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**NOTE :** Fractional cover data retrieval using eCognition

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## 1 Objective

For the overall calibration and validation of the AquaCrop model decent information on the development of the canopy cover is crucial. Throughout the growing season overhead canopy pictures were taken. Different image treatment programs have been evaluated on their capacity to retrieve the fractional cover data from these images. The findings are presented in this technical note. The objectives (and/or constraints) were manifold:

- determine for each image the percentage of canopy cover of the monitored crop (maize or cabbage);
- in case of mixed-cropping, calculate a separate canopy cover for each crop;
- weeds are to be excluded;
- mask all non-desired items (camera operator, field borders, ...).

## 2 Data collection and treatment

### 2.1 AquaCrop data

Over the years (2008 – 2010) 17 maize and 6 cabbage fields were closely monitored. Soil humidity, irrigation and fractional cover were weekly measured. Yield was weighted at the end of the growing season. For the study of the fractional cover evolution 15 overhead canopy pictures were taken each time randomly distributed throughout the plots, resulting in 135 pictures per field.

The presence of weeds complicated the treatment of the canopy pictures for cabbage. At some stages these weeds obtain the same height of the cabbage, provoking a mixed-cropping situation. More elaborated image treatment algorithms had to be elaborated. This problem is far less present on the maize plots.

All data are available for the calibration and validation of cabbage, and the testing of the maize parameter for the case of Burkina Faso. But it must be noted that the treatment of the canopy cover images is a tedious and time-consuming task (23 fields x 135 pictures).

### 2.2 Fractional cover data retrieval

#### 2.2.1 ASSESS and ImageJ

Thousands of overhead canopy pictures are available for treatment. They are either issued from the detailed field surveys made for the calibration and validation of AquaCrop or from the inventories at satellites overpasses for the spatialization of the model. Hence the need for an automated fractional vegetation cover data retrieval. Previously research has started on using eCognition for the segmentation, classification and calculation of the  $f_c$  of the overhead pictures. eCognition is an expensive software package and needs a trained operator, so some other free tools have been tested.

ASSESS is a free image treatment tool for the quantification of crop diseases. It allows the measurement of leaf surfaces, infected surfaces and, for this case, the fractional green cover. In this approach thresholds in the different colour histograms need to be identified separating the image into bare soil (blue coloured) and green matter (Figure 1). But as shown in Figure 1, small patches of green, presenting wild grasses, can't be differentiated from maize and need to be manually (!) cleared using the 'eraser' option. Macros can be created in order to treat a batch of images, but the necessary manual corrections render this approach impossible.

Secondly a combined use of PhotoShop and ImageJ, mainly used for the analysis of medical imagery, was tried. With PhotoShop the colour planes were stretched, and maize selected using the 'pipette colour selector' and defining a tolerance. The resulting selection is then sent to ImageJ to determine the overall leaf area (Figure 2). This procedure can also be automated to treat batch files. But unlikely to Assess, a single threshold (or pipette selection) gave different results for images taken on the same field at the same time.

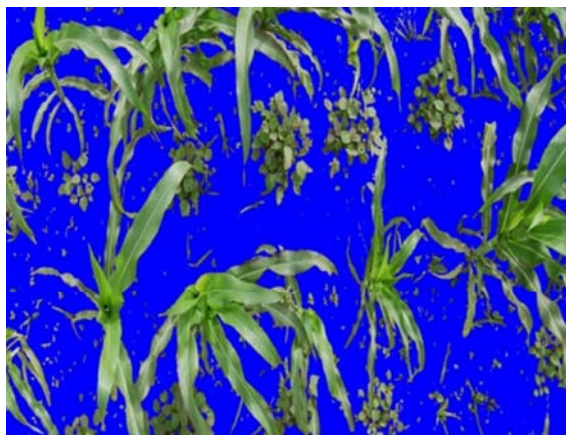


Figure 1 – Selection of the fractional vegetation cover using Assess.

