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Extracting Slums from High-Resolution Satellite Images

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Abstract:- Remote sensing has become a necessary tool in planning and urban management. It complements conventional tools such as aerial photogrammetry, and surveying, very accurate, certainly, but the cost factor is required, the thing that has attracted much attention from planners and scientists conducting studies on the extent of urban sprawl, taking into account the problem of slums and its impact on congestion, pollution, environment, leading to the implementation of the principle of intervention.

This type of habitat is deprived of basic sanitary conditions. Most slum dwellers are from the rural exodus with insufficient income to meet the basic needs of everyday life. Faced with this alarming situation, the Moroccan government launched in 2004 a "Cities without Slums" program (TWS).

The control and monitoring of the program first requires identification and spatial detection of these habitats. To accomplish these tasks, conventional methods such as information gathering, mapping, use of databases and statistics frequently turned out even little used.

This article comes from this perspective aims to develop new approaches for the detection of slums mainly based on supervised classification of very high spatial resolution (VHR) with SVM method (Support Vector Machine). The data in this classification will then be used in a spatial database to be introduced into a GIS.

Keywords:- SVM (Support Vector Machine), Slums, Remote sensing, GIS, TWSP (town without slums Program)

I. INTRODUCTION

The phenomenon of slum is one of the global issues that concern the international community because of its continuous growth since the end of last century and the complexity of its economic and social dimensions. Faced with the growth of this phenomenon, the UN Habitat has highlighted the dangers arising from this phenomenon especially in southern countries where the number of people living in slums could increase from 1 billion to 2 billion today to 2030.

To address this challenge, several countries have launched various public policies to improve housing conditions. Today, 20 countries in the south have made considerable efforts that have earned them recognition from the international community for their efforts in the fight against slums.

In Morocco, the efforts and the performance achieved in this area through a new approach of resoption based primarily on:

- the essential role of Urban Agencies across the kingdom of Morocco that is to cover cities and administrative centers of rural communities by planning documents and to simplify procedures and reduce the time of issue of the building permit.
- The mobilization of public land.
- An agreement with the Royal Centre for Remote Sensing, which aims to have a fast and efficient tool for monitoring the evolution over time of the land use by the slums.

Since its launch in 2004, the “Cities without Slums” program has:

- Reduce the demographic weight of households living in slums in the Moroccan cities of 8
- Resorption of proper urban slums through the "city without slums program, which led to a partnership2% to 3.9% between 2004 and 2010;
- Improve the living conditions of nearly 1 million people;
- Declare 45 cities without slums among the 85 cities covered as illustrated in the following map(Fig 1):

