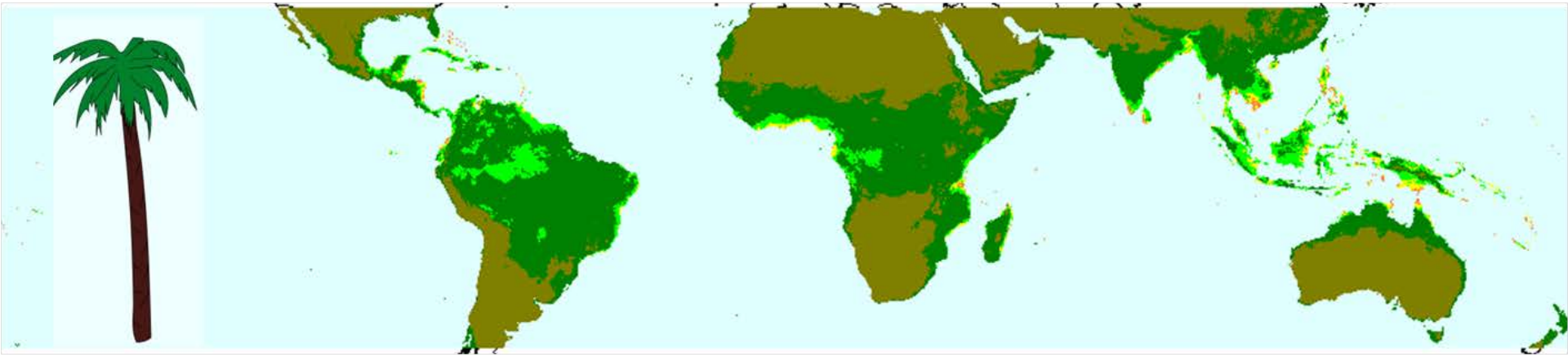
Developing a method to process satellite images for mapping coconut agrosystems

By Prune Komba Mayossa & Geo Coppens & Fréderic Borne & Gaëlle Viennois

INTRODUCTION

❑ Context :

Cocos nucifera L., perennial oil seed crop of intertropical area :



- Warm and humid climate
- 21° C < average temperature < 27° C
- 1500 mm < annual rainfall < 2500 mm, uniformly distributed.
- Altitude up to 300 m

→ **Coconut palm : tree of life**

Copra: Important place in the economy of several regions of the Pacific (e.g. Vanuatu, Tuamotu), **Africa** (e.g. Ivory Coast and Tanzanian coasts) and **Asia** (India and the Philippines).

INTRODUCTION

❑ **Problematic : resource management of long-term coconut** (COGENT network, 39 countries)

Existing : ***Few studies of mapping and characterization of coconut plantations***

-Lelong et *al*., 2004: Typology of coconut plantations.

-Teina, 2009: use of watershed to estimate, count and conceive maps of density.

➔ ***Not generalizable methods***

❑ **Objectives : Development of a simple and generalizable method for**

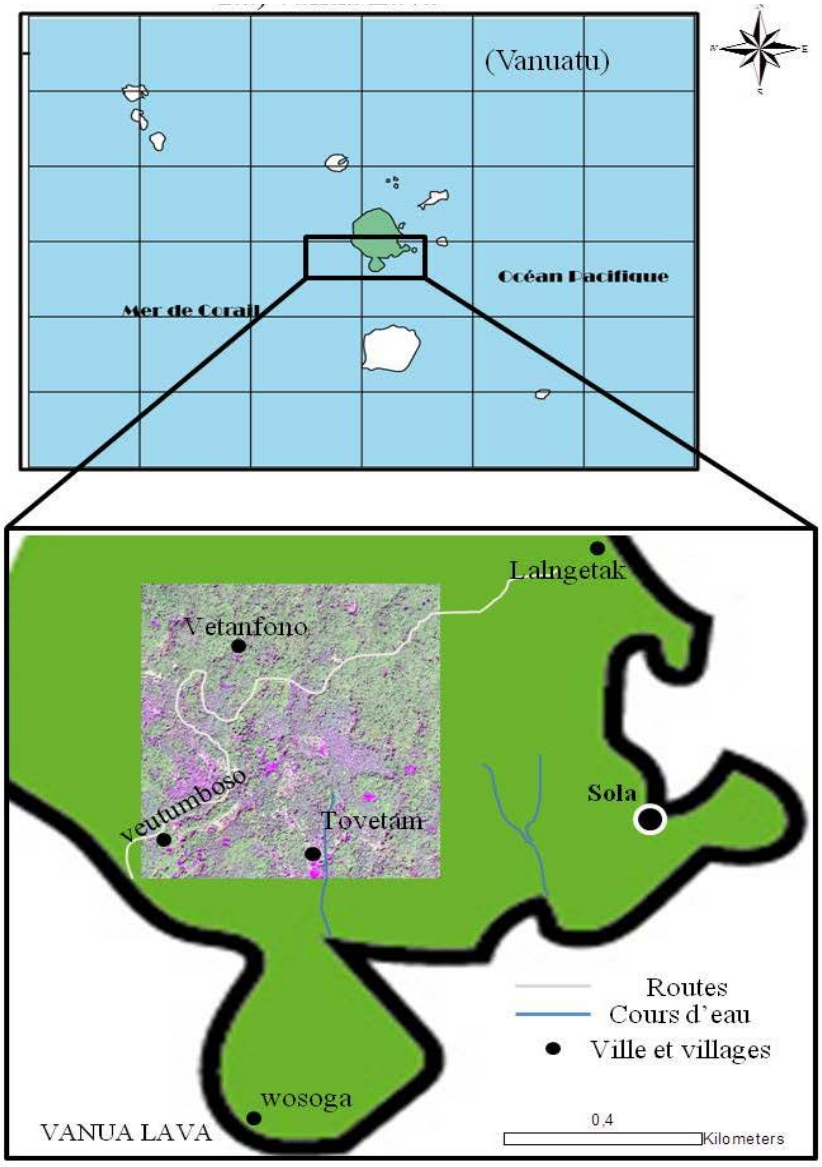
- **mapping the agro-systems involving coconut palm,**
- and **differentiating them from oil palm.**

Two different agricultural contexts :

- **Heterogeneous environment :** Vanuatu (Vanua Lava island) ; **ancient coconut orchards, several stages of maturity.**
- **Homogeneous environment :** Ivory Coast (Marc Delorme Research Station) ; **coconut palm in monocultivation, neighbouring oil palm groves.**

MATERIALS AND METHOD / « Sites of study »

❑ Vanua Lava



North Vanuatu :

