The legacy of environmental and societal dynamics on landslide risk in the Kivu Rift

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PAStECA

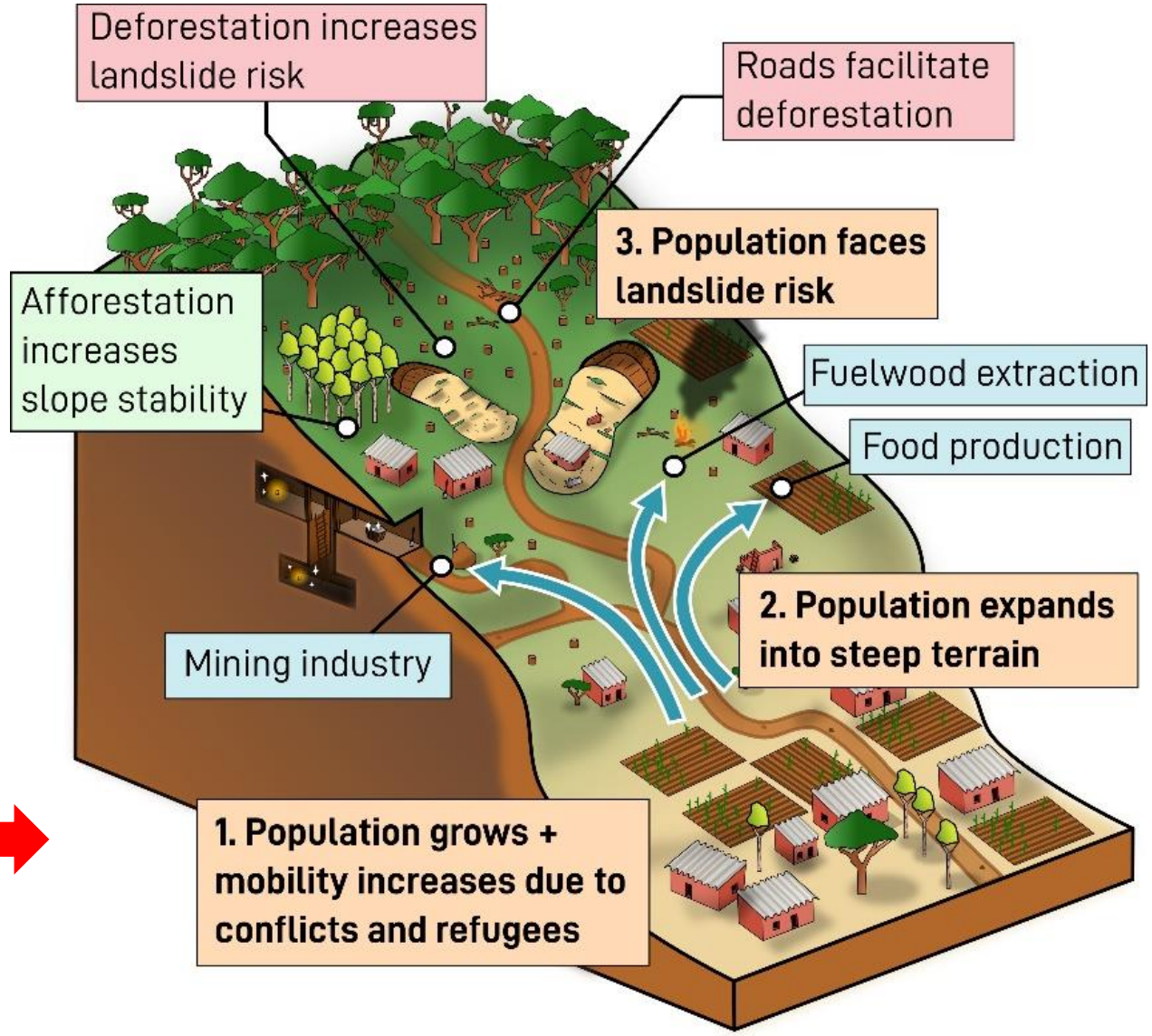
Main Menu

Overview of the Kivu Rift

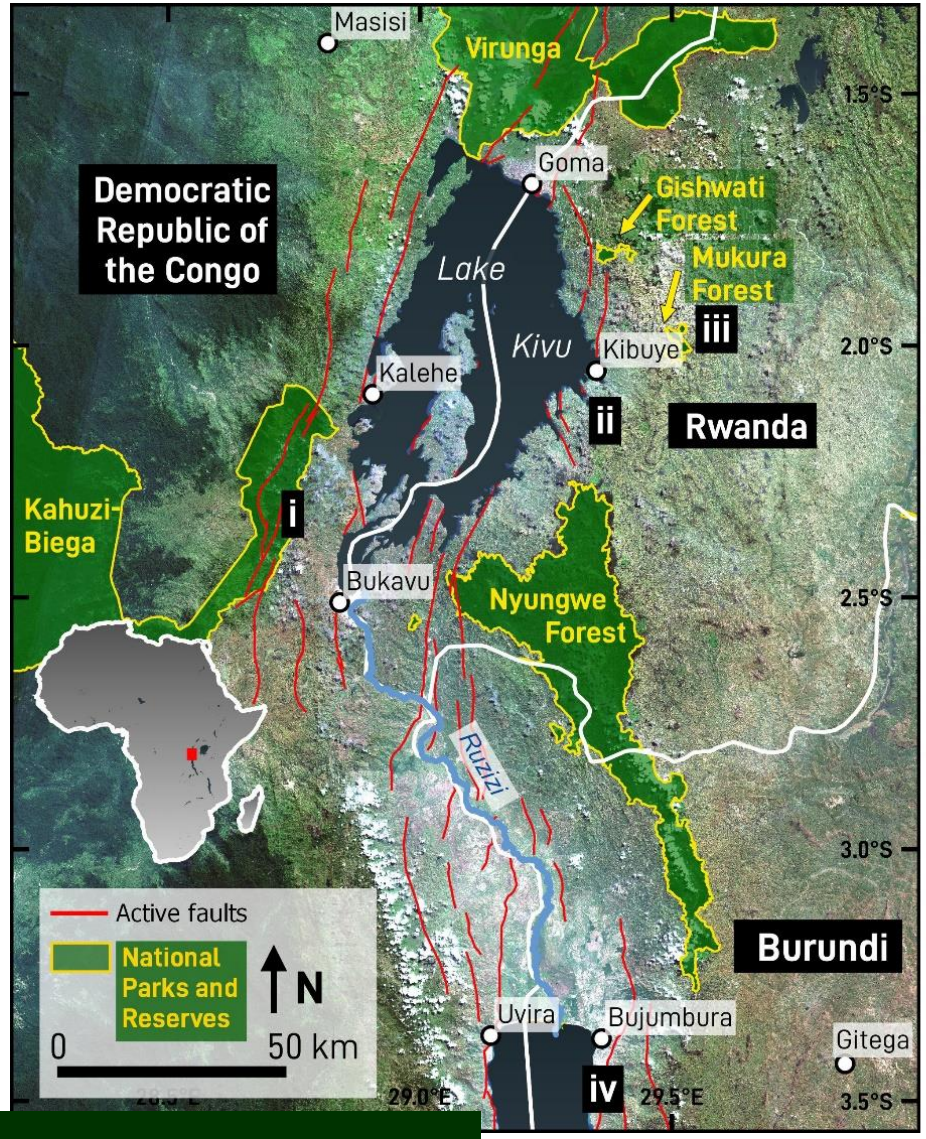
