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CLIMATE ACTIONS AND JUST TRANSITION: SECOND INTERNATIONAL CONFERENCE

Critical remote sensing to track unleakable carbon: using satellite imagery to track post-ban gas flaring activities in the Ecuadorian Amazon

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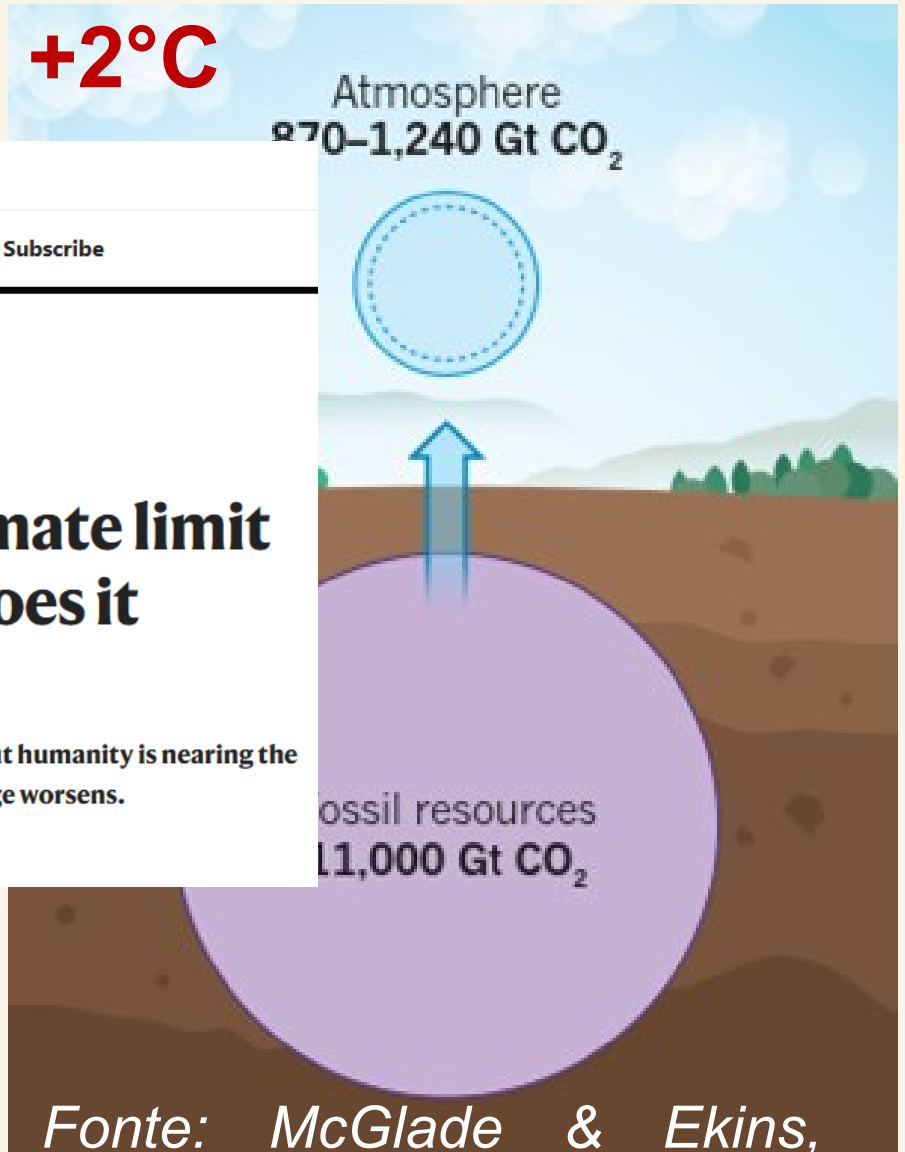
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NEWS | 10 January 2025

Earth breaches 1.5 °C climate limit for the first time: what does it mean?

The threshold has been exceeded for only one year so far, but humanity is nearing the end of what many thought was a 'safe zone' as climate change worsens.

By Jeff Tollefson



Fonte: *McGlade & Ekins, 2015*

Unleakable carbon

Unleakable Carbon refers to the *uncombusted carbon-based gases that are also associated with the extraction, distribution, and consumption of fossil fuel reserves, otherwise referred to as ‘fugitive’, ‘leaked’, ‘vented’, ‘flared’, or ‘unintended’ emissions.*

Table 1. Given best- and worst-case CH₄ leakage and GWP scenarios we demonstrate that unless unleakable carbon is curtailed, up to 80–100% of our global natural gas reserves must remain underground if we hope to limit warming to 2°C from 2010 to 2050

GWP	Time horizon (years)	1.8% Leakage rate	5.4% Leakage rate
		Low	High
34	100	80%	139%
86	20	127%	280%

Notes: When low and high CH₄ leakage rates (Brandt et al., 2014) are applied to the combustion emissions associated with the utilizable portion of our remaining natural gas reserves, estimated to be 50% if we aim to meet a warming target of 2°C from 2010 to 2050 (McGlade & Ekins, 2015), we find that the warming contribution of unleakable carbon is large enough to enhance CO₂e between 30% and 230% over best- and worst-case leakage and GWP scenarios, respectively. Here combustion emissions are converted to CO₂e to reflect uncombusted CH₄ using the most recent GWP data published for 20- and 100-year time horizons (IPCC, 2013). Stakeholders may need to prepare to leave 80% of remaining global natural gas reserves untouched in a best-case scenario, and all reserves untouched in a worst-case scenario where even current, ongoing CH₄ leakage may present a challenge to limiting warming to 2°C from 2010 to 2050. See Supplementary Materials for details.