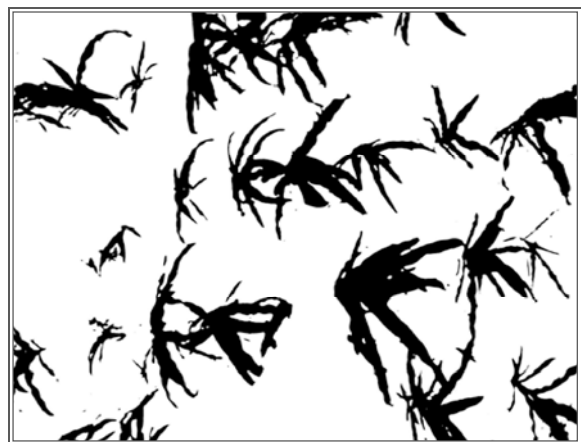


Figure 2 – Selection of the fractional vegetation cover using Image J.

None of these two alternatives produced satisfying possibilities for the automation of the image data retrieval. New trials are being carried out using eCognition. eCognition provides a panoply of colour related and customizable treatments (hue, saturation, colour ratios, ...).

### 2.2.2 eCognition

Due to the mixture of weeds and cabbage, and the changing texture and color of cabbage throughout its growing cycles, the fractional cover data retrieval presented more difficult than for maize. As a result, a mayor focus was given to the development of data retrieval algorithms in eCognition. Two typical steps are differentiated in eCognitions object-based image analysis: image segmentation and classification.

Image segmentation groups pixels in each image into objects or segments based on three parameters: scale, color and shape. The scale parameter is the expression of the allowed level of heterogeneity of the resulting segments (the higher the scale parameter, the higher the level of heterogeneity), whereas color and shape parameters determined how pixels in the digital image were to be grouped.

These segments are then further classified into user-defined categories. Based on differences in hue, saturation, texture and uniformity different algorithms were created for the different phonological stages and the amount of weeds present in the images. Technical details with screencaps of the 5 five needed algorithms are added at the end of this report.

The results for the fractional cover evolution for 4 cabbage crops are presented in the Figures 3a-d. A mean fractional cover progress is presented in Figure 4. The remaining 2 cabbage fields will be treated in due time, followed by the easier to treat maize data.