1. Reconstruct forest cover changes 1958-2016
2. Link forest cover changes to landslide susceptibility
3. Link landslide susceptibility to hazard
4. Risk = hazard x exposure x vulnerability

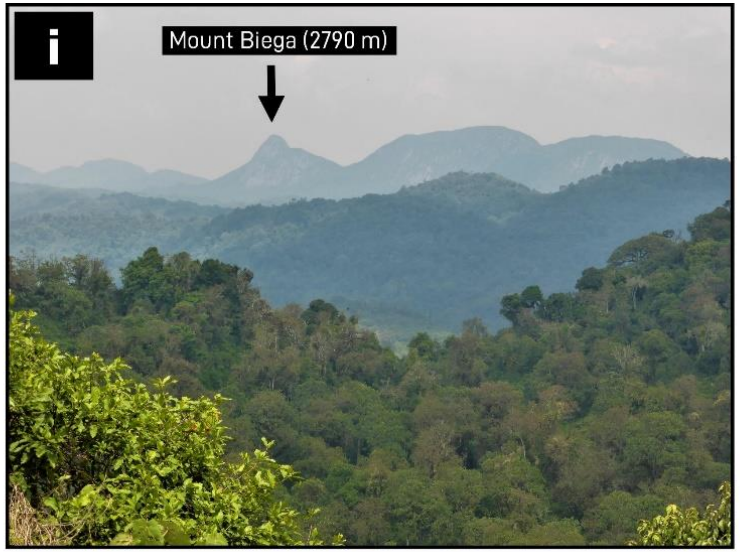
Conclusion

Click on this figure to get more information!



