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Analysis of built-up areas extension on the Petite Côte region (Senegal) by remote sensing

Analyse de l'extension des espaces bâtis dans la Petite Côte (Sénégal) par télédétection

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Abstract :

The goal of this work is to study urban dynamics on the Senegalese littoral by satellite image processing. Built-up areas have markedly increased during the last decades, especially on the Petite Côte region, which is becoming the first region of the country regarding tourism and leisure activities. SPOT images from 1988 and 2000 are processed here in order to characterise the distribution pattern and the spatial dynamics of built-up areas. A method for the extraction of built-up areas through a semi-automatic way, by means of spectral and spatial satellite image processing is presented. Quantification of built-up dynamics is finally provided by granulometric analysis on the pre-processed satellite images.

Key words: mathematical morphology - quantitative geography - remote sensing – Senegalese littoral - urban growth.

Résumé

L'objectif de ce travail est d'étudier la dynamique urbaine sur le littoral sénégalais par le biais du traitement d'images satellite. Au cours des dernières décennies les surfaces bâties ont fortement augmenté, en particulier sur la Petite Côte, qui accueil un nombre croissant d'infrastructures touristiques et de résidences secondaires. Des traitements numériques à partir des images SPOT des années 1988 et 2000 ont permis de caractériser la distribution et la dynamique spatiale des espaces bâtis. Une méthode d'extraction semi-automatique des surfaces bâties est présentée, basée sur de traitements spatiaux et spectraux des images satellites. La dynamique du bâti est quantifiée par des analyses granulometriques effectuées sur les images SPOT pré-traitées.

Mots clés : croissance urbaine - géographie quantitative - littoral sénégalais - morphologie mathématique - télédétection.

INTRODUCTION

Urban and littoral areas in West Africa may be characterised by a markedly demographic growth during the last decades. Demographic changes are accompanied by an evolution of land use, which is reflected by landscape transformations. We are interested in landscape transformation analysis, particularly when it concerns urban areas. Satellite images directly provide information about the "*instantaneous state of earth surface*". Therefore it considers only the biophysical space, excluding social interactions, which are intrinsically associated to urban notion. As De Keersmaecker and Lambin (1987) pointed out, remote sensing images record the landscape referring to the "visible space". This landscape is expressed on the false colour image by a patchwork of forms and colours. We study here the *built up areas*, which may be recognized on the SPOT scenes as specific entities belonging to such a patchwork, rather than *urban areas,* the definition of which implies some knowledge about human land use.

Pixels corresponding to built-up areas on the satellite images are more or less spectrally similar to the mineral surface response. Moreover, authors agree with the limitation on urban studies from remote sensing because of the inadequacy between SPOT and Landsat spatial resolution and the discrimination of elements that are studied in respect to their dimension (Ballut, 1982; Welch, 1982 in Weber, 1995). Several elements may be then simultaneously present within a pixel (including vegetation and water), making difficult a whole built-up surface discrimination, only based on the spectral properties (De Keersmaecker and Lambin, 1987). Hence a great inter and intra pixel variance is found over built-up areas in a satellite image (Forster, 1985). Higher spatial resolution sensors, like IKONOS, suitable for intra-urban studies, may solve the problem related to high intra-pixels variance. On the other hand, inter-pixel variability is used to define textures whatever is the resolution of the sensor under study. Moreover, high local variability of grey tones values provides one of the principal ways to characterise built-up areas from satellite data.

In the present study spatial and temporal pattern of built-up zones is analysed by the processing of remote sensing data in a region of the senegalese littoral, called the *Petite Côte* (fig. 1). Diachronic analyse considers a 10 years period, from 1988 to 2000. In a previous study, urban contour has been extracted at a local scale, from aerial photos in order to analyse Mbour's growth (Ackermann *et al.* 2001). A method, still in progress, to extract built-up areas in a semi-automatically way, is proposed. In the next section, we will briefly introduce the study area. Finally, the image processing as well as its advantages and limits to extract built-up areas are exposed.

The study area

The study area, known as *Petite Côte*, is localised in the Senegalese littoral, between Bargny and the *Pointe de Sangomar* (fig. 1). It corresponds to the littoral band of the region of Thies, of approximately 100km long and less than 10 Km large. Thies is the second region, after Dakar, regarding population and density, as well as economic performances.

Economic activity of the region was traditionally turned to fisheries. In the early 1980's, tourism has been promoted by government policy. Nowadays, the Petite Côte is the second place in touristic affluence after Dakar (Cazes, 1992). As a result of this activity, a sensible extension and sprawl of built-up areas has been recorded.

Fisheries and commercial activities contribute to main cities growth such as Mbour and Joal, while leisure activity is responsible for the sprawl of built-up areas along the seafront, between the fisher settlements. Different kind of housing structures are found such as touristic resorts, touristic camps -‘*campement’*- and residential areas. The three existing international touristic complexes are located near Mbour. On the other hand, secondary residences are sprawled hugging the seafront, predominantly between Mbour and Bargny, filling up the empty spaces between fishing villages. This accelerated development of secondary residences, owning for the most part to Europeans, Lebanese and the rich and powerful elites inhabitants from Dakar, leads to an important land speculation.

The aim of this study is to analyse the extension of built-up areas. It must be outlined that spatial and spectral resolutions of available SPOT images are still insufficient to discriminate the different kinds of infrastructures, such as camps and secondary residences.

