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Ernane Rosa Martins
(ORGANIZADOR)

Ciência, tecnologia e inovação:

Fatores de progresso e de desenvolvimento

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Telefone: +55 (42) 3323-5493
www.atenaeditora.com.br
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APRESENTAÇÃO

A nossa sociedade está em constante evolução, visivelmente percebida no Brasil e no mundo, generalizada em todas as áreas do conhecimento. Esta obra pretende elucidar o panorama atual das organizações relacionando-as com a ciência, a tecnologia e a inovação, apresentando diversas análises sobre questões extremamente relevantes, por meio de seus capítulos.

Estes capítulos abordam aspectos importantes, tais como: os impactos causados pela implementação da BR-158 no cotidiano das comunidades indígenas no Estado do Mato Grosso; o quão a Profissão de Físico Médico é reconhecida ou desconhecida pela sociedade; os desafios enfrentados ao transformar o processo de Pré-Incubação para o formato virtual; a taxa de transferência padrão de oxigênio de um aerador comercial trifásico do tipo aspersão/chafariz 1,5 cv, através dos índices de SOTR (taxa padrão de transferência de oxigênio) e SAE (eficiência padrão do aerador); a análise da eficiência de websites de e-commerce a partir dos resultados de testes de usabilidade e dos dados que abrangem o desempenho dos mesmos na web; analise do Programa de Extensão “Reciclando o dia a dia - Promovendo a Cidadania”; quantificar os compostos Oxidativos e enzimáticos da Peroxidase - POD e Polifenoloxidase - PFO de 4 variedades de lúpulo (Chinook, Cascade, Columbus e EK Golding); analise dos motivos que levaram aos indeferimentos de depósitos de patentes em instituições de ensino, pesquisa e tecnologia no Brasil.

Nesse sentido, esta obra engloba uma coletânea de excelentes trabalhos de extrema relevância, por meio de experimentos e vivências de seus autores, socializando-os no meio acadêmico, proporcionando aos leitores a oportunidade de análises e discussões de textos científicos. Assim, desejamos a cada autor, nossos mais sinceros agradecimentos pela contribuição. E aos leitores, desejamos uma leitura proveitosa e repleta de excelentes reflexões.

Ernane Rosa Martins

SUMÁRIO

CAPÍTULO 10

DETECTION LAND USE CONFLICTS THROUGH HIGH PASS FILTER IN SATELLITE IMAGES IN THE MUNICIPALITY OF MEDELLÍN, COLOMBIA

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Michael Javier Avendaño Calderón
Universidad Distrital Francisco José de Caldas
Ingeniería Catastral y Geodesia
Bogotá - Colombia
https://orcid.org/0000-0002-6075-028X

Edwin Santiago Mora Acuña
Universidad Distrital Francisco José de Caldas
Ingeniería Catastral y Geodesia
Bogotá - Colombia
https://orcid.org/0000-0002-4362-9015

ABSTRACT: One of the techniques implemented to detect land use conflicts is analysis by means of satellite images, since these represent the reality of the territory at a certain time. However, these images can be very expensive because of the level of detail that these types of analyzes require; hindering municipalities, with limited economic levels, from accessing these types of techniques. Therefore, a multitemporal analysis was carried out between two Sentinel images from the years 2015 and 2019, implementing the image enhancement technique by group of pixels called spatial filtering (high-pass filter) and the classification method supervised by the Minimum algorithm. distance. These images were obtained from the USGS, taking as a study area a portion of the periphery of the Villa Hermosa commune, next to the village of Santa Elena, in the south east of the city of Medellín. The results obtained revealed that the classification obtained by the filtered images led to less error and a high percentage of correctness at the time of generating the classification, and, therefore, led to being a more reliable source to detect and affirm the conflict of use of the soil present in the study area.

KEYWORDS: Land use conflict, image enhancement, remote sensing.