Climate justice

YAKU MAMA FLOATING CLIMATE ACTION CARAVAN TO COP30

We are sailing from the Andes to the Amazon, heading to COP30 in Belém. This is our call for true climate justice, led by those of us who inhabit the territories.



Gas flaring: “mecheros”

Global impacts

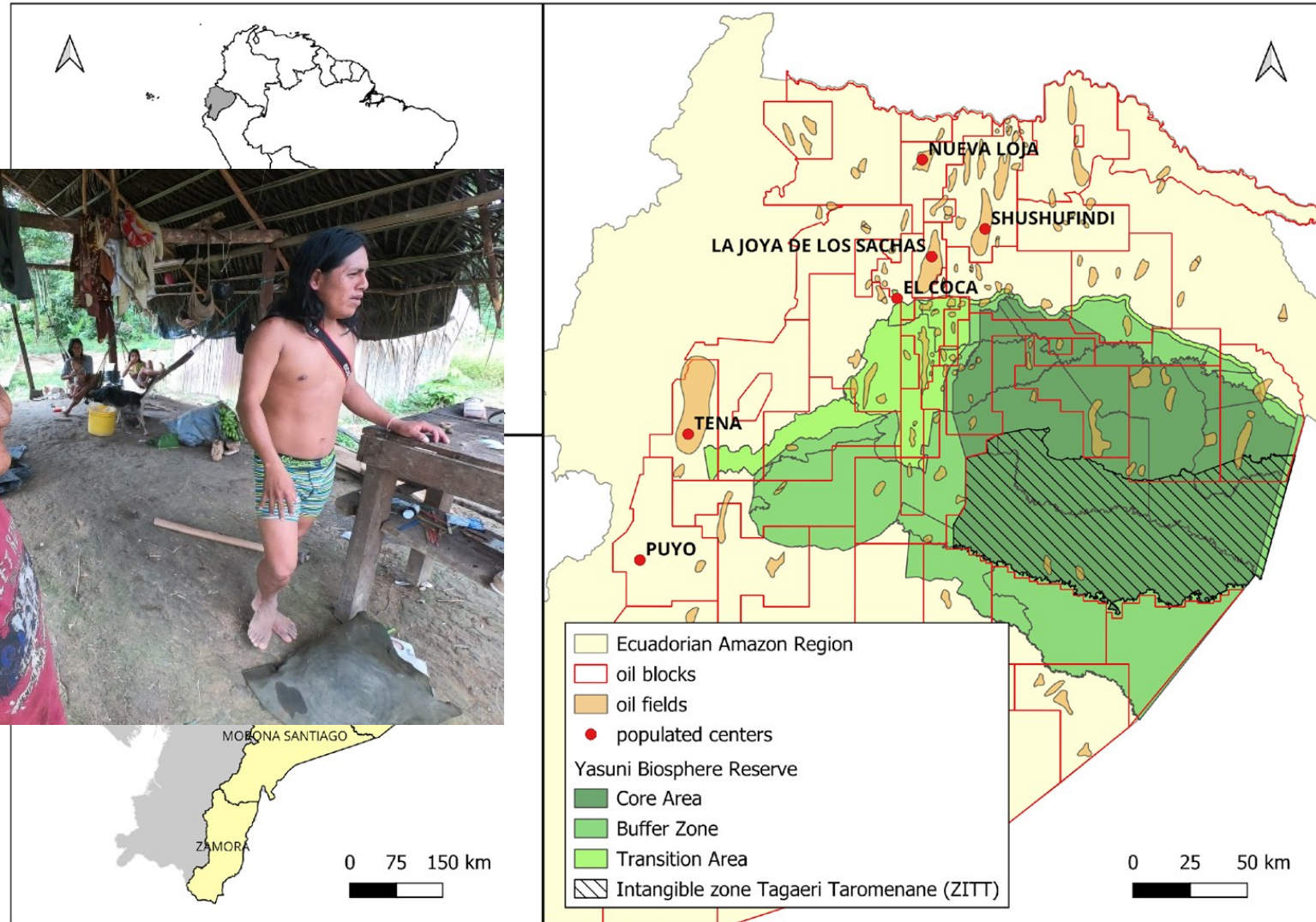
- 151 billion cubic metres of gas burned in 2024
- Emissions of 389 MMtCO₂e, of which 46 MMtCO₂e in the form of methane

Local impacts

- Emissions of over 150 toxic substances, including H₂S, SO₂, NO_x, VOC, PAH and black carbon
- Acid rain
- Impacts on human health
- Heat islands, i.e. alterations in the microclimate depending on the distance from the flame
- Alteration of the phenological stages of vegetation and reduction of biomass
- Alteration of soil biogeochemical cycles and damage to microfauna



The Ecuadorian Amazon Region



“Apaguen los mecheros”



26 de enero de 2021 17:47

Corte de Ecuador acepta demanda de niñas para eliminar mecheros en la Amazonía



Una corte de Sucumbíos aceptó la demanda de un grupo de niñas que busca eliminar los mecheros en la Amazonía. Foto: Archivo/ EL COMERCIO.

gencia EFE

Una corte de justicia de la provincia ecuatoriana de Sucumbíos aceptó este martes 26 de enero del 2021 la **apelación** a una **demand**a presentada por varias **niñas indígenas** de la **Amazonía**, que busca eliminar más de 400 **mecheros** de **combustión de gas** asociado a la explotación de crudo en esa región selvática.

