Correctly assessing forest change in a priority West African mangrove ecosystem : 1986–2010 : an answer to Carney et al. (2014) paper "Assessing forest change in a priority West African mangrove ecosystem : 1986–2010"

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Abstract

In order for decision-makers to adjust environmental policy appropriately, it is essential that they utilize reliable data. Now, on a global scale, mangroves are considered endangered, yet there is a general consensus among recent scholars that mangroves in Saloum and Casamance estuaries are currently experiencing regeneration. In contrast with the results of these papers, Carney *et al*. (2014) published a paper in Geoforum mapping and quantifying a massive mangrove loss. However, remote sensing and mapping shortcomings have been identified. The 2010 map used in the Carney *et al*. (2014) paper is accurate, however, as a result of errors in georeferencing, window extraction and classification, their 1986 map is not. Mangrove and mudflats are grouped in the same class. The addition of a stacked classification to the image processing used by Carney *et al*. (2014) enables the realization of a correction of the map, and thus the production of results similar to other studies. The supposed loss of mangroves appears to have been the consequence of this classification error. In fact, we observe a progression of 8,804 ha instead of the regression of 37,196 ha assessed by the authors. This published discrepancy, which is in opposition to any other study of this area, must be discussed in order to clarify for scholars and policymakers the actual dynamics of mangrove change in the studied region.

Introduction

Monitoring forest cover and habitat conservation is important (Lambin & Elrich, 1997). Mangroves, as with any other habitat, require the state of their conservation to be monitored by studying any changes that arise from both environmental and anthropogenic sources (Aizpuru *et al*., 2000; Alongi, 2002). Therefore, it is important to ensure that open, accurate and reliable data is available. Yet, uncertainty is a key issue in scientific papers that are often read by decision-makers (Friess & Webb, 2011; Friess & Webb, 2014, Mejía-Rentería *et al*., 2018, Ruiz-Luna *et al*., 2008). Remote sensing is not a fundamental science and thus it invariably produces a degree of uncertainty (Hamilton *et al*., 2018). It is expected to find small differences in remote-sensed results according to choices in methodology. These differences are often limited to this expected margin of uncertainty; however, at times they can reveal shortcomings (Hamilton *et al*., 2018). This paper aims to ensure that readers searching for information about mangrove cover change in the Gambian and Casamance estuaries are able to distinguish between consistent results on mangrove increase (albeit with a small margin of uncertainty) and a single contradictory paper indicating significant loss as a result of methodological shortcomings.

The Atlantic West African mangroves of Senegal and Gambia are characterized by a dry climate and, with the exception of the Gambia, small river basins (Diop, 1990). From 1968, West Africa underwent a period of intense drought, with rainfall only rebounding after 1994 (Nicholson, 2005; Nicholson, 2013; Descroix *et al*., 2005). The consequences of the drought on water and soil salinity, and consequently on mangroves (intended here as mangrove forests), have been studied since Vieillefon (1977) and Marius (1985). Studies that precede the early 2000s agree on the fact that there has been significant mangrove loss (Valiela *et al*., 2001; Cormier-Salem, 1999). Demonstration has been made of the role of increased salinity in this loss (Marius, 1985; Cormier-Salem, 1999). However, there is a general consensus among recent scholars that mangroves in Saloum and Casamance estuaries are currently experiencing regeneration (Ackermann *et al*., 2007; Andrieu, 2008; Conchedda *et al*., 2008; Conchedda *et al*, 2011; Lourenço *et al*., 2009; Andrieu & Mering, 2008; Diéye *et al*., 2013a; Temudo & Cabral, 2017; Andrieu, 2018). Naturally, some exceptions exist, such as around the Affiniam dam (Tendeng *et al*., 2016) and in the Soungrougrou sub-basin where the natural regeneration is still very weak (Sané, 2017).

In contrast with the results of these aforementioned papers, Carney *et al*. (2014) published a paper in Geoforum mapping and quantifying, between 1986 and 2010 a mangrove loss of 35 % in the Gambia and Casamance area; with a 43 % loss for the Casamance and 92 % in the northern section of Casamance, south of the international border between Senegal and The Gambia.

After reading this paper and examining the maps, three cases of remote sensing and mapping shortcomings have been identified: georeferencing, background homogenization and mainly classification errors. Quite important, indeed, is the fact that the northernmost part of Casamance is mapped as a drastic loss of mangrove, while every study (for example Viellefon, 1977 or Marius, 1985) has described this part of the Casamance as mainly covered by mudflats (tannes or hypersalted back-mangrove areas) due to its natural salinity and acidity. These studies of the years 1970 and 1980 are based on field study. Carney *et al*., 2014 paper is also in total opposition with all previous remote sensing papers that have produced maps of the area (Andrieu, 2008; Conchedda *et al*., 2008; Andrieu & Mering, 2008; Diéye *et al*., 2013a).

This paper aims to demonstrate that, while the Carney *et al*. (2014) dataset produced for 2010 is accurate, the one produced for 1986 is inaccurate, due mainly to remote sensing error. We reproduced the method used and described by Carney *et al*., 2014 on the very same data and found the same error. The addition of a stacked classification step (Andrieu & Mering, 2008; Andrieu, 2018), to the method used by Carney *et al*. (2014) enables the realization of a correction of the map, which led to the production of results similar to other studies.

Data

In order to be able to demonstrate the remote sensing shortcomings of the cited paper, we sourced exactly the same data: "*LANDSAT* 5 Thematic Mapper imagery (Path 205, Row 51) was downloaded from the USGS Earth Resources Observation and Science Center from 9 February 1986 and 26 January 2010" (Carney *et al*., 2014). The KMZ file of the 2010 map from the authors' work has also been used to ensure the reproduction of the same method with results close enough to enable a comparison.