DETECÇÃO DE CONFLITOS DE USO DO SOLO UTILIZANDO FILTRAGEM DE ALTA PASSAGEM EM IMAGENS DE SATÉLITE NUMA ÁREA DO MUNICÍPIO DE MEDELLÍN, COLÔMBIA

RESUMO: Uma das técnicas implementadas para detectar conflitos de uso do solo é a análise por meio de imagens de satélite, uma vez que estas representam a realidade do território em um determinado momento. No entanto, essas imagens podem ser muito caras devido ao nível de detalhes que esses tipos de análises exigem; dificultando o acesso dos municípios, com níveis econômicos limitados, a esses tipos de técnicas. Para tanto, foi realizada uma análise multitemporal entre duas imagens Sentinel dos anos de 2015 e 2019, implementando-se a técnica de realce de imagens por grupo de pixels denominada filtragem espacial (filtro passa-altas) e o método de classificação supervisionado pelo algoritmo Mínimo. distância. Essas imagens foram obtidas junto ao USGS, tomando como área de estudo uma porção da periferia da comuna de Villa Hermosa, próxima ao povoado de Santa Elena, no sudeste da cidade de Medellín. Os resultados obtidos revelaram que a classificação obtida

pelas imagens filtradas levou a menos erros e um alto percentual de acerto na hora de gerar a classificação e, portanto, tornou-se uma fonte mais confiável para detectar e afirmar o conflito de uso de o solo presente na área de estudo.

PALAVRAS - CHAVE: Conflito de uso da terra, aprimoramento de imagem, sensoriamento remoto.

1 I INTRODUCTION

Land-use conflicts are a common problem in developing countries, as is the case of Latin American countries, because due to inefficient regulations, besides being irrelevant for the cadastral authorities, they facilitate informality in rural and especially urban settlements, causing not only a great problem in land use, not by the potential use it should have and the capacities to use it; but also serious social and environmental problems, such as invasion areas generating poverty and insecurity and desegregation of natural resources and land.

As a consequence, countless preventive public policies are implemented to detect, prevent, regularize and control informal settlements, which is one of the main causes of land-use conflicts. To this end, regularization programs are created to correct such irregularities; however, their solution often turns out to be stuck and impartial, showing purely legal solutions (titling). Despite the possible problems, they use registration and information detection tools that make it possible to fulfill the objectives of the regularization programs, sometimes resulting in cost.

Since this phenomenon of conflict of use can occur in any territory, not everyone has the financial resources to provide truthfulness of this phenomenon by traditional methods as they can become slow and costly (Liranza de la Cruz et al., 2013), which leads to the use of effective and economical alternatives for obtaining information, such as satellite images. Nevertheless, the use of images with high spatial resolution, which are the type of images required for these cases, is also very expensive (Macías, 2005). For this reason, it is necessary to implement new techniques and methodologies to take advantage of the information obtained from satellite images offered free of charge to the public.

Thus, this paper will try to show the effectiveness of a certain technique of digital processing of satellite images, to give an approximation at the time of detecting the conflict of land use. The technique implemented is called image enhancement by high-pass filtering; using Sentinel 2 images (A and B). For this purpose, first, a review of the literature on land use conflict was made, revealing some reference data in Colombia and showing some important descriptions that allow contextualizing the use of images with spatial filtering processing as a technical resource to detect possible land-use conflicts.

Then the effectiveness of the application of the high pass filter was checked by thematic evaluation; and finally, an analysis of the results of the filter classification obtained and contrast between the land classification in the *P.O.T. (Plan de Ordenamiento Territorial)* of Medellin, as an urban planning instrument and the result of the filtering obtained, was developed, to confirm the presence of land use conflict.

2 I LITERATURE REVIEW

Currently, land tenure informality is a relevant issue in Latin America, developing different problems in the urban, social, and cadastral context due to land use disputes caused by changes in land possession and usufruct. Referred to as land use conflict, it corresponds to the discrepancy between the uses made by the different land tenure actors and what should be the use of the land according to its environmental, ecological, cultural, social, and economic potential and limitations (IGAC, 2012).

This conflict generates serious problems such as invasion zones, known as favelas in countries such as Brazil and Argentina, for example. These are described as any type of settlement that is not registered by the state, is not legalized, nor do they have an owner recognized by the cadastral authorities. However, according to the Colombian norm, this phenomenon is understood as the human settlement of incomplete development (Decreto 0419 de 1999) and it is here, as in many Latin American or developing countries, where the norm gives room to facilitate the growth of land-use conflicts throughout its territory and convenience to informal actors to cover their irregular settlements to regular (pirate properties), covering up especially through the payment of taxes for their titling and future registration. This affirms how one of the social groups most willing to pay taxes is the irregular possessor who uses the tax as proof of possession, as a means of citizenship or even to demand services. (Erba, 2007)