Historic ruling by the Nueva Loja Court (January 2021)

- Elimination of flares located ‘**near**’ populated centres within 18 months (March 2023, Phase I)
- Elimination of routine flaring by December 2030 (Phase II: Zero Routine Flaring by 2030)

Research Group of the University of Padova

“Climate change, territories, diversity”

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Unburnable and Unleakable Carbon in Western Amazon: Using VIIRS Nightfire Data to Map Gas Flaring and Policy Compliance in the Yasuni Biosphere Reserve

by  Francesco Facchinelli^{1,*}  Salvatore Eugenio Pappalardo^{2,*}  Daniele Codato²  Edoardo Crescini¹ and  Massimo De Marchi² 



ENVIRONMENTAL RESEARCH LETTERS

LETTER • OPEN ACCESS

Extreme citizens science for climate justice: linking pixel to people for mapping gas flaring in Amazon rainforest

Francesco Facchinelli¹ , Salvatore Eugenio Pappalardo^{10,2} , Giuseppe Della Fera³, Edoardo Crescini⁴, Daniele Codato⁵ , Alberto Diantini², Donald Rafael Moncayo Jimenez⁶, Pablo Estenio Fajardo Mendoza⁶, Elisa Bignante⁷ and Massimo De Marchi^{8,9} 

 Landscape and Urban Planning
Volume 240, December 2023, 104898

The Apaguen los Mecheros campaign: Supporting climate justice in the Amazonian cities of Ecuador by estimating the health risks of gas flaring

Francesco Facchinelli^a , Edoardo Crescini^b , Giuseppe Della Fera^c , Massimo De Marchi^{c d} 

<https://doi.org/10.1016/j.landurbplan.2023.104898> 

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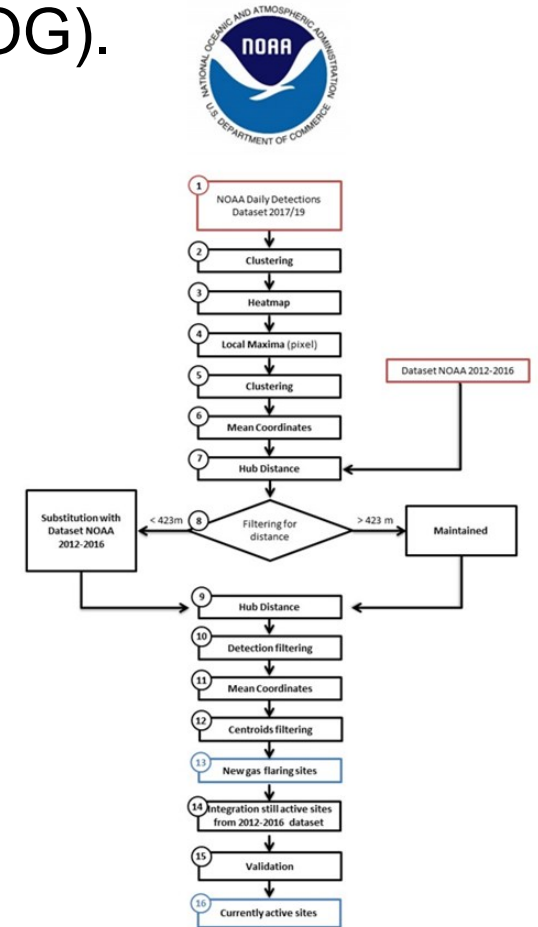
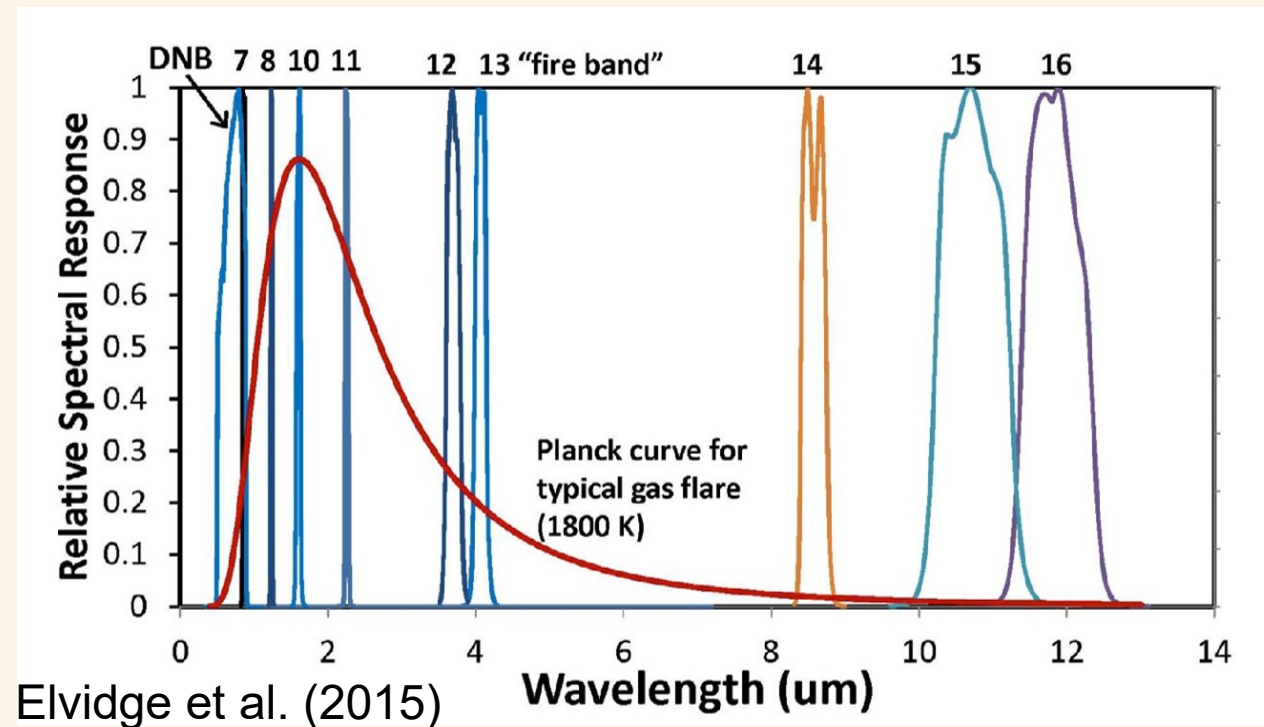
Aims of the study

