Change Detection Analysis Using Radar Images in the Quito River, Colombia

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Abstract.

The SAR Technology exists many years ago but, usually it is not the first option when remote sensing images are needed for monitoring deforestation and other phenomenon. The weather conditions in some regions where almost always there are clouds make of the SAR technology the main ally.

This project explores the use of SAR data to calculate the footprint of the illegal gold mining in the Quito River. It will stablish a timeframe in order to choose the beginning and ending of analysis.

This paper provides a simply but powerful approach for detecting deforested areas on the side of Quito River as a result of illegal mining, so the proposed methodology is applied to images from different years which allows user to do a change detection analysis.

The basis for this project come from methodologies proven in other cited projects and researches. The results obtained for this project allows to think in radar images no just as a second option for usual activities like image classification. At the end there will be a vector product which enable to the users to discriminate and measure illegal mining area affected.

Keywords. *Change detection, radar, illegal mining, deforestation*

1 Introduction

The Quito River was transformed by illegal gold mining, it is one of the main tributaries of the Chóco, Department of Colombia in the Pacific Region, currently the river bears the scars of illegal activity. The Interest area is focus on specific section of the river of approximately 33 kilometers. Chóco is the Colombia's department with the highest rate of precipitation between 9000 mm and 11000 mm per year, then the sky almost always has clouds.

The local communities have been used the river as source of water for their lives but also as a source of income extracting gold from the river bed using ancestral methods. However, at the end of 2010 criminal groups started to affect the ecosystem extracting gold using machinery.

According to (Ballère et al. 2021) SAR Images have a great potential in tropical areas in order to monitor issues in the forest land cover but SAR technology has been used few times compared with optical images. Several researches have been done in that field of study.

SAR technology increase the accuracy in the mapping of forest disturbances as (Hirschmugl et al. 2020) concludes in their paper where they combine optical and SAR images. The climate and meteorological conditions also few access routes of the region do not offer enough opportunities to capture optical images even aerial images or drone images.This project will take advantage of the SAR features and will perform a change detection analysis in order to determine how much has been affected in the ecosystem on the river banks.

Nowadays even exists some approaches of using many types of software and algorithms for monitoring different phenomena using SAR technology as is showed in (Canty et al. 2020)

The main objective is to calculate how much area of natural land cover (forest, water bodies, etc) has been affected by the illegal gold mining; using only radar images, it will possible to get a reliable result of the situation in the Quito River is the hypothesis of this project. A timeframe was established with initial date in the past around 2010 and a final date on nowadays (2020) and also some intermediate intervals in order to show if the proposed workflow adjusts and performs well in different years.

2 Methodology

The methodology includes three main stages, pre-processing where the radar images are clipped to the Are of Interest (AOI) and an intermediate product is created, right after the image classification process is run where the classified image is obtained and lastly the post-processing is performed, there some GIS tools clean and filter what is considered the footprint in the Quito River due to the illegal mining. Figure 1 depicts an overview of the methodology.

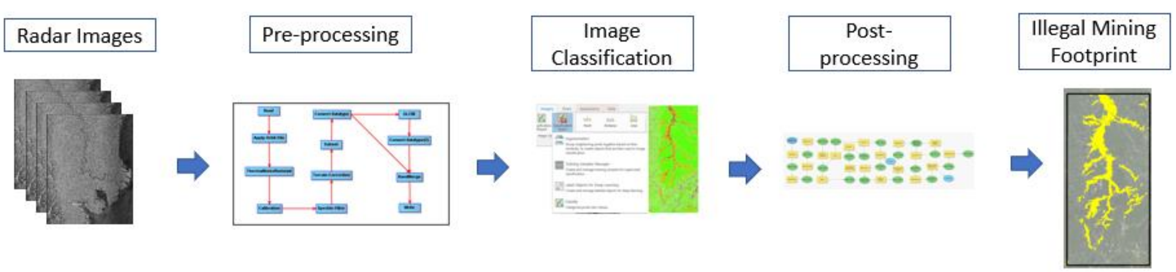

Figure 1. Methodology Scheme

The Area of interest is located in the Pacific region in Colombia, the coordinates that illustrate the rectangle used as AOI has the following coordinates: upper left corner 76°49’27” W 5° 28’ 26” N and bottom right corner 76° 37’ 26’’ W

5° 3’ 43” N. The data downloaded for this project were 4 sentinel-1 images (years: 2014,2016,2018,2020) and 1 ERS-2 image (year: 2010).