But even though there are other types of problems of informality of cadastral order, such as irregular improvements of urban settlements or undesirable conurbations between municipalities; the vast majority of conflicts occur on urban and rural border boundaries, producing not only a change of land use and displacement of the former land tenure actors, but also a serious desegregation of natural resources. Due to this, the Colombian standard also defines through resolution 1415 of August 17, 2012, the possible categories of land use conflict, which can be presented in three main types: land without use conflict or adequate use, which are used according to their capacity and potential use; overutilization, which corresponds to land with a current use that exceeds its capacities, exploiting above the adequate land; and otherwise, underutilization, which is defined as the current use of land used inadequately and below the capacity of the potential use that they should have. Except optimal use, the other categories can be considered light, moderate or severe, depending on the level of conflict that may cause either land and natural resource degradation (overutilization) or serious social problems (underutilization).

In Colombia, thanks to a study carried out by a commission of several state entities led by the IGAC, it is known that by 2012 the territory presented 13% underutilized soils (15 million hectares), 16% overexploited soils (18 million hectares) and the remaining 67.6%

(76 million hectares) in soils with an adequate use (IGAC, 2012). Even though studies like that one has not been carried out again, where the inefficiency of land use (especially rural) is clear, it is known that the land use conflict continues to develop throughout the Colombian territory, where urban settlements expand in large conglomerates, being more notorious in large cities such as Bogota, Medellin and Cali; while rural settlements are displaced and located on soils that are not for the required use, causing irreparable damage or social problems.

To counteract the problem of conflict, different public prevention policies are implemented as a countermeasure to prevent, control and regularize irregular settlements, especially urban settlements, which are the ones that cause the most land use conflicts. As a result, regularization or improvement programs are defined which, although aimed at correcting the legal, environmental, social and technical problems inherent to irregular occupation, which in some cases are partially unfulfilled, the main objective of most of them is to deliver property titles (ERBA, 2007). The same author also affirms that regularization programs that are of term multifinal in-situ cadastre should contain information regarding the location of risk areas and the potential problems that may exist for human settlements in those locations. Once again, in these cases, the alternative that allows reducing costs and shortening inspection periods, and consequently increasing the efficiency of the process, is the use of satellite images.

In Latin America, a change has only just begun from the regulation programs of said informal settlements to public policies of prevention, which likewise of their opposite; It must present a cartography, information or geographic spatial input that allows to attend in real time or before a land use conflict is generated. That is why some countries like Colombia are already beginning to use satellite images for these policies.

"The images acquired for updating the territorial cadastre are also very useful in regularization programs, because with them you can clearly visualize the constructions through which the real occupation of the plot is manifested. High resolution images such as those generated by the sensors of the Quick Bird and Ikonos satellites, they are already being used for the monitoring of irregular occupations in some municipalities of Latin America, despite the fact that the cost is quite high, when compared with lower resolution images "(Erba, 2007).

However, despite the boom in the use of satellite images in policies on the territory; The techniques used for digital image processing (PDI) have not been taken into account for possible use in said policies, so the technical background is almost nil in the country and in Latin America. To better understand the usefulness of these techniques, the methodological part of the document will make a description of the context and process of the technique for the territorial problem in question.

3 I APPLIED REMOTE SENSING CONCEPTS

It is worth highlighting and mentioning some key remote sensing concepts that will be mentioned throughout the methodology. This is to contextualize the descriptions and techniques referred to in this article.

3.1 Remote sensing sensors

It is important to keep in mind, for any remote sensing work, the source of acquisition of the satellite images to be handled, that is to say, to be clear about the sensor that produced it. Coming from the Latin *sensus* "sense", it can be said that a sensor is a device sensitive to any physical effect of the environment, being the medium through which the information of the energy coming from the terrestrial surface is received and translated (Chuvieco, 1995).

Also, the sensors have certain characteristics that identify them, these are the types of resolutions with which they are designed. The term resolution refers to the sensor's ability to discriminate objects in an image. This "discrimination" means being able to distinguish, detect and/or differentiate objects from others. Thus, the ability to discriminate is relative, since it is possible to distinguish objects in different ways thanks to the characteristics of the image (Calle & Salvador, 2012). The various types of resolutions are:

- Spectral resolution: type of wavelengths that can be captured by the sensor.
- Radiometric resolution: the sensitivity of the sensor to capture the spectral radiance variations it receives.
- Spatial resolution: the smallest object that can be distinguished in the image.
- Temporal resolution: Periodicity with which the sensor can capture images of the same place.