- Update the spatial distribution of gas combustion sites and quantify the phenomenon over a 12-year period (2012–2023) using annual satellite estimates of gas combustion volumes.
- Identify new gas flaring sites activated between 2019 and 2025 by comparing current observations with participatory mapping carried out in 2019.
- Assess the degree of alignment between satellite observations and national commitments, including court rulings and climate and environmental policies.

Materials and Methods

Nightfire (VNF) dataset from the Visible Infrared Imaging Radiometer Suite (VIIRS), developed by the Earth Observation Group (EOG).

- Annual database (2012–2023)
- Daily observations (2019–May 2025)



Facchinelli et al.
(2020)

Daily observations

```
library(readr)
library(dplyr)
library(data.table)
library(R.utils)

# Folder for input/output
zip_folder <- "# Enter the path to the folder with files .csv.gz (Downloaded from the
Earth Observation Group)"
output_csv <- "# Enter the path desired to store files in a folder "
output_csv_gz <- paste0(output_csv, ".gz")

# Insert coordinate to clip Area of Interest
# Coordinate bounding box Ecuador
lon_min <- -81
lon_max <- -75
lat_min <- -5
lat_max <- 2

# List of compressed files to analyse
files <- list.files(zip_folder, pattern = "\\..csv\\.gz$", full.names = TRUE)

# Removes existing files
if (file.exists(output_csv)) file.remove(output_csv)
if (file.exists(output_csv_gz)) file.remove(output_csv_gz)

# Flag header
first_write <- TRUE

for (file in files) {
  file_name <- basename(file)
  message("Elaboro: ", file_name)

  try({
    df <- read_csv(file, show_col_types = FALSE)

    if (!all(c("Lat_GMTCO", "Lon_GMTCO") %in% names(df))) {
      warning("Colonne Lat_GMTCO o Lon_GMTCO mancanti in ", file_name)
      next
    }

    # Filter Area of Interest
    df_ecuador <- df %>%
      filter(
        Lat_GMTCO >= lat_min, Lat_GMTCO <= lat_max,
        Lon_GMTCO >= lon_min, Lon_GMTCO <= lon_max
      )

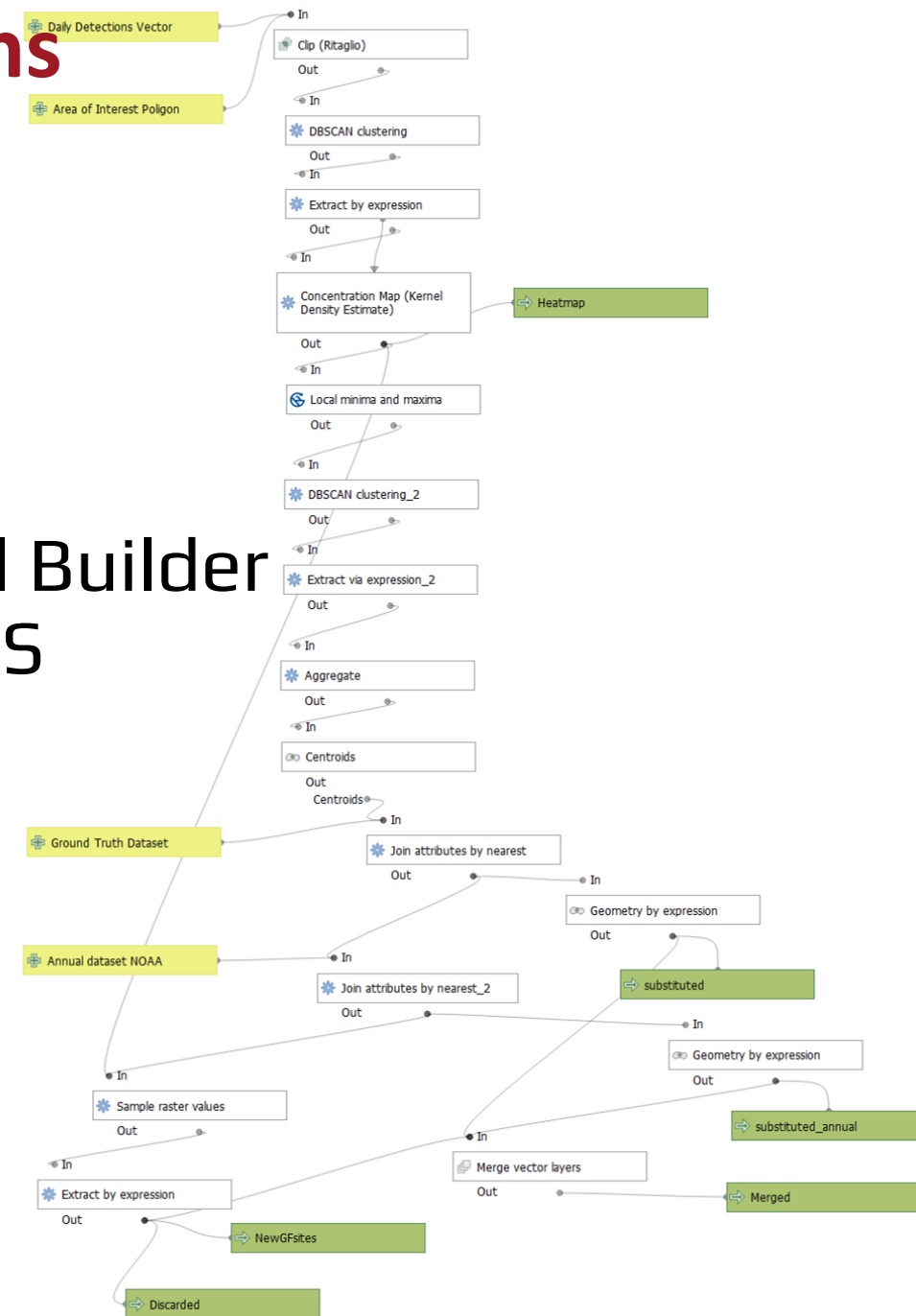
    if (nrow(df_ecuador) > 0) {
      fwrite(
        df_ecuador,
        file = output_csv,
        append = !first_write,
        col.names = first_write
      )
      first_write <- FALSE
    }

    rm(df, df_ecuador)
    gc()
  }, silent = TRUE)
}

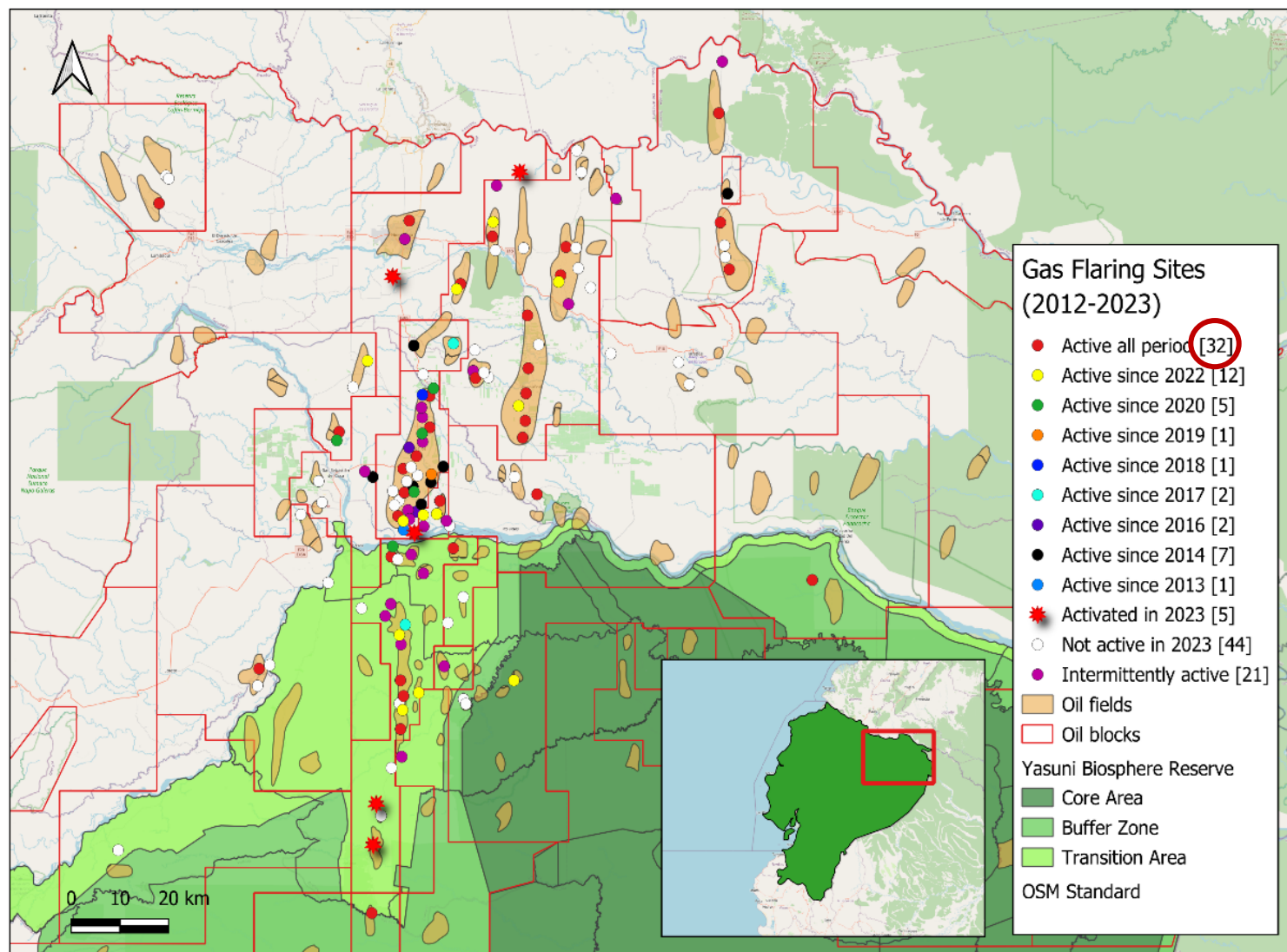
# Compress everything at the end
R.utils::gzip(output_csv, destname = output_csv_gz, overwrite = TRUE)
```