Method

Testing the projection accuracy

All change maps from Carney *et al.* (2014) display a global shift southward by 120 to 150 m. Georeferencing errors are most obvious in their figure 3, in which a number of identifiable patches of mangrove have all moved southwards by four to five pixels (120 to 150 m). This figure is clearly erroneous and our diachronic color-merged map below shows no such shift southwards. Each island patch of mangrove contains a "loss" stripe on the north side and a "gain" stripe of the south side. Consequently, we made the hypothesis that it was due to a georeferencing error on one of the two sets of images utilized by Carney *et al.* (2014). We checked for georeferencing errors with our downloaded raster dataset using stable landmarks. We first produced a color composite using the same bands for both dates and checked the primary urban features and crossroads. Unlike in the Carney *et al*., 2014 change maps, no southward shift appeared. We also reproduced this on some mangrove patches using Google Earth's time slider. Once again, no such shift southward appeared.

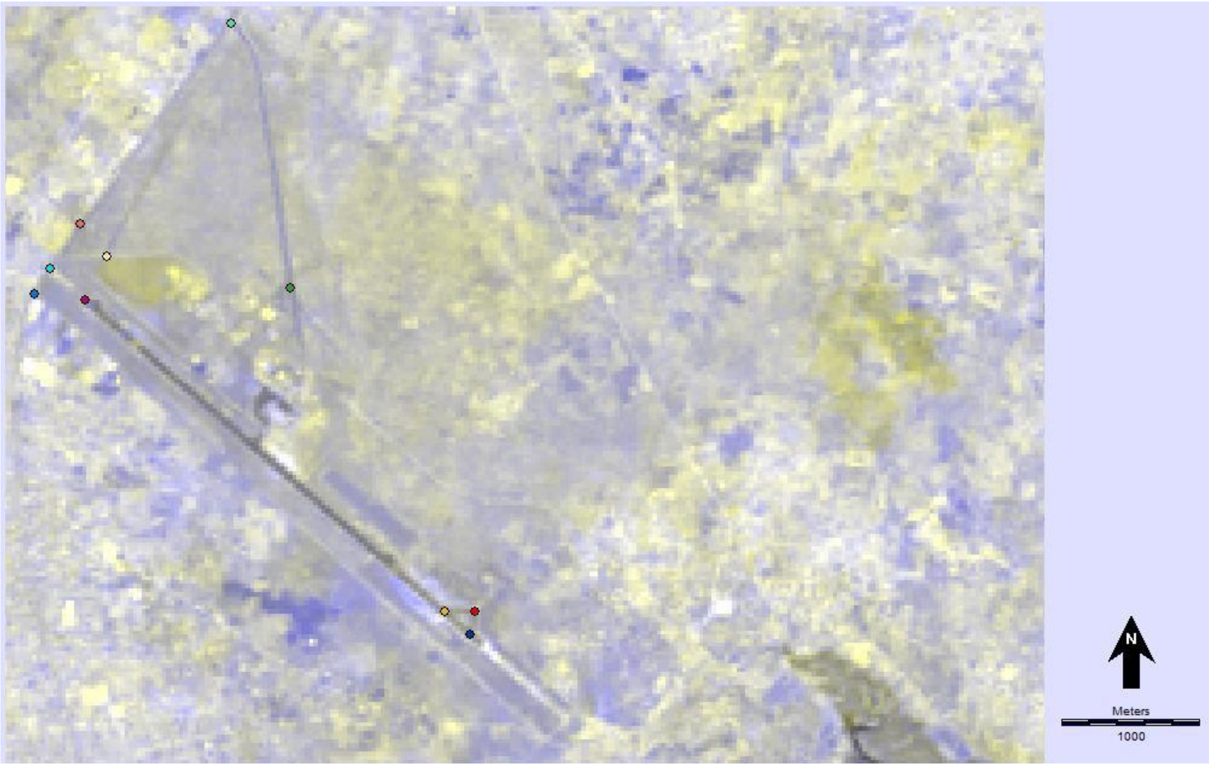

Figure 1: Diachronic color-merged map with examples of recognized stable landmarks.

In order to affirm that the errors are due to incorrect georeferencing, we artificially reprojected the 1986 imagery 150 m northward. Figure 2 contrasts this artificially reprojected map with an extract of Carney's map of the Tanbi wetlands. The changes that appear in each of these two maps are strikingly similar. Consequently, we would like to propose that the linear "changes" on the banks of the Casamance River in the Carney *et al*. (2014) paper are likely due to georeferencing or geometric errors.