Concerning the above, it is possible to define an image as the result of a set of several grids organized in the form of a mesh. These grids, cells, or pixels represent the minimum recognizable unit in an image where a single value is stored. This value is the record of the radiation (energy) reflected from each of the objects on the earth's surface, such value is called Digital Level. (ERDAS, Inc, 1999)

3.2 Satellite image enhancement

Image enhancement is a technique that improves the visual interpretability of an image, facilitating the discrimination of objects in the images. This technique does not mean that it adds additional information to the image (Julian et al., 2016). This affirms that the processing does not modify the geometric or radiometric properties of the image.

Likewise, this technique, according to (Aldalur, 2002), is divided into two types of operations: point processing (pixel by pixel) or by a group of pixels (neighborhood). This first operation is responsible for altering, using a mathematical algorithm, the gray levels of each pixel of the image, thus improving its contrast; on the other hand, the second operation alters the brightness levels of the pixel from 1) the brightness values of its neighbors and 2) the purpose sought, whether that of homogenizing or differentiating. The characteristic of the enhancement by groups of pixels (differentiate) can be stated by the author (Aldalur, 2002) as the objects that are present in the image that composes it has different brightness frequencies, and it is at the edge of the objects where these frequencies change abruptly; he also adds that these frequencies can be eliminated or accentuated, softening or highlighting by a process called spatial filtering.

3.3 Thematic classification of satellite images

Image classification consists of extracting classes of information from an image to create thematic information about a particular area. According to Willington & Nolasco, this classification is divided into two types:

Classification methods can be supervised and unsupervised; the former are procedures employed for the identification of spectrally similar areas (training samples) within an image, whereby the user preliminarily recognizes known regions of interest in the ground area, and the chosen algorithm extrapolates these spectral features for other regions of the image, thus performing the classification. Unsupervised classification aims to group cases by their relative spectral similarity, without field sampling. (Willington & Nolasco, 2013, pp 208)

3.4 Thematic reliability assessment

When there is thematic information in a map (or in this specific case information obtained from a classification process), the certainty and confidence of its content are subject to uncertainties, since this confidence depends on the inputs used for its elaboration. One way to evaluate these inputs is using an error or confusion matrix. This matrix, “allows confronting the information of the verification sites with that of the cartographic base to be evaluated” (Mas et al., 2012). To interpret the matrix, (Muñoz, 2016) states that two types of errors can be interpreted from it:

- Errors of commission: Elements that are in the class but do not belong to it.
- Errors of omission: Elements that are not in the class because they are contained in another class.

Similarly, two coefficients can be extracted from this matrix: overall accuracy and kappa. The former indicates the reason for the correct classification and the latter is an indicator that adjusts the value of the global precision, removing the effect of chance. (Mas et al., 2012)

4 I METHODOLOGY

4.1 Location of the study area and data collection

The study area was determined as a portion of the periphery between the Villa Hermosa commune and the Santa Elena district, in the southeast of the city of Medellín (see Figure 1); an area from which two satellite images were chosen for the multitemporal analysis process: a 2015 image from the Sentinel 2A satellite and a 2019 image from the Sentinel 2B satellite. These images were obtained from the United States Geological Survey (USGS) in its online platform Earth explorer.