Preprocessing in R

Model Builder in QGIS



Results – active sites in the years 2012–2023

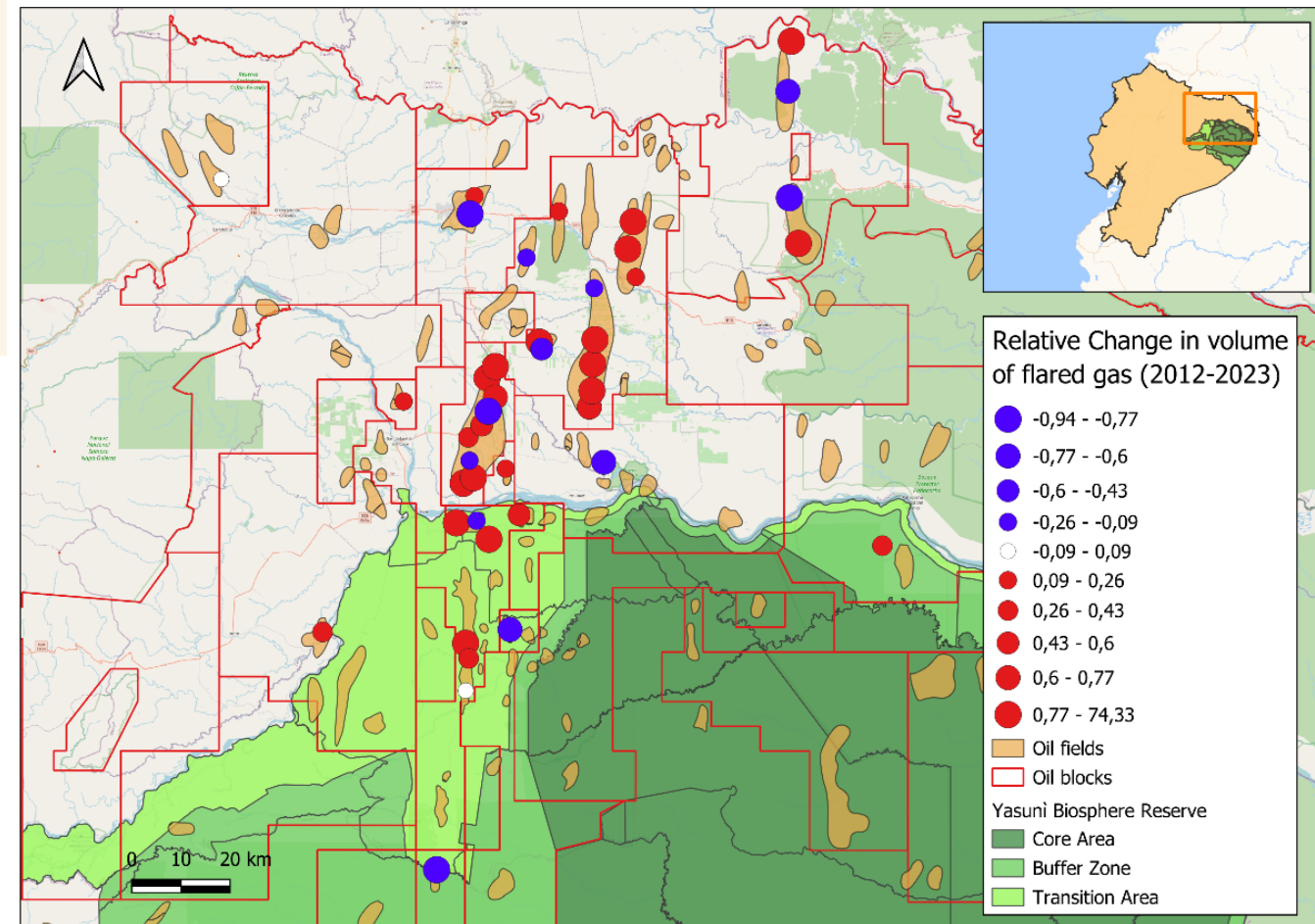
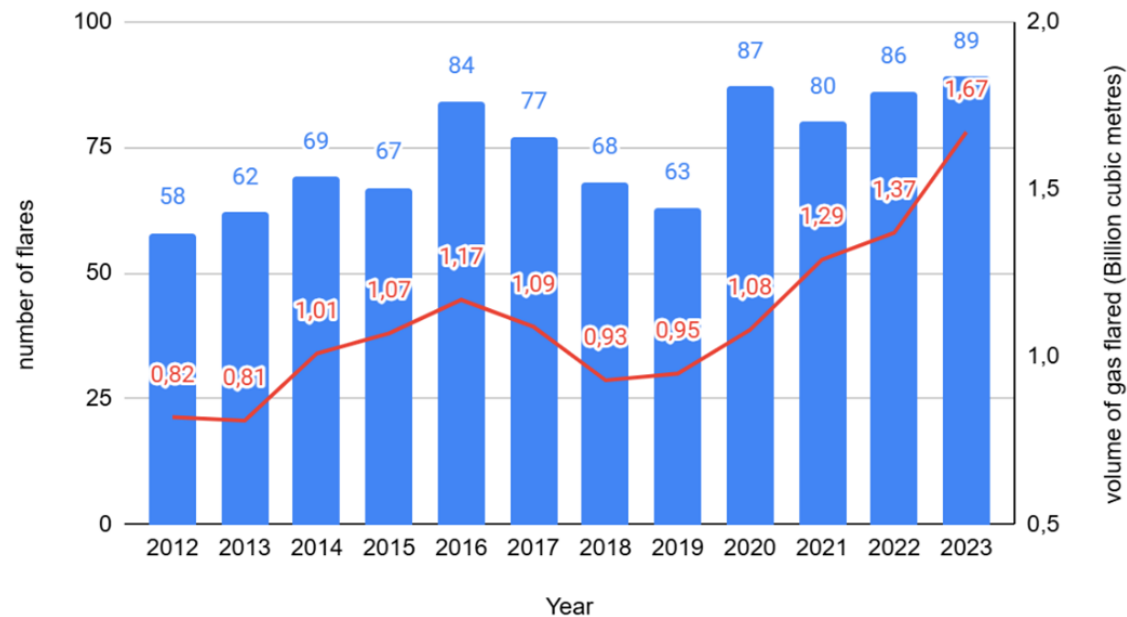