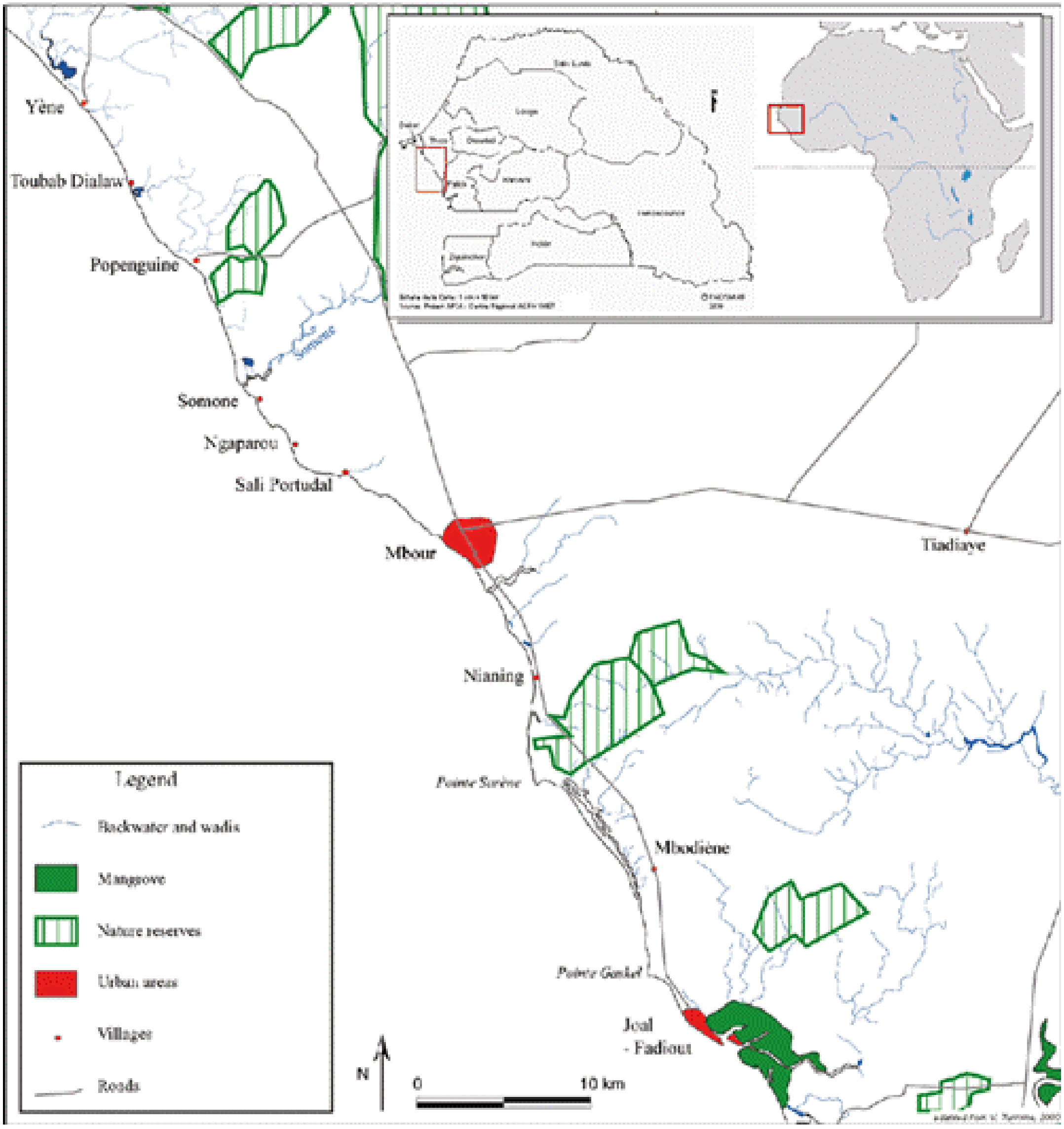

Figure 1. Study area. The *Petite Côte* (label in red) corresponds to the littoral region localised between the *Cap Vert* and the *Saloum* regions.

METHODS AND RESULTS

In this section image analysis methods used for extraction and evolution of built-up patterns from SPOT images are described. The first part is devoted to image processing adapted to urban pattern extraction from high-resolution images, and the second part describes an original method for mapping the growth of urban settlements. SPOT images corresponding to three-band multispectral mode (XS) and panchromatic mode (P) were explored over a twelve-year period. The data sets are described on table 1.

SPOT Image (level 1A)	**1988**	**1999**	**2000**
Multispectral (20m)	24th October	-	2nd March
Panchromatic (10m)	10th April	11th November	-

Table 1. SPOT data set.

1. Built-up area extraction.

Process of built-up area extraction is organized in three parts. In the first one, a multispectral spectral analysis is achieved in order to discriminate vegetalised cover lands from mineral and water surfaces. In the other two parts, the use of image processing based on textural and structural criteria are shown.

A scheme of the whole stepwise image processing is set out in figure 2.