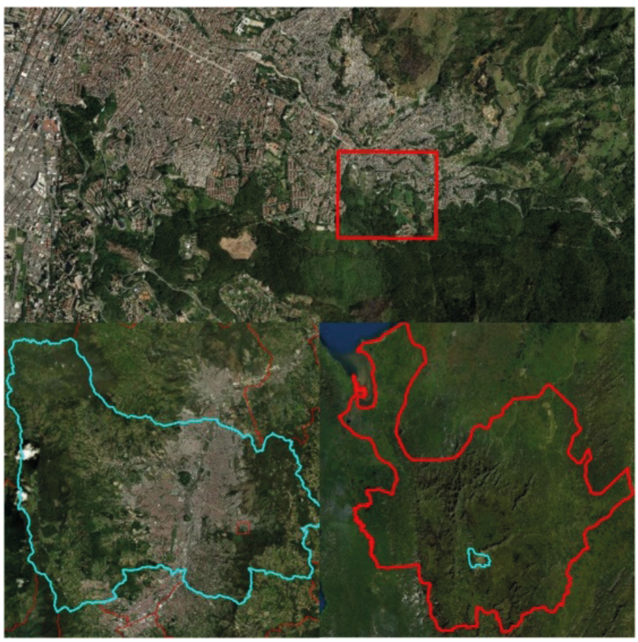


Illustration 1 Study area of the city of Medellín

Source: Google Earth

4.2 Satellite image processing

The ERDAS Image 2015 and ENVI version 5.3 software were used to process the satellite images. With the ERDAS software, the visible bands were concatenated: Band 4 in the Red canyon, Band 3 in the Green canyon, and Band 2 in the Blue canyon (both 2015 and 2019 images). This combination of bands was chosen since Sentinel 2A and 2B satellite has the highest spatial resolution (10 meters) with the visible bands; a resolution that will be important to better discriminate the objects. Subsequently, since the original image presents very heterogeneous information, which could cause a non-optimal classification, a reduced sub-scene is cropped so that the resulting image information is as homogeneous as possible.

Once the sub-scene was cropped with the combination of bands 4, 3, 2, the ENVI software was used to implement the actions of spatial filtering and thematic classification for both images. For the spatial filtering, the Convolutions and Morphology tool was used and the implemented filter was the high pass filter (whose Kernel is shown in Figure 2).

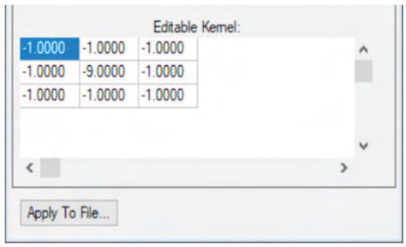


Illustration 2 High Pass Kernel

Source: ENVI Software

Finally, for the thematic classification process, it used the so-called supervised classification with the Minimum Distance algorithm; an algorithm that assigns each pixel to a certain class according to its minimum distance. The supervised classification requires the user to previously enter the “classes” or “clusters” which are those classifications by which the image will be finally categorized. The classes that were defined were: a) for the 2015 image: Bare Soil, High Vegetation, Grass, Urban Soil and Clouds; b) for the 2019 image: High Vegetation, Grass, High Urban Soil, Low Urban Soil.

4.3 Thematic analysis and evaluation of results

The thematic evaluation of the classification analysis process, the so-called error matrices of the ENVI software were used using the Matrix Error tool. In them, the general accuracies and their Kappa coefficients of the 2015 and 2019 images with filter and without filter were observed. This to contrast and evaluate how accurate was the level of agreement between the sample for the classification and its referent. Evaluation that will allow us to affirm if the application of the filter improves the thematic classification.

However, due to the lack of detail that these images offer, the Google Earth software is used to determine with greater clarity the possible coverages and/or objects that the area presents at a given time.

5 I ANALYSIS OF RESULTS

As result, 8 images were obtained: 2 true-color images of the area of interest, 2 as a result of the filters, 2 true color classifications, and 2 filter classifications.

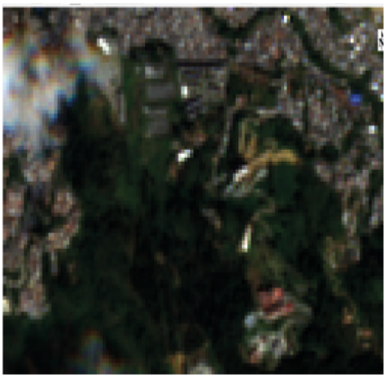


Illustration 3 2015 study area in true color.

Source: USGS

Illustration 4 True-color 2019 study area.

Source: USGS

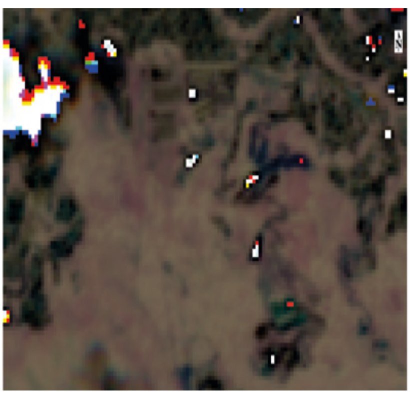


Illustration 5 2015 study area with high pass filter.