Kivu Rift





Main menu

Mining industry

- Gold
- 3T minerals
  - Tin
  - Tantalum
  - Tungsten
- Boom during 90s

Coltan mine in Western Rwanda

Main menu

Fuelwood extraction

- Wood (and charcoal) are an important source of energy for rural *and* urban households

Deforestation and charcoal production north of Goma, DRC

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Main menu

Food production

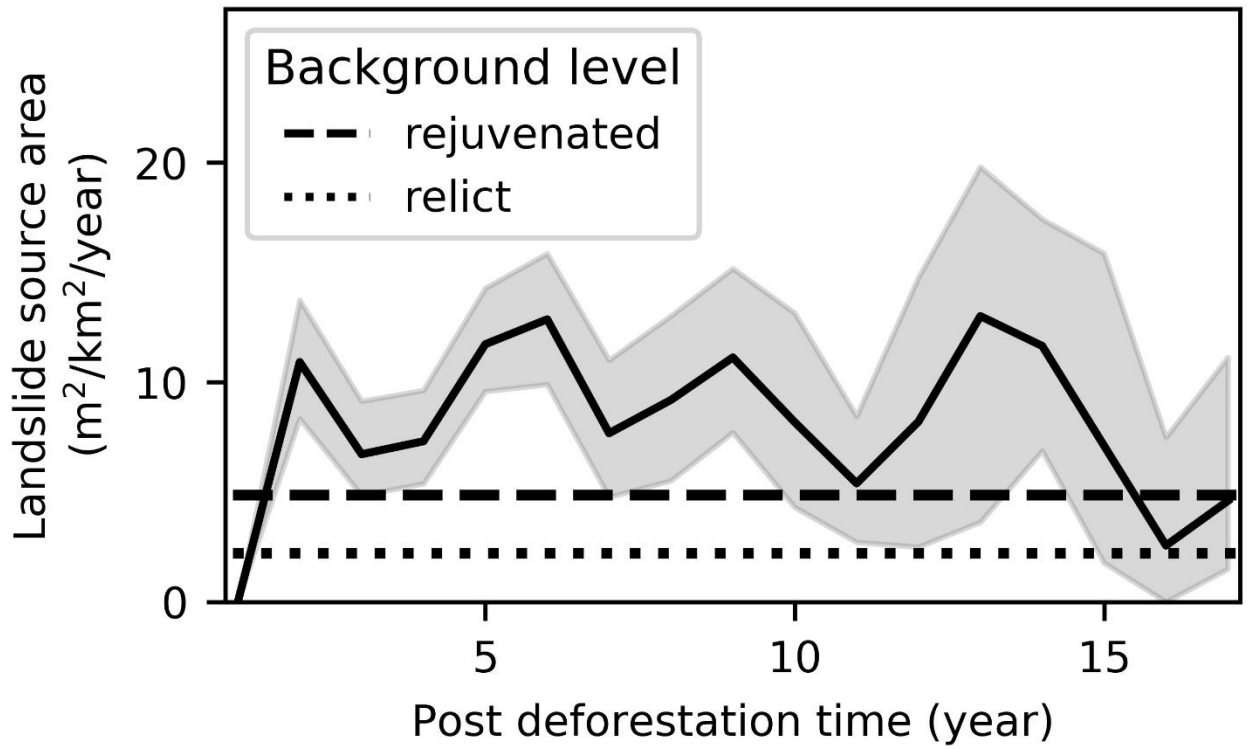
- The growing demand for food incites people to cultivate steep terrain

Most of the hillslopes in Rwanda have been converted into cropland

Main menu

Deforestation increases landslide hazard

- Deforestation alters drainage and decreases soil cohesion as roots decay
- Deforestation increases landslide hazard.
- **Potentially, the increased hazard can also exacerbate risk**



Deforestation increases landslide activity for a period of roughly 15 years
(Depicker et al., 2020 - Interactions between deforestation, landscape rejuvenation, and shallow landslides in the North Tanganyika - Kivu Rift region, Africa)

Main menu

Afforestation decreases landslide hazard

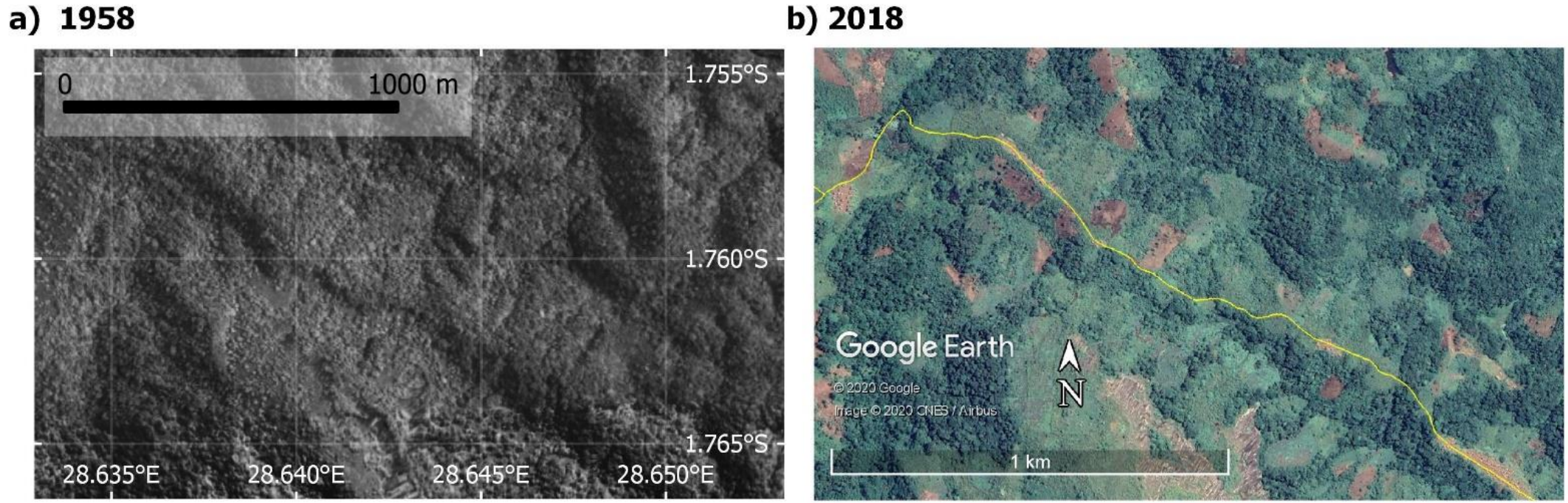
- Tree plantations and naturally regenerated forests may increase the slope stability