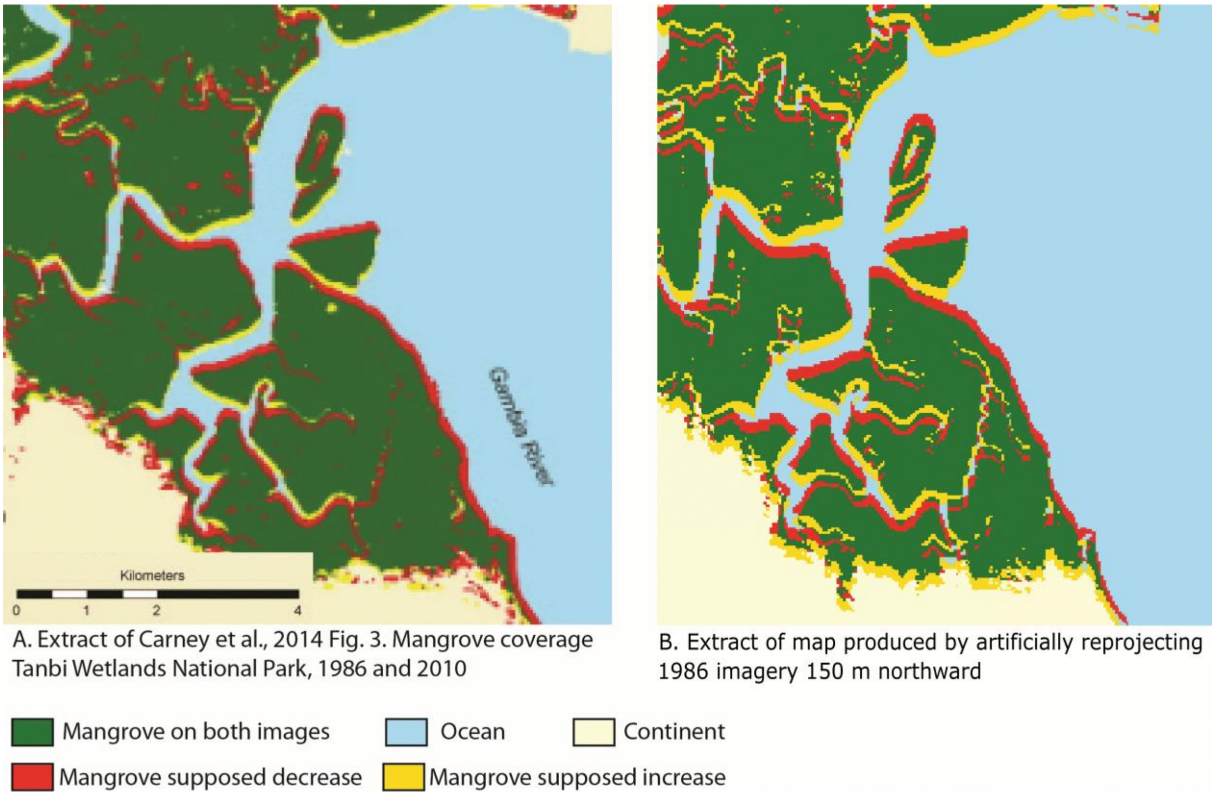

Figure 2: Contrast of Carney changes map with a change map resulting from the 1986 imagery being artificially reprojected 150 m northward.

In order to get an idea of the scope of this error's impact on the final results, cross tabulation has been performed between a binary map (mangrove/non-mangrove) and the same map with a georeferencing error of 4 and 5 pixels. The error of 4 pixels produced 24.78 % of false changes while the error of 5 pixels produced 17.65 % of false changes for mangrove land cover only.

We cannot determine with certainty the magnitude of the georeferencing error in Carney *et al*., 2014, nor the extent to which it changed the results, however the similarity between the maps in Figure 2 indicates that such georeferencing errors have been made. The global area quantification by Carney *et al*., 2014 may not have been impacted by this error, but the change maps certainly were.

The south-east section of Figure 2 in Carney *et al*. (2014) shows changes from continent to water in a geometrical stripe along the border. The LANDSAT program offers images with the same path and rows in order to facilitate the study of changes, however two images with the same path and row do not exactly fit spatially. The Carney *et al*. (2014) change map shows changes from continent (in 1986) to water (in 2010). These pixels are outside of the LANDSAT scene for 2010. This is unlikely to have interfered with mangrove quantification here, as both the mangrove and the background are mapped as water. However, it does highlight the lack of robustness in the preprocessing, in conjunction with the incorrect georeferencing.

Testing the classification accuracy

We used exactly the method of the cited paper:

> *"Each image was atmospherically and spectrally corrected using a dark object subtraction algorithm (Chavez, 1988). Bands combinations 4, 5, 3 at a 30 m pixel resolution were used to identify mangrove forests. We perform an unsupervised classification using ISODATA clustering*

algorithm to map mangrove extent. Pixels were divided into a minimum of 20 classes using a change threshold of 5.0%, the minimum number of pixels in each class was set to 2000, and the classification was then instructed to run for a minimum of 15 iterations. The resulting classification was then divided into three classes based upon visual interpretation: water, land cover other than mangroves, and mangrove forests (Boyd et al., 2006)"
(Carney *et al*., 2014).

To ensure that we reproduced almost the same procedure, we downloaded the 2010 dataset of the Carney *et al*. (2014) paper and made a cross-tabulation of our results with theirs. The maps for 2010 correspond for 98.5% of the surface. A comparison of our results (Table 1) with Carney's in terms of area quantification shows that the total mangrove surface in 2010 is very similar between the two sets of results: they mapped 68,442 ha in total, which exceeds our map by only 0.7 %. Only this total comparison is possible, as we could not extract sub-regions which correspond exactly to theirs, since the sub-regions are not strictly defined. Therefore, we agree with Carney *et al.* (2014) about the 93 % accuracy of their 2010 dataset, which has been verified with robustness and precision.

Having concluded that the 2010 map appeared to be accurate, we explored the 1986 maps (which aren't given as supplementary material). The same classification on the 1986 LANDSAT imagery has been produced. We also obtained the very same class, comprising of a combination of mangroves and the wettest mudflats. We tried different numbers of classes (10, 15, 18 and 20) and different algorithms (ISODATA and *k*-means) and this same mixed class consistently appeared. The general contrast of the radiometric dataset is vast and these two land cover units are not distinguished with a simple classification (Andrieu & Mering, 2008). If we were to have "visually interpreted" this mixed class as a mangrove class as the authors did, we would have produced the same inaccurate results.

However, with a careful visual interpretation, it can easily be observed that the class identified as "mangrove" on the 1986 classification contains both mangrove and mudflats (Figure 3). On the color-merged image below, under the stripes, mangrove appears in dark red while mudflats appear in grey.