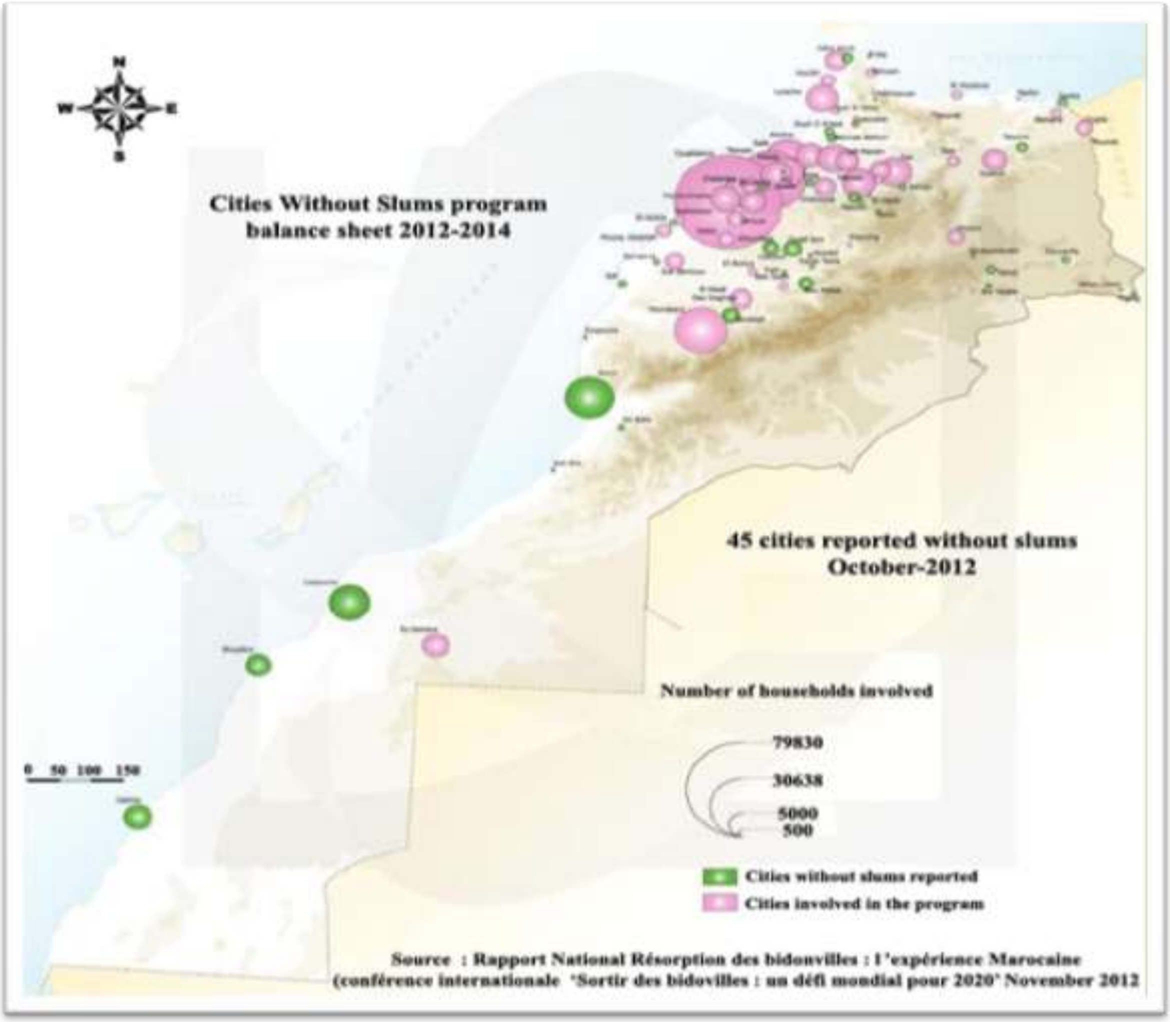

Fig. 1: Map showing cities covered by the TWSP and those declared without slums cities in the kingdom of Morocco.

We must say that monitoring the slums by satellite imagery is more effective than conventional methods based primarily on human observations ; this has allowed Morocco to receive from the United Nations, the Honorary UN prize "Habitat in 2010" for his national fight against slums, especially slum clearance in urban areas;

This method can be improved by an automatic advantage and effective treatment applied to very high-resolution satellite images (VHR) and it is the purpose of this article, by introducing a supervised classification by SVM method (Support Vector Machine) for the identification and extraction of slums, and enter the data into a GIS.

II. STUDY AREA

The study area (Fig.2) concerns the rural common of Moulay Bousselham, it is located northwest of the province of Kenitra, is bounded on the west by the Atlantic Ocean, to the north by RC of Chouafaa, on the east by the RC of Lalla Mimouna and south by RC of Bhara Ouled Ayad. It extends over an area of about 174 square kilometers and has a population of 16,167 inhabitants (RGPH 1994) and 21462 (RGPH 2004), a growth rate of 2.9 belonging to the fraction Mechraa Lahdar composed of Douars Ksaksa, Dlalha, Oulad Aguil, Oulad Rafaa, Cibara, Chouafa, and Ryah Zaouia.

The urban problem of the Rural Common of Moulay Bousselham is marked by :
- Integration of the sub sectors and Ryah Zaouia organized urban center consisting of itself and the saturation of the urbanized area of the latter because of the waste that characterizes its current occupation almost exclusively by second homes.