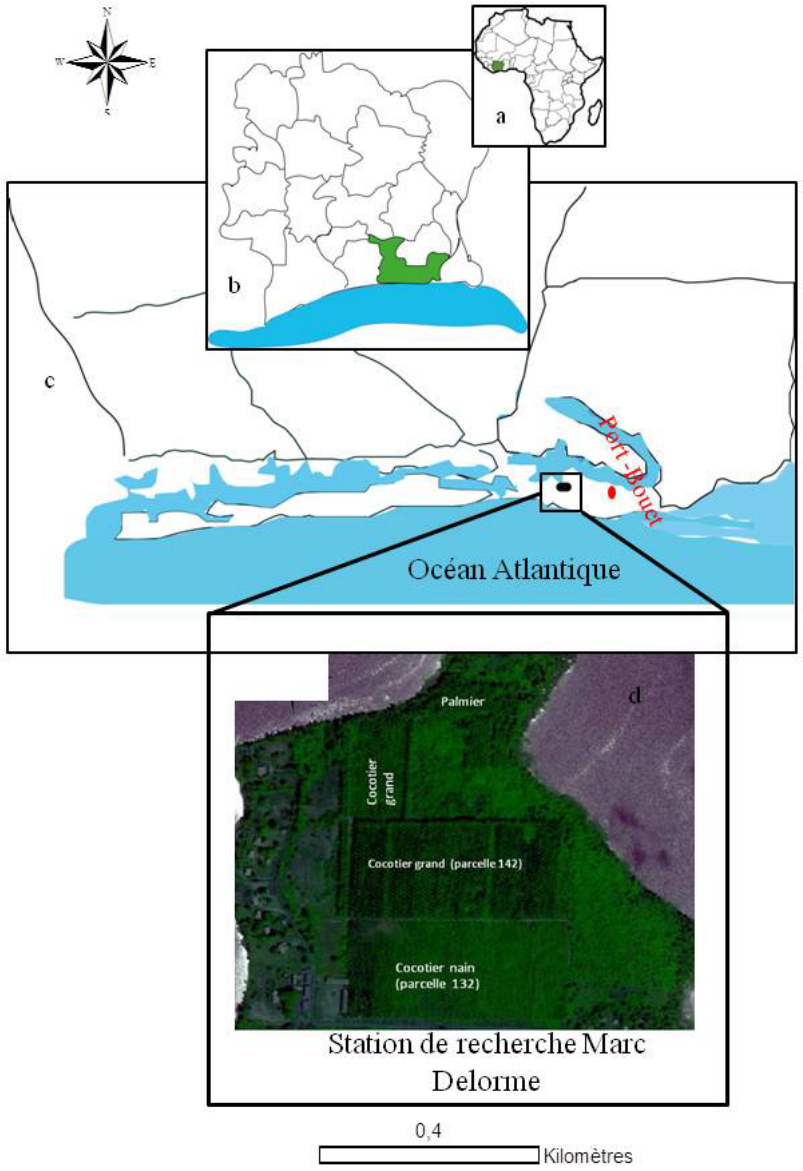
- Oceanic equatorial climate
- Area : 334,3 km² (2597 inhabitants)

Tool:

Pléiades image (29/10/2013)
- Multispectral mode (B,V,R,PIR) in 2m of resolution
- Panchromatic mode in 0.5m of resolution

MATERIALS AND METHODS / « Sites of study »

❑ Marc Delorme Research Station



Lagoon Region (Ivory Coast)

- Equatorial climate : (25-30° C) ; very high rate of humidity (80-90%) ; High precipitation(2129 mm).

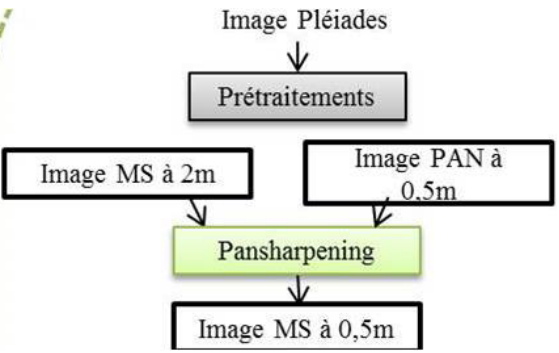
- Genebank of coconut palm managed by COGENT.

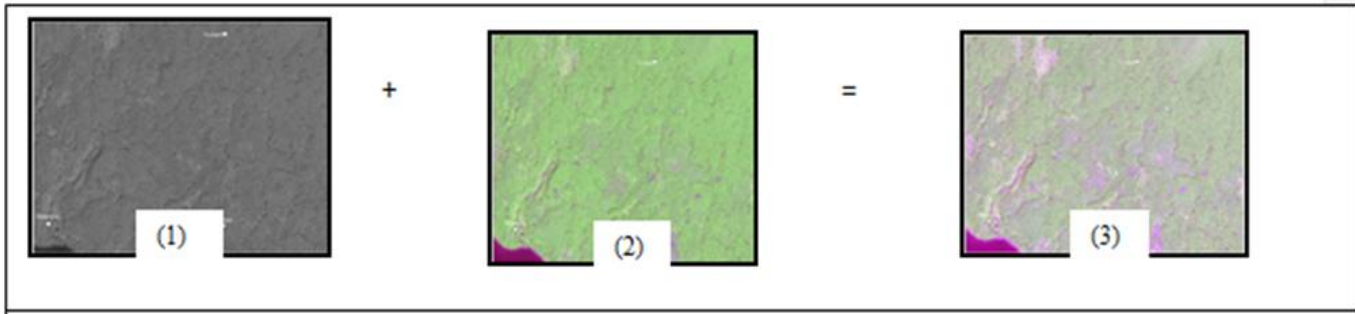
Tool :

GeoEye-1 image (10/10/2013)

- Multispectral mode (B,V,R,PIR) in 2m of resolution.
- Panchromatic mode in 0.5m.

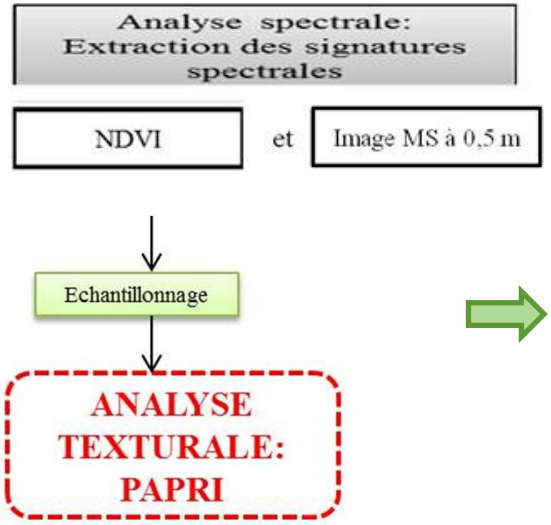
MATERIALS AND METHODS / «Extraction and counting of coconut palms»





(1) : image panchromatique à 0,5 m de résolution ; (2) : image multi spectrale (R,PIR,R) à 2m de résolution ; (3) : image ré échantillonnée (R,PIR,R) à 0,5m de résolution.