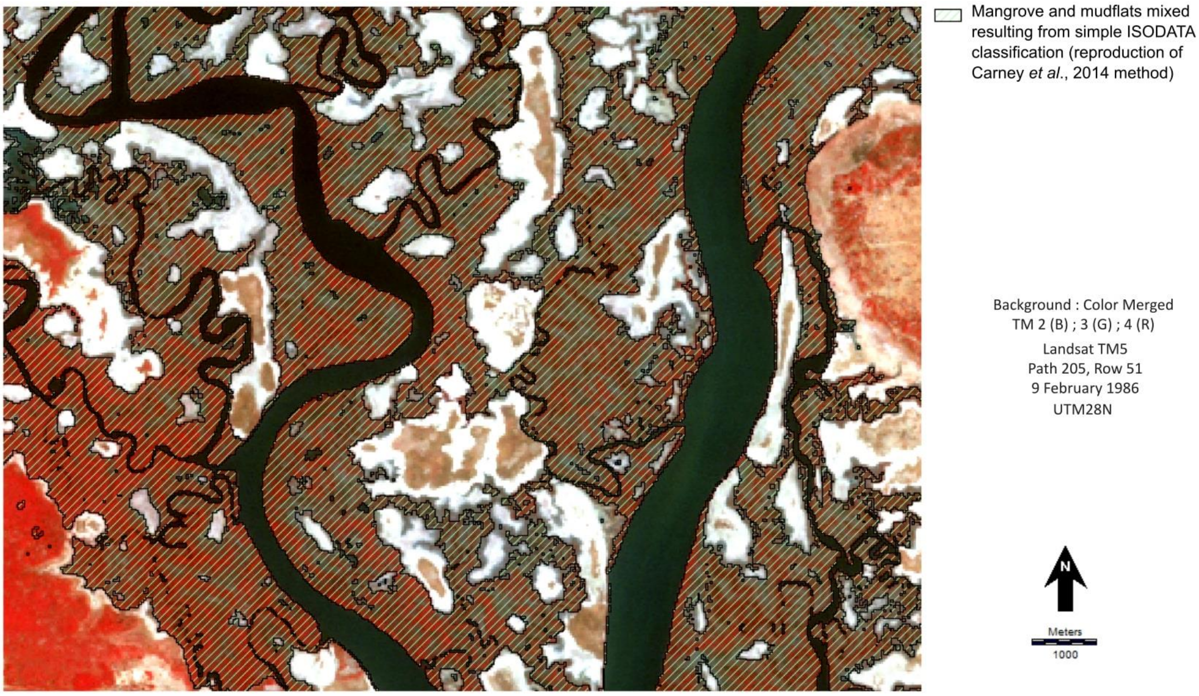

Figure 3. Color-merged LANDSAT image from 1986 showing a single mixed class comprising of both mangrove and mudflats

In addition to our color-merged visual interpretation, five polygons have been digitized on the Google Earth 1986 image near Ziguinchor in Casamance: one polygon of water, two of mangroves and two of mudflats for a total of 1381 pixels. The polygons have been added as supplementary material for total transparency. The aim of this comparison with Google Earth is not to quantify the errors in the Carney *et al*., 2014 map of 1986. We can only quantify the errors with the use of a simple classification. The comparison of this simple classification produced using Carney's method shows a Kappa index of 0.42, indicating that it is 58 % erroneous. As a matter of fact, out of the 360 pixels appearing as mudflats on Google Earth imagery (which we acknowledge as inferior to ground truth), only 4 pixels are classified as mudflats (likely consisting of dry mudflat), while the other 356 are categorized as mangrove. This is coherent with the color-merged interpretation.

Table 1: Error matrix between a map from a simple ISODATA classification and polygons digitized on 1986 Google Earth imagery.

		Google earth digitized parcels				
		Mangrove	Mudflats	Water	Total	Error of commission
Mapped	Mangrove	8	4	0	12	0.33
	Mudflats	564	356	0	920	0.61
	Water	1	0	448	449	0.002
	Total	573	360	448	1381	
	Error of omission	0.98	0.01	0		0.41

Adding a step of stacked classification in order to obtain a better map.

We used this class of mangrove and mudflats as a mask for a stacking classification with the same method. The stacked unsupervised classification has shown itself to be a good method for mangrove detection (Ackerman *et al*., 2007; Andrieu & Mering, 2008; Turmine *et al.,* 2011; Andrieu, 2018). Being a stacked classification, only 6 classes (instead of 20) were set up as the maximum number of classes. This second step enabled, with visual interpretation and radiometric analysis, the separation of mangroves and mudflats (Figure 4).

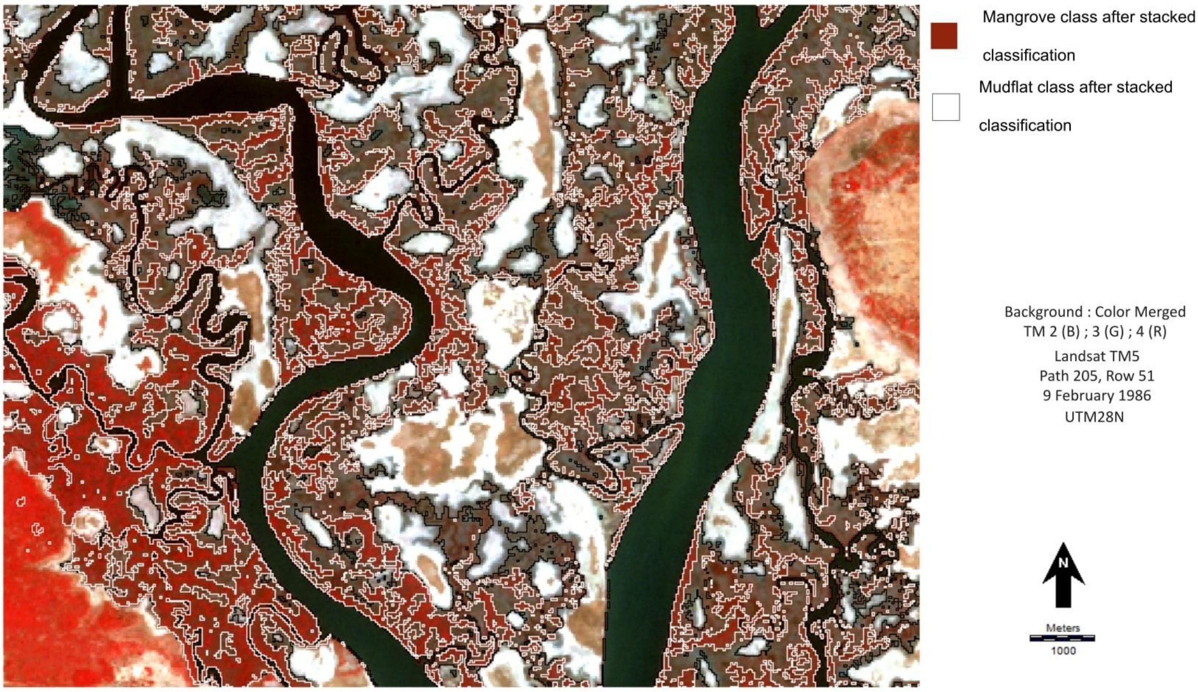

Figure 4. Color-merged LANDSAT image from 1986 showing separate classes for mangrove and mudflats

Remote sensing is based on radiometric information. Accurate interpretation of a radiometric curve does not enable an assessment of accuracy, but is instead a robust method of class interpretation and validation of the number of classes. It is, therefore, a step in the remote sensing procedure that leads to the identification of errors. In order to strengthen the justification of the distinction between these two “sub-classes”, we produced spectral curves (Figure 5). The comparable values in blue, green, and medium infrared and thermal infrared explain why the first classification produced the mixed class. However, the radiometric curves clearly show that a portion of the class corresponds to vegetation cover (mangrove), with a positive slope between the red (TM3) and near-infrared (TM4) bands. The curves for the remainder of the class possess equal values for the red and near-infrared bands, thus corresponding to land cover without vegetation, here interpreted as mudflats.

