern Vietnam)

- **Vietnamese cluster** (Dao The Tuan, 2004):
  Production system concentrating in a specific geographical region where enterprises and households **specialize** in one or a group of activities and together create **relationship**, cooperation, competitiveness and **innovation**.
  Industrial cluster: a **group** of industrial villages in the same commune or in the neighboring communes.
- 668 craft villages with 147 in Ha Tay province in 2002
- Vietnam is willing to encourage the existing potential of the craft villages and create a further 1,000 by 2010
- Numerous **middlemen** within the value chain (collectors, traders) and connecting different activities.



Issues

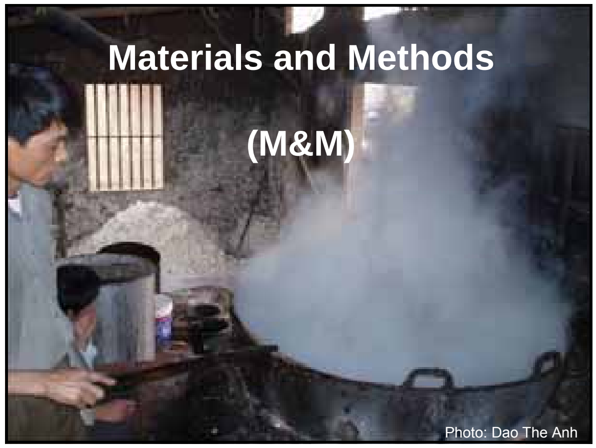


(CIP, 2001)

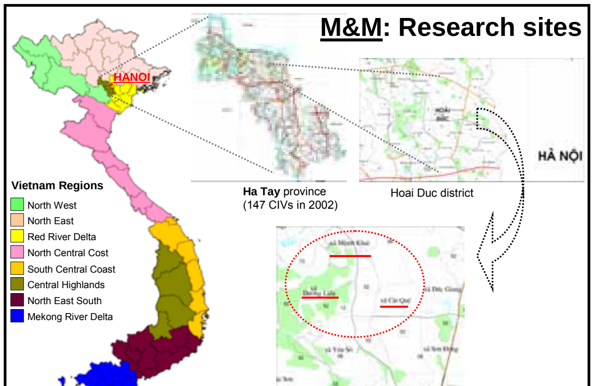
- Challenging future for the small firms producing Cassava starch (Goletti, 1998): is this scale can be competitive?
- Income benefits versus agriculture (SIUPA, 2001)
- CIVs: Territorialized system of production adapted to the specificity of rural industrialization in transition in Vietnam (Franchette, 2006)
- Energy and environmental issues (Peters, 2003) at any scales
- High density of population : up to 3500hab/km^2 in 2006

Objectives

- To propose a **qualitative and quantitative diagnosis** methodology **at household's scale** to identify bottlenecks and strengths of cassava starch processing in the cluster
- To make a **typology** of cassava starch processing units (Gottret *et al.* 1997) based on the different technologies currently used within the cluster
- To quantify the **efficiencies of starch extraction and water consumption** during the cassava starch processing (Duc, 1994)



M&M: Research sites

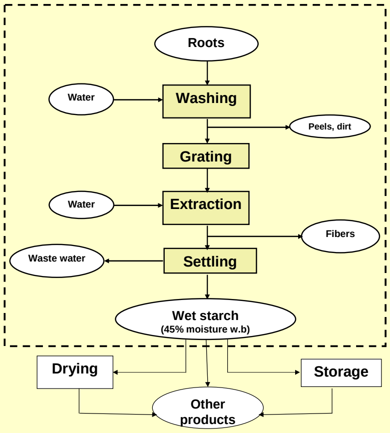


A cluster of 3 processing communes adjoining Hanoi

M&M: Diagnosis phase 1: qualitative

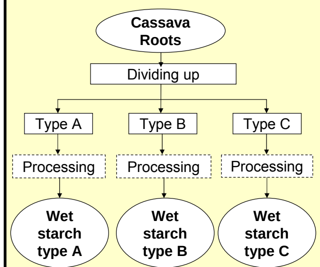
- **Information gathering:** Key informal interviews with researchers, officials, institutions, projects, stakeholders.
- **Participatory Rural Appraisal** (Calub, 2003) in the selected communes (group of 12 people per commune):
  => PRA tools: time line, seasonal calendar, processing flow diagram, SWOT analysis, trend analysis, …