Menu ENVI : Transform → Image sharpening → Gram-Schmidt Spectral Sharpening



NDVI

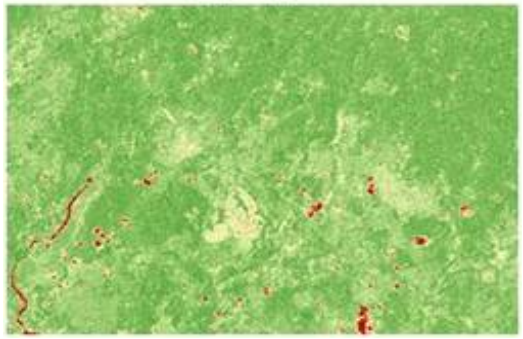
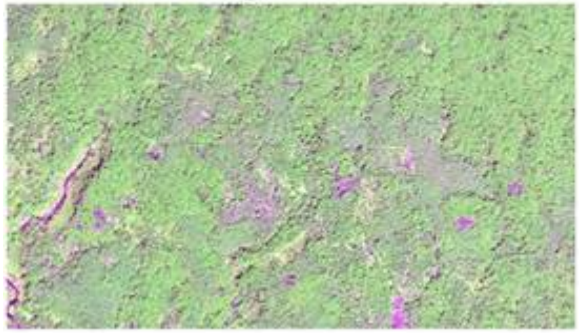
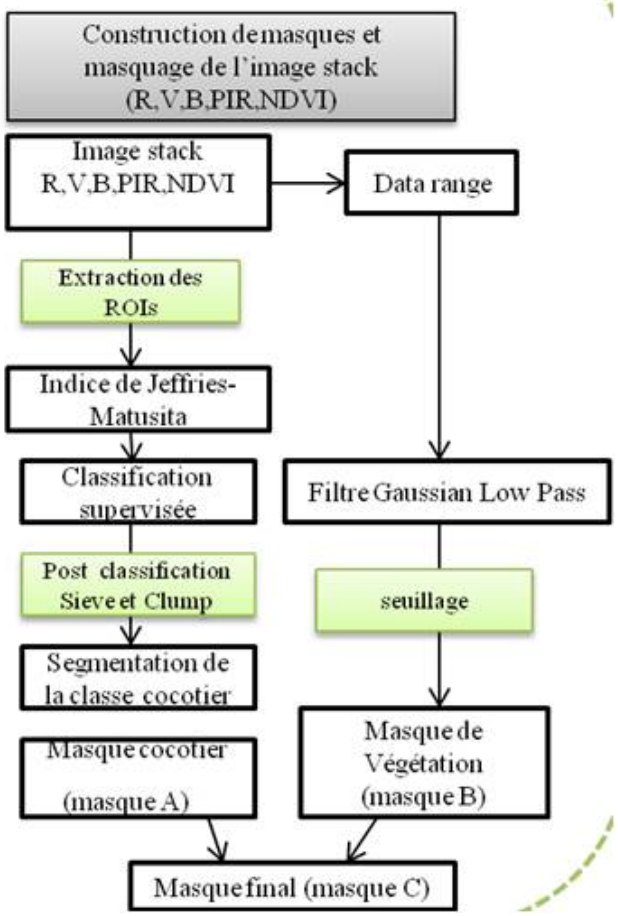
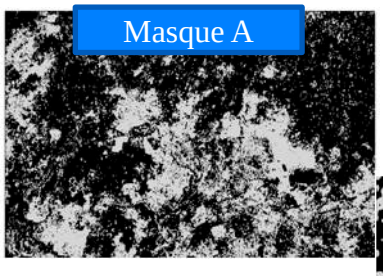


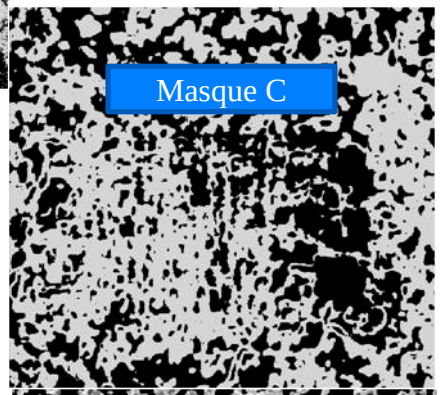
Image MS

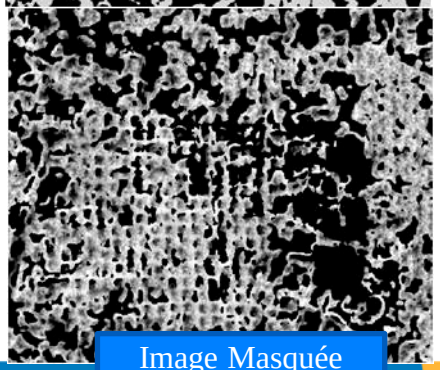


MATERIALS AND METHODS / «Extraction and counting of coconut palms»

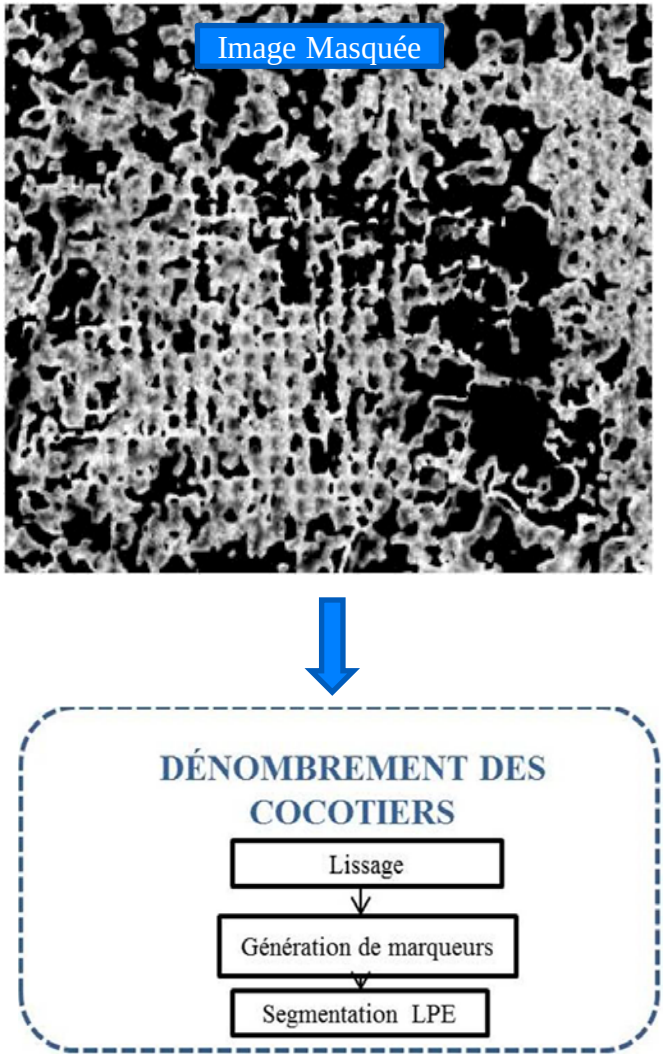








MATERIALS AND METHODS /
«Extraction and counting of coconut palms»



TIDA method (Culvenor,2002)

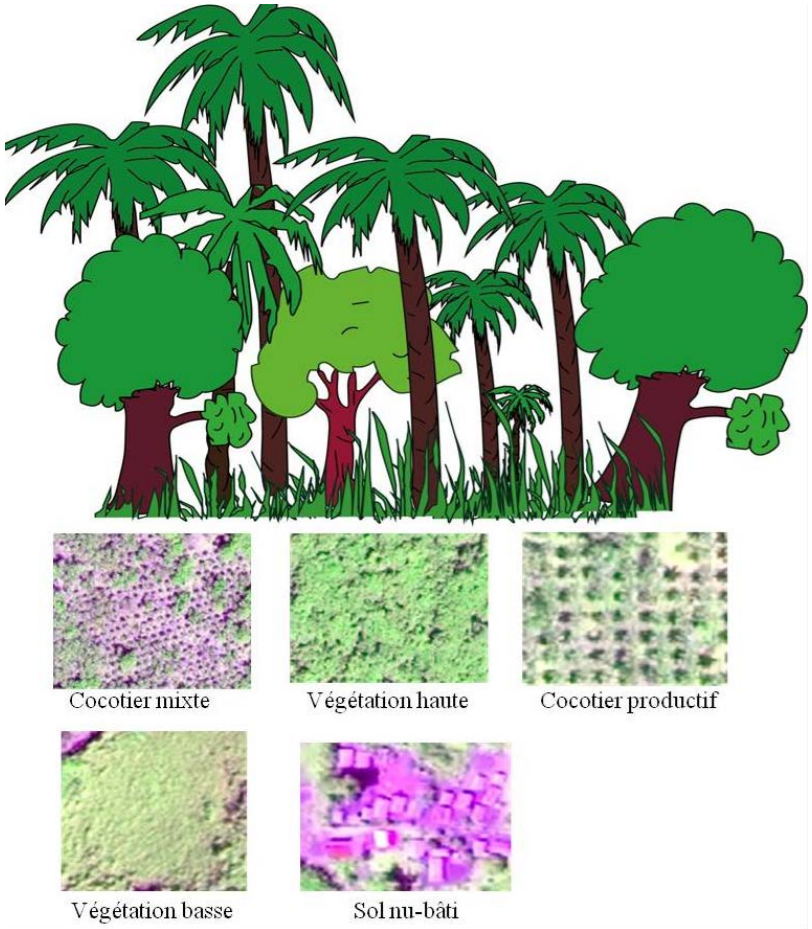
Watershed (LPE) :

- **Smoothing:** filter, reduce texture.
-**Markers:** local minima and maxima in 4 directions.