133 gas combustion sites
out of a total of 486
(Ecuadorian Ministry of
Energy and Mines, 2022)

32 sites burned 8,971
MCM of gas (67.7% of
the total volume burned
during the entire period)

Results – volume of gas burned

Cumulative volume of gas burned: 13.24 billion cubic metres over the entire twelve-year period (2012–2023)



Results – volume of gas burned

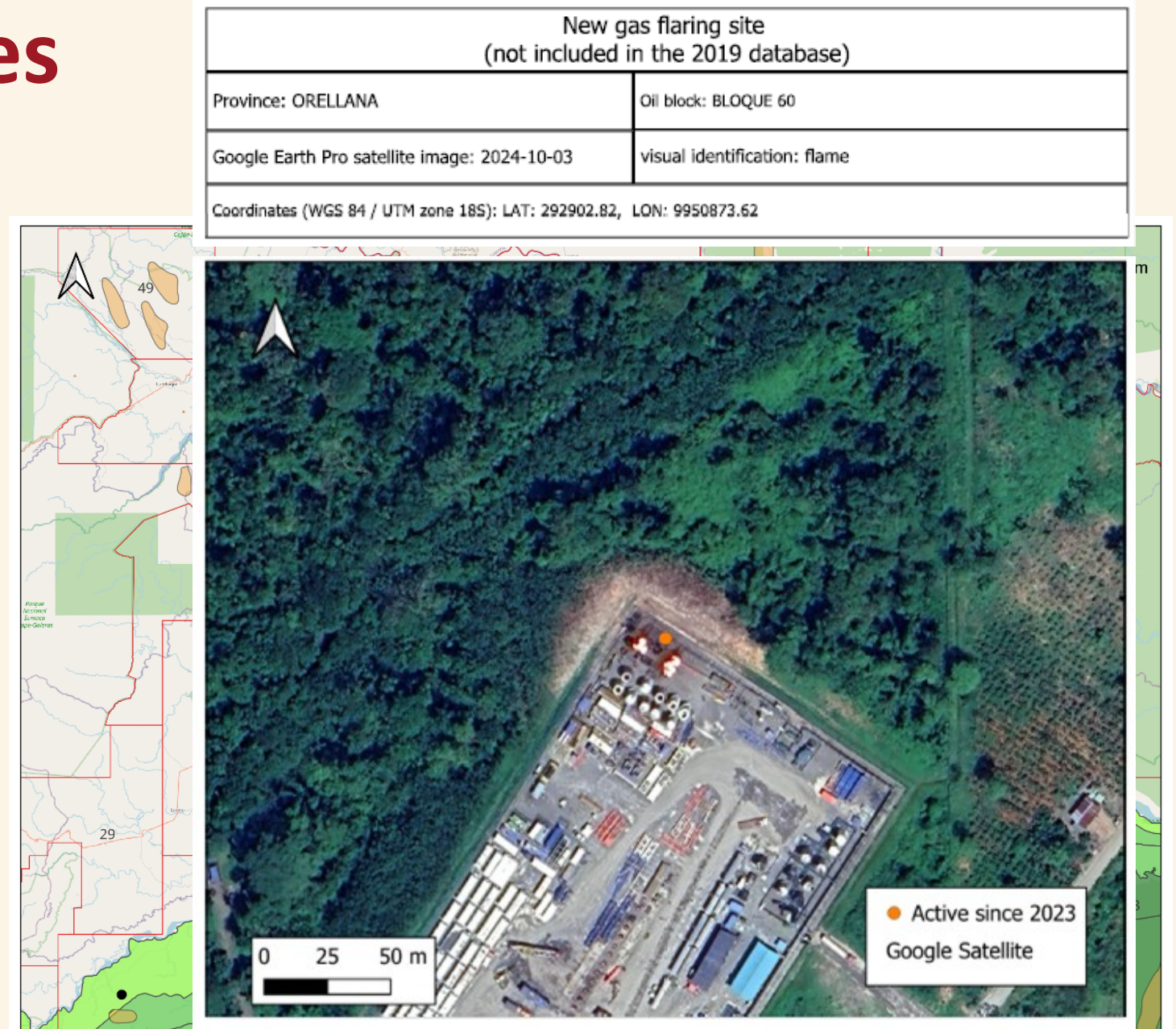
Volumen de gas quemado en millones de metros cúbicos (MCM)												
Sitio de quema de gas	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Estación Sacha Norte 1	27,0	16,1	9,6	7,0	8,5	12,9	12,5	14,0	22,4	17,4	16,5	40,9
Estación Central Shushufindi	27,8	19,0	-	24,3	20,4	18,0	31,0	35,0	40,5	52,8	80,2	84,6
Estación Shushufindi Norte	2,8	11,5	14,9	17,5	44,4	25,2	19,6	41,0	50,3	65,3	83,5	110,9
Estación Shushufindi Sur	28,1	27,4	36,5	25,1	33,7	29,3	22,6	31,3	15,4	36,6	36,8	70,8