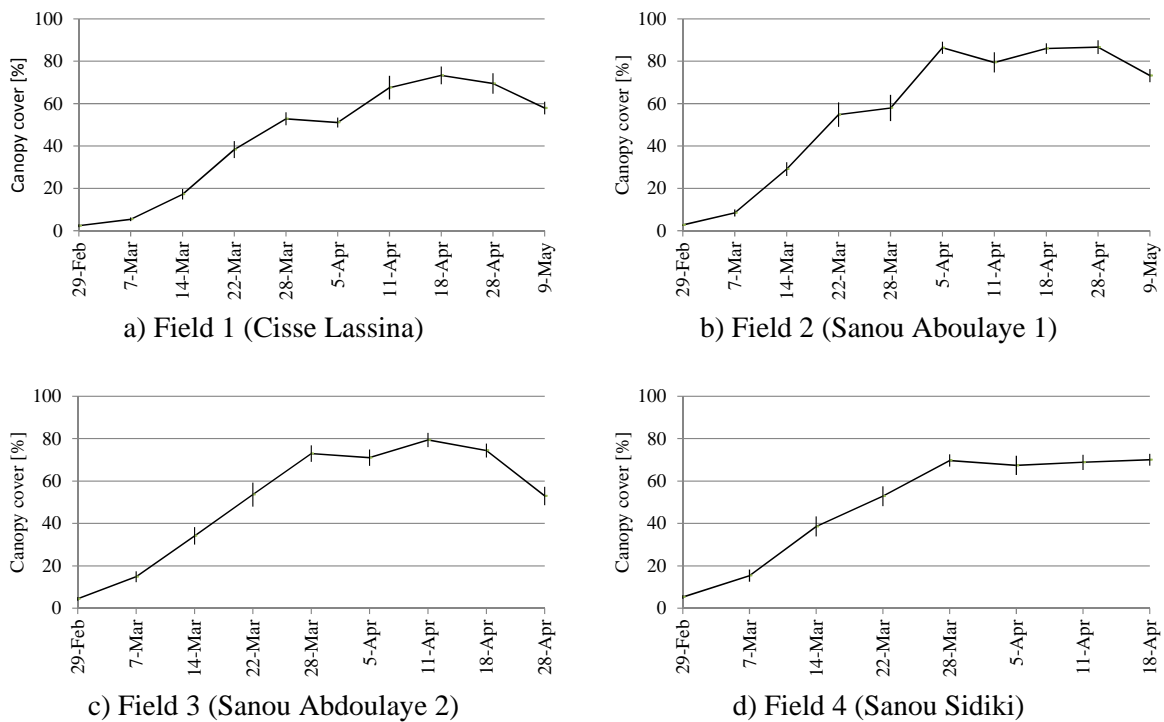


Figure 3 – Observed green canopy cover progression for 4 cabbage fields (dots with error bars).

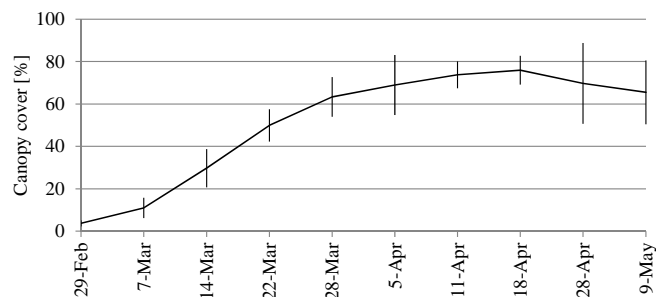
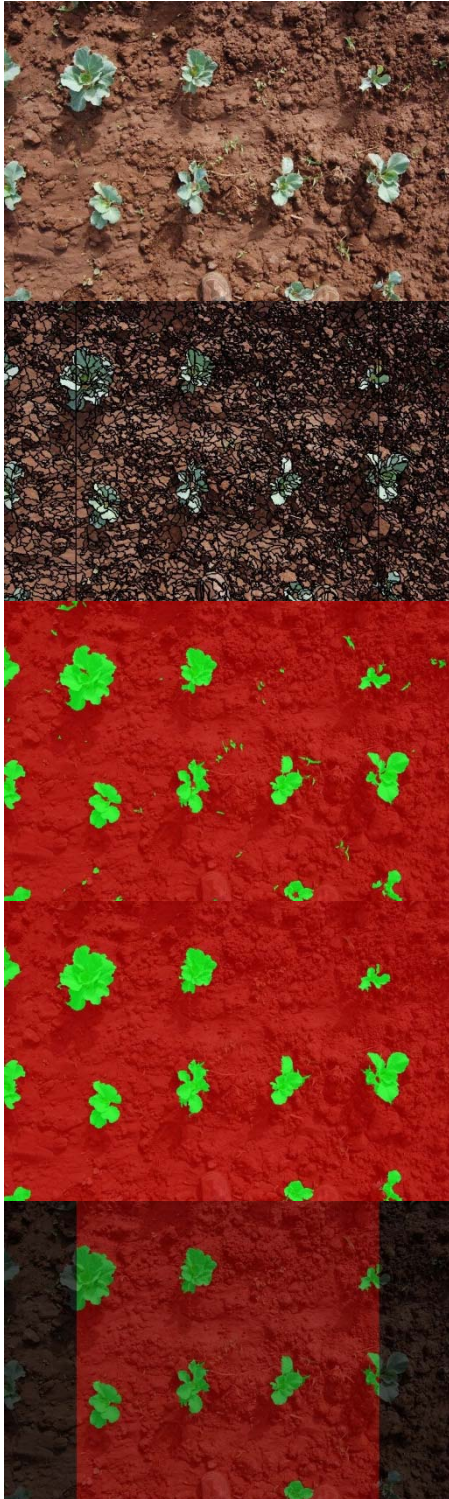


Figure 4 – Mean observed canopy cover progression, with error bars (average of 4 data sets).