Cassava wet starch processing diagram within the cluster



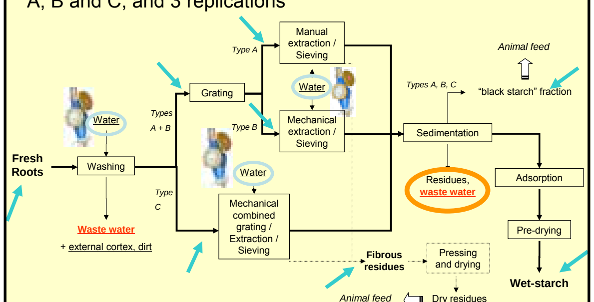
M&M: Diagnosis phase 2: technological

- **Developing** a methodology in a technological hall
- **Dividing up** roots deliveries (in bulk) among the different types (A, B, C) in the selected communes



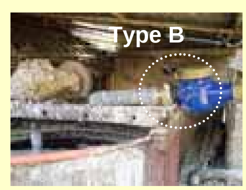
M&M: Diagnosis phase 2

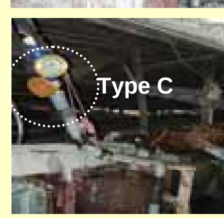
- **Following-up** the manufacturing process from one delivery of HYV in bulk and divided up into 3 types of processing systems A, B and C, and 3 replications



M&M: Diagnosis phase 2

Water consumption follow-up for the 3 types of processing units





M&M: Diagnosis phase 2

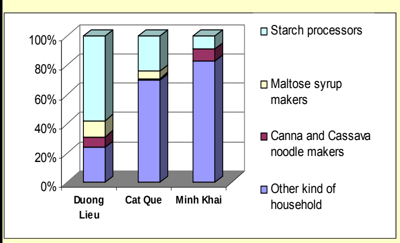
For each type of processing system (A, B and C):

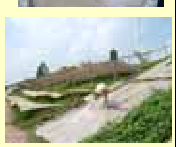
- Calculation of **mass balance** during the manufacturing process for producing wet starch
- Follow-up of the **production capacities** and **labor**
- Estimation of the **electrical consumption** for rasping and extraction stages
- Noting down the daily **prices** and **quantities** of raw materials (roots), by-products (fibers, black starch) and final products (wet starch)
- **Composition analysis** of the samples (3 aliquots) during trials (dry matter content, starch content, ash)

R&D: diagnosis phase 1

The PRA has shown

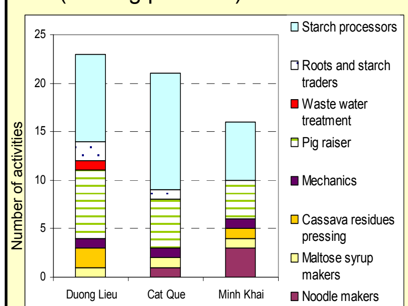
- a diversity of activities **within the three communes:** Duong Lieu, Cat Que and Minh Khai (cluster)

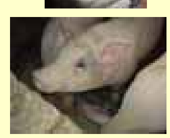




R&D: diagnosis phase 1

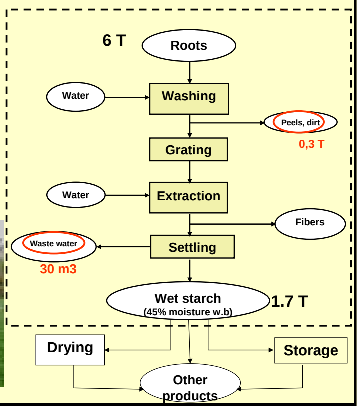
- A range of activities **per household** (ranking priorities)





R&D: diagnosis phase 1: conclusion

- A major constraint on the environment created from the discharge of the waste water from processing activities.



Environment

Solid wastes issue from processing during the peak season in the communes have been almost solved (market opportunities) for **cassava** but not for **canna**

No	Nature of waste	Unit	Cat Que	Duong Lieu	Minh Khai
1	Canna waste	ton/day	4.44	21.46	27.38
2	Cassava peels	ton/day	9.0	12.56	3.6
3	~~Cassava residues~~	ton/day	32.4	45.00	12.9
4	Coal residues	ton/day	2.64	8.58	2.15
	Total	**ton/day**	**48.72**	**88.60**	**46.28**

Source: Science and Technology department form Ha Tay province, 2002

Environment (cont.)