Results – new sites

31 new gas flaring sites not included in participatory mapping (Facchinelli et al., 2022) and in the annual EOG database

- Flame (8)
- Infrastructure (15)
- No identification (8)



Results

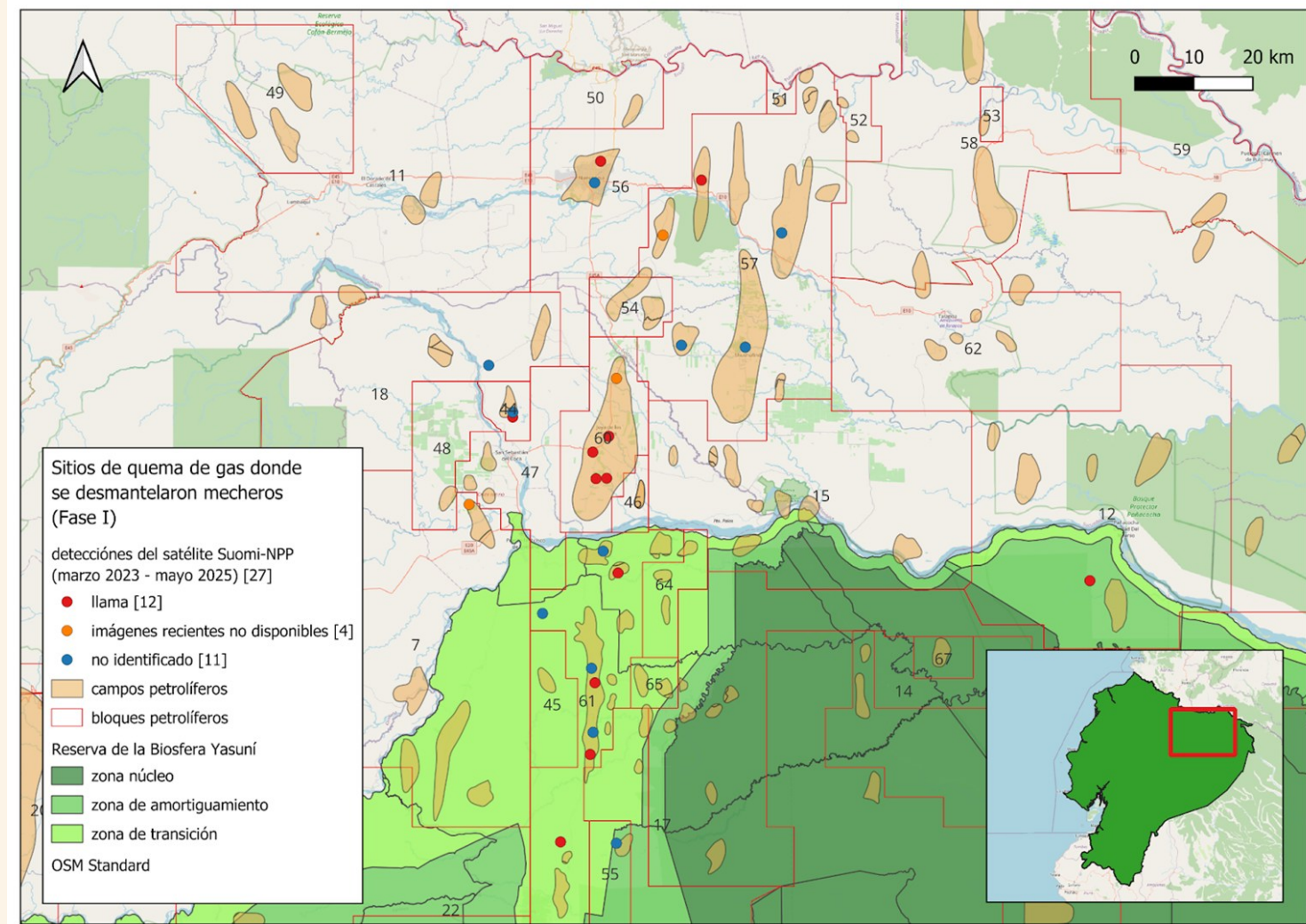
2 extinguished *mecheros* ($d < 100$ m)
by March 2023
(Phase I)

+

110 dismantled *mecheros*
(Phase I)

48 dismantled *mecheros*
(Phase II)

- **27 sites** still registering thermal activity after March 2023



Discussion and conclusions

- **Open-source** GIS technologies and **open access** satellite data are important tools to track unleakable carbon and **support climate justice**
- Limited number of sites detectable by satellite (133 out of 486, 27%) and poor availability of satellite images for verification □ need for **field mapping**/validation by local communities
- Volume of gas burned is still increasing (recent publication of EOG data from 2024) □ **partial and inconsistent application of the ruling**
- **Data** can be a useful **tool** in the hands of **local communities** in their **fight for environmental and climate justice**.

What now?

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...ace presión la guardia de derechos ya en riesgo con la
aceleración del neoliberalismo. Además es una alerta de
lo que podría ser el horizonte de este gobierno: empezar

3:59 a. m. · 25 jul. 2025

Photo: Gia Gabriela



Thank you for your attention!