### 3 Conclusion

For cases with a rather complicated ground cover, eCognition gave the best results in the least time. For the easier treatment of maize crops (in general no weeds, just soil/shadow and crop) PhotoShop or ENVI are recommended, since only 2 different classes need to distinguished.



### Algorithm : 'Cabbage 1' :

- initial stade cabbage
- little or no weeds

Level 1 : mask camera-operator:

- 'chess board segmentation' (res. 50)
- select zones to mask
- 'assign' class \_mask

Level 2 : segmentation :

- 'multi-resolution segmentation' (res. 50)

Level 3 : classify cabbage & soil :

- if Hue (R,G,B) > 0.15 → \_cabbage
- all rest → \_soil

Level 4 : refine classifications :

- 'merge' \_cabbage areas
- if \_cabbage area < 1000 pixels → \_soil
- \_soil 'grow region': if Hue(R,G,B) > 0.09 → \_cabbage

Level 5 : export result :

- clip borders to avoid parallaxes influences
- fc = 7.5 %



### Algorithm : 'Cabbage 2' :

- development stage cabbage
- with weeds

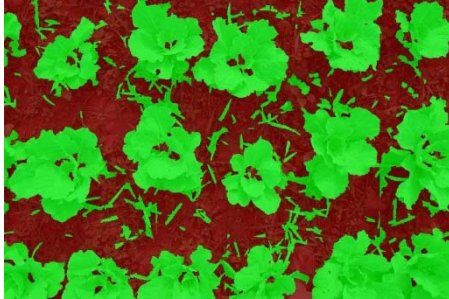
Level 1 : mask camera-operator :

- 'chess board segmentation' (res. 50)
- select zones to mask
- 'assign' class \_mask



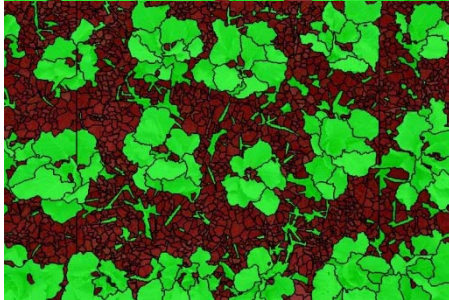
Level 2 : segmentation :

- fine 'multi-resolution segmentation (res. 30)



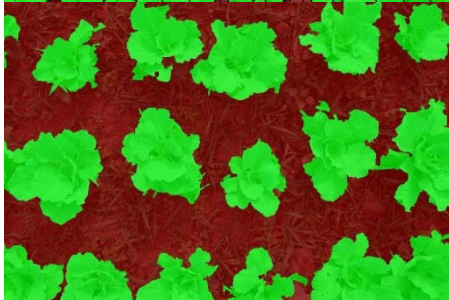
Level 3 : classify cabbage & soil :

- if Hue(R,G,B) > 0.26 → \_cabbage
- all rest → \_soil



Level 4 : re-segmentate \_green areas :

- for \_cabbage coarser 'multi-resolution segmentation' (res. 150)



Level 5 : re-classify cabbage & soil :

- for \_cabbage if Hue(R,G,B) < 0.31 → \_soil
- for \_soil → \_cabbage if :  
rel. area of \_cabbage (level 3) = 1 and  
rel. border to \_cabbage > 0.5



Level 6 : export result :

- clip borders to avoid parallax influences
- fc = 43.7 %



**Algorithm : 'Cabbage 3a' :**

- mid-season stage cabbage
- few or no weeds, but shadow

Level 1 : mask camera-operator and field bunds :