Source: Own elaboration

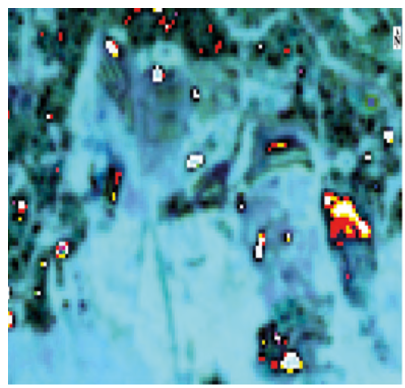


Illustration 6 2019 study area with the high pass filter.

Source: Own elaboration

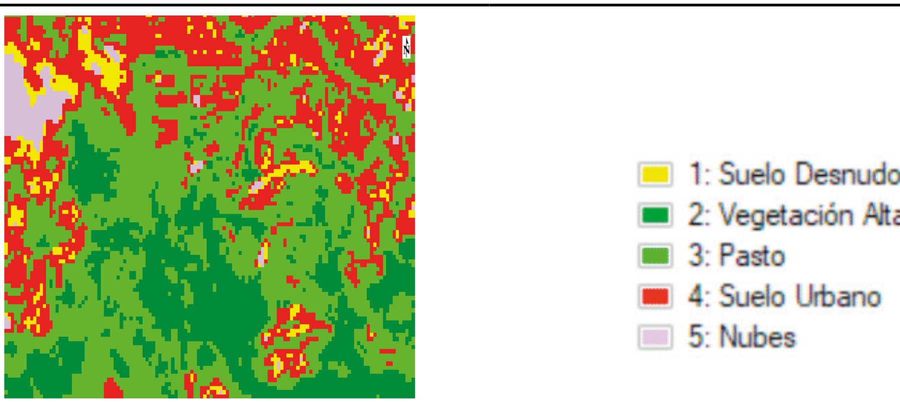


Illustration 7 Classification of the 2015 study area in true color.

Source: Own elaboration

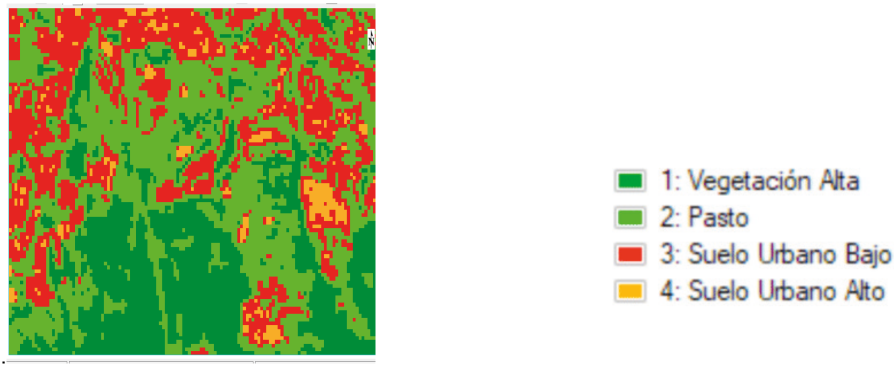


Illustration 8 Classification of the 2019 study area in true color

Source: Own elaboration

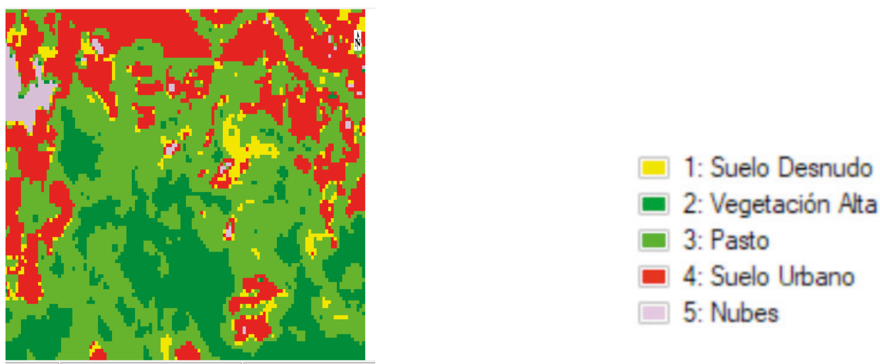


Illustration 9 Classification of the 2015 study area with the high pass filter.

