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Experience in MAPATÓN 2021: "ApuMayu" a Tool for the Analysis of Flood Risk Zones in Piura

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***Abstract*—MAPATÓN 2021 was organized by CONIDA (Peruvian Space Agency) as part of the celebrations for the bicentennial of Peru's independence. MAPATÓN was oriented to disaster management. This work aims to transmit the experience of participation in MAPATON and communicate the results achieved. The authors participated in developing flood simulation models and analyzing SENTINEL-1 satellite images to identify areas affected by floods that occurred in 2017, 2019 and 2020. The results obtained, shown in a story map, show the great utility of this type of analysis for risk management and disaster management.**

***Keywords*—MAPATON 2021; natural disasters; Peru; disaster management; Sentinel; satellite images**

I. INTRODUCTION

This 2021, Peru celebrates 200 years of independence. Within the framework of celebrations for this bicentennial, the Peruvian Space Agency (CONIDA), together with the Ministry of Housing, Construction and Sanitation, the National Institute of Civil Defense (INDECI), the National Center for Estimation, Prevention and Reduction of the Disasters Risk (CENEPRED), the Pontificia Universidad Catolica del Peru (PUCP) and AmeriGEO, organize MAPATÓN 2021 [1]. This MAPATON is titled “Unidos en las Observaciones para la Gestión Comunitaria del Riesgo de Desastre”. The main idea of the MAPATON is to collectively propose different solution proposals that help Disaster Risk Management (DRM).

Peru is a country that suffers from different disasters such as earthquakes (mainly due to the Nazca tectonic plates), landslides, floods (mainly due to El Niño and La Niña phenomena), forest fires, oil spills, among others [2].

El Nino, La Nina and El Niño Costero produce heavy rains with which the level of the rivers increases; the lands are soaked; landslides, known as "huaycos", occur; the rivers rise in level and flow, causing floods.

One of the cities most affected by this type of disaster is the city of Piura [3].

Different studies and reports have been made regarding the risks, dangerousness, susceptibility and vulnerability to floods in the Piura region [4-7].

Likewise, different disaster risk prevention and reduction plans such as those presented in [8-10] have been proposed.

In disaster management, modelling and simulation are critical. Using tools such as HEC-RAS, data from meteorological services and digital elevation models, risk areas can be assessed [11,12].

The satellite images give us a global vision from space on the area affected by the disaster. An analysis of satellite images allows us to identify the most affected areas, the aid to carry and the roads or routes to deliver said aid. This type of analysis can help better decision making. Some examples of this type of analysis can be seen in the papers presented in [13-15].

Entering into a collaboration between colleagues from the Image Processing Research Laboratory (INTI-Lab) of the Universidad de Ciencias y Humanidades and the company Business on Engineering and Technology S.A.C. (BE Tech) decided to participate in MAPATON 2021 by forming the INTI-Tech team. The objective of the participation was to contribute from 3 technical aspects, mapping buildings in Openstreetmap, simulating floods with HEC-RAS, and analyzing areas affected by floods using SENTINEL-1 satellite images. All of this being shown through a StoryMap.

This work continues as follows; Section 2 will show the methodology followed in developing the different contributions to MAPATON 2021. Section 3 presents the obtained results. Finally, Section 4 shows an analysis of the results through a broad discussion.

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II. METHODOLOGY

The methodology followed in this work is framed in different actions that are described below:

A. Selection of the study area

The selected area is the district of Piura, as it is one of the areas most affected by floods in Peru. The district of Piura is the capital of the Piura region in northern Peru; it has an area of 621.2 km² and a population of approximately 484,475 inhabitants. In Figure 1, one can see the delimitation of the area under analysis.