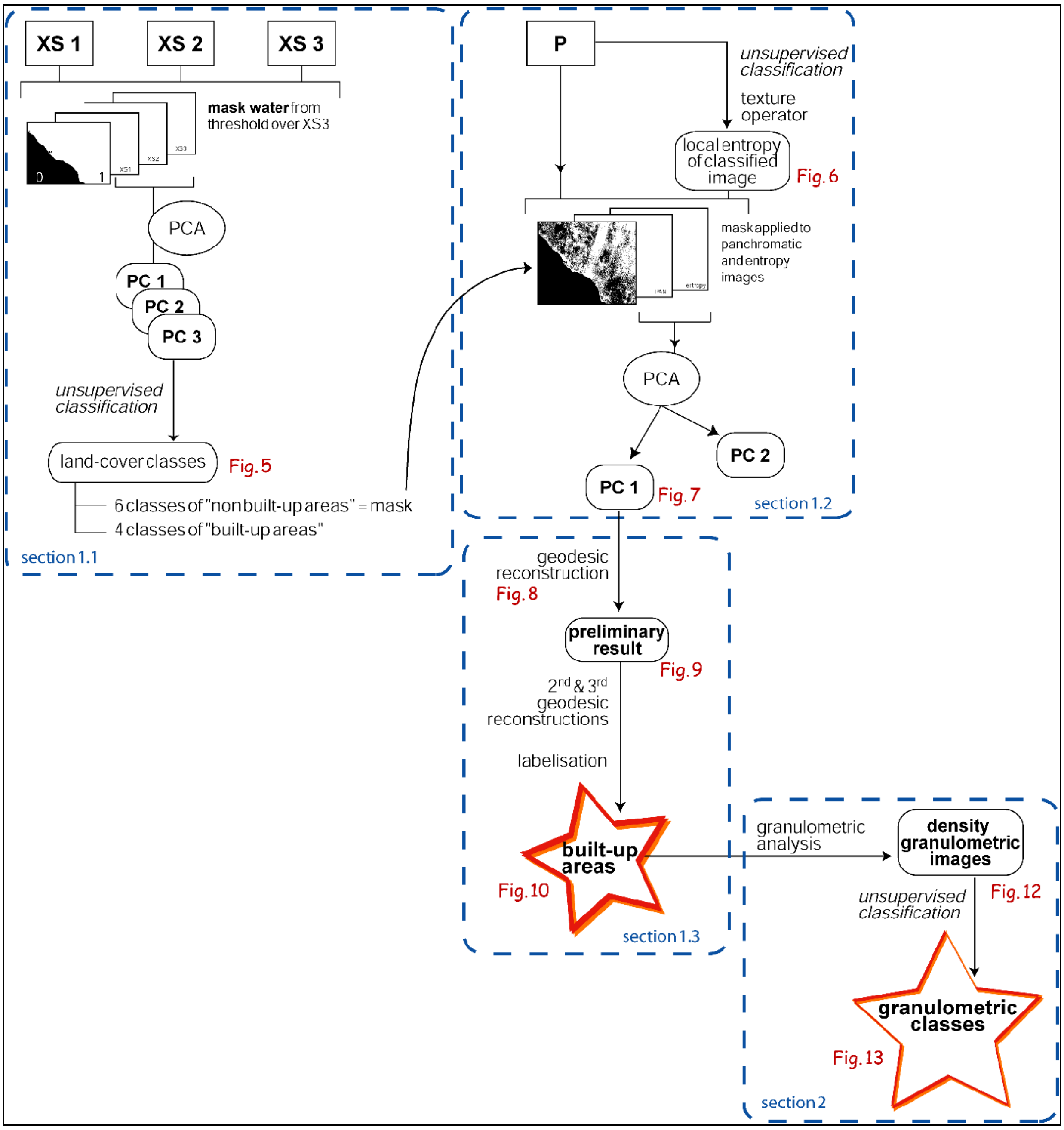

Figure 2. Synopsis of the images processing sequence.

1.1. Multispectral analysis

A standard false colour composition (fig. 3a and b) as well as a data fusion between XS and P bands (fig. 4a and b) has been made in order to visualise the whole studied region. Multispectral and panchromatic images are then merged in order to take advantage from both spectral resolution of multispectral mode and spatial resolution of panchromatic mode. The intensity, hue and saturation system (IHS) is currently used to merge SPOT XS and P bands (Welch and Ehlers, 1987 in Carper *et al.*, 1990). This data merging method is the simplest one and is quite useful for urban resource inventory, but seems less appropriate for vegetation type mapping (Carper, *et al.*, 1990). IHS composition has been preferred than RGB one, because it allows a visual interpretation of the image closer to human colour perception. Here, IHS components are obtained from XS bands and then intensity is directly substituted by P image.

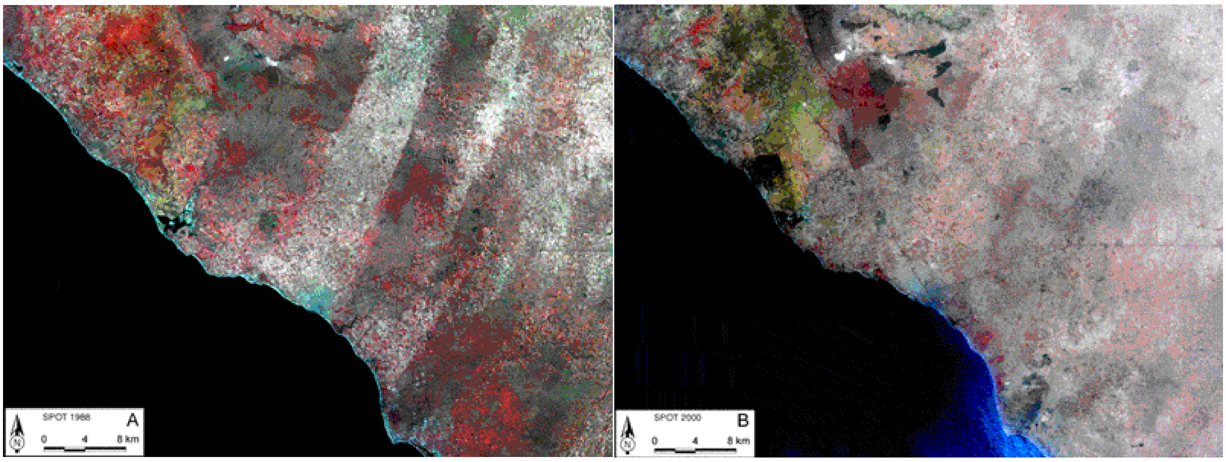

Figure 3. False colour compositions from SPOT scenes for 1988 (a) and 2000 (b). Urban settlements appear in blue tones.

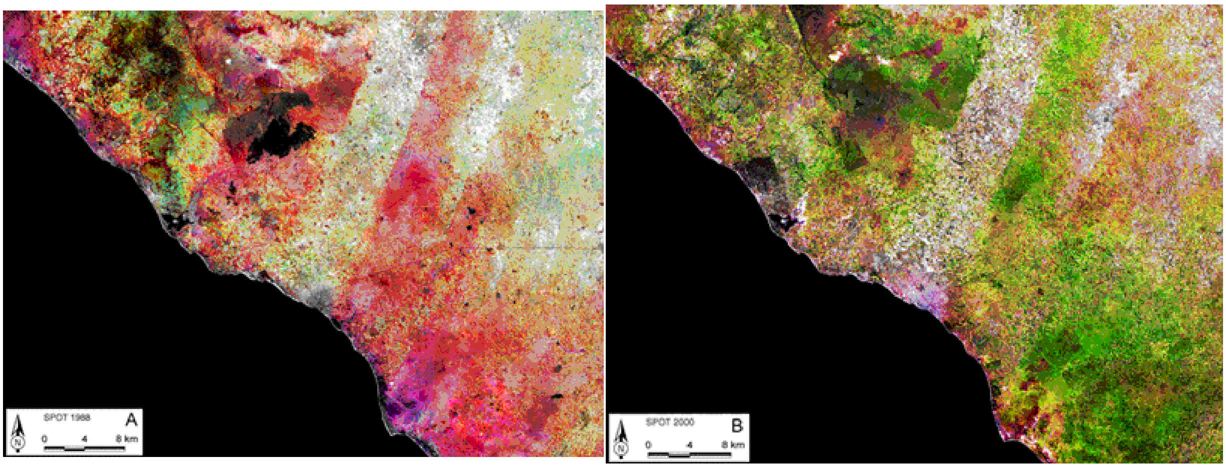

Figure 4. IHS images for 1988 (a) and 2000 (b) scenes. The intensity, hue and saturation system is used here to merge multispectral and panchromatic bands from SPOT satellite. Urban settlements appear in grey tones.