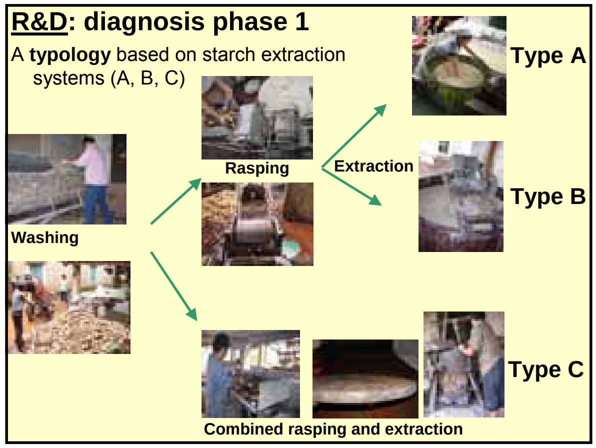
A high level of **waste water discharged** from processing during the peak season in the communes is a remaining unsolved issue

No	Production	Unit	Cat Que	Duong Lieu	Minh Khai
1	Rice vermicelli	m^3/day	-	-	1,500
2	Canna vermicelli	m^3/day	800	2,550	1,200
3	Cassava starch	m^3/day	2,200	3,800	2,400
4	Animal livestock	m^3/day	500	450	400
	Total	**m^3/day**	**3,500**	**6800**	**5500**

Source: Science and Technology department form Ha Tay province, 2002

R&D: diagnosis phase 1

A **typology** based on starch extraction systems (A, B, C)



R&D: diagnosis phase 1

Distribution of the 3 types A, B, C into the processing cluster of communes (2005)

		Type A	Type B	Type C
Capacity (t of roots/day/HH)	-	0,8 - 1	<= 2	<= 4
# Households among wet starch processors				
in Cat Que (%)	**184**	**107** (58)	**67** (36)	**10** (5)
in Duong Lieu (%)	**514**	**10** (2)	**384** (75)	**120** (23)
in Minh Khai (%)	**35**	**0** (0)	**25** (71)	**10** (29)
Estimated quantity of roots processed (t/day)	**More than 1500 (with 733 HH)**			

⇒Rapid evolution from type A to B and C depending on local constraints and specialized activities (noodle making, pig raising, maltose production…)

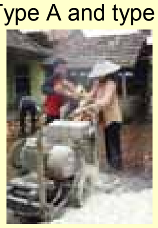
R&D: diagnosis phase 1

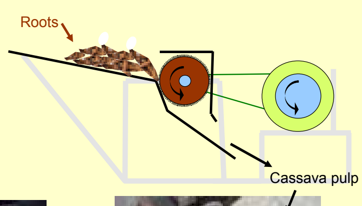
Development of the technology in Cat Que and Duong Lieu communes

Date	Technique	Capacity (ton/h/HH)	Marketing in Duong Lieu commune
1982 - 1986	Starting Root cleaned by feet reeling **Grating machine** using Gas, diesel motor **Manual stirring** Carried water from lakes,…	0.1 -0.2 ton/day/HH	Starch sold to other commune => Maltose producing Root grating HH appeared
1986 - 1996	**Root cleaning machine** appeared Improved Grating machine (Higher capacity) **Stirring machine (type B)**	0.3 - 0.5 ton/h/HH 0.5 -0.6 ton/h/HH 0.8 ton/h/HH	Many starch traders appeared Number of Canna starch HH increased
1996 - 2006	**Separating machine (type C)** **Tile tanks**	0.5 – 0.9 ton/h/HH	Many Root grating HH appeared Reduced number of root grating HH Reduced number of small-scale processing HH. Increase number of large-scale processing HH

R&D: Diagnosis phase 2: Equipment

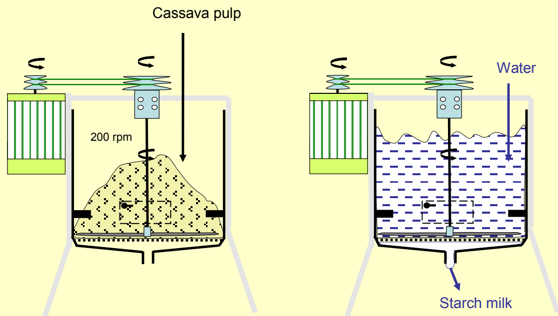
- Type A and type B : Loading and Rasping stages