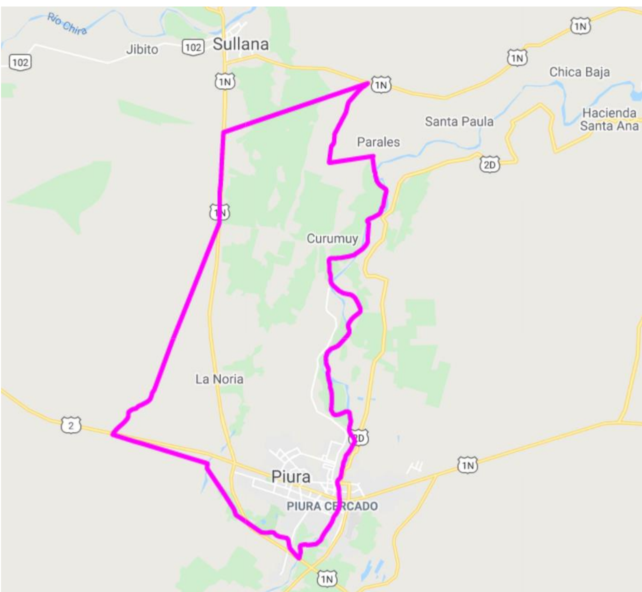


Fig. 1 Selected study area, Piura district.

B. Data collection

In the present work, one has two processes: the modelling and simulation of floods and, on the other hand, the processing and analysis of satellite images to identify affected areas.

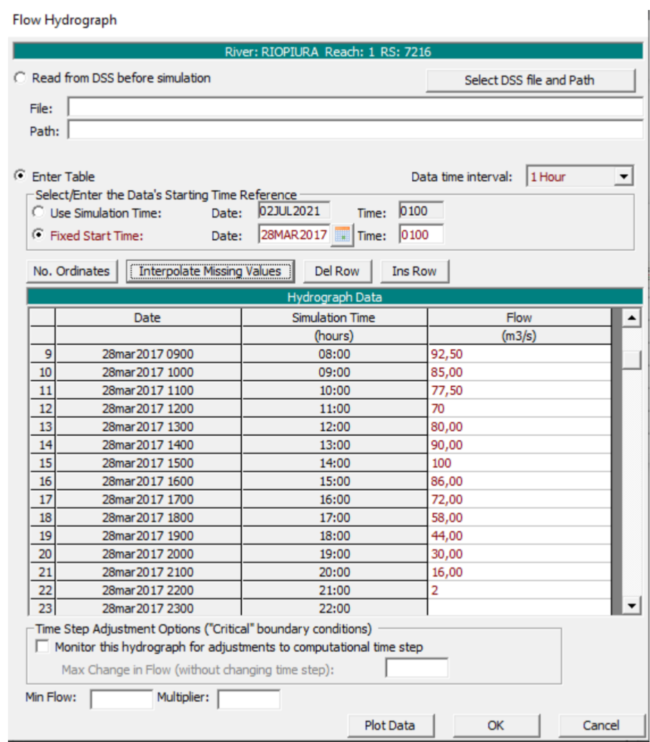
For the modelling and simulation of floods, information related to the historical record of rainfall is required, obtained from the National Service of Meteorology and Hydrology of Peru (SENAMHI). Likewise, digital elevation models of the area under analysis are required. These data can be obtained from SRTM DATA (Shuttle Radar Topography Mission), a NASA mission with a resolution of 90 m in some cases and 30 m in other cases.

Finally, information on the urban layout and vital infrastructure are needed; this information can be mapped and found on the free access platform Open Street Map.

For identifying affected areas from satellite images, radar images from the SENTINEL-1 satellite, which is part of the European constellation Copernicus, were used. One can download these images by accessing the Copernicus Open Access Hub (https://scihub.copernicus.eu). The idea is to download images before and after a flood event to compare and analyze differences. The collected images correspond to the SENTINEL-1 satellite in medium precision image mode (IMM) with a pixel size of 10m and with vertical-vertical polarization (VV), corresponding to the dates April 12, 2016, March 20, 2017, August 9, 2018, March 25, 2019, August 10, 2020, and March 26, 2021.

C. Simulation

For the simulation, the HEC-RAS (Hydrologic Engineer Center - River Analysis Simulation) tool will be used. For this task, one needs the hydrographic data (Figure 2) and the sediments with cross-section data (Figure 3).