Planted forest in Northern Rwanda

Main menu

Roads facilitate deforestation

- Road construction unlocks the access to primary forest, facilitating deforestation

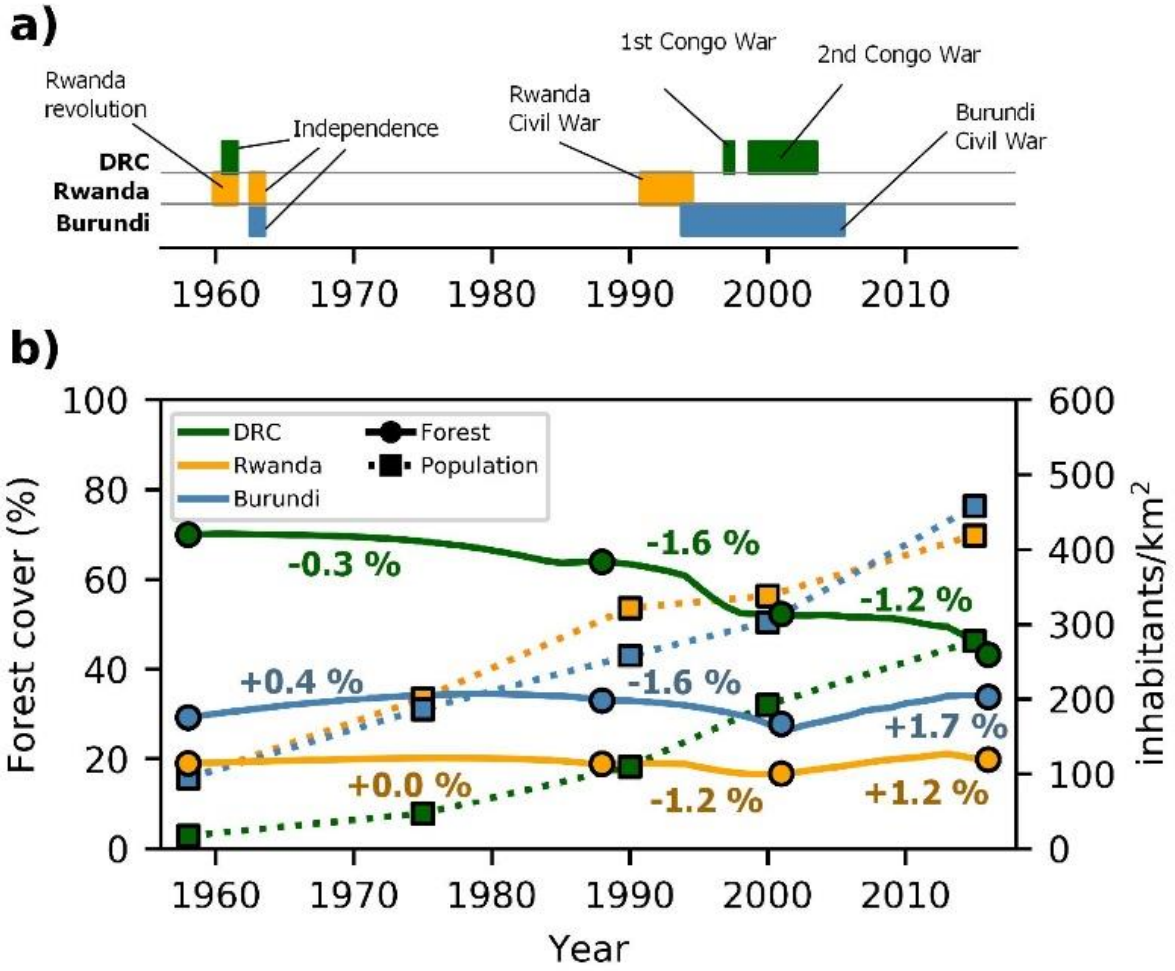


Impact of a new road on land cover in the eastern DRC

Main menu

Population growth

- Exponential population growth since the 60s
- Conflicts increase mobility
- 1 M Rwandan refugees were relocated in the eastern DRC in 1994