Urban areas are characterised in the image by light blue tones on the RGB mode (fig. 3a and 3b) and by grey tones on IHS mode (fig. 4a and 4b). One can notice that on the 2000 SPOT view (fig. 3b and 4b) the built-up areas are much less perceptible than on the 1988 view (fig. 3a and 4a) and that the vegetalised surfaces are weakly contrasted in comparison with those visualised in 1988 scene. Weakness of radiometric contrast on the 2000 view is widely due to the season of shooting. The view has been registered in march (see table 1) which corresponds to half of the dry season and therefore on images taken from a passive sensor such as SPOT, the mineral surfaces are not very well discriminated from vegetalised ones. It may be noticed that when studying Sahelian region one will always be confronted to the lack of good views, which means shoots taken during wet season but without clouds. This peculiar configuration of the database explains the difficulty in reaching the announced objective, and has led us to elaborate a sophisticated process, with numerous steps, in order to perform an accurate extraction of built-up areas from the 2000 scene.

Radiometric and textural contrast within mineral continental surfaces must be widely enhanced in order to discriminate built-up surfaces. For this purpose, we use a technique consisting in the creation of a “mask” over the regions of the image which are highly contrasted with the required one and therefore introduce a big noise in an automatic analysis such as multispectral classification or Principal Component Analysis (PCA). Pixels belonging to such mask will have the same value and will be so recognised as a single entity. As variability is eliminated by the mask, the contrasts within unmasked zones will be enhanced by both type of processing. In the images analysed here, vegetalised and water surfaces may be considered as creating such noise, so that multispectral treatments were used to create a mask over these surfaces.

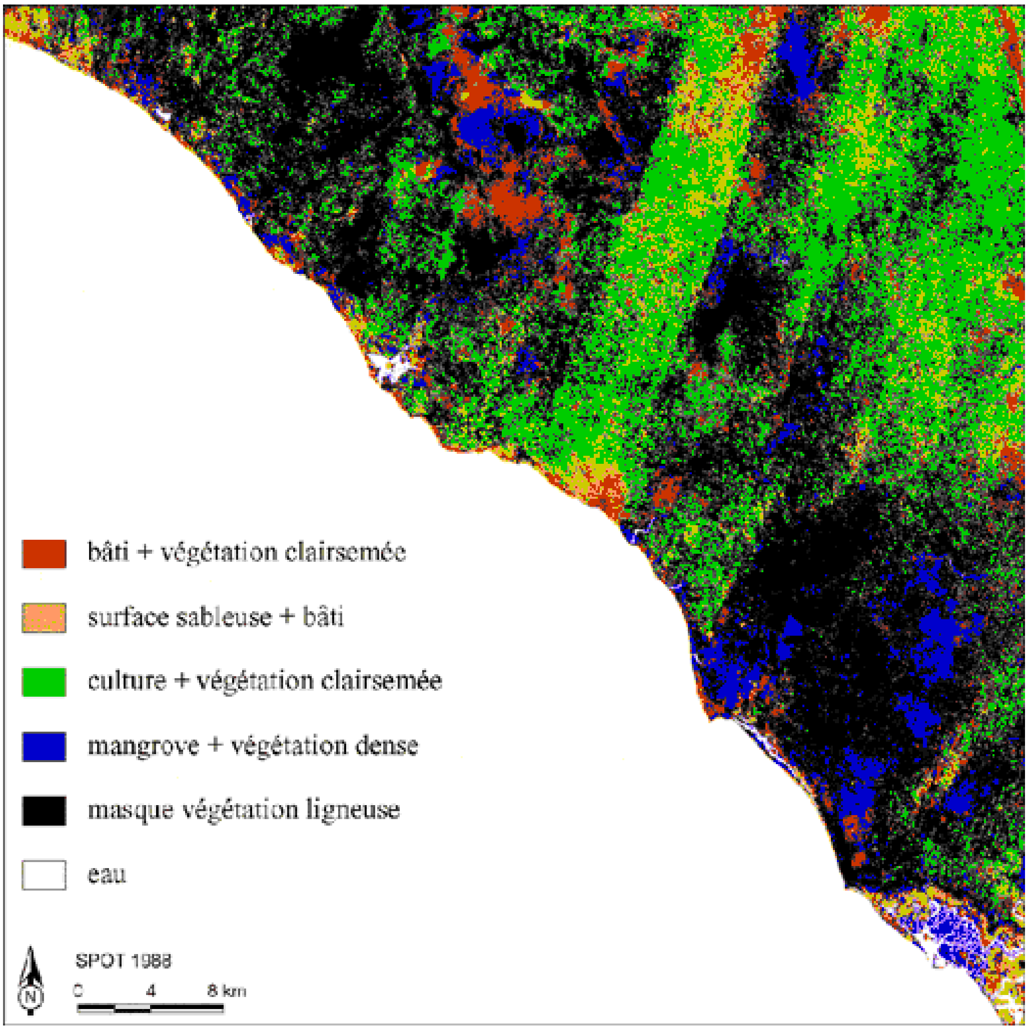

Figure 5. Masks and classification obtained from multispectral analyses for the 1988 scene. Class interpretation is large, nevertheless the objective of this classification is not to individualise each class but to elaborate a mask of non urban surfaces, and in this sense all classes retained include built-up surfaces. Legend: built-up and sparse vegetation (red); sandy soils and built-up (orange); fields and sparse vegetation (green); mangrove and dense vegetation (blue); woody vegetation mask (black); water mask (white).

First, water surfaces are easily individualised in XS3 band thanks to their low reflectance and are then masked using a low threshold. Second, for masking ligneous vegetation a PCA is computed from the three XS bands followed by an unsupervised K-means classification upon the components previously obtained. Classes corresponding to non-urban areas were merged in order to create a spatial mask on this region. Classes leading to doubts, for example containing intra urban vegetation, are excluded from the mask. As an illustration of this path, figure 5 shows both masks (for water and vegetation) and the classes obtained outside the mask for the 1988 scene.

On figure 5, two classes correspond mostly to built-up areas and bare soils(in red and orange). The other two classes (in green tones) represent more vegetalised zones, such as herbaceous surfaces. Class in dark green is retained because its presence is highly related to built-up areas. This class of pixels may correspond to mixed pixels representing intra-urban vegetation as well as mineral surfaces. The class in green is often present next to urban areas, particularly on Mbour city neighbourhood. It may include mixed pixels representing built-up areas extension with herbaceous areas and is then retained for forwards image processing. Next step consists in the analysis of textural characteristics of panchromatic scenes.