Flow Hydrograph
River: RIOPIURA Reach: 1 RS: 7216
Read from DSS before simulation
Select DSS file and Path
File:
Path:
Enter Table
Data time interval: 1 Hour
Select/Enter the Data's Starting Time Reference
Use Simulation Time: Date: 02JUL2021 Time: 0100
Fixed Start Time: Date: 28MAR2017 Time: 0100
No. Ordinates | Interpolate Missing Values | Del Row | Ins Row
Hydrograph Data

	Date	Simulation Time (hours)	Flow (m3/s)
9	28mar2017 0900	08:00	92,50
10	28mar2017 1000	09:00	85,00
11	28mar2017 1100	10:00	77,50
12	28mar2017 1200	11:00	70
13	28mar2017 1300	12:00	80,00
14	28mar2017 1400	13:00	90,00
15	28mar2017 1500	14:00	100
16	28mar2017 1600	15:00	86,00
17	28mar2017 1700	16:00	72,00
18	28mar2017 1800	17:00	58,00
19	28mar2017 1900	18:00	44,00
20	28mar2017 2000	19:00	30,00
21	28mar2017 2100	20:00	16,00
22	28mar2017 2200	21:00	2
23	28mar2017 2300	22:00	

Time Step Adjustment Options ("Critical" boundary conditions)
Monitor this hydrograph for adjustments to computational time step
Max Change in Flow (without changing time step):
Min Flow: Multiplier:
Plot Data | OK | Cancel

Fig. 2 Piura hydrographic flow data.

EXPLORING RESEARCH AND INNOVATIONS

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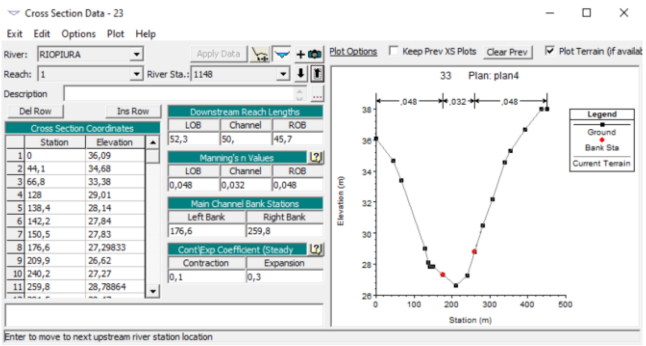

Fig. 3 Cross-section data of the Piura river.

Once both data have been loaded in HEC-RAS, the Digital Elevation Model of the Piura district, which is the selected study area, must also be loaded.

D. Satellite image processing

The pre-processing of satellite images follows five steps. First, one reads the image; then one applies a radiometric calibration [16 - 18], it is also necessary to apply a speckle filter [19, 20], it is necessary to apply a terrain correction [21]; finally, one saves the result as a new picture. The different stages of the used methodology can be visualized in Figure 4.

Fig. 4 Block diagram of the pre-processing of satellite images for the identification of areas affected by floods.

For the processing of the corrected image, the image histogram must be analyzed to observe the distribution of the backscatter values in the scene. The SNAP toolbox from the European Space Agency (ESA) was used for this task, specifically the histogram tool.

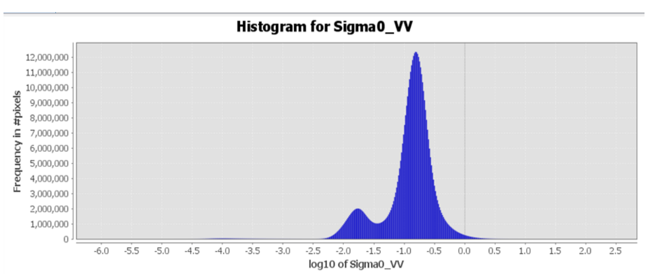

Fig. 5 Histogram of the corrected image

In Figure 5, it can be seen that the histogram shows two peaks, one representing the water present in the scene and the other representing the earth's surface. By examining the pixel values, the threshold for the differentiation between water and land can be found. This information will be used to create the delimitation and mask of the flood in the study area.

III. Results

The results obtained from the participation in MAPATON 2021 can be divided into four different aspects.

One of the results obtained is the nearly 6800 buildings mapped using the Open Street Map platform, as shown in Figure 6. With this number of mapped buildings, our INTI-Tech team occupies second place in the table.

On the other hand, one has the results of the simulation using HEC-RAS. A part of the results can be seen in Figure 7.

Another essential result to show is the satellite images processed with the affected areas identified. The results can be seen in Figures 8, 9 and 10.