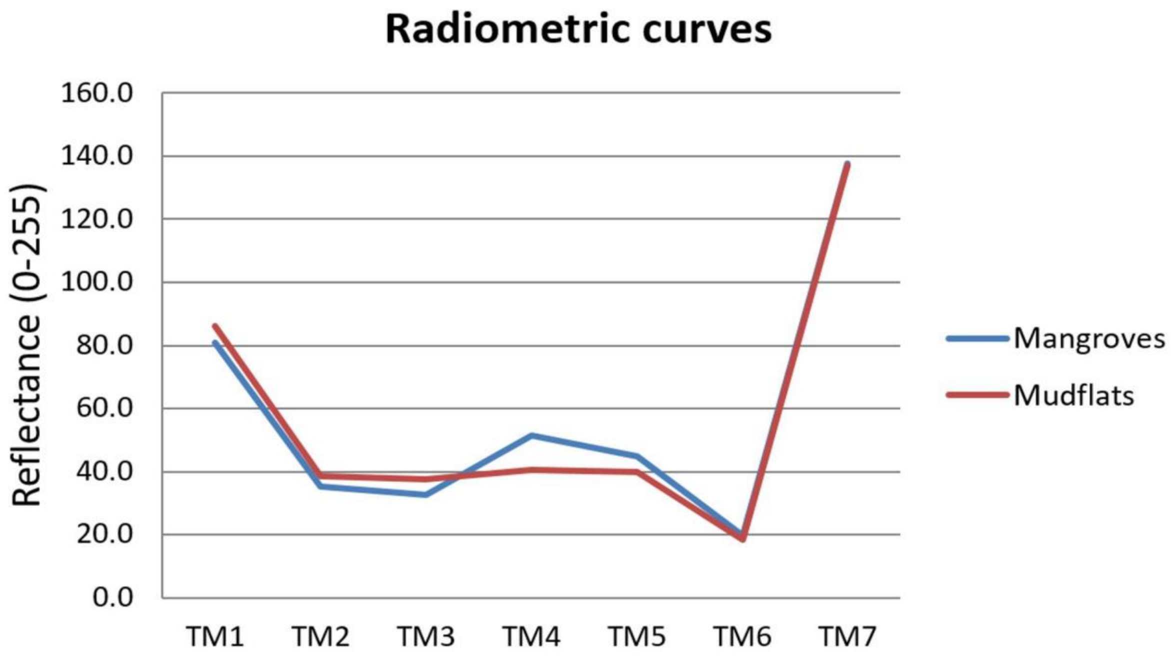

Figure 5. Radiometric curves of mangrove and mudflats

After subdivision and radiometric analysis, it is evident that the class obtained by simple ISODATA classification and labelled as mangrove by Carney *et al*. (2014) is in fact a mixture of mangrove and mudflats. The different colors appearing in the color-merged LANDSAT image, as well as the presence of two distinct radiometric curves is strong evidence that the subdivision is justified. Mixed classes are frequent in remote sensing. Stacked classification is a simple method that enables the user to find and correct such mixed classes (Andrieu & Mering, 2008; Andrieu, 2018).

Table 2: Error matrix between a map from stacked ISODATA classifications and polygons digitized on 1986 Google Earth imagery.

		Google earth digitized parcels				
		Mangrove	Mudflats	Water	Total	Error of commission
Mapped	Mangrove	565	12	0	577	0.02
	Mudflats	7	348	0	355	0.01
	Water	1	0	448	449	0.002
	Total	573	360	448	1381	
	Error of omission	0.01	0.03	0		0.01

The same digitized polygons from the 1986 Google Earth imagery give a Kappa index of 0.97 if the mixed class of mangrove and mudflats is divided. While the error matrix (Table 1) doesn't support the accuracy of the map by Carney *et al*. (2014), the difference between both error matrices (Table 1 and Table 2) certainly substantiates the gain in accuracy between a simple classification and a stacked classification in the case where the first classification computes a mixed class (Figure 6).

A. Map produced by one round classification mixing mangrove and mudflats

A. Map produced by stacked classification and separation between mangrove and mudflats when mixed at first.

Figure 6. Comparison of mangrove map of 1986 LANDSAT imagery between one round ISODATA classification (A) and Stacked classification in order to subdivide mixed classes (B).

Results

Table 3. Mangrove coverage in three sub-regions of Senegambia, 1986 and 2010

Sub-regions	1986 (ha)	2010 (ha)	Change (ha)	% Change 86-10 after stacked classification	% Change 86-10 (Carney *et al*., 2014)
Tanbi Wetlands	3,548	4,084	536	+15.1	<1
South Bank Gambia River, including Bintang Bolong	15,540	18,711	3,171	+20.4	-12
Gambian border to Casamance River	40,072	45,169	5,097	+12.7	-43
Total of three sub-regions	59,160	67,964	8,804	+14.8	-35

The stacked classification drastically reduced (therefore, corrected) the surface of mangrove for the map of 1986, since it reclassified erroneously-assigned mangrove surface as mudflats. With this correction, the loss of mangroves, assessed by Carney *et al*. in 2014 disappears. The loss of mangroves appears to have been the consequence of this classification error. In fact, we observe a progression of 8,804 ha (+14.8 %) instead of the regression of 37,196 ha (-35%) assessed by the authors.