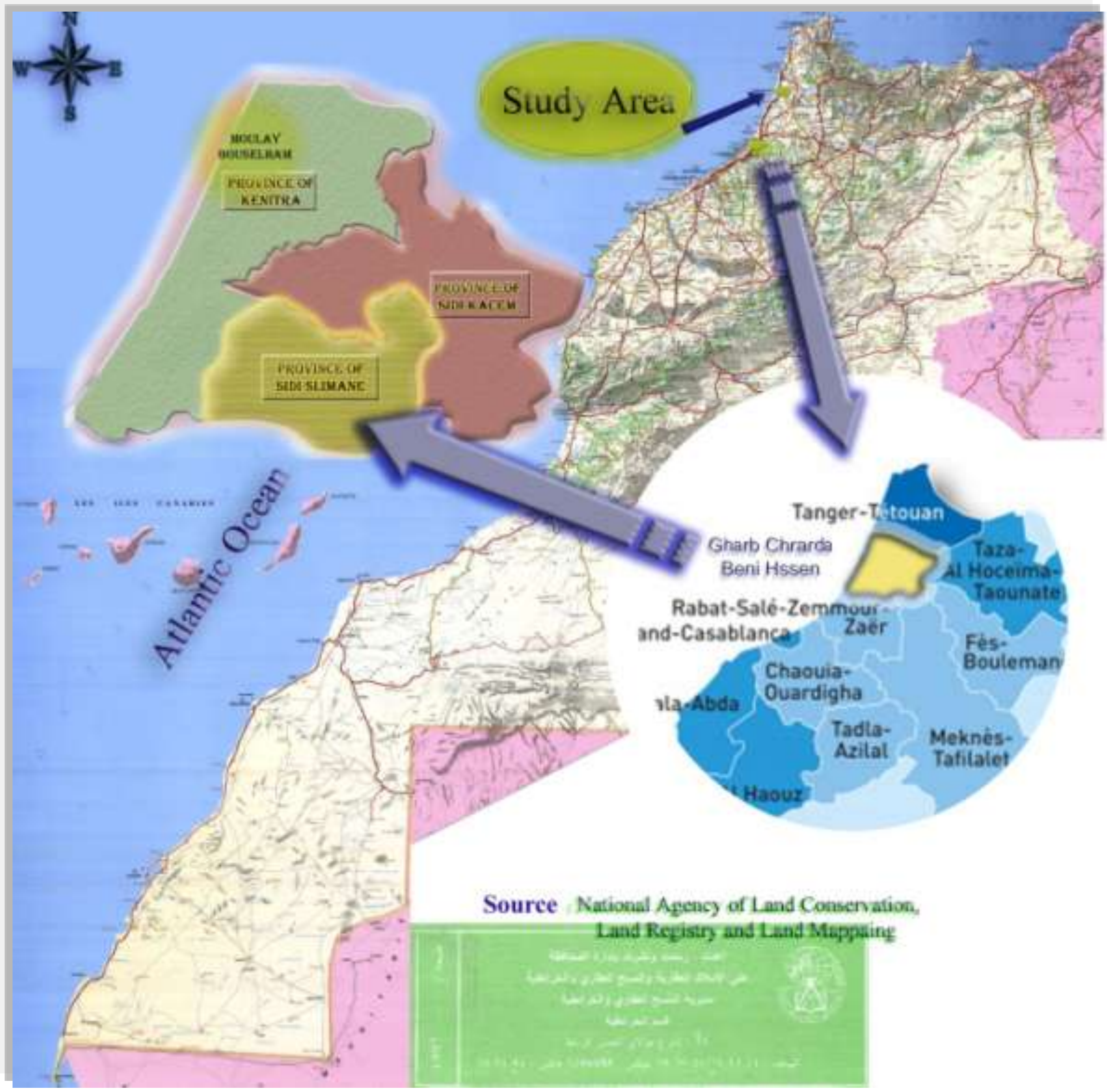

Fig. 2: Map of the study area

The occupation of the building lots from the center is dominated by the construction of individual homes, inter alia through subdivisions of the State (Endowments, Al and Al Mandar Aljamil Mohit).

This situation has led to the development of devices and Ryah Zaouia Douars occupied by the exclusion from the center of Moulay Bousselham land market populations.

- Existence of the site of biological interest Merja Zerga and eucalyptus forest serving as a protective shield against desertification of agricultural land;

- Existence of sand dunes that require consolidation to preserve against the encroachment of the ocean;
- Existence of two areas of substandard housing and Ryah Zaouia to restructure and integrate the organized urban fabric;
- Lack of a sewerage network and constituting one of the main problems of Moulay Bousselham. The technique used today is based on the installation of septic tanks.