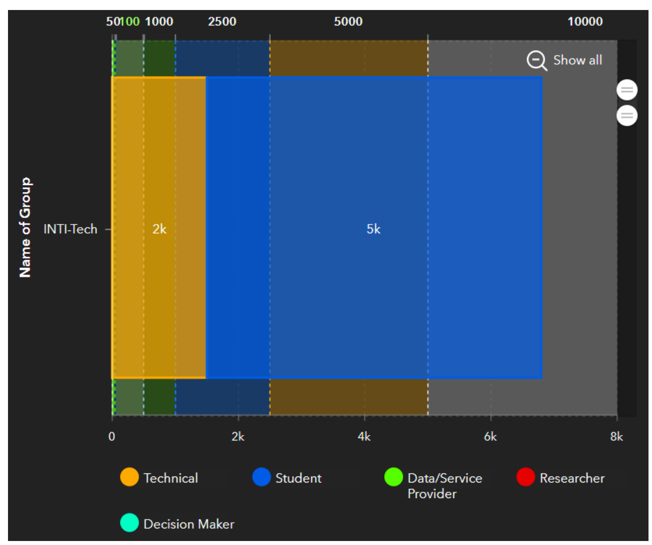

Fig. 6 Number of elements mapped by the INTI-Tech team in MAPATON 2021.

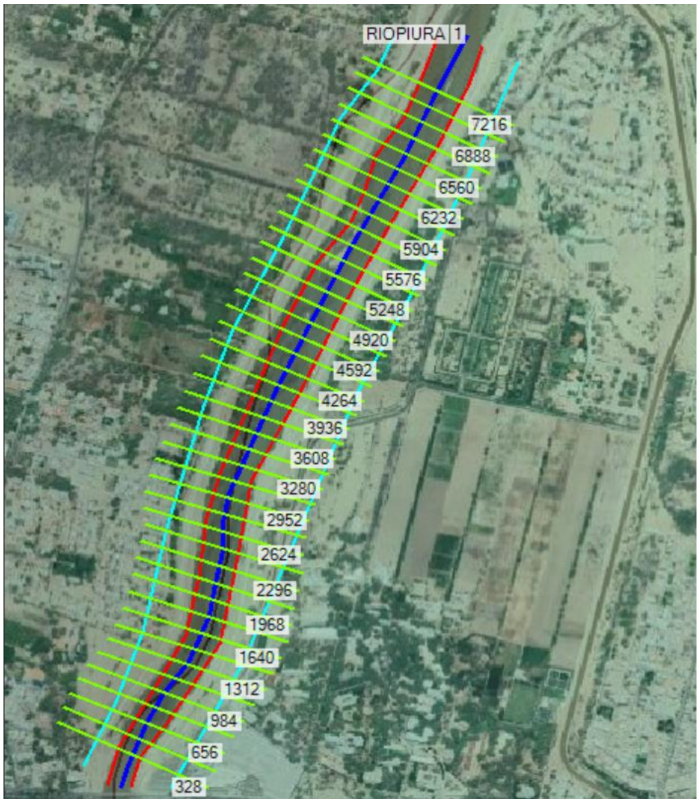

Fig. 7 Flood simulation with HEC-RAS.