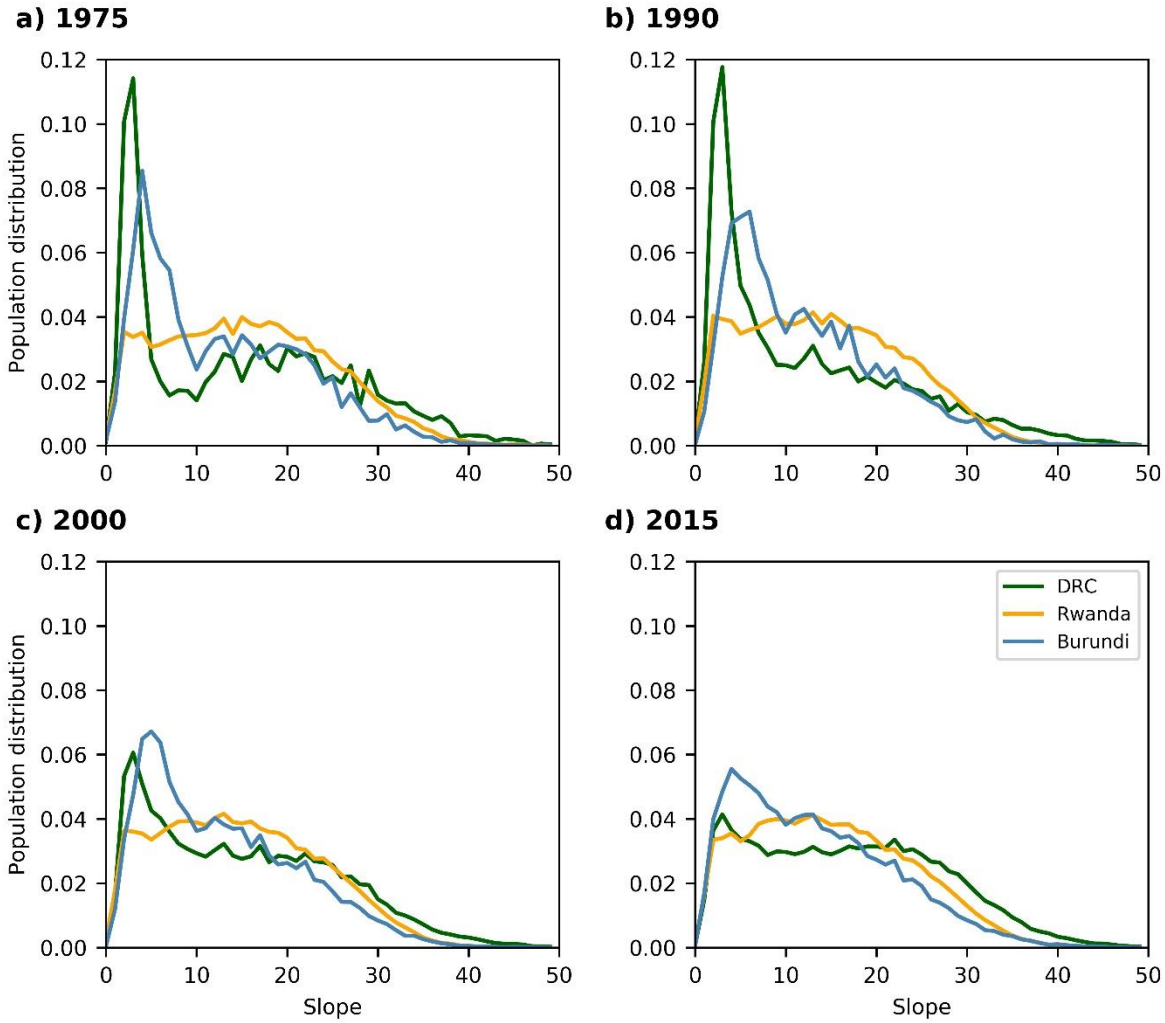


Population growth and deforestation between 1958 and 2015. The percentages indicate the average annual forest loss.