It is clear that the area of Moulay Bousselham has many strengths (sea, strategic area Merja) at the same time there are risks to the ecosystem by the uncontrolled proliferation of slums in Douars Zaouia and Ryah, these risks are presented in the map below :

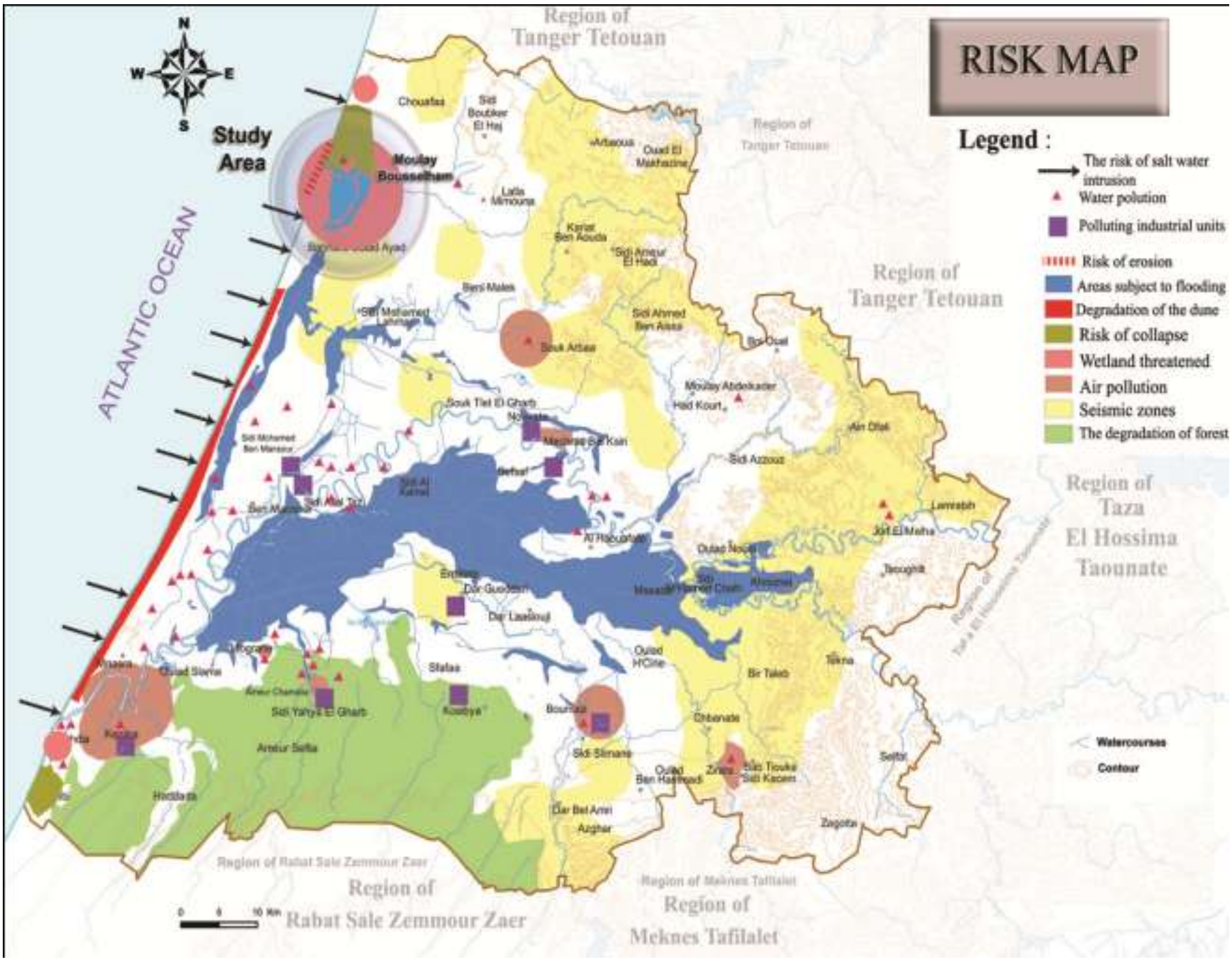

Fig. 3: Risk Map of the Region of Gharb Chrarda Beni Hssen[.....]

III. MATERIALS AND METHODS

A. Data used

The study was conducted using satellite Quick Bird of 0.6 m spatial resolution image and as training area we have a series of aerial photos and other data as illustrated in the following table1.