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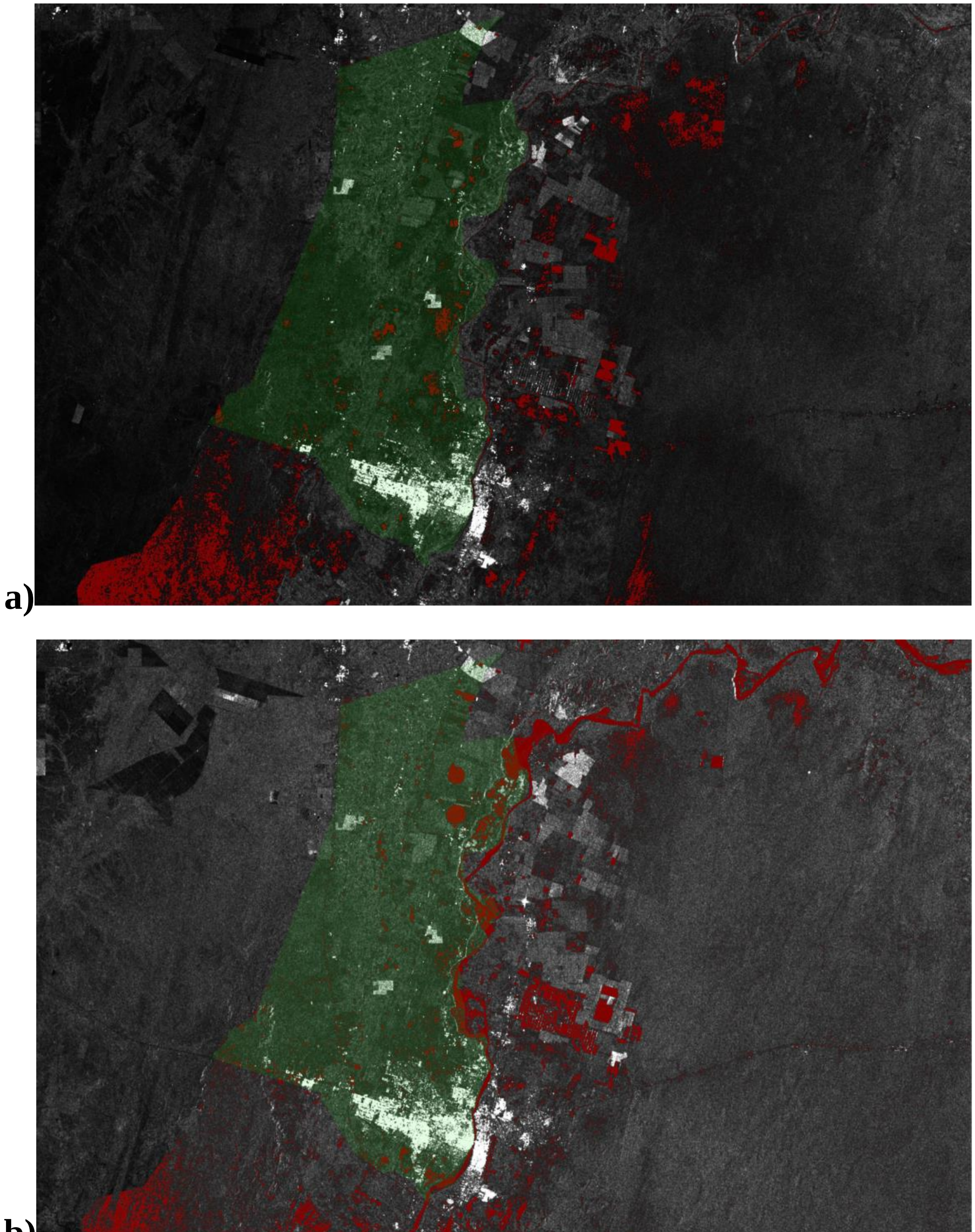

Fig.8 Before and after the floods in Piura in March 2017. a) Image from August 2016, b) Image from March 2017.