1.2. Exploring panchromatic image

This section examines the information provided by panchromatic scene, giving emphasis to texture analysis. Built-up area presents a big variety of spectral signatures due to the very large variety of materials (aluminium, tile, clay, concrete, perpen, laterite) from which they are compounded. Moreover, the reduced dimension of its elements with respect to pixel size (100 squares meters for a SPOT4 panchromatic image) is responsible for the higher local heterogeneous texture of this type of areas when compared to other land cover types such as cultures or bare soil surfaces. Therefore, criterion of texture is used here to quantify the various types of arrangements of radiometric values within a given neighbourhood. The texture is defined here by the local organisation of the radiometric value or radiometric class. In order to compute the texture several local operators such as *standard deviation*, *local entropy* and *gradient filters* are classically used. Large inter-pixel variability of built-up areas will be then translated by a high value of the pixels when applying these operators. The mask created in previous section (see figure 5) is applied to panchromatic scene to restrict the area analysed for further analysis and enhance then textural and radiometric characteristic of pixels outside the mask.

Spatial operators such as morphological filters (Serra, 1988) and gradients were studied upon aerial photographs (Ackermann *et al.* 2001). The local entropy proved to be the best spatial index for the discrimination of built-up areas (Armand et Hernandez, 1987). Several tests on the SPOT images have shown that the local entropy index has a better discrimination power when applied on classified images than on grey tone ones (cf eq. 1). Therefore, the "local entropy image" was computed from a classified image obtained by the K-means unsupervised classification method from the panchromatic scene. Local entropy, computed here inside a moving window of 5*5 pixels, is defined by equation 1.

$$Ent_N(i,j) = \sum_{k=1}^{nk} -2p_k \log(p_k) \qquad (1)$$

where p_k is the occurrence of the k class within i,j pixel's neighbourhood, wich is computed in a moving windows of N size

n_k is the number of classes

Figure 6 shows the image resulting from the application of the local entropy over the classification of panchromatic scene corresponding to 1988. Dark to white grey tone scale represents an increase from very low to very high local entropy of radiometric classes.

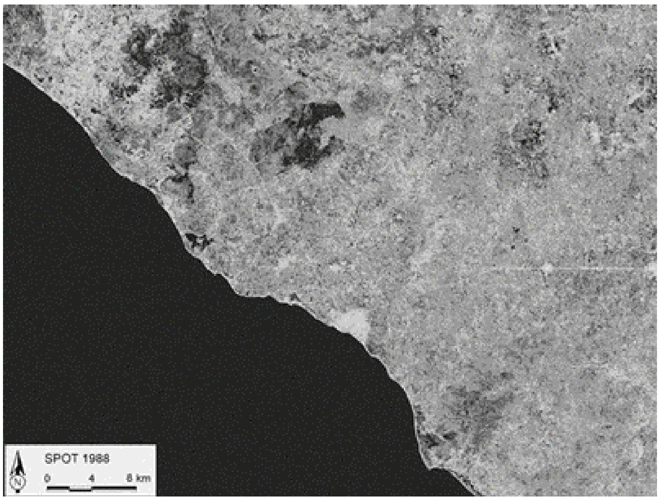

Figure 6. Local entropy image computed from the unsupervised classification of panchromatic image. A 5*5 neighbourhood is considered. Example given for 1988 scene.

Panchromatic and local entropy images were combined in a PCA in order to enhance the discrimination of built-up areas from other mineral surfaces. On first component image, shown in figure 7, light tones correspond to pixels having both heterogeneous texture and high radiometric values. Several thresholds have been applied but not single threshold leading to the extraction of built-up areas could be found. High thresholds images exclude an important part of the built-up areas, while low thresholds images kept pixels that do not correspond to built-up surfaces. To solve this problem geodesic reconstruction methods, described in next section, have been achieved.

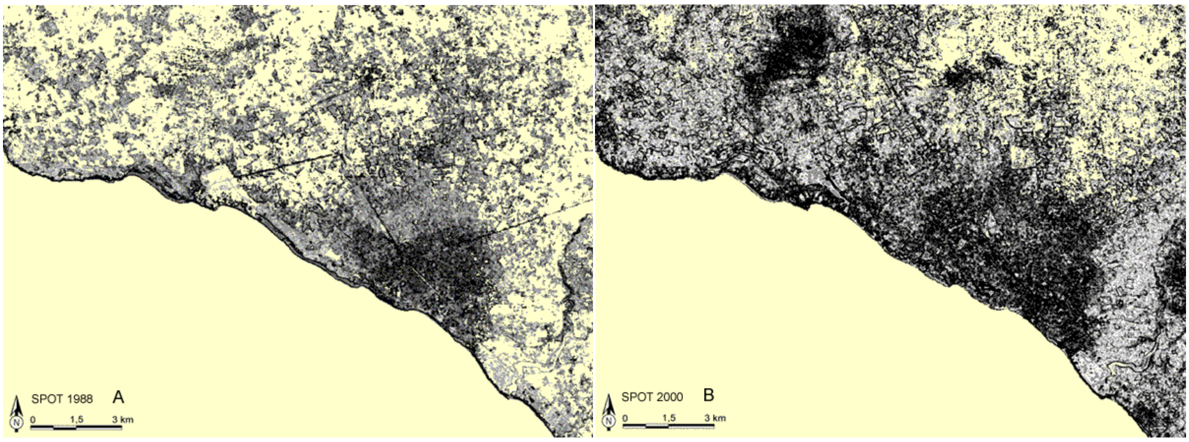

Figure 7. First principal component of the PCA computed from panchromatic classification image and entropy image for 1998 (a) and 2000 (b) scenes. A zoom of the figure 6 is shown for both dates over Mbour region. Background is shown in light yellow in order to enhance de contrast between grey tones.

1.3 Geodesic reconstructions

In order to obtain continuous surfaces corresponding to built-up areas, a *reconstruction* has been made-up from binary images computed from the first component of the PCA. *Geodesic reconstruction* is one of a large list of morphological filters based on mathematical morphology approach. Mathematical Morphology (MM) is based on the set theory combined with topological notions (like continuity or limit of a phase). The general principle is to compare the object studied with an object of known form, named *structuring element* (Serra, 1982 and Coster and Chermant, 1989). Several algorithms of MM were explored in order to extract built-up regions from a SPOT image (Davie and Drouot, 2000) as well as urban contours from a topographic map (Bailly, 1996) at a more local scale.