It is important to specify that this increase in the total mangrove cover is the result of a regression of 3,727 ha and a progression of 12,531 ha. Figure 7 shows the Tanbi Wetlands, a predominantly stable region with patches of mangroves densifying by 2010 to cover smaller patches of mudflats in 1986.

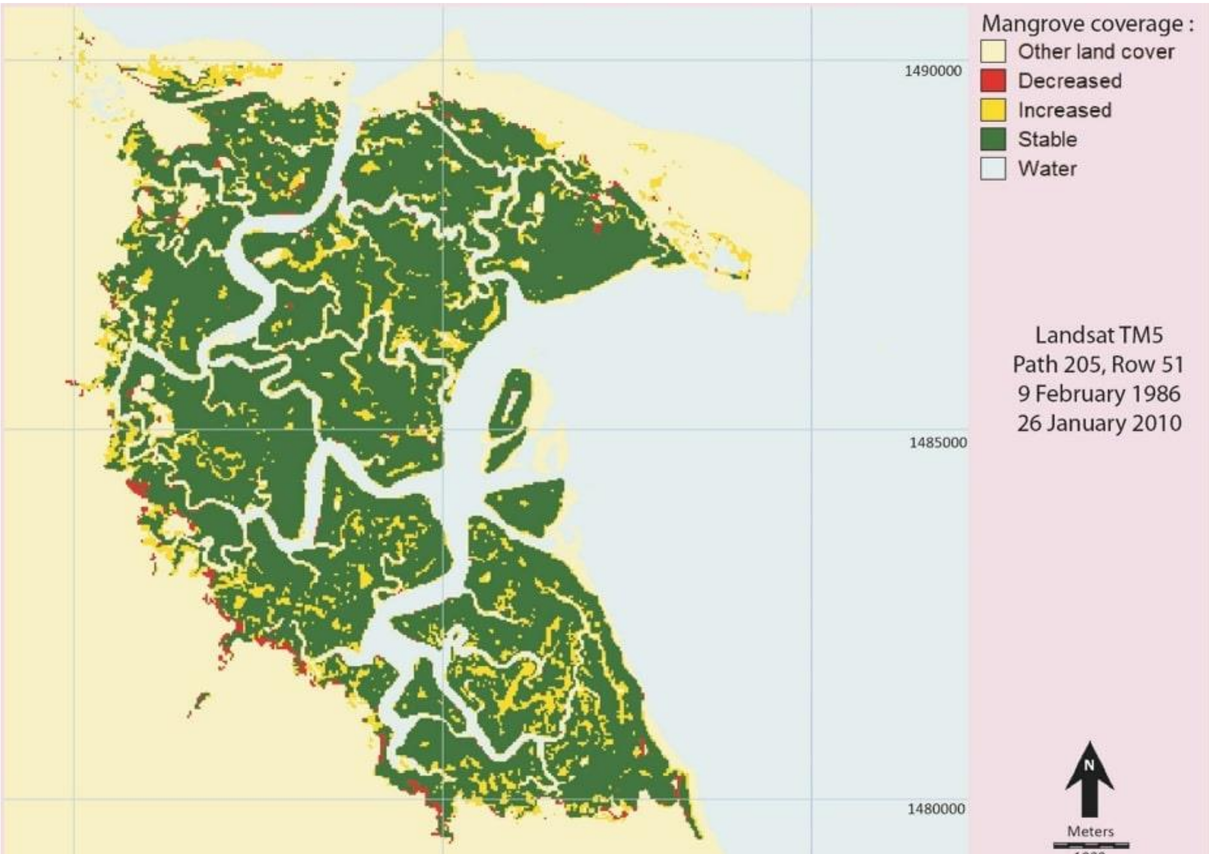

Figure 7. Mangrove coverage change map, Tanbi Wetlands National Park, 1986 and 2010 (Andrieu, 2018).

Figure 8 shows the northern section of the Casamance Delta, where the difference between our results using stacked classification and those of Carney *et al.* (2014) were at their greatest, as a result of classification error. It can be noted that the mangroves stayed stable for the most part, appearing as patches in both 1986 and 2010. It is also possible to identify some areas of decrease as well as areas of increase, growing denser towards the south.