- 'chess board segmentation' (res. 75)
- select zones to mask
- 'assign' class \_mask

Level 2 : segmentation :

- medium 'multi-resolution segmentation' (res. 80)

Level 3 : classify cabbage & soil/shadow :

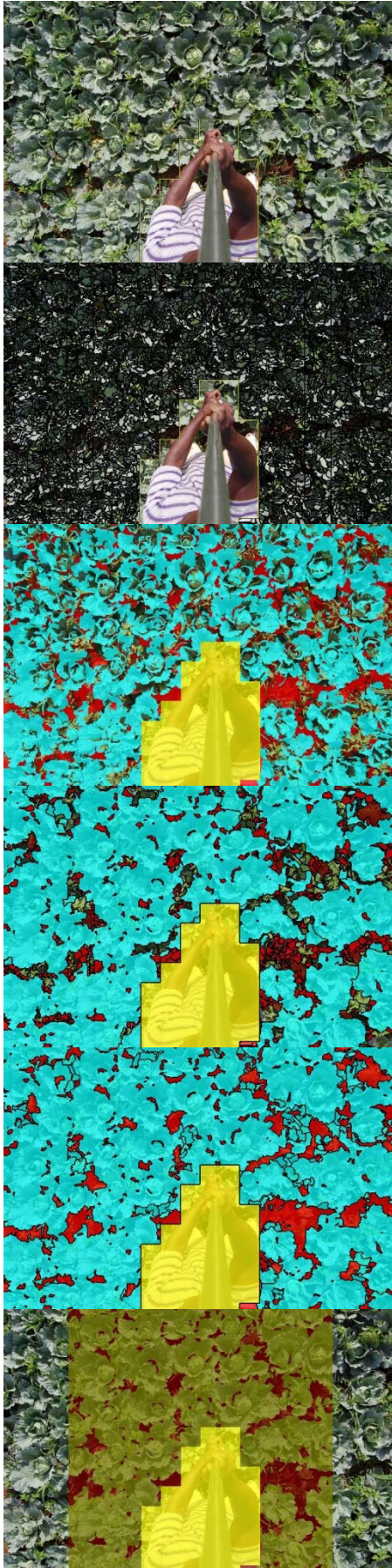
- if Hue (R,G,B) > 0.2 → \_cabbage
- all rest → \_soil

Level 4 : refine classifications :

- 'merge' \_cabbage areas
- if \_cabbage area < 1000 pixels → \_soil

Level 5 : export result :

- clip borders to avoid parallaxes influences
- fc = 84.8 %



**Algorithm : 'Cabbage 3b' :**

- mid-season stage cabbage
- weeds and shadow

Level 1 : mask camera-operator :

- 'chess board segmentation' (res. 75)
- select zones to mask
- 'assign' class \_mask

Level 2 : segmentation :

- fine 'multi-resolution segmentation' (res. 25)

Level 3 : Classify cabbage, soil and weeds :

- \_cabbage if Hue(R,G,B) = 0.5 and  
Sat(R,G,B) < 0.3 or(max) Max diff (texture) < 0.3
- \_weeds if Hue(R,G,B) = 0.5 and  
Sat(R,G,B) > 0.55 or(max) Max diff (texture) > 0.8
- \_soil if Hue(R,G,B) = 0 or(max)  
Intensity(R,G,B) < 0.11
- 'merge' \_cabbage, \_weeds and \_soil

Level 4 : Re-segmentate and re-classify :