Geodesic reconstruction by dilation consists in a sequence of dilations of an image, called *marker* by structuring elements of increasing sizes, inside a *geodesic space*, delimited by a *mask* image (Coster and Chermant, 1989). Both, marker and mask images are coded in zero-one and generally extracted from the same original image. All patterns of the marker image are included in the mask image. Moreover, objects to be reconstructed have to be represented in the marker image at least by one pixel. Figure 8 shows the marker (in black), obtained from a high threshold of the first component and the mask (in red) obtained from a low threshold. The next step consists in the reconstruction of the mask from the marker. As a result, all the surfaces which are not materialised by any pixel on the marker image, will disappear (fig. 8a and 8b).

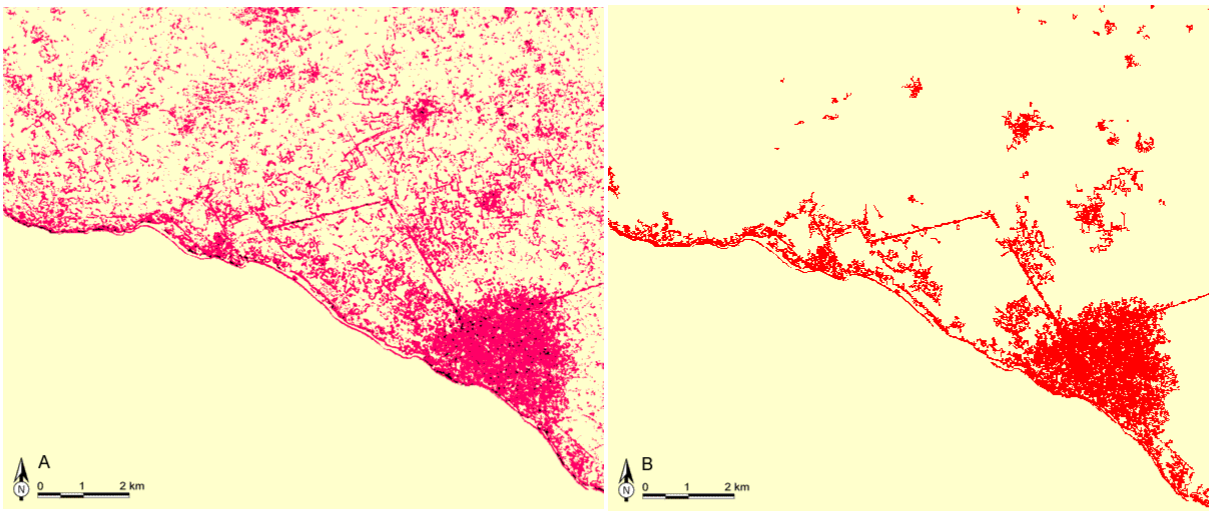

Figure 8. Geodesic reconstruction by dilation computed from first component. In first figure (a), black pixels correspond to marker and red ones to the mask. Second figure (b) shows the result of reconstruction. In order to visualise pixels belonging to maker, only a part of the SPOT scene of 1988, focalised over Mbour city is shown.

This algorithm leads to the first binary image representing built-up areas, obtained in an automatic way.

For a visual validation, a superimposition of this image with the original false colour image (fig. 3a) has been made. For this purpose the binary image obtained, coded in zero-one, is multiplied by false colour composition. It could be seen that several non built-up areas were still present in green and brown tones (fig. 9). These pixels that do not correspond to built-up zones also show high heterogeneity or radiometric values (see in fig. 6).

Figure 9. Evaluation of preliminary result by the superimposition of the binary image obtained from reconstruction and the original false colour composition. Example shown for 1988 scene.

1.3.1 Looking for the relevant markers

The key for reconstruction methods is to find the relevant marker, which means to capture only the pixels that are highly specific to the object that has to be reconstructed.

In order to reduce the image marker previously used (see fig. 8a), multispectral criteria are reviewed in addition to spatial ones. First, a high threshold was established through XS1 and XS3 bands to eliminate pixels corresponding to bare soils and vegetation respectively. The reconstructed image will be used as the mask for the final reconstruction. The second marker is produced by elimination of areas with less than one hectare (100 square pixels) by erosion with an octagonal structuring element of size 2 (5*5 pixels). The extension of eliminated surfaces was determinate by experimentation, the goal was to minimise noise given by little mineral surfaces other than built-up. A labelisation was finally necessary to individualise the areas obtained and to eliminate, through a manual way, the ones that do not correspond to built-up zones according to ground knowledge.

1.3.2 Results

The resulting binary images are presented on figure 10 (a and b). At both dates 1988 and 2000 (fig. 10a and 10b respectively), most built-up areas observed are spatially organised according to a linear distribution along the coastline, while their presence is decreasing towards inland territories. One can notice that inland settlements are smaller and more dispersed than littoral ones. From field observation it can be said that littoral settlements correspond mostly to fisheries and touristic activities as well as to secondary residence areas built-up close to fishing villages. Several inland areas correspond to small cities and villages characterised by rural and commercial activities. The distribution pattern of inland built-up areas seems to be partially determined by the presence of the only road joining main cities (Mbour and Kaolack) to Dakar as well as by the localisation of the crossroads towards the littoral (fig. 11a and 11b). Smaller villages with exclusively rural activities are sparkled out towards the inland zone.