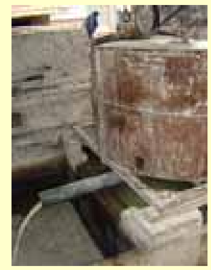


- Type A extractor : manual Stirring

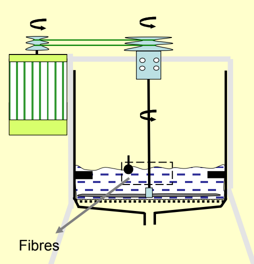
Type B extractor : Loading and Stirring stages



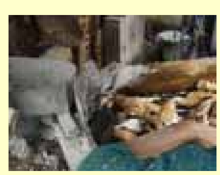
Type B extractor : Stirring stage

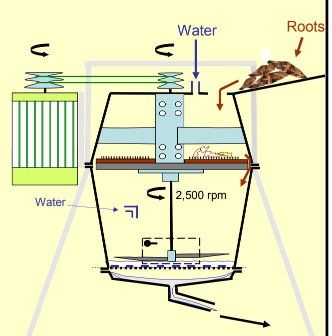


Type B extractor : Emptying the tank

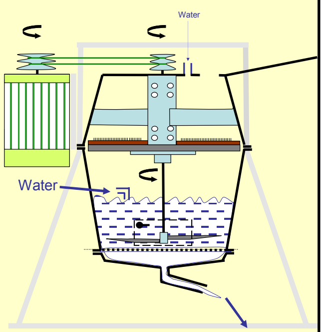


Type C: Loading and Rasping stages

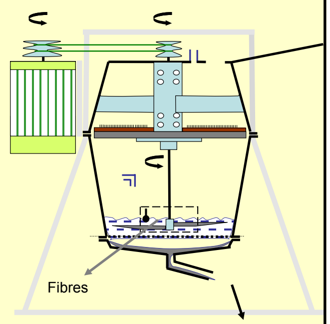




Type C: Stirring stage

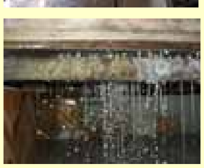


Type C: Fibers emptying stage

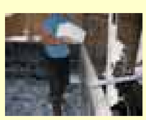


Types A,B,C…

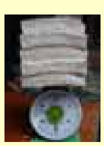
Filtration and settling



Predrying



Selling and/or **Storage**



Wet starch (45% moisture w.b.)

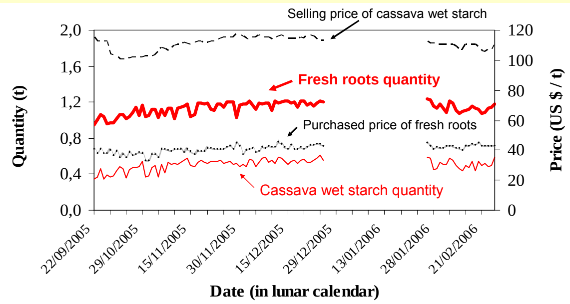
<u>R&D</u>: diagnosis phase 2: raw materials

- Long distance (transport) between cassava production and starch processing: 2-5 days
- Cassava varieties with:
  - High dry matter content (40% ± 1.5 w.b.)
  - High starch content (27 to 33% w.b.)

- **Processing depends STRONGLY on the delivering quantity and the type of the raw materials (cultivars)**
- **Competition with other cassava markets (cassava chips for China)**

R&D: diagnosis phase 2

Production follow-up of a type A processor during the processing season in Cat Que commune



Cassava processing is a Seasonal activity (benefit) => diversity of activities

R&D: diagnosis phase 2

Production capacities for the three systems (A, B, C) within Cat Que commune (2005)

	Processing capacities (t roots/h/Household)		
Stage	A	B	C
Washing	1.9	1.9	5.1
Grating	2.1	2.1	**0.9**
Extraction	**0.3**	**0.5**	
Settling	0.1	0.1	0.2

⇒ Bottlenecks: Settling and extraction => optimization of washing and grating capacities

⇒ Type C is largely adopted to reduce labor and space constraints.