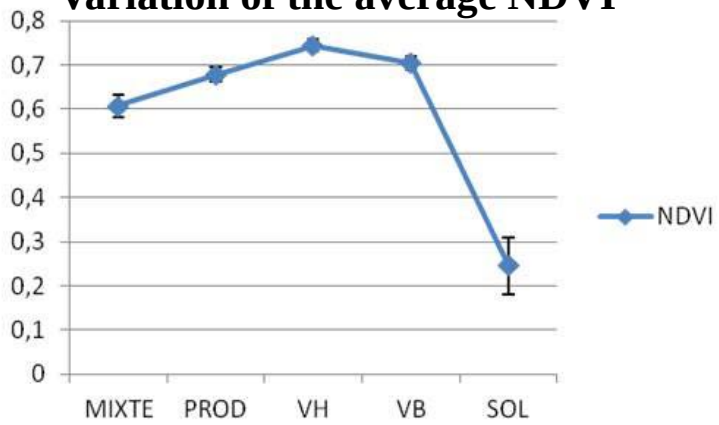
RESULTS / « Extraction and counting of coconut palms : spectral analysis »

Spectral variation by class

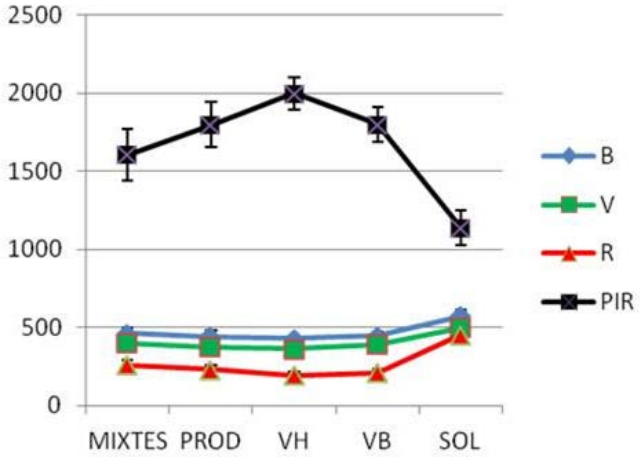
❑ Vanua Lava



Variation of the average NDVI



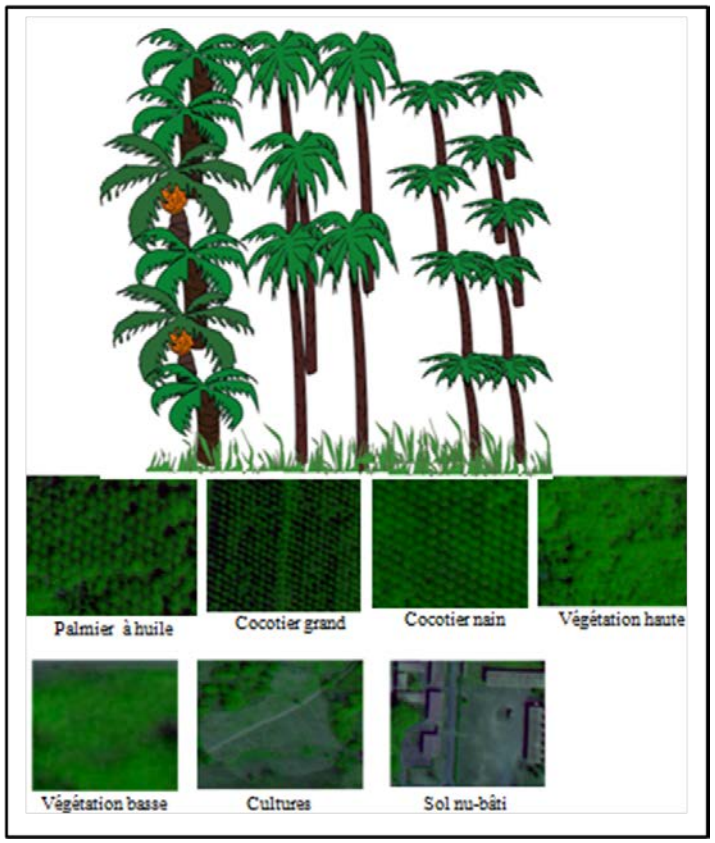
Spectral variation B,G,R, NIR



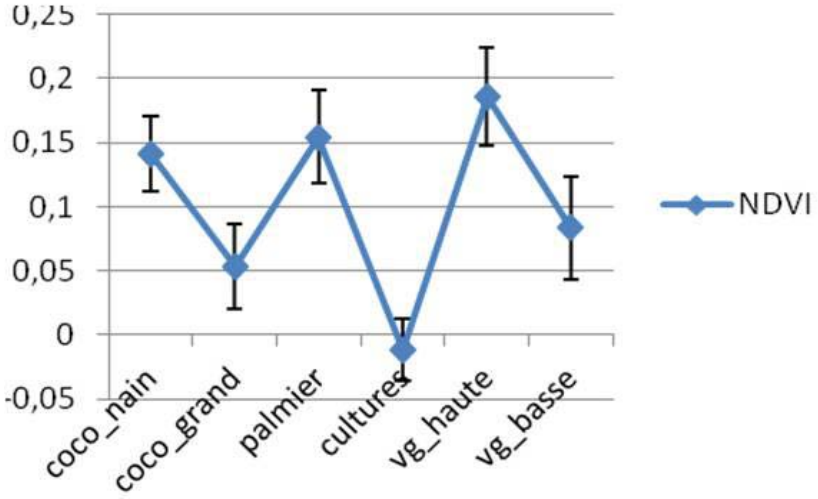
NDVI allows to distinguish the mixed coconut palms (average NDVI = **0.60) of the productive coconut palms (average NDVI = 0.67).**

RESULTS / « Extraction and counting of coconut palms : spectral analysis »

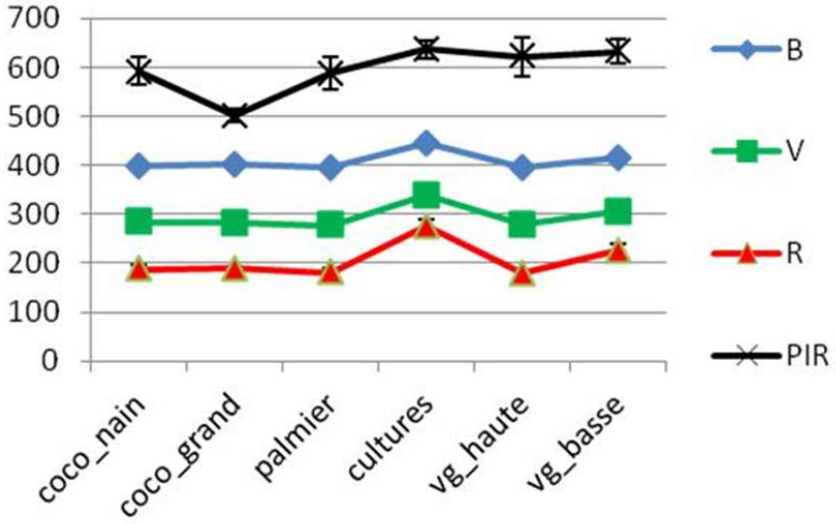
❑ **Marc Delorme Research Station**



Variation of the average NDVI



Spectrale B,G,R, NIR



Coconut palms : varietal distinction by the NDVI.