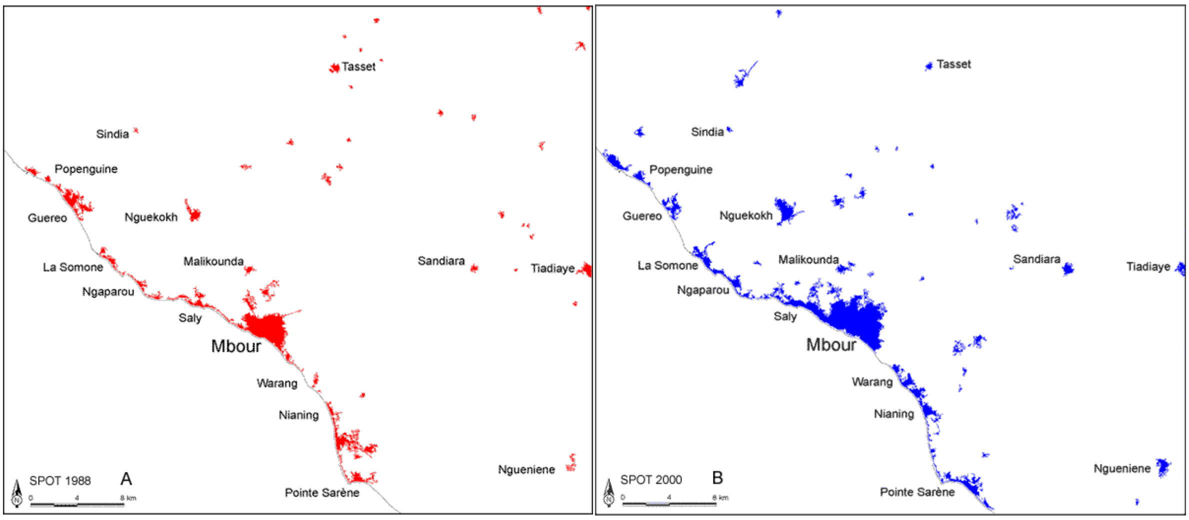

Figure 10. Built-up areas extracted from SPOT scenes corresponding to 1988 (a) and to 1999 (b).

Figure 11. Superimposition of figure 10 and the extraction from IGN topographic maps 1/200000 (Feuilles: Dakar ND28XIII, Thies ND28XIV). 1988 result is shown in red and 1999 in blue.

The sequential image processing developed here allows the effective extraction of built-up areas from SPOT images. The difficulty encountered in obtaining such results is due to fact that, at this scale, even the exhaustive use of relevant iconic criteria such as grey level texture, used to recognise built-up areas, do not provide as robust results as it could be obtained for the extraction of cultivates areas, forest and hydrographic networks. The entity of built-up objects corresponds to a very large variety of elements in the image: cities such as Mbour or Nguekokh have highly different construction materials, dimensions and spatial arrangements than the small scattered inland villages. For example, accuracy of the results is not so good when considering small built-up areas on rural zones, where construction may be more dispersed or, as it is the case for the scene corresponding to middle dry season (2000), where there is a too small contrast between villages and their surrounding. Moreover one can point out that the built-up areas has been misled with vegetalised ones such as the forests of Nianing and of Popenguine. This misclassification is probably due to an artefact of the reconstruction method which extract all areas that were originally connected on the mask image.

2. Built-up evolution analyses by granulometric method

The second objective of this work is to achieve the comparative spatial analysis of built-up areas on the Petite Côte region in 1988 and 2000. Granulometric method, based on binary Mathematical Morphology, is used for this purpose. This method enables the classification of entities according to their size on a binary image, by analogy with sieving procedures. It is applied here in order to discriminate the various built-up areas according to their surface on the satellite image.

2.1. Creating density granulometric images

A binary image can be described as a set of the Euclidean space R^2. Such a set consists in many subsets that are the connected components of the image. In order to assess the size distribution of the components of a set X, we use the method of granulometry by opening with a convex structuring element B (λ) with a size λ (Serra, 1982). The texture is quantified by computation of the granulometric density $g_\lambda(X)$, which is defined as follows:

$$G_\lambda(X) = [A\ (X_{B(\lambda)})\ A\ (X_{B(\lambda+1)})]\ /\ A\ (X) \qquad (2)$$

Where A (X) is the measure of the set X.

Granulometric density images V_i are deduced from the computation of $g_\lambda(X)$ for all the pixels P of the binary image as follows:

$$V_i(P) = g_i\left(F(P)\right) \qquad (3)$$

Where $g_i\left(F(P)\right)$ is the granulometric density computed at the step i of the opening sequence, inside the sliding measuring mask $F(P)$ centred on pixel P (Mering and Chopin, 2002).

I is the size of B such that all the pixels of $F(P)$ are eliminated after the *opening* by B_I. This value is computed for all sets $F(P)$. Each pixel of the image is then described by the I variables V_i.

Granulometry analysis is computed from binary images with built-up areas extracted on precedent section (see figure 10a and b). One granulometric density image is obtained for each step of the analysis. At the end thirty-five granulometric density images are obtained before all pixels are eliminated by the openings.

Figure 12 illustrates some of the granulometric density images (V_i) obtained at intermediate steps. For each image is shown in darkest tones the cluster of areas having the size determined by the current opening step. Granulometric density image V_1 (fig. 12a) is deduced from the step one of the granulometric density analysis for each pixel of the original binary image. Therefore, on this image, spots with darkest tones correspond to the cluster of individual entities with smallest size (size one) as spots with lighter tones correspond to the cluster of entities having bigger sizes. Then, at latest step on the granulometric density image V_{12} (fig. 12d) the only visible spot corresponds to the cluster of pixels localised in the area of Mbour, which is the larger built-up area of the region.

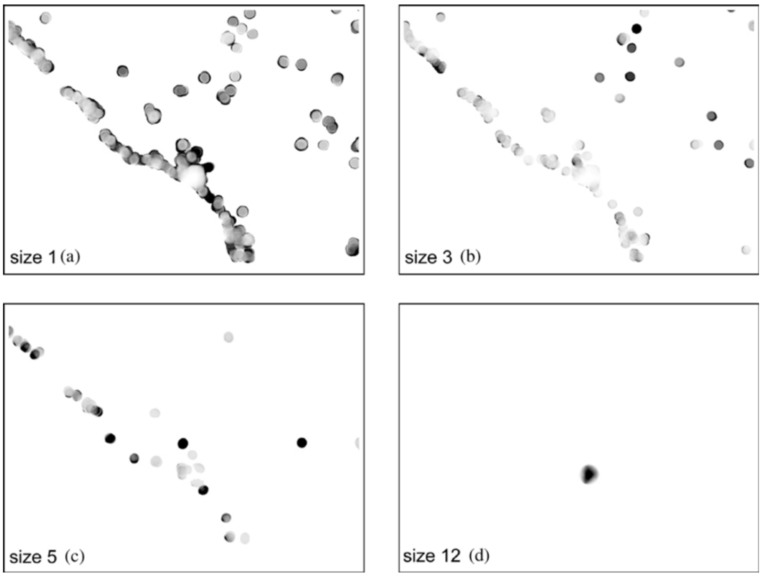

Figure 12. Sequence of granulometric density images. In order to simplify de illustration only four of the thirty-five granulometric images are shown. It was arbitrary chose those ones where changes are more perceptible. Example shown for 1988 scene.