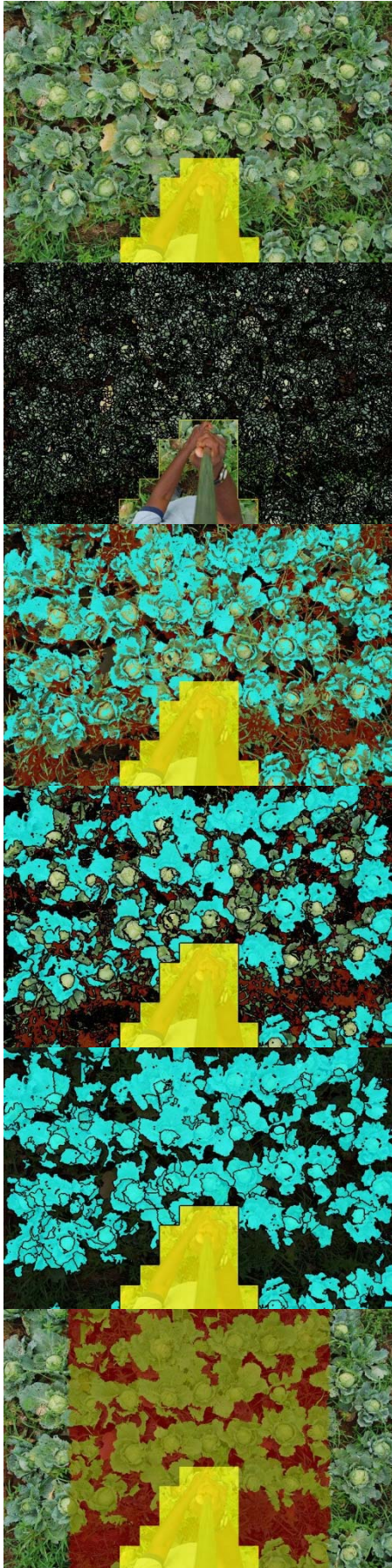
- for \_cabbage coarser 'multi-resolution segmentation' (res. 60)
- same classification rules as for level 3
- 'merge' \_cabbage

Level 5 : Re-segmentate and re-classify

- for \_weeds coarser 'multi-resolution segmentation' (res. 60)
- \_unclass Existence \_soil (level 4) = 1 → \_soil
- rel. area of \_cabbage (level 4) = 1 → \_cabbage
- unclass rel. area of \_cabbage (level 3) > 0.1 → \_cabbage
- unclass rel. area of \_weeds (level 3) > 0.1 → \_weeds
- unclass Max diff(texture) < 0.6 \_cabbage

Level 6 : export result :

- clip borders to avoid parallax influences
- fc = 87.5 %



**Algorithm : 'Cabbage 4' :**

- late-season stage cabbage
- lots of weeds and shadow

Level 1 : mask camera-operator :

- 'chess board segmentation' (res. 75)
- select zones to mask
- 'assign' class \_mask

Level 2 : segmentation :

- very fine 'multi-resolution segmentation' (res. 21)

Level 3 : Classify cabbage, soil and weeds :

- \_cabbage if Hue(R,G,B) = 0.5 and  
Sat(R,G,B) < 0.3 or(max) Max diff (texture) < 0.3
- \_weeds if Hue(R,G,B) = 0.5 and  
Sat(R,G,B) > 0.55 or(max) Max diff (texture) > 0.8
- \_soil if Hue(R,G,B) = 0
- 'merge' \_cabbage and \_weeds

Level 4 : Re-segmentate and re-classify :

- for \_cabbage coarser 'multi-resolution segmentation' (res. 75)
- same classification rules as for level 3
- 'merge' \_cabbage

Level 5 : Re-segmentate and re-classify :

- for \_weeds coarser 'multi-resolution segmentation' (res. 60)
- rel. area of \_cabbage (level 4) = 1 → \_cabbage
- unclass rel. area of \_cabbage (level 3) > 0.1 → \_cabbage
- unclass rel. area of \_weeds (level 4) > 0.1 → \_weeds
- \_unclass Existence \_soil (level 4) = 1 → \_soil
- unclass Max diff(texture) < 0.6 \_cabbage

Level 6 : export result :

- clip borders to avoid parallax influences
- fc = 61.6 %