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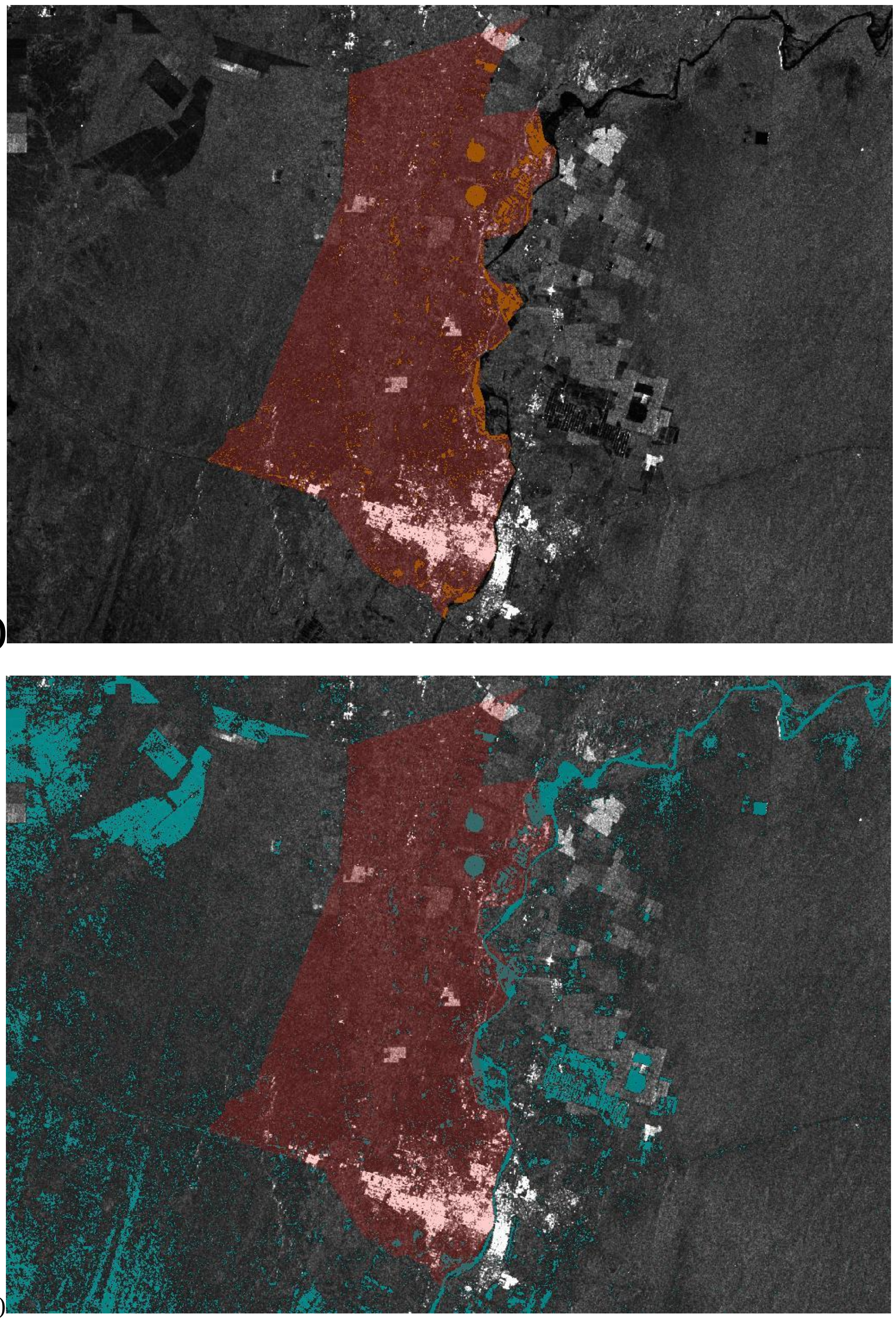

a)

b)

Fig.9 Before and after the floods in Piura in March 2019. a) Image from August 2018, b) Image from March 2019.