2.1 Pre-processing

This stage performs several tools where radar images are calibrated and clipped, it makes possible to compare images from different dates and sensors and suitable to the purposes of this analysis. The workflow include 10 steps for this stage.

2.2 Image Classification

For image classification it was performed a supervised method using Support vector Machine (SVM) algorithm, this type was selected because it allows to have good results based on unbalanced training set, which is the case of this study where the dominant class is forest (different types of forest) and the other classes have less occurrences in the image.
Each classification process was based on an image with 5 bands where the band 1 is the texture image of contrast, band 2 is the texture image of homogeneity, band 3 is the texture image of Mean, band 4 is texture image of Variance and band 5 is the calibrated band (radiometric corrected range) on VV polarization.

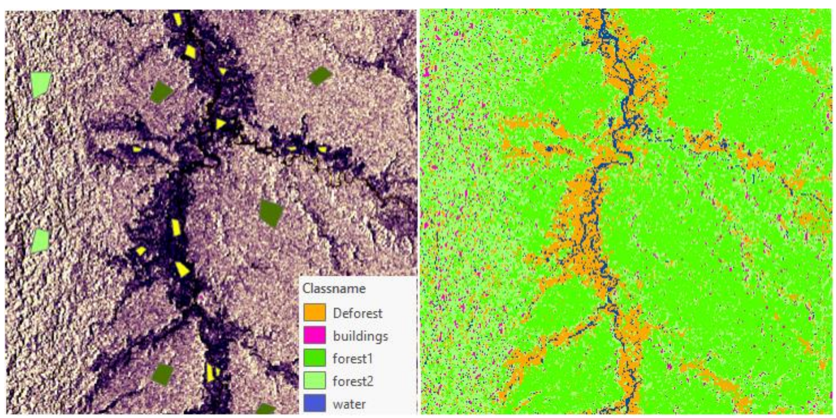

Figure 2. On the left samples for image classification, on the right classified image for 2020

2.3 Post-Processing

The workflow for the post-processing stage includes to remove small regions and individual misclassified pixels and later create a vector file which contains the footprint of illegal mining for each image, the stage includes 20 steps.

3 Results

For validation results, it was performed a visual interpretation of the illegal mining using two Landsat 8 images which have a close date to the radar image, the “Table 1” shows the accuracy percentage of identifying the illegal mining in the Quito River for the last year of the analysis (2020).

Table 1: Percentage Accuracy and Validation total Areas for 2020

Item	**Area (ha)**
Validation 2020 - Using visual interpretation	11108
Footprint 2020 - using workflow radar images	10705
Intersection between validation and calculated footprint	10673
Overall Accuracy in percentage	96,08

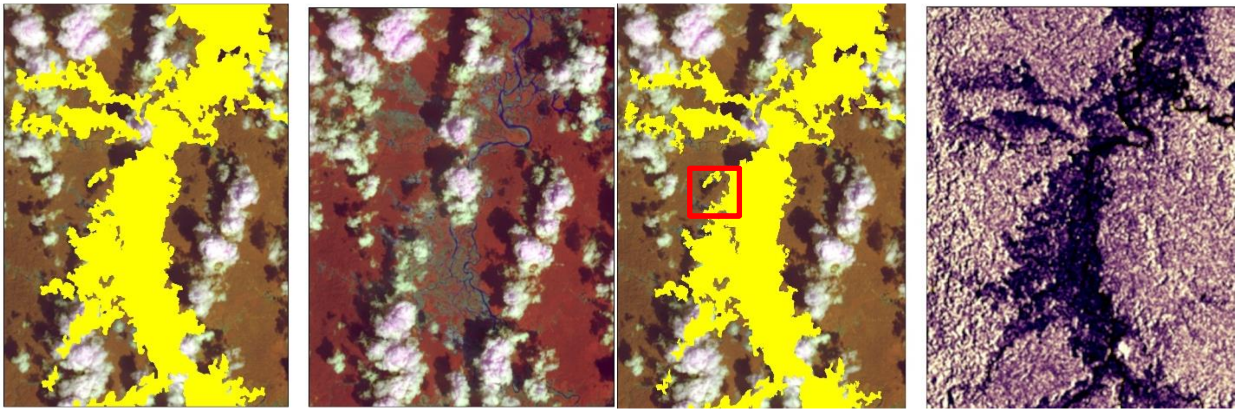

Figure 3. On the left visual interpretation based on Landsat 8 , On the right result based on methodology on sentinel-1

Figure 3 depicts some small difference between the visual interpretation and the result obtained using the methodology proposed in this paper.

