Understanding the drivers of land use changes: the case of oil palm managements in Sumatra (Indonesia)

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Context:

In Indonesia, 10% of the oil palm area is managed by the state, 50% by private companies and 40% by smallholders. Smallholders are currently divided into:

- "Plasma" smallholders whose **land management is supervised** by the mill or estate to which they are bounded by contract.
- "Independent" smallholders whose **land management is not constraints by contract** to a mill or an estate.
- Most of the recommendations in terms of palm oil sustainability are based on this distinction.

Hypothesis :
Agricultural practices combinations mostly depend on the fact that a plot is independent or plasma.

One oil palm agricultural management
=
one land use type (1)

Independent plots → plots freely managed by the growers

Plasma plots → plots managed by supervised growers

The sustainability of palm oil production is nowadays largely criticized.

- Agricultural management contribute to palm oil production global impacts.

To propose efficient measures to induce changes towards sustainable palm oil production, initiatives such as the Round Table for Sustainable Palm Oil, need to better understand the drivers of oil palm agricultural management.

- It implies characterizing and understanding the real diversity of palm oil agricultural practices to better identify locks towards sustainability and to propose efficient changes.

Objective:
To define homogeneous groups of oil palm plots characterized by similar agricultural practices.

Material and Method:

Data collection:
In 2013, a survey was carried out in Jambi and Riau provinces (Sumatra, Indonesia) to describe the agricultural practices of 87 oil palm plots.
The area surveyed in Riau is characterized by the development of oil palm through private companies and supervised smallholders estates. On the other hand, the area surveyed in Jambi is characterized by the development of oil palm in traditional villages.

78% of the plots are "independent" and 22% of the plots are "plasma" (V0, Table1).

Statistical analysis (R software):
The data collected were quantitative and qualitative.
Table 1 shows the variables describing the agricultural practices after discretization of the quantitative variables.

To identify homogeneous groups of agricultural practices, we carried out:

- Khi2 test (V0*Each agricultural practices)
- Multiple Component Analysis (MCA), 11 active variables
- Hierarchical Ascending Classification (HAC), 4 first dimensions, 41,8% of total cumulative variance

Variables		Description	Modalities	P-Value Khi2 Test
Inactive	V0	What is the plot type?	Plasma/Independent	
Active	V1	What was the previous land use ?	Food use/No agricultural use/Old rubber	1,5e-4
	V2	How many palms have been planted on the plot ? (palm/ha)	[69-120[, [120-128[, [128-138[, [138-200]	2,1e-2
	V3	How is the quality of seedlings ?	Certified Uncertified	2,4e-7
	V4	How much nitrogen nutrients (N) is applied on the plot ? (g/palm/y)	0, [0,04-0,39[, [0,39-0,92[, [0,92-1,42[, [1,42-4,14]	9,1e-4
	V5	How much phosphorus nutrients (P) is applied on the plot ? (g/palm/y)	0, [0,02-0,32[, [0,32-0,65[, [0,65-1,05[, [1,05-1,88]	9,7e-8
	V6	How much potassium nutrients (K) is applied on the plot ? (g/palm/y)	0, [0,02:0,32[, [0,32:0,6[,[0,6:1,4[, [1,4:5,72]	1,2e-9
	V7	Is biological fertilizers applied on the plot ?	Yes/No	1
	V8	Are micro-elements (Mg, Cu, …) applied on the plot ?	Yes/No	7,9e-10
	V9	Which fertilizers are applied on the plot ?	None/NPK/Others	0,07
	V10	How much glyphosate is spread on the plot? (g/ha/y)	0, [180-594[, [594-1080[, [1080-2160[, [2160-5400]	1
	V11	How much paraquat is spread on the plot? (g/ha/y)	0, [20,7-583[, [583-1000[, [1000-2140[, [2140-6900]	1,9e-2

Table 1: Variables description

1. Taken one by one, are agricultural practices different between independent and plasma plots?

Khi2 p-values are below 5% for 8 variables out of 11 (Table 1). Plot type is correlated to most agricultural practices alone.

- Plot type allows to describe differences between agricultural practices modalities.

However, for example, most plasma plots (93%) receive micro-elements nutrition but a number of independent plots too (12%).

Moreover, agricultural practices are usually correlated between each other. The technical management of the plot is a logical and ordered flow of agricultural practices.
For example, estate extension services deliver recommendations for plasma plots taking into account the dependence between the agricultural practices.