Data Type	Date/of aerial shooting	Type Of Data	Scale/ Resolution	Source of Data/ Organization
Road map of Gharb, Chrarda, Bni Hssen	2000	Raster	1/250000	Centre National des Etudes et des Recherches Routières
Topographical map of Moulay Bousselham, Lalla Mimouna	1986	Raster	1/50000/ 1/25000	National Agency of Land Conservation, Land Registry and Mapping
Photogrammetric data/Aerial photos/Orthophotoplan .	2007	Vector Vector Vector	1/2000 1/5000 1/10000	Urban Agency of de Kenitra-Sidi Kacem
Satellite imagery : SPOT 5 Quick Bird	2006 2010	Raster	2.5 m 0.60 m	Convention between A.U.K.S (Urban Agency of de Kenitra-Sidi Kacem) and the C.R.T.S (Royal Centre for Remote Sensing) for the acquisition of satellite images

Table 1: Data used in the study

B. Support Vector Machines

Classification by Support Vector Machines is another recent non-parametric method [Vapnik, 1998].

It consists in solving a binary classification by placing a hyperplane in that space as data decision boundary such that:

- Hyperplane that maximizes the classification rate of training samples,

- The distance between the plane and the nearest pixel is maximized.

This plan is defined by a combination of the samples closest to this plan, which are called support vectors. This approach is interesting, since optimization is supposed to directly maximize the classification, but its developments mainly concern the two-class problem. nevertheless, the results are satisfactory, as shown by some applications on remote sensing image [Huang et al, 2002] [Melgani et Bruzzone, 2004] [Roli et Fumera, 2001] [Zhang et al, 2001].

B.1 Basic principle of SVM :

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Initially SVM approaches have been proposed to search for the optimal separation between two classes. A classification problem into two classes can be stated as follows:

let X be a set of N training examples, each element is represented by a pair $(\vec{x_i}, y_i)$ with i = 1 ... N, a class label yi can take the value +1 or -1 and et $\vec{x_i}$ a vector of size k $(xi \in \Re^k)$.

The purpose of the classifier is to determine, using the training data, a decision function $f(x, \alpha) \rightarrow y$ (α the classifier parameters) and then use it to classify new data.

In the case of a linear classifier, the function f can be defined using a hyperplane equation $\vec{w}.X + b = 0$ (with d denote the parameters for the hyperplane respectively a plane normal vector and bias). The classification of a vector $\vec{x_i}$ is given by the sign of the function f, $\text{sgn}\lfloor f\vec{w}, b(\vec{x_i})\rfloor$ ie $y_i = \pm 1$ if $\text{sgn}\lfloor f\vec{w}, b(\vec{x_i})\rfloor > 0$ with $yi = -1$ if $\text{sgn}\lfloor f\vec{w}, b(\vec{x_i})\rfloor < 0$.

The principle of SVM approaches is to find the optimal hyperplane among all possible hyperplanes (figure 1.7-a) to properly classify data (i.e the label data classes +1 and −1 located on each side of the hyperplane) as well as its distance vectors (learning example) the closest is maximal (i.e. as far as possible all of the examples) Closest vectors are then referred to as "support vector" and the distance is the optimal range.

The support vectors are located on two parallel hyperplanes (H1 et H2) the optimal hyperplane equation $\vec{w}.X + b = 0$ and for respective equation $\vec{w}.X + b = -1$ & $\vec{w}.X + b = +1$ (Fig 4). No example of learning to be located in the margin, they satisfy the following equations:

$$\vec{w}.\vec{x_i} + b \geq 1 \text{ si } y_i = +1, \qquad (1)$$
$$\vec{w}.\vec{x_i} + b \leq -1 \text{ si } y_i = -1, \forall\, i = 1 \ldots\ldots N$$

These constraints can be combined into one following inequality: $(\vec{w}.\vec{x_i} + b) - 1 \geq 0$.

Thus, the margin is at least equal to the distance between the two hyperplanes H1 et H2 is then : $\frac{2}{\|\vec{w}\|}$, with $\|\vec{w}\|$ refers to the magnitude of the vector $\vec{w}$. Maximize this margin is therefore to minimize $\|\vec{w}\|$ under the constraint that the hyperplane remains separator that is to say : $y_i(\vec{w}.\vec{x_i} + b) - 1 \geq 0, \forall\, i = 1 \ldots\ldots N$.

" Here we find the justification for the name "separator wide margin".

It can be shown, using appropriate methods of optimization (duality principle and Lagrange multipliers), the vector $\vec{w}$ realizing the optimum can be written: $\overrightarrow{w^*} = \sum_{i=1}^{n} \alpha_i^* y_i \vec{x_i}$

The α_i^* are the Lagrange multipliers and are determined only for non-zero points $\vec{x_i}$ located exactly "on line", that is to say the support vectors.