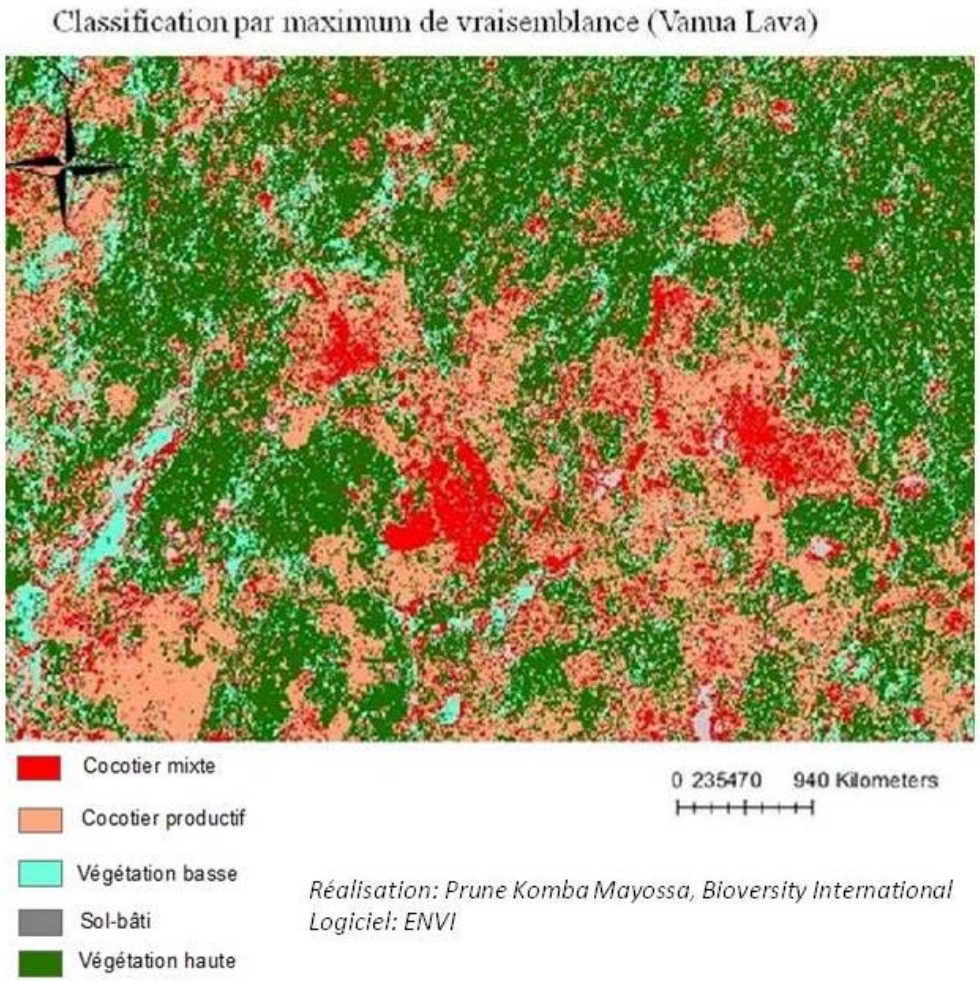
NDVI dwarf = 0.14 and NDVI large =0.5.

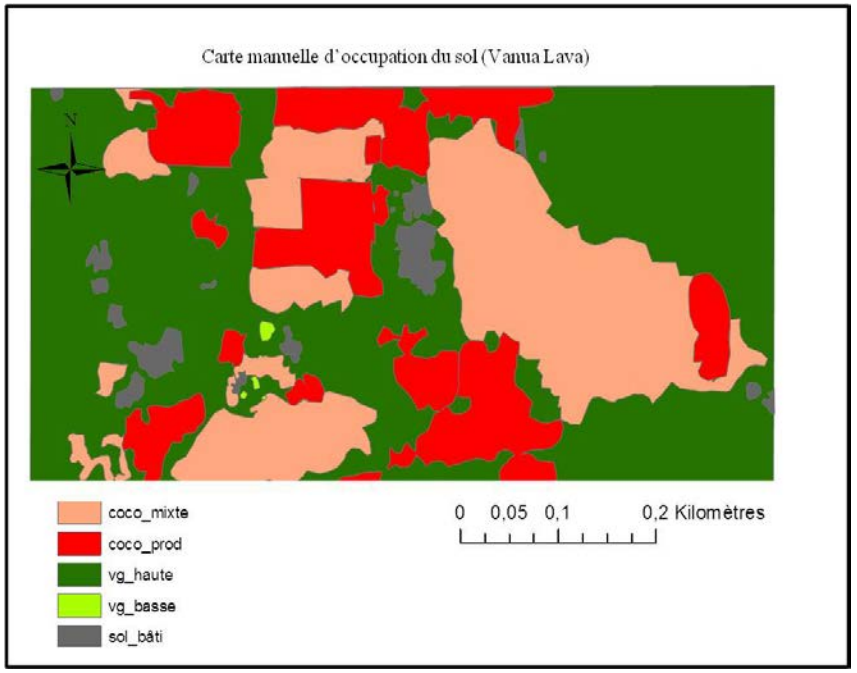
Oil palm: NDVI of 0.15

→ Confusion with vegetation (high and low) and dwarf coconut palms.

RESULTS / « Extraction and counting of coconut palms : spectral analysis »

Maximum Likelihood Classification Vanua Lava





- **Manual validation :**

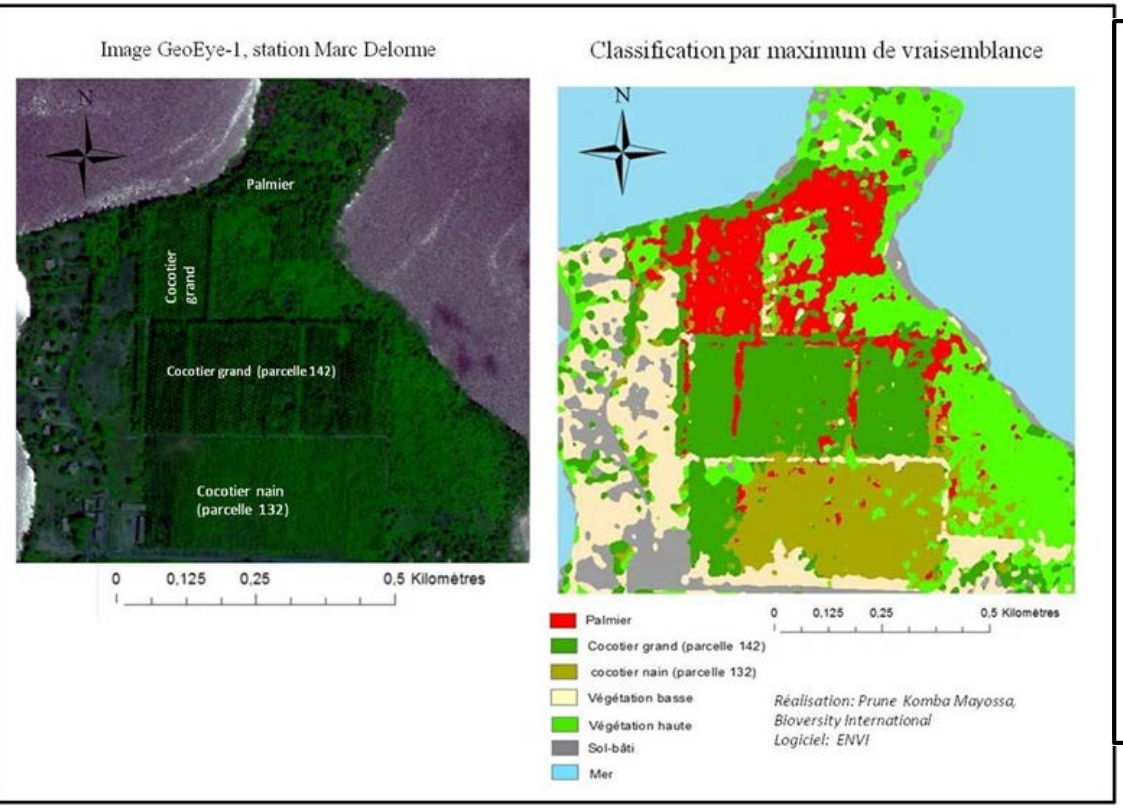
Map of overall accuracy 57%, **Kappa of 0.4**
Confusion between mixed (57%) and productive coconut palms (68%)