Source: Own elaboration

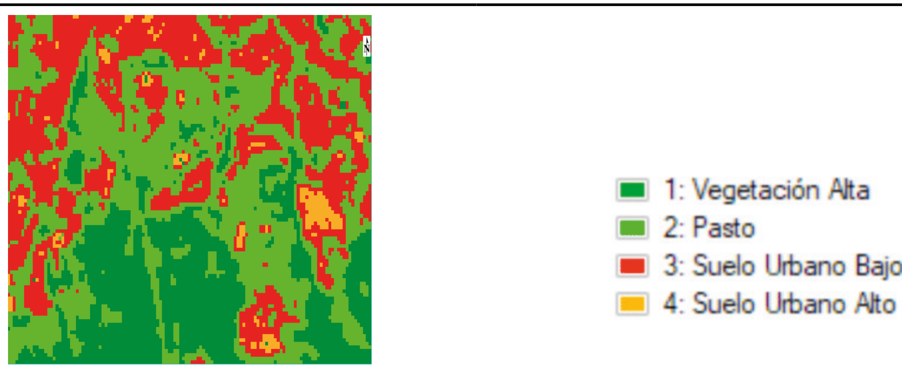


Illustration 10 Classification of the 2019 study area with the high pass filter.

Source: Own elaboration

As a first result, it is evident that in illustrations 3 and 4 of the year 2015, in the central right part the soil was merely low vegetation or grass, while in 2019 it becomes urban use. According to the recognition by Medellin geoportal, these new coverages are constructions of new houses and buildings.

Regarding the filters applied in illustrations 5 and 6, it is evident how the convolution operation with the high-pass kernel enhances the vegetation areas and leaves the urban areas opaque. Likewise, the brightness level is not the same in both, this is due to the time of image acquisition and the presence of cloudiness in the 2015 image.

Now, concerning the classification, before analyzing the results using the error matrices, it is worth mentioning that the same coverages were not used in the 2015 and 2019 images. This is because in the 2015 image the presence of clouds and bare soil can make the classification offered by ENVI not work effectively and not yield erroneous information, for this reason, it is necessary to have the largest possible number of predefined coverages. The same happens with the types of urban coverages present in the 2019 image. This is not a major obstacle since the objective is to contrast the urban area with the vegetation cover.

Therefore, we proceed to analyze the error matrices and coefficients to determine whether the filters improved the classification.

Concerning the classification of the 2015 image in true color and with the application of the high-pass filter, first of all, the classification in true color obtained an overall accuracy of approximately 92% and a kappa coefficient of 89%; likewise, the classification with the high-pass filter had an overall accuracy of 99% and a kappa coefficient of 98%. This means that the true color had a 92% correct classification of the coverslips and an 89% correct classification of the coverslips and an 89% correct classification with the random factor removed; on the other hand, with the filter, a 99% correct classification of the coverslips and a 98% correct classification with the random factor removed was achieved. In these two contrasts, although in both cases the results were very good, the fact of having implemented the high pass filter improved substantially in reducing the occurrence of randomness, obtaining a correct classification of almost 100%.

Classes	Producer's percentage of accuracy	Commission error	Percentage of user accuracy	Error of omission
Suelo desnudo	57%	43%	80%	20%
Vegetación Alta	100%	0%	100%	0%
Pasto	100%	0%	88%	12%
Zona urbana	94%	6%	88%	12%
Nubes	100%	0%	100%	0%

Table 1 Error matrix of the 2015 true-color image

Source: Own elaboration

Classes	Producer's percentage of accuracy	Commission error	Percentage of user accuracy	Error of omission
Suelo desnudo	90%	10%	100%	0%
Vegetación alta	100%	0%	100%	0%
Pasto	100%	0%	94%	6%
Zona urbana	100%	0%	98%	2%
Nubes	100%	0%	100%	0%

Table 2 Error matrix of the 2015 high pass filter image

Source: Own elaboration

Similarly, analyzing the error matrices in Tables 1 and 2, the most notorious result has to do with the Bare Soil coverage. The 2015 image, presents a commission error of 43% and an omission error of 20%. This means that, in the true color classification, 43% of the pixels that belong to this coverage are not because they are confused with another coverage, and 20% of the pixels that appear in the coverage do not belong to the coverage. On the other hand, the classification with the filter only obtained a 10% commission error and a zero-omission error. Therefore, this is evidence of a substantial improvement in classification thanks to the implementation of the high-pass filter.

Classes	Producer's percentage of accuracy	Commission error	Percentage of user accuracy	Error of omission
Vegetación alta	100%	0%	100%	0%
Pasto	100%	0%	100%	0%
Zona urbana baja	100%	0%	93%	7%
Zona urbana alta	86%	14%	100%	0%

Table 3 Error matrix of the 2019 true-color image.