Main menu

Population expands on steeper terrain

- Expansion is driven by
  - Need for cropland
  - Need for fuelwood
  - Mining industry



Population density shifts towards steeper terrain, especially in the eastern DRC

Main menu

Population faces landslide risk

May 6, 2018. Twenty people were killed by rainfall-induced landslides in Western Rwanda

Landslide along road in Rwanda

Main menu

1. Reconstruct forest cover changes

- Panchromatic orthomosaic with historical aerial photographs
- Resolution ~ 1 m

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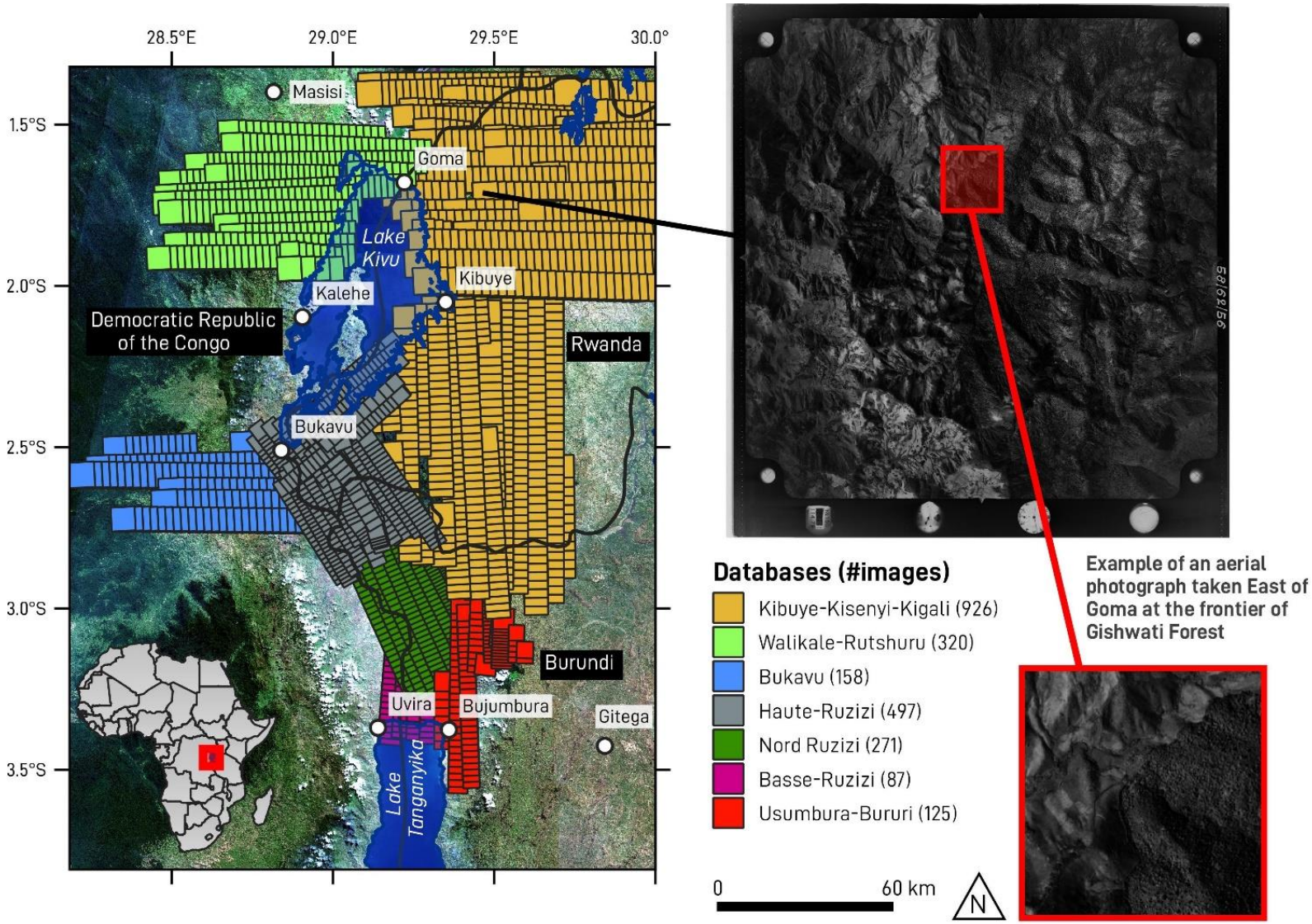