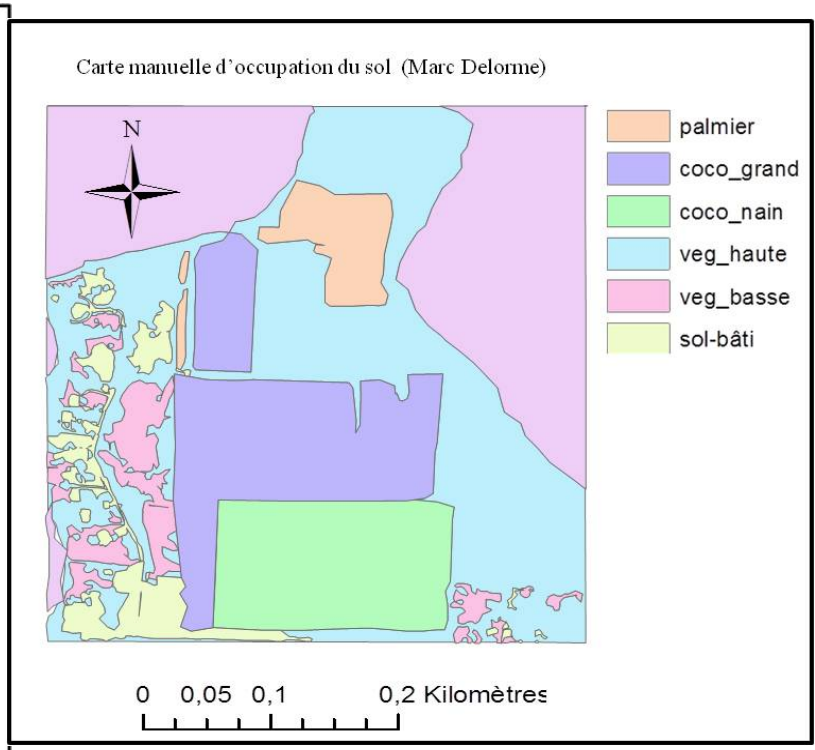
- **Automatic validation :**

Overall Accuracy of 85% (**Kappa = 0.71**)

RESULTS / « Extraction and counting of coconut palms : spectral analysis »

Maximum likelihood classification Marc Delorme research station





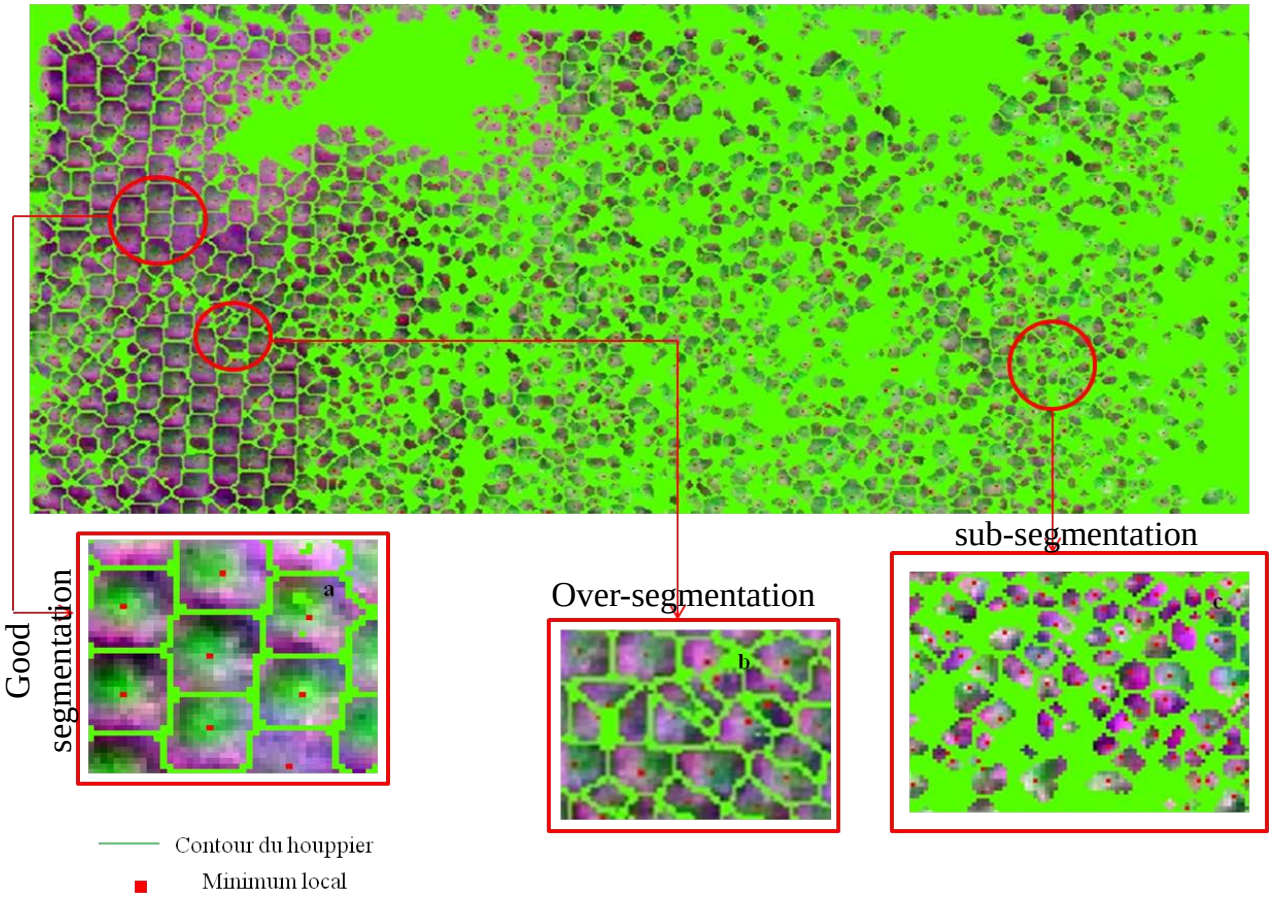
Manual validation :

→ Map of overall accuracy 58% (Kappa of 0.4)

Confusion between oil palm, large coconut and dwarf coconut palms

RESULTS / « Extraction and counting of coconut palms : spectral analysis »

Counting of coconut palms



Segmentation is not uniform on the whole image :

We succeed in counting **65 %** of the coconut palms.

Conclusion 1:

NDVI important :

Differentiate coconut palms besides of the vegetation; possible varietal discrimination.