The calculation b^* is performed either by taking an individual i (a learning sample) by averaging all of the b^* vector obtained for each carrier.

Is then $vs = \{j \in \{1, 2 \dots . l\} | \alpha_j^* \neq 0\}$ all indices of support vectors. Once the parameters Calculated α^* and b^*, the rule for classifying a new observation $\vec{x}$ based on maximum margin hyperplane is given by n: sgn($\sum_{j \in vs} y_i \, \alpha_j^* \vec{x} . \vec{x_j} + b^*$).

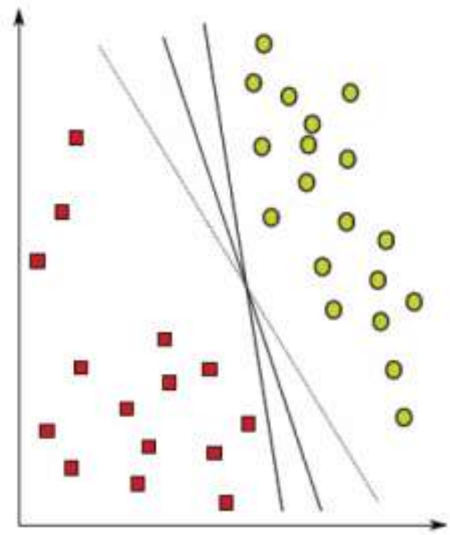
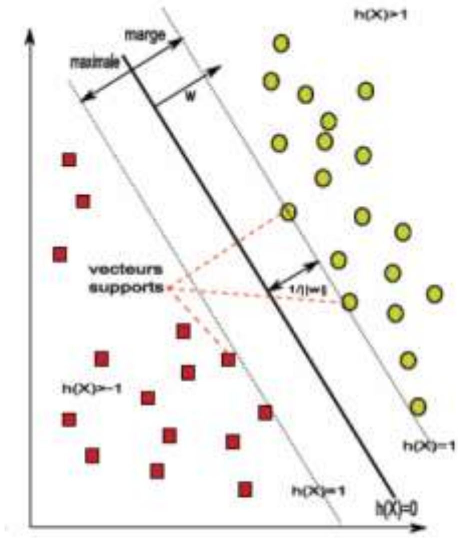


Fig 4 : Principle of SVM: (a) Research the optimal hyperplane



(**Fig 5**Optimal hyperplane, margin and support vector

B.2 Nonlinearly separable case :

However, in many cases, the drive samples are not linearly separable. The procedure then is to introduce a function Φ for projecting the data into a higher dimensional space (*D*) where they become linearly separable (see Figure 1.8):

$$\Re^k \quad (2) \quad vec\, D \gg d \quad \Phi(\vec{x})$$

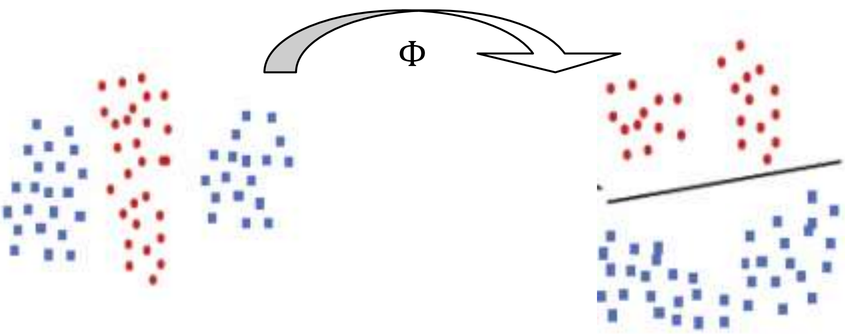


Figure 6 Representation of the kernel

In the same way as before, we search in this new space, given this time by the optimal hyperplane:

$$f^*(\vec{x}) = \vec{w}^* . \Phi(\vec{x}) + b^* \qquad (3)$$

with $\vec{w}^* = \sum_{i=1}^{n} \alpha_i \, y_i \, \Phi(\vec{x}_i)$ **is then** $\vec{f}^*(\vec{x}) = \sum_{i=1}^{n} \alpha_i \, y_i \, \Phi(\vec{x}_i) . \Phi(\vec{x}) + b^*$ (4)