Main menu

1. Reconstruct forest cover changes

- Object-based classification techniques to derive forest cover

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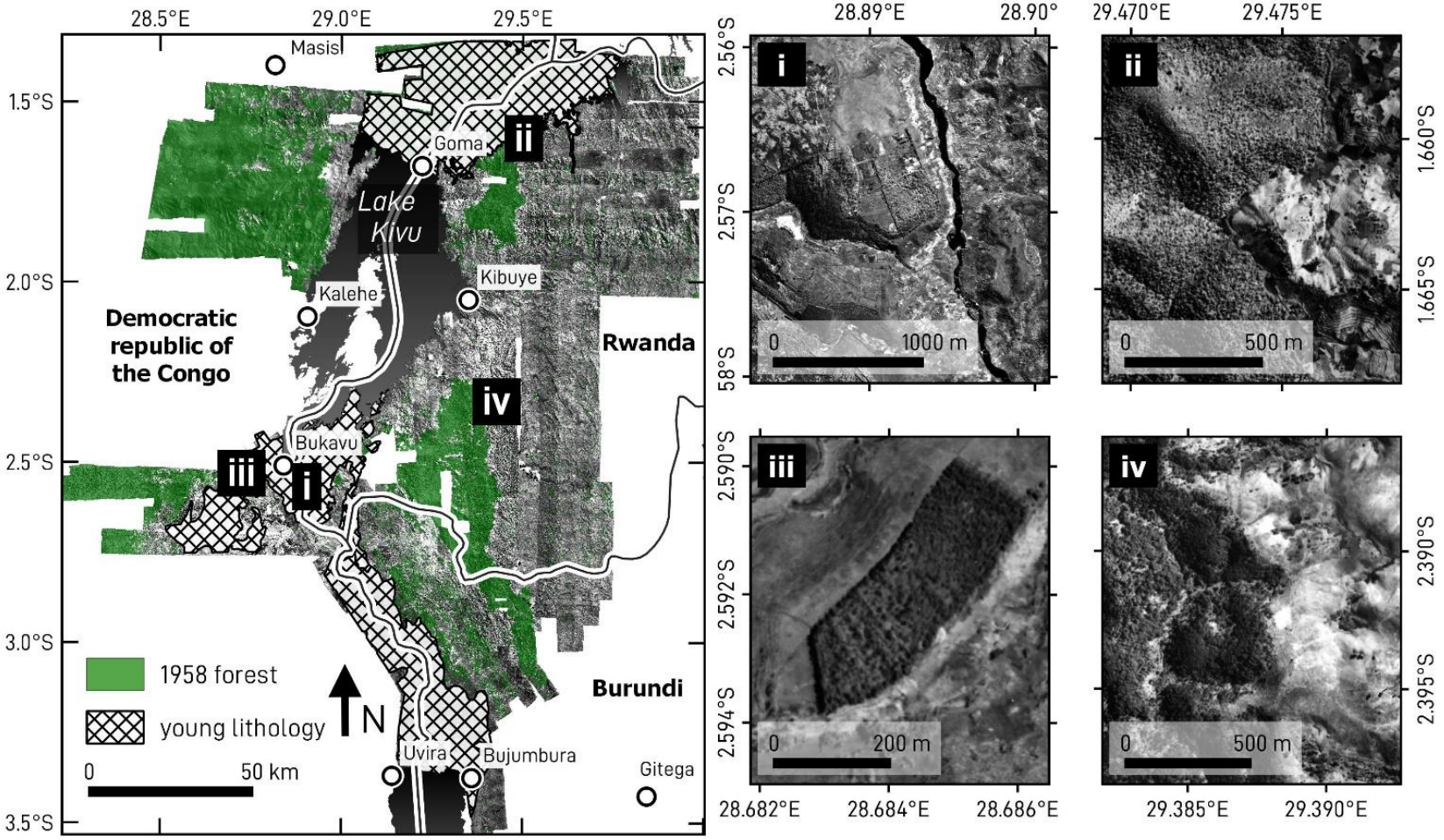
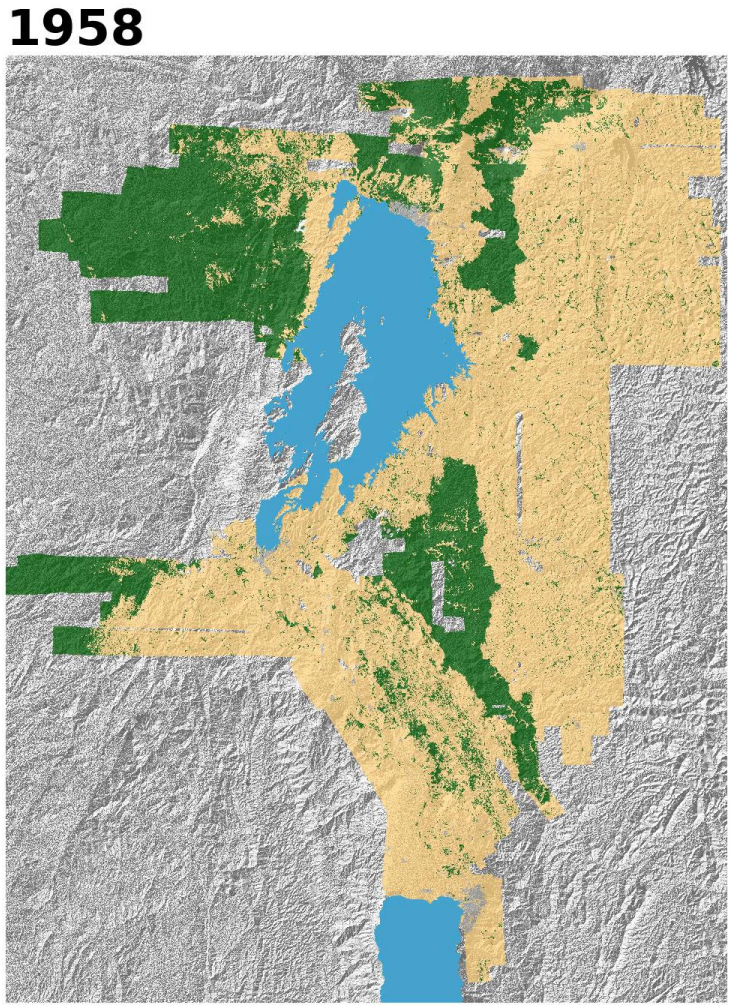