RESULTS / « Textural analysis : PAPRI method »

❑ Vanua Lava

Small window

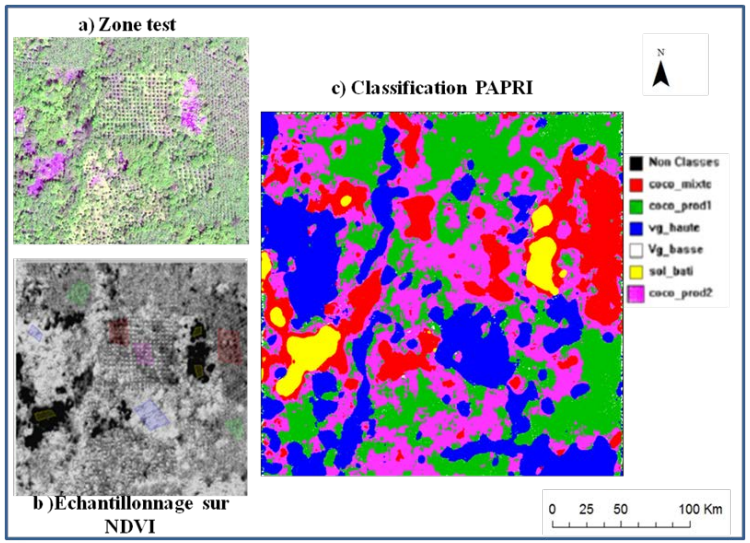


Table 1: Confusion matrix: small window

VALUE	mixtes	prod	vh	vb	sb
mixtes	46,41	31,69	26,42	0,00	2173,00
prod	34,42	52,23	25,68	17,58	1428,25
vh	10,69	10,96	30,95	21,10	1084,75
vb	1,70	1,33	3,07	61,32	116,50
sb	6,79	3,79	13,89	0,00	54,56

Large window

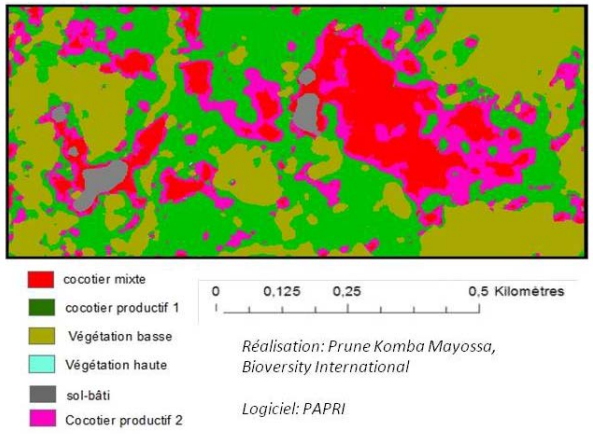


Table 2: Confusion matrix: large window

VALUE	mixte	prod	vh	vb	sb	total
mixte	60,57	3,23	5,57	15,74	20,94	106,05
prod	34,38	93,46	36,68	1,94	18,17	184,62
vh	5,05	3,31	57,25	0,00	1,20	66,81
vb	0,00	0,00	0,00	82,32	0,00	82,33
sb	0,00	0,00	0,50	0,00	59,68	60,19
	100	100	100	100	100	500,00

Better accuracy with large window sizes : Accuracy of 70% and Kappa of 0.63

RESULTS / « Textural analysis : PAPRI method »

❑ **Marc Delorme station**

Small window

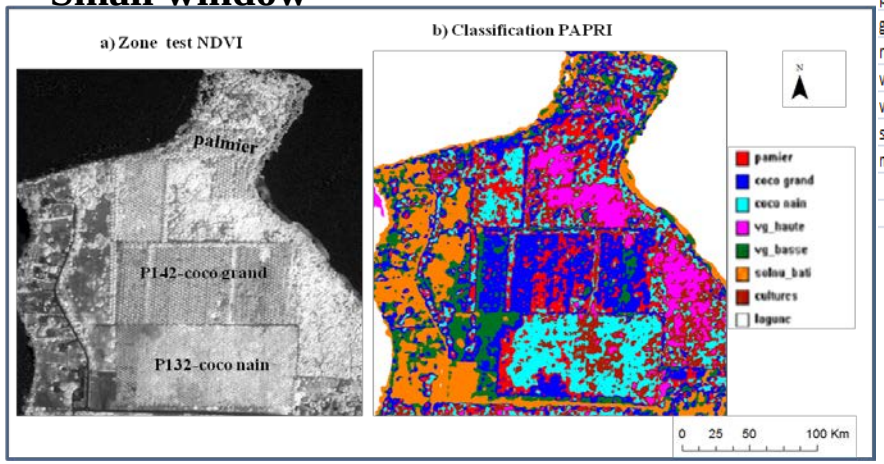


Table 3: Confusion matrix small window

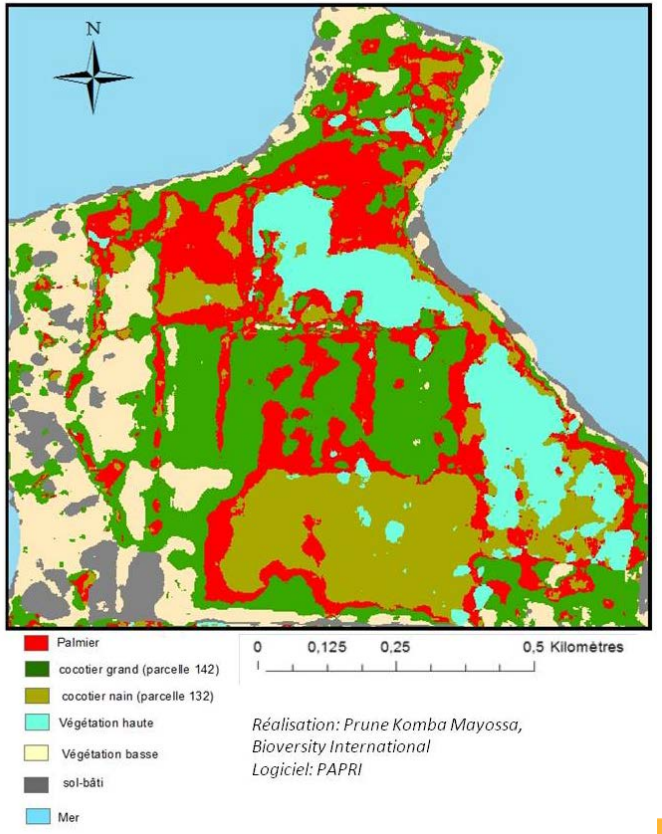
VALUE	palmier	grand	nain	vb	vh	sb	mer	total
palmier	48,5125	29,2072	17,5153	15,5883	3,8645	0,1769	0,0000	66,3522
gran	27,6895	52,0708	9,9710	22,2335	17,0324	1,5650	0,0188	130,5810
nain	16,2880	9,4416	63,0470	17,4158	0,4964	0,0247	0,0000	106,7135
vb	3,1929	0,9640	7,2735	22,9572	0,0686	0,0037	0,0000	34,4599
vh	3,7836	8,2381	2,1932	16,4136	70,2552	39,7064	0,2356	140,8258
sb	0,5336	0,0782	0,0000	4,9889	8,2830	58,5232	1,7515	74,1585
mer	0,0000	0,0000	0,0000	0,4027	0,0000	0,0000	97,9940	98,3967
	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	651,4875

Table 4: Confusion matrix large window

VALUE	palmier	grand	nain	vb	vh	sb	mer	total
palmier	65,61	29,53	16,43	19,53	3,20	0,35	0,00	134,65
grand	24,53	57,91	10,00	23,82	18,71	2,53	0,01	137,51
nain	6,03	5,52	69,38	12,42	0,04	0,02	0,00	93,40
vb	1,50	0,37	2,66	24,11	0,09	0,00	0,00	28,73
vh	2,09	6,64	1,53	15,51	74,54	45,56	0,39	146,27
sb	0,24	0,03	0,00	4,23	3,42	51,54	1,67	61,14
mer	0,00	0,00	0,00	0,37	0,00	0,00	97,92	98,29
	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	100,00000000000	700,00

Better accuracy with large window sizes Accuracy of 56% and Kappa de 0.56

Large window



Conclusion 2:

The texture is best expressed with large window sizes.