An important observation is that mere knowledge of the inner products between dots is sufficient to find and calculate the fonction f^*. Simply being able to calculate $\Phi(\vec{x}_i).\Phi(\vec{x}_j) = k(\vec{x}_i, \vec{x}_j)$. The term $k(\vec{x}_i, \vec{x}_j)$ is called the kernel. Vapnik [Vapnik, 1998] showed that any function satisfying the conditions (symmetric positive definite) can be used as core. Among the more conventionally used for image classification method to remote sensing, we find the Gaussian kernel or RBF kernel (for Radial Basis).

$$k(x,y) = \exp\left[-\frac{\|x-y\|^2}{2\sigma^2}\right] \qquad (5)$$

or the polynomial kernel [Gualtieri and Chettri, 2000] [Huang et al, 2002] [Camps-Valls et al., 2006].

$$k(x,y) = (x.y+1)^p \qquad (6)$$

C. Methodology :

The flowchart of methodology followed is illustrated in Figure 2.

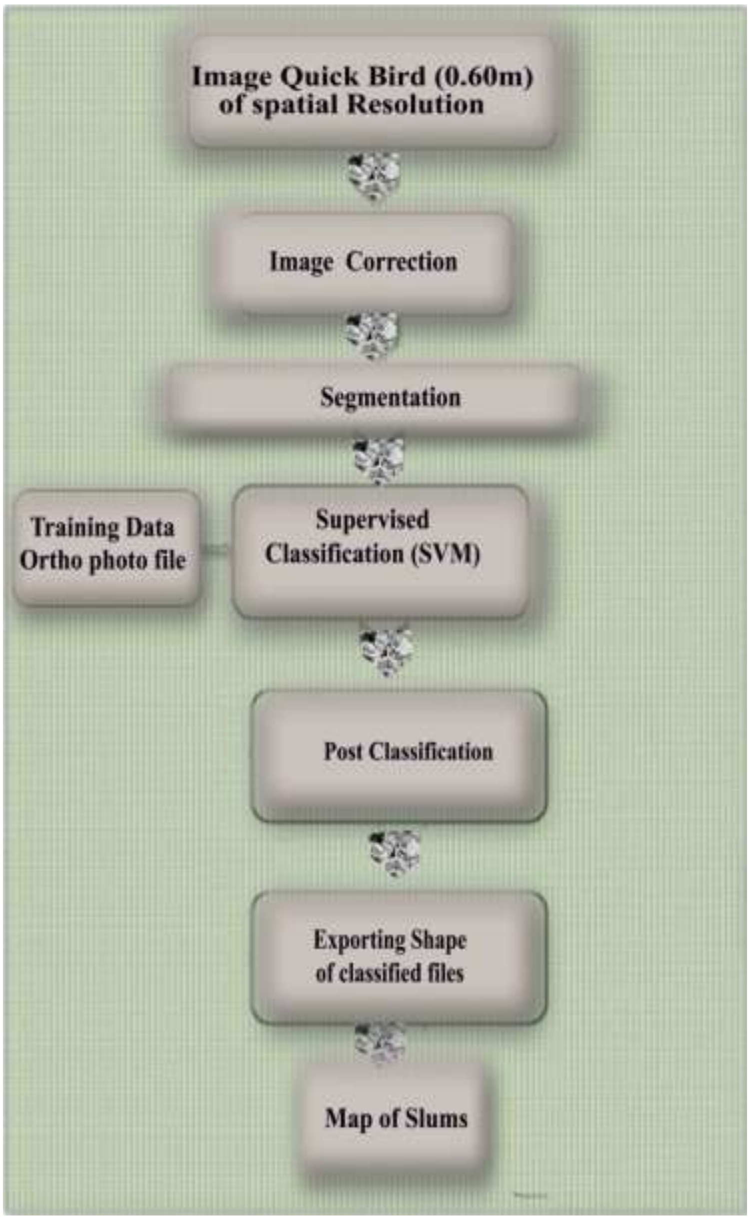


Figure 7 : The flowchart of methodology

IV. RESULTS AND DISCUSSION

In a first step, we proceed to the unsupervised classification using a Quick bird picture of 0.6 m of spatial resolution, as shown in the following figure :