Source: Own elaboration

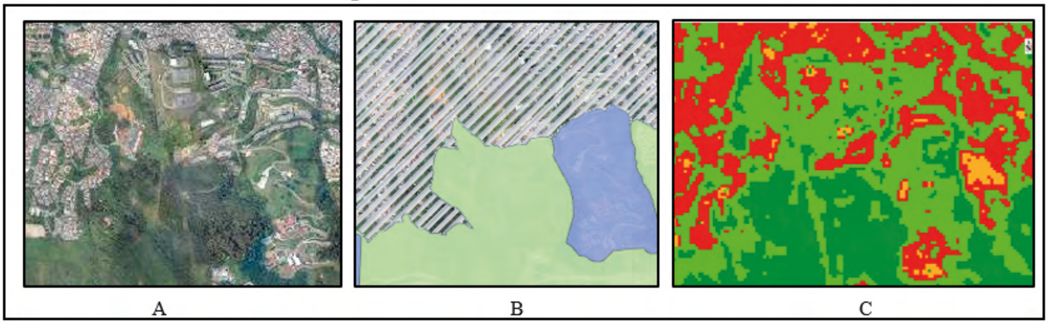
Classes	Producer's percentage of accuracy	Commission error	Percentage of user accuracy	Error of omission
Vegetación alta	100%	0%	100%	0%
Pasto	100%	0%	100%	0%
Zona urbana baja	100%	0%	95%	5%
Zona urbana alta	90%	10%	100%	0%

Table 4 Error matrix of the 2019 image with high pass filter.

Source: Own elaboration

On the other hand, the results obtained concerning the classification of the image to 2019 in true color and with the application of the high-pass filter, first of all, the classification in true color obtained an overall accuracy of approximately 97% and a kappa coefficient of 96%; likewise, the classification with the high-pass filter had an overall accuracy of 97% and a kappa coefficient of 98%. This means that the true color had a 97% correct classification of the coverages and a 96% correct classification of the coverages without the random factor; on the other hand, with the filter, we obtained a 98% correct classification of the coverages and a 97% correct classification of the coverages without the random factor. These results, and if we add the results of the confusion matrices in tables 3 and 4, are practically the same, their variation is minimal, but, even so, it still affirms that the classification with filter increases more the rates of correct classification and decreases the errors of commission and omission.

Thanks to these results it is possible to make a first visual comparison between the results obtained with spatial filtering and the normative classification of land use in the POT of the municipality of Medellin.



Comparison A) Study area, Medellín mayor's office geographic viewer B) Soil classification according to POT, Medellín mayor's office geographic viewer C) High pass filter.

Source: Own elaboration

As can be seen, between illustration 11-B of the classification of Medellin's POT being the representation of strips (urban land), green (rural land), and blue (rural land, areas for the location of equipment), and illustration 11-C the result of the high pass filtering of the satellite image year 2019; it can be differentiated that there are changes in the rural land confirming a possible conflict of land use in the category of medium and light overused land.

6 I CONCLUSIONS

When implementing the use of satellite images to solve territorial issues, such as land-use conflicts, it is necessary to have good detail to differentiate the changes, the costs involved in this implementation can be very high and not very fruitful for a municipality or entity with limited resources. Now, there are entities such as the USGS that offer free satellite images to the public, taken recently and in the past; and although they do not have sufficient spatial resolution, the image enhancement processes and the various remote sensing techniques allow to treat this raw information and process it to improve the visual interpretation. As a result, the application of these techniques makes it possible to estimate an approximation of possible changes in land use to determine possible conflicts and provide greater veracity at the time of decision making, thus becoming an economical and effective alternative for those municipalities and/or entities that do not have sufficient economic capacity to acquire more detailed data.

Finally, and in a complementary manner, it is worth making the last comparison between the 2015 and 2019 images with the implementation of the filter. Although the results of the coefficients and error matrices in the 2019 classifications were not so different, those of 2015 were. Looking at Figures 3 and 4, which are only the true color representation, it is evident that the 2015 image is overshadowed by the presence of cloud cover, causing the classification algorithm to not operate in the same way. However, the application of the filter could solve this natural implication, thus obtaining coefficients close to 100%, being this a possible solution to various natural phenomena presented by satellite images affecting the results of digital image processing.

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ÍNDICE REMISSIVO

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