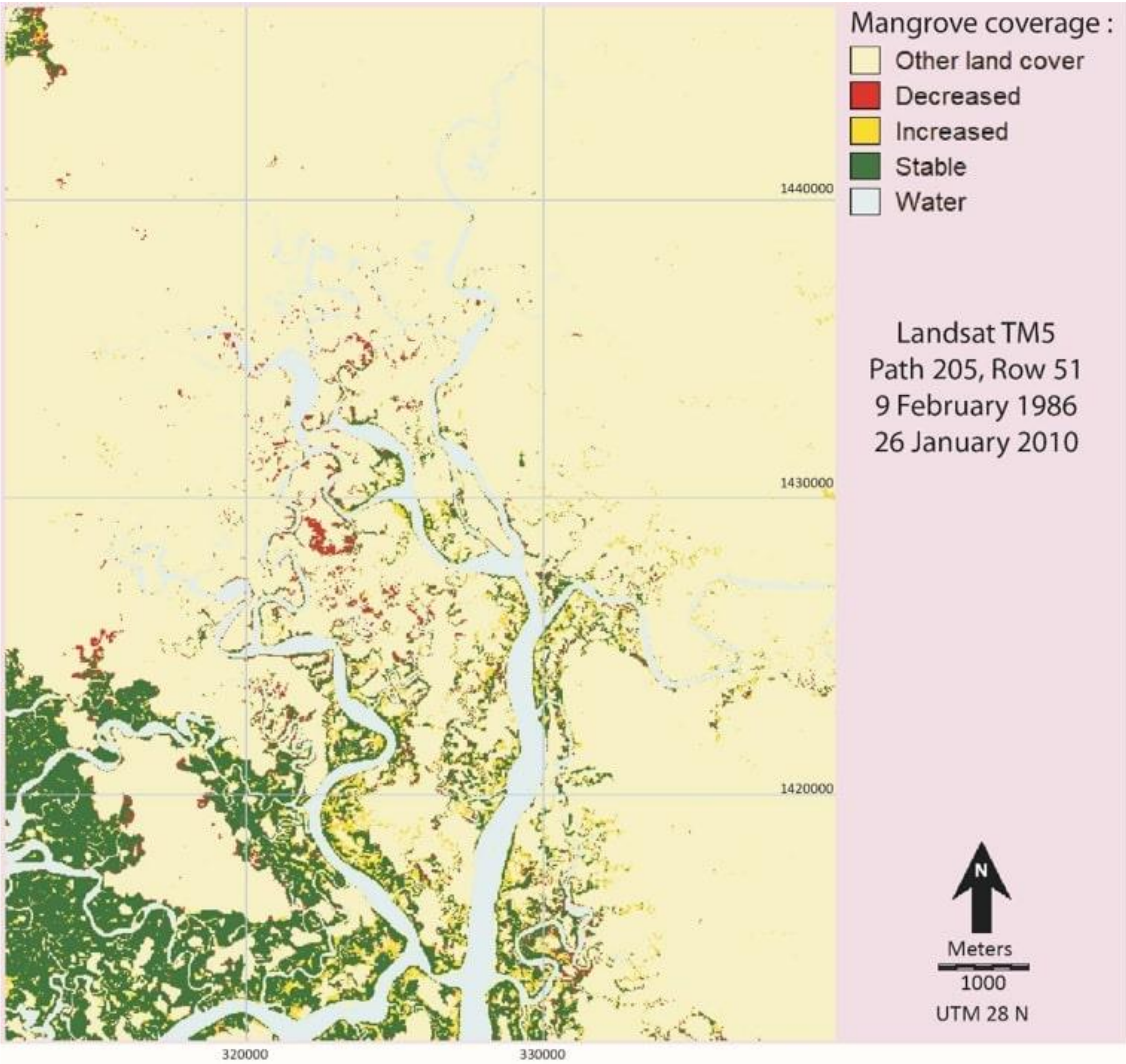

Figure 8. Mangrove coverage change map, North of Casamance Delta, 1986 and 2010 (Andrieu, 2018).

Discussion

Obvious shortcomings corrected but some uncertainty remains

In this paper, we produced a map of changes with an intentionally erroneous projection very similar to the one used by Carney *et al*., 2014 showing an artificial 150 m shift southward. This map displayed striking similarities to the change map produced by Carney *et al*., 2014 and thus it is very likely that there was a georeferencing error at play in one of Carney's datasets (1986 shifted north or 2010 shifted south). Despite the high similarity between the maps, this provides no certainty regarding the exact projection error in the 1986 imagery used in Carney *et al*. (2014), nor the accuracy of the imagery used in this paper.

The processing of the same classification on the same image as described in Carney *et al*., 2014 produced the same mixed class of both mangrove and mudflats. The method used in Carney *et al*. (2014) contains no step regarding the verification of homogeneity within classes. Therefore, the possibility of the inclusion of a mixed class was not taken into account and this common error was neither tracked nor corrected. We cannot quantify the extent of the confusion between mangroves and mudflats, since no good ground truth dataset from the 1980s exists. We can say with assurance, however, that the use of stacked classification is necessary to distinguish mangrove and mudflats in these images. Once again, the accuracy of this stacked classification is not guaranteed, however visual validation and radiometric analysis corroborate the suitability of the subdivision.

Carney et al. (2014) results not consistent with the state of the art - but corrected results are.

Ruiz-Luna *et al*. (2008) wrote:

> *"We believe that to reduce the uncertainty in the assessment of the mangrove extent and to have reliable inventories, it is necessary to compare results from different research groups, working independently with the same data set and criteria, but using their own techniques. The comparison of the final outputs will lead to recognize similarities and to discuss and reduce discrepancies, to arrive to unique figures (including confidence intervals), which can be used as the official figures for any purpose".*

We set out to discuss the consistency of this current work with every other work on these mangroves, as well as the discrepancy between that of Carney *et al*. (2014) and these same other works.

The rates of mangrove progression have been compared with a more recent remote sensing analysis (Andrieu, 2018). After an extraction of the same area (from the south bank of the Gambia to the north bank of Casamance), this recent analysis exhibited, between 1988 and 2015, a mangrove increase of 25%. Considering the relative similarity of the time periods, the rates are sufficiently comparable.

Conchedda *et al.* (2008 & 2011) mapped, with SPOT images, a progression of 4,377 ha in the Casamance Delta (north and south bank) between 1986 and 2006. This study furnished results that were significantly closer to ours (+8,804 ha) than those of Carney *et al.*, 2014 (-37,196 ha), which is especially notable considering the fact that it used different dates, satellites and sub-regions.

The short NASA "image of the day" article from March 21, 2018 entitled "The Spread of Mangroves in Senegal" illustrated the same phenomena in Casamance and cited some of the studied refered in the last paragraph.

The 2010 map used in the Carney *et al*. (2014) paper is accurate, however, as a result of errors in georeferencing, window extraction and classification, their 1986 map is not. With the simple addition of stacked classification along with the same classification method used in the first step, we have been able to distinguish mudflats and mangroves on the 1986 LANDSAT image, as well as more accurately map changes and quantify areas. This correct assessment shows a progression of mangrove instead of a regression. The mapped progression globally corresponds to results of Conchedda *et al.* (2008 and 2011); Andrieu & Mering (2008) and Andrieu (2018).

Factors affecting mangrove gain and loss in Casamance and Gambia

Hence, the Gambian river banks and the Casamance Delta have not experienced significant deforestation over the course of the last 20 years. On the contrary, the population has undergone a real awakening, which can be observed principally through local initiatives that have been implemented to protect and restore the mangrove, the results of which are clearly visible in the Low-Casamance Estuary. Naturally, some areas have displayed a loss of mangrove, however these areas are far smaller than those which have displayed gains. This progression is known to be the consequence of natural processes linked to the wetter conditions since the end of the 1990s, as well as "reforestation" programs (Conchedda *et al*., 2008; Diéye *et al*., 2013b; Cormier-Salem & Panfili, 2016; Cormier *et al*, 2016; Andrieu, 2018), and also the abandonment of mangrove swamp rice fields.