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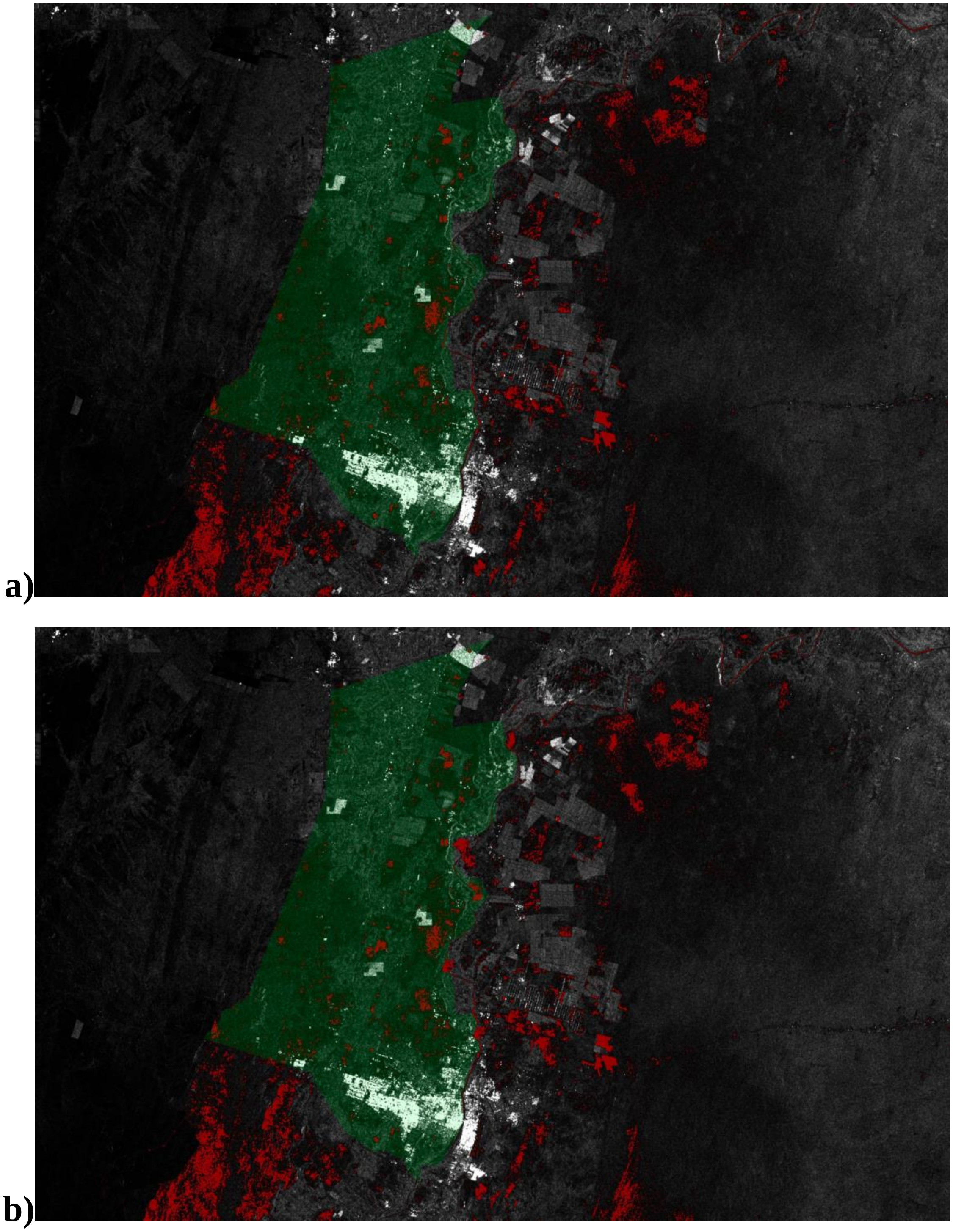

Fig.10 Before and after the floods in Piura in March 2021. a) Image from August 2020, b) Image from March 2021

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Finally, everything developed by the INTI-Tech team during MAPATON 2021 can be seen in the following StoryMap: https://storymaps.arcgis.com/stories/f4ed89c5da36497e8f92832f962771c4

Fig. 11 StoryMap with the results of the INTI-Tech team at MAPATON 2021.

Fig. 12 Number of elements mapped per team in MAPATON 2021.

IV. Discussion And Conclusion

MAPATON 2021 registers 601 participants grouped into 94 teams, and approximately 55,037 buildings have been mapped. Being in second place out of a total of 94 groups is an outstanding achievement for the INTI-Tech team (Figure 12).

The use of satellite images to analyze and identify areas affected by disasters allows us to have a global vision of the situation and make better post-disaster management, helping us to make better decisions, identify the most affected areas, define the type of aid to carry and where to transport such aid.

The importance of recognizing the affected areas in the Piura region contrasts with the more than 4500 homes built with vulnerable materials [22] such as wood, Quincha, plywood, or even stone and clay.

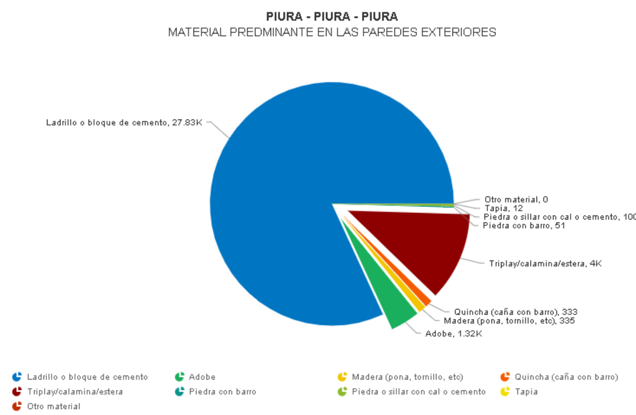

Fig. 13 Statistical analysis of housing material in the study area.

Acknowledgment

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