Figure 7 : Quick bird picture of 0.6 m of spatial resolution

A. The result of the classification using SVM classifier :

The evaluation of a classification is a complex concept that includes the reference to several criteria that can occur in several stages (Caloz and Collet, 2001).
The main idea is to determine the accuracy of this classification by comparing the results with data provided from the reality in the field. These realities are the orthophoto plans of the study area.
In general, the classification evaluation is done by calculating two indices from the confusion matrix: overall accuracy and Kappa index. The Kappa index indicates how to classify the data agree with reference data (Congalton, R.G., 1991, Congalton and Green, 1999).
The result of this supervised classification is shown in the following map :

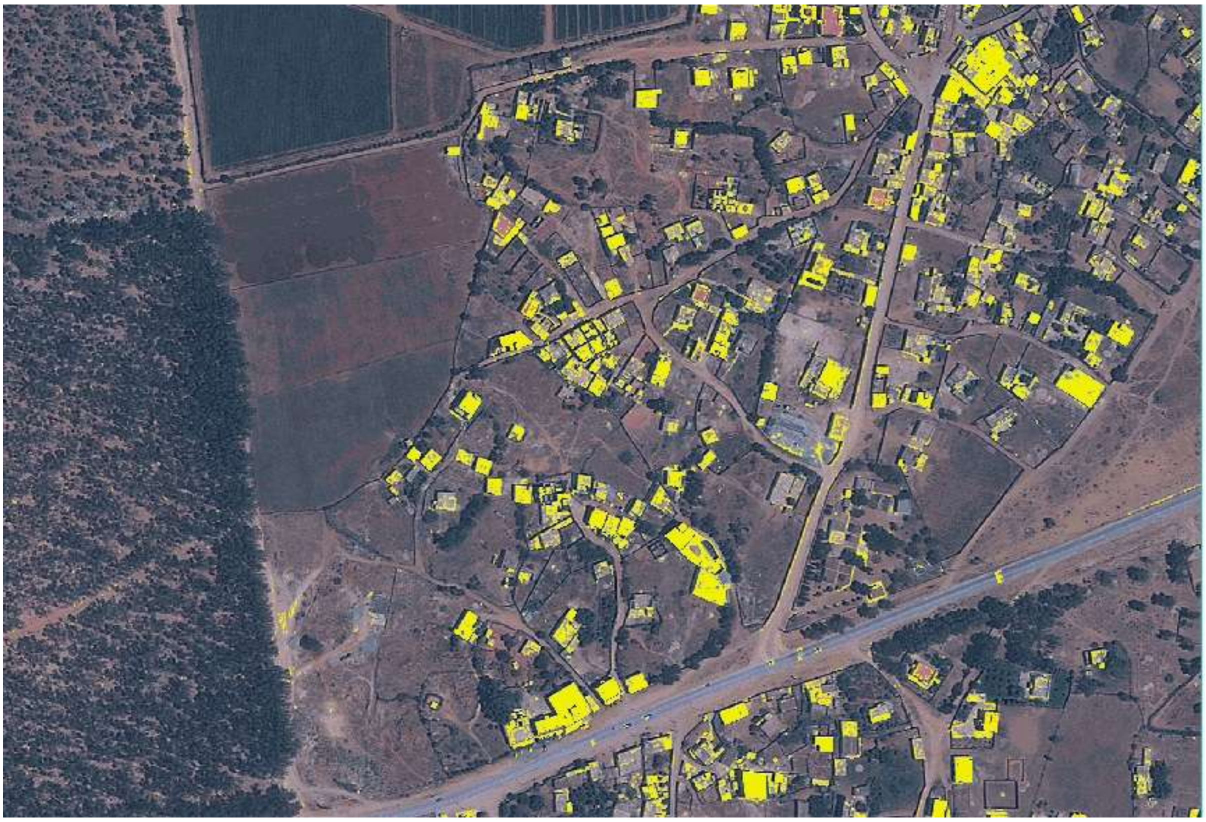


Fig.8: The result of supervised classification using SVM classifier with kernel

V. CONCLUSIONS

Through this study, it was demonstrated the effectiveness of the method of supervised classification with the SVM classifier using satellite images with high spatial resolution Quick Bird.

This allowed the identification and quantification of slums, where a Master accurately proliferation of slums at the region of Gharb Chrarda Beni Hssen.

Although the results are very satisfactory, but our goal is to make this more automatic operation, which pushes us to further improve this process and find adequate solutions for extreme cases of classification, it is critical if there is a total confusion between classes slum and home to some steady degradation that have a similarity in texture.

We think of a different approach to this method by acting on the algorithm of SVM classifier.

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