2.2. Obtaining and computing granulometric classes

In order to obtain a typology of built-up areas according to their sizes on the original binary image, an unsupervised K-means classification from the sequence of the twelve granulometric density images $(V_i ; i = 1,12)$ is computed. In this study, each one of the k classes is then interpreted according to its mean granulometric density value, v_i. The resulting image is a k-levels image, where each level determines a set of pixels belonging to the same class, which is characterised by the value of v_i.

A K-Means unsupervised classification from the granulometric density image is processed for both dates. Figure 13 (a and b) display the 6 classes where increasing built-up surface is represented by a gradient from cold to warm colours. For both dates, blue colour represents the smaller built-up areas while red colour corresponds to the bigger areas. Granulometric method provides a striking illustration of spatial organisation of urban zones from binary images. Besides, comparison between images obtained for each date leads to the analysis of the evolution of built-up areas during the period under study.

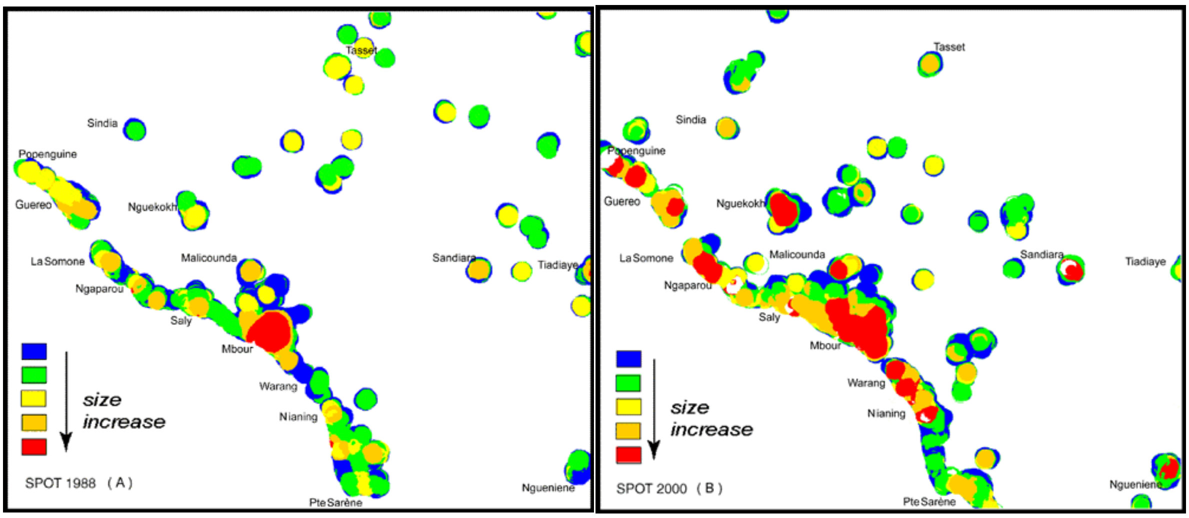

Figure 13. Granulometric classes for 1988 (a) and 2000 (b).

At both dates (fig. 13a and 13b), red and orange classes representing spots from intermediate to big granulometric size are predominantly localised on coastal zone, while for inland region most spots correspond to classes representing smaller objects, in yellow to blue colour. As these results are derived from the binary images obtained in previous section (Fig. 10a and 10b), the same errors are present here, corresponding to the disappearance of small entities towards inland. For the classified image corresponding to 1988 scene (fig. 13a), the only spot appearing in red corresponds to Mbour area, while in the figure corresponding to 2000 (fig. 13b) new entities around Mbour and along the coastline appear in red. It can also be observed by comparing both images that small-scattered villages presented on inland region, as seen before, do not present a sensible built-up growth during the period under study. In contrast, an important built-up dynamic is perceived along the littoral zone, between the coastline and the main road. On this road, it is observed that two cities, Nguekokh, localised between Dakar and Mbour, and Thiadiaye, between Mbour and Kaolack, change colours from yellow to red between both dates. On the coastline itself, one may observe a markedly increase of the number of red and orange spots from Mbour towards Dakar on the 2000 image. The urban development in this peculiar part of the littoral may be explained by the proximity of the capital, which doubtless plays a crucial role for the accessibility to touristic resorts and to secondary residences. One may point out moreover that built-up areas have dramatically grown between Mbour and Saly Portudal, which is the largest touristic resort of the West African littoral since the early eighties.

DISCUSSION

Two patterns of built-up development have been identified at this regional scale. One corresponds to scattered small inland villages, where few temporal changes are perceived. The other one, submitted to a more dynamic built-up process, concerns the zone between the coastline and the main road. Some comments may be provided with respect to the identification of the different 'built-up sets' by field observation and by remote sensing analysis.

Scattered small inland villages were partially extracted. Discrimination of these surfaces, at a regional scale, depend highly on the contrast between the settlements themselves and their environment. For the 2000 scene, the absence of vegetation erases all contrast, making the extraction of villages in dry season difficult. Nevertheless it would be necessary to try to point out the evolution of the villages localised on the inland during the recent period by processing very high resolution images. Regarding the coastal zone, the sequential process presented, even if complex, allows a satisfying extraction of main built-up areas, like Mbour or Nguekokh. Moreover, classification from density granulometric images shows that these towns correspond to the regions which had the more intense building-up activity during the period under study. Furthermore, by surimposition of both images of built-up areas on topographic maps (Fig 11a and 11b), it can be said that the coastal villages as well as the bigger international complex hotels are correctly extracted by image processing. Nevertheless, the isolated constructions present all along the coast are not extracted by the image processing due to an insufficient spatial resolution of the images. This problem must be solved by the use of higher spatial resolution images such as SPOT5 satellite images, which are now available (since October 2002).

As pointed out in the introduction, limits of our research reside in the few remote sensing data for the Petite Côte region available for the wet season. SPOT images, like the 1988 scene are unusual. Problems related to date of shoot sight are difficult to solve for this region. As a matter of fact suitable sights would be the ones corresponding to the last half of the wet season but without clouds (an important presence of clouds makes the image unexploitable). In this sense, we think that the interest of the method presented here is to extract information from images of weakly radiometric contrast at the regional scale. A study focusing only on the littoral region, by the creation of a mask for the inland territories, may reduce the landscape variability detected and facilitates the task of extracting built-up. Further works will be focused in reproducing this method at a local scale, in order to study built-up growth for each city, combining information of satellite images and older aerial photographies.

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