DISCUSSION AND CONCLUSION

Reminders of the main result

1. Spectral analysis

- Homogeneous and heterogeneous agricultural landscape : spectral signatures do not allow a sufficiently precise classification (Kappa =0,4).
- Confusion palm tree / coconut palm, also coconut palm dwarf / large coconut palm.

Watershed not effective in any area of the image (problems of sub-segmentation and over-segmentation).

- NDVI, Important for the study of the vegetation: separability of vegetable classes.

→ **Simplification and improvement of the method proposed by Teina (2009).**

2. **Textural analysis**

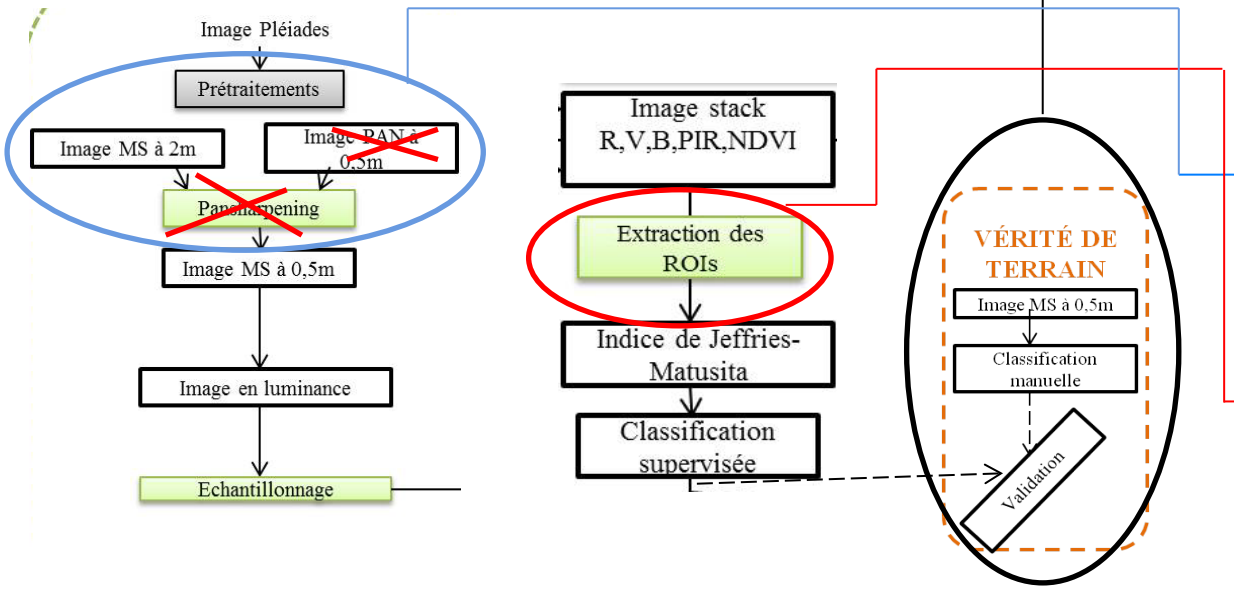
- Increasing the window size allows a better expression of the texture.
- Better mapping(0.63 and 0.56 for the two sites vs. 0.4 for spectral method)
- According to Lelong and *al., 2004 : «* ***not possible to map the types of coconut plantations by PAPRI method (CLAPAS) »***

→ By our approach *:* ***Possible to map them by sampling from NDVI.***

DISCUSSION AND CONCLUSION

Prospects for improved mapping

1- Problem bound to the data and to the validation of the method



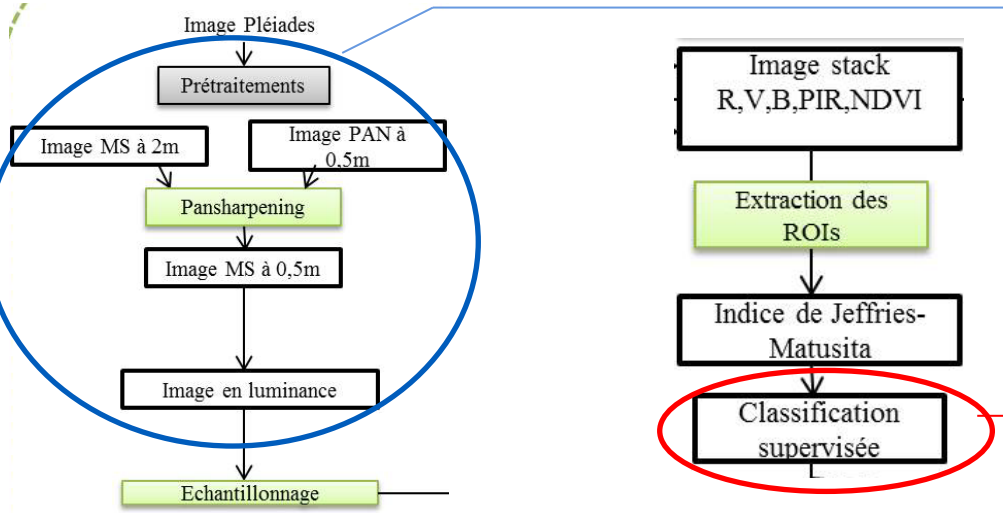
Statements of ground :
→ Improved determination of ROIs

Finer resolution
→MS image at 0.5m : Avoid the pansharpening

Creation of a database of ROIs

DISCUSSION AND CONCLUSION

2- Problem bound to the classifier :



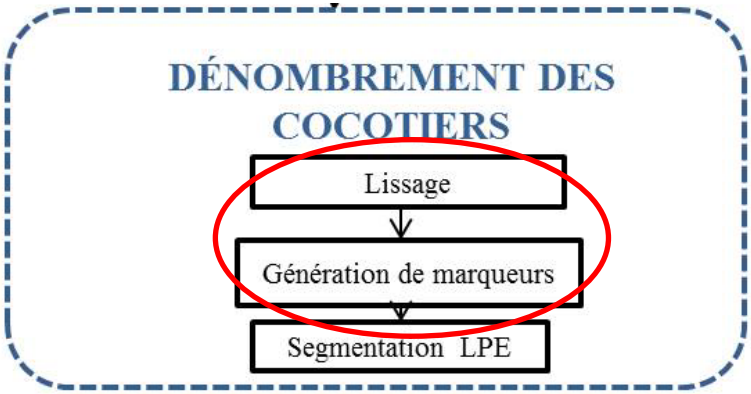
Reducing the dynamic range of the image :

→ Using filters; other color system HSV

Object-oriented approach / multi-scale approach :

→eCognition, ENVI Fx

3- Problem bound to the algorithm of counting



Sub-segmentation problem:

→ **Reconstruction of masks, similar to the classification problem**

Over-segmentation problem:

→**Homogenization of the image :** controlling the generation of markers (local minima and maxima)

DISCUSSION AND CONCLUSION

1- Possibility of distinguishing agrosystems with coconut palm, even in heterogeneous landscapes (Vanuatu) → Perspectives of fine study on the structure of the production and the social importance of the coconut palm and their evolution in time.

2- On a large scale (e.g. India) : **the problems and methodological limitations met and analyzed at a very fine scale** (e.g. sub-segmentation and over-segmentation**) lose their importance.**

3- It is now more important **to develop mapping methods that allow the change of scale for a GIS.**


Thank you for your attention…