As a secondary results, it was obtained the change in each analysis period and how much area around the Quito River was affected by illegal mining. Table 3 shows the problem was very critical at the beginning of the analysis period, between 2010 and 2014

Table 2: Changes between periods of analysis

Period	Illegal Mining Footprint size (ha)	Forest cover loss (ha)
From 2018/10/06 to 2020/08/20	10705	119
From 2016/10/16 to 2018/10/06	10586	1620
From 2014/10/27 to 2016/10/27	8966	2929
From 2010/01/29 to 2014/10/27	6037	5257
Initial date 2010/01/29	0	

From “Table 2” we can infer the rate per day of forest cover loss during the whole analysis period was almost 3 Ha. i.e., three football soccer fields daily.

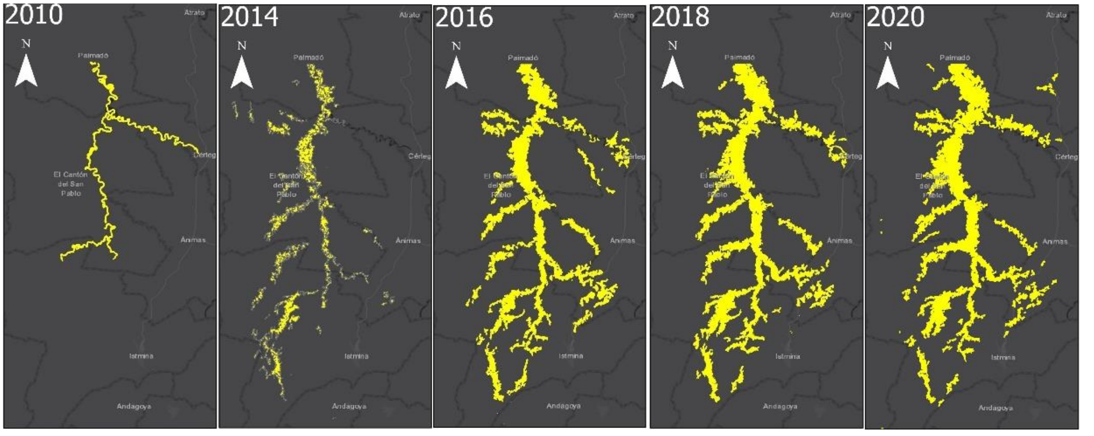

Figure 4. Change Detection Analysis for illegal gold mining in the Quito River, Chóco- Colombia.

4 Discussion

The results presented in section 3 showed that SAR technology allows to have reliable products about the deforestation caused by illegal mining activity on the sides of Quito River. In regions with few anthropic activities like the Quito River where the dominant cover on the surface is tropical natural forest, radar images provide opportunities to monitor the ecosystems with out worries for the weather conditions.

While to choose radar images for the purpose of this project was straightforward, when we chose optical images for validation was very difficult to find images in the same year that allows to see the Quito River path.

In a product environment of a monitoring system of this phenomenon would imply you need to include tasks for mask clouds and tasks for combine pixels from different dates, if the purpose is to have a clear view of the phenomenon using optical images.

The validation result was only for 2020 year but, the results for the other periods were also good despite they were not measured quantitively, they were assessed visually against the experience as image interpreter; in all cases at least for purposes of indicating the location where the deforestation is happening, the result is useful.

5 Conclusions

Apart from some limitations in the project, the general objective was achieved, more than 10.000 Ha of tropical natural forest have been destroyed in the surrounding areas of the Quito River, with many serious consequences such as the river pollution due to the chemicals substances for obtaining the gold mineral.

Part of the limitations was not to find free radar images between the period 2010 and 2014, so it was not possible to see the moment the phenomenon spread out and which was the zone where it began. Another limitation of the project was the supervised classification, for each period was necessary to take training samples, so each classification was performed individually.

In future research several paths can be carry out, one of them could be focused on automation where each time a new image is available the workflow will run and the user will get a new vector layer with the deforestation.

Other approaches could be monitor not only deforestation also the rate of recovery in those ecosystems, or how behaves the workflow in presence of other land covers, or use part of this approach to perform a complete land use classification.

Finally, with this project it is expected to promote the use of SAR technology for applications where usually the first thought is related to the optical images. Most of the references of this paper showed that results obtained from radar images are no far from the results using optical images.

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