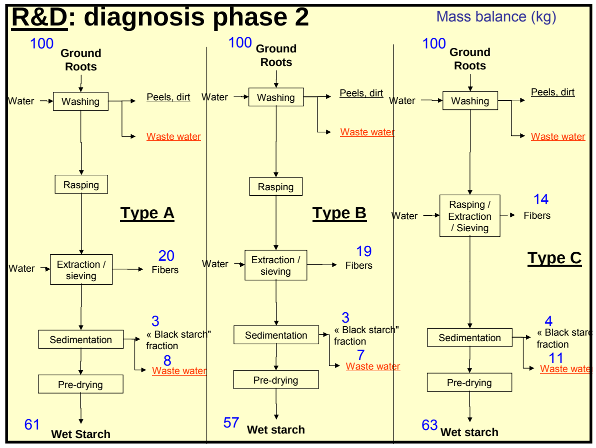
R&D: diagnosis phase 2

Extraction efficiencies

	Type A	Type B	Type C
Weight of fresh processing roots (t)	1.13 ± 0.04	1.12 ± 0.03	2.26 ± 0.04
Conversion rate (%) *kg of dry starch / kg roots*	25.3 ± 1.6	24.3 ± 0.8	26.1 ± 1.0
Total water used in liter per kg of dry starch	**16.8** ± 2.4	**13.6** ± 2.3	**21.9** ± 1.4

⇒ Type C requires higher water consumption than types A and B, but it is largely adopted for other reasons.

R&D: diagnosis phase 2



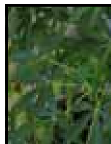
Comparison with other processing units

	Ivory Coast (Bietrix, 1996)	Brazil (Guesdon, 2002)	Colombia (Rivier, 2001)	Thailand (Sriroth, 2000)	Vietnam cluster
Conversion rate (%) *kg of dry starch / kg roots*	**17.2**	**24.0**	**17.2**	**18.3**	**25.2**
Total water used per kg of dry starch (l)	**29.1**	**18.8**	**43.6**	**12**	**17.4**
Total solid in waste water per kg dry starch (%)	**13**	**12**	**-**	**low**	**13**
Starch content in Dry Starch (%)	98	97	95	>= 98	89-97

Different solutions have been tested to reduce water consumption up to 50% with hydrocyclones technologies (Trim *et al.*, 1996)

A waste water treatment device has been studied (Thuy, 2006) => 30m^3/day, 2days

=> Space shortage limits the adoption within the cluster (local constraints)



Cassava wet starch processing benefits ?

	Amount (USD/day/HH) A	B	C
Fresh roots	-49.8	-49.2	-96.1
Water (sinking wells excluded)	0	0	0
Electricity (3P)	0	-1.3	-2.5
Labor	-4.6	-3.5	-5.7
Depreciation (rasping + extraction)	-0.1	-0.2	-0.7
Equipment renting (washing + rasping)	-1.9	0	0
Expenses for processing	**-56.4**	**-54.2**	**-105.0**
Wet starch	49.8	56.3	119.4
Black starch	2.2	1.4	2.8
Fibers	2.5	1.7	6.0
Gross benefit from processing	**54.4**	**59.4**	**128.2**
Net benefit from processing	-1.9	5.2	23.2

=> Up to 91% of the expenses

During the peak season only

1USD = 16,000VND

=> Based on our trials, processing looks not economical for type A and give a limited profitability for type B versus C (largely adopted)

=> Other costs/benefits must be considered (first investment + other activities)

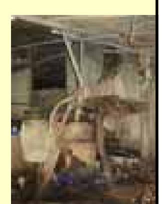
Conclusion

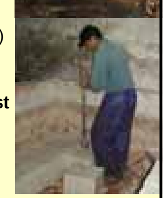
The **methodology of diagnosis** at household level within a cassava processing cluster has allowed :

- To identify **local constraints** which mainly concern the space limitation and related environment issues (liquid waste management)
- To make a **typology** based on extraction systems:
  - **Quantification** of the differences between processors on stage capacities, **water consumption** and discharged water levels
  - Indicating a **high efficiency** of cassava starch extraction compared to other locations but **lower quality** level of the final product
- To **roughly estimate** the profitability of the different systems of extraction

Perspectives

- What principles do the rasping/extraction work on different aspects:
  - the available technology (Vietnam, other locations)
  - the raw materials (Cassava, Canna)
- Further research on **quality levels** of the final products depending on the applications (end-uses) and the local constraints (with or without storage)
- A complementary study at household scale on **cost analysis** by integrating the other activities (pig raising, labor renting, energy, by-products valorization…)





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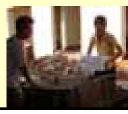

Processors from Hoai Duc district in Vietnam