- **Regarding fertilizer annual quantities, some independent plots seem to have similar practices to plasma plots.**
- **Common oil palm plot classification between plasma and independent doesn't seem to be the only driver of agricultural management.**

Changing agricultural practices requires to better describe the diversity of plots to further understand the drivers of agricultural practices.

For example, some plasma smallholders also own independent plots which could lead to the same management for independent and plasma plots within the same farm holding.

Other drivers from different scales (eg. the farm holding) may be stronger drivers.

2. What are the agricultural practices that best describe the diversity of the plots management ?

The MCA shows that the best represented variables are those related to fertilizers (Variables V5, V6, V4, see Figure 1 for the representation of the variables according to the two first dimensions).

In our sample, the annual quantities of N, P and K best represented the diversity of the plots management.

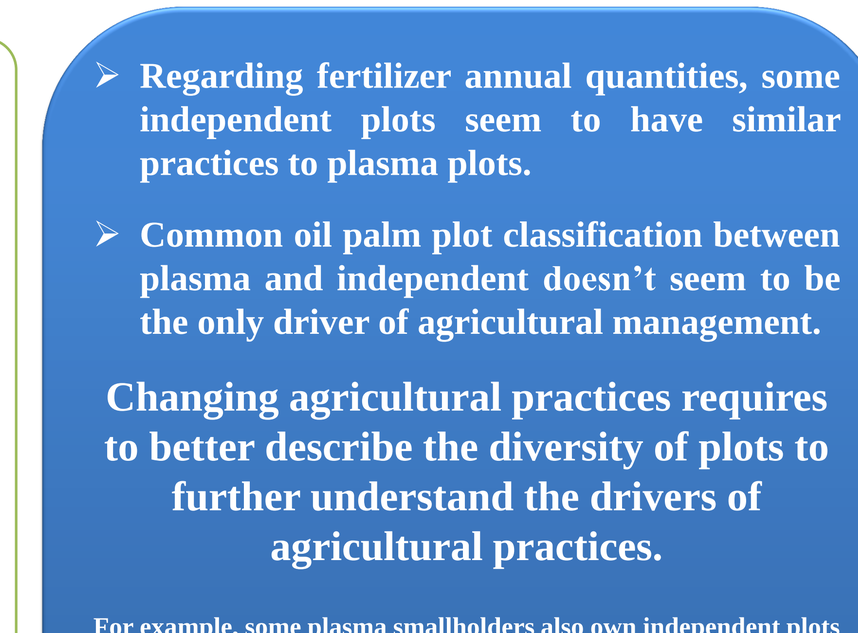

Figure 1: Variable representation

3. What are the groups yielded taking into account all the agricultural practices ?

The HAC yields 3 clusters (table 2). They partly reflect the plasma-independent plots partition (most plasma are in cluster 2 and independent are mostly in cluster 1 and 3).

- Taking into account combinations of agricultural practices yield consistent results with the Khi2 analysis.
- Agricultural practices are partially grouped by plot types.

Cluster 2 is constituted of both plasma and independent plots.

- Some independent plots share more characteristics with plasma plots than with the other independent plots.

Independent plots are distributed in the 3 clusters whereas most plasma plots are only in one cluster (Figure 2).

- The diversity of agricultural practices may be greater among independent plots.

However, the apparent homogeneity of plasma agricultural practices may be linked to the weak representation of plasma plots within the sample. Therefore, to better estimate the diversity among the plasma plots, we intend to independently analyze plasma plots agricultural practices.

Cluster	1	2	3
Cluster main charac-teristics	- Absence of fertilization - Absence of paraquat use - Mostly independent	- Micro-element fertilization - N, P, K high fertilization - Certified seedlings - Independent and Plasma	- Low fertilization - No micro-element fertilization - Mostly independent

Table 2: Clusters description

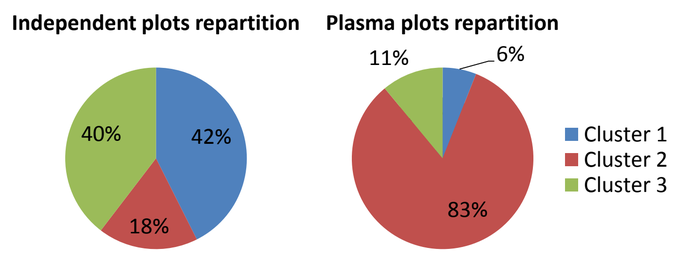

Figure 2: Plots repartition among clusters

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Sources:
(1) Verburg, Peter, Paul P. Schot, Martin Dijst J, and A. Veldkamp. "Land Use Change Modelling: Current Practice and Research Priorities." *GeoJournal* 61 (2004): 309–324.

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