In 2018, a field campaign in Casamance Delta has been built upon the change map of Andrieu (2018) in order to study the level of vegetation cover in areas that have undergone mangrove increase between 2000 and 2016. All 20 sites possess mangrove cover higher than 30%. All 20 sites contain small trees or bushes of young mangrove with thin trunks or thin branches regenerating over old empty trunks.

In the vast majority of places experiencing mangrove regeneration in this study, this has occurred spontaneously for both *Rhizophora mangle* and *Avicennia Africana*. No alignment due to reforestation can be observed and the vegetation presents a high degree of heterogeneity (Figure 8).

Figure 9: Spontaneous mangrove regeneration in Casamance (Andrieu, 2018)

In a small number of places, the increase is due instead to reforestation programs. We can observe monospecific populations of the same age with clear alignment (Figure 9).


Figure 10: Mangrove regeneration in Casamance due to a reforestation program (Andrieu, 2018)

The abandonment of mangrove swamp rice fields is known to be a third factor of the mangrove increase, although this was not investigated on the ground as part of this study. This phenomenon has, however, been observed by some authors of this paper (Figure 10). As highlighted by Temudo & Cabral (2017) in Bissau Guinea and our up-to-date data in Casamance (Sané *et al*, 2017; Cormier-Salem, 2017), the mangrove swamp rice cultivation crisis is linked to a diverse array of factors, both natural (the long lasting drought and the resulting increased salinity of water and soil, coastal erosion and the destruction of the dykes due to the rise in sea level) and anthropogenic (the neglect of rice fields as a result of a lack of manpower due to the rural exodus of young people; the unproductivity of rice fields; the inadequate agricultural and market policies; the war and the lack of infrastructure; the changes in the social organization of production, etc.). This trend of the increase of mangrove forests to the detriment of mangrove swamp rice cultivation raises the question of mangrove restoration policies in a forest-related context and not an agricultural one. This brings with it a reassessment of the value of mangroves, which differs depending on the context and the stakeholders.

Figure 11. Mangrove increase over a rice field in the wake of a dam break in Mangagoulack (Dieye, 2018).

Broader implications of inaccurate data

The gains in West African mangroves are compelling, given that mangroves are threatened by loss on a global scale. Often in environmental science, it can be thought-provoking to consider a local area that is experiencing a countertendency. Now, a study that presented inaccurate results purporting that mangroves in this area had experienced a gain that was either inflated or understated would warrant debate, but not such a critical review as this paper. However, Carney *et al*. (2014) have not underestimated or overestimated the gain. They have instead published a paper alleging massive mangrove loss where the state of the art has consistently attributed gain. Such inaccurate data could lead to an even more coercitive environmental policy which may not be justified (Peluso, 1993). Faulty data like this can trigger a loss of trust in methodologies in monitoring the environment, such as remote sensing. It also could serve to justify or perpetuate the belief that the African environment is only able to deteriorate decade after decade. While it's true that a certain margin of uncertainty should be tolerated in environmental science, a paper that announces a massive loss in forest cover instead of a substantial gain must be based on strong methodology and careful verification methods. It is important to present a clear message to those who read scientific literature regarding how to better manage the environment.

Conclusion

In conclusion, we would like to insist on the necessity of the verification of remote sensing classifications and results before their use. Radiometric analysis can be used to help distinguish between mixed classes that emerge after a simple unsupervised classification. Stacked classification is a simple way to expose such mixed classes and the analysis of these classes' radiometric curves can serve to reduce errors that could otherwise prevail when relying on a single unsupervised classification. While field verification is not always possible, such as when studying past images, other verification methods exist, including digitizing polygons on Google Earth's historical imagery. In our case, given that the imagery displayed on Google Earth is of the same style as those used in our analysis, we used it to quantify the difference between simple classification and stacked classification. This was all we used them for, however, as we recognize that Google Earth would not provide a precise accuracy assessment of the Carney *et al*. (2014) 1986 maps.

It is important that geographers, when using remote sensing methods, keep a sharp critical posture toward their own results. Being better informed technically and thematically could have here dissuaded Carney *et al.,* 2014 from publishing the contrary of that which various other papers had already published.

As a result of their misleading degradation results, the authors proceeded to write about illegal practices, such as illegal cutting and illegal smuggling. While these illegal practices may exist, they are not present at a level so as to generate such a land cover change. In this geographical context, there is no conspicuous link between the gain and loss in forest cover and the management of the ecosystem. Mangrove forest loss has been propounded as the evidence of ill practices since the 1970s. So, despite the fact that the mangrove gain doesn't prove good environmental management, we must stress the fact that the mangrove gained 20% instead of losing 35% and thus the conclusions on smuggling are to be dismissed, as they are not based on objective data. As underlined by many scholars, degradation narratives very often serve to justify the dispossession of small-holders or land grabbing (Leach and Mearns, 1996). It is necessary to avoid reinforcing, without a real scientific base, the rhetoric that "poor people make poor land". The steps are first, to measure and describe environmental changes (in this case, to confirm or refute the deforestation trends) thanks to data from the field, aerial photos and satellite images; second, to investigate the people responsible for this degradation and their rationalities; and third, to question the internal and external forces on mangrove management. Accurate remote sensing analysis seems to show that the mangrove surface is growing larger, which could signify that the resources are being well-managed. Notwithstanding, we would also insist on the fragile link between area quantification and resource management. Remote sensing is a good tool for the quantification of forest cover change. However, it must be combined with other approaches, such as interviews with the people managing the mangrove as a whole (and not only the forest), in order to know how this complex socio-ecosystem is managed and if there is a relation between this management and the change in forest cover.

Finally, the spatial interactions between mangrove forests and the other components of mangroves (mudflats, tannes, rice fields, etc.), must be clearly assessed in order to better understand the drivers and the effects of changes and to help decision-makers promote policies that are adapted to the local context.

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