Main menu

1. Reconstruct forest cover changes

- Use of 1958, 1988, 2001 and 2016 data to **reconstruct annual change**
- 2 components:
  - **Where** does deforestation/afforestation happens? (likelihood)
  - **How much** of it happens per year? (rate)



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Main menu

1. Where will deforestation happen?

- Deforestation and afforestation likelihood model
- Logistic regression
  - Distance to roads
  - Protected area (0/1)
  - Forest edge (0/1)
  - Deforestation contagion (0/1)
  - Elevation
  - Slope
  - Distance to rivers

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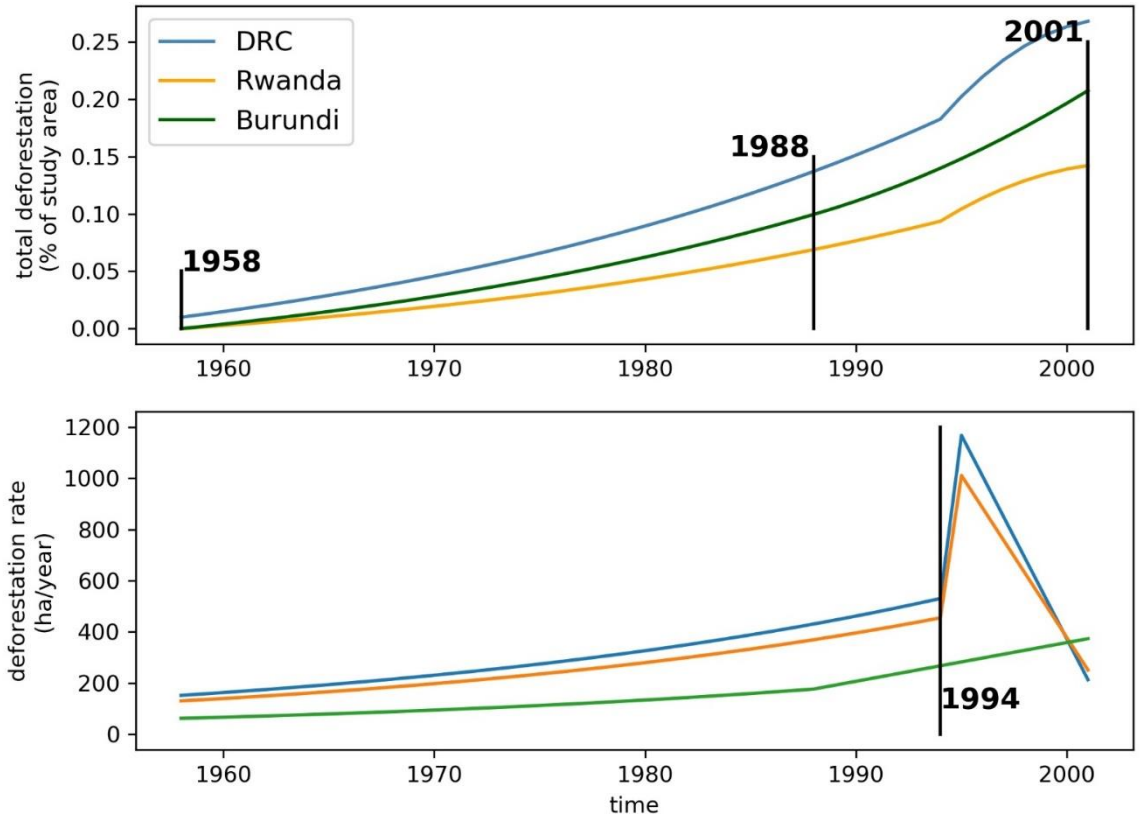
Main menu

1. How much deforestation per year?

- Annual deforestation rate?
  - Doubles evry 20 years
  - Surge after 1994 Rwandan Civil War
- Annual afforestation rate?
  - Assumed constant

Reconstructed deforestation rate. Literature describes a surge in 1994 due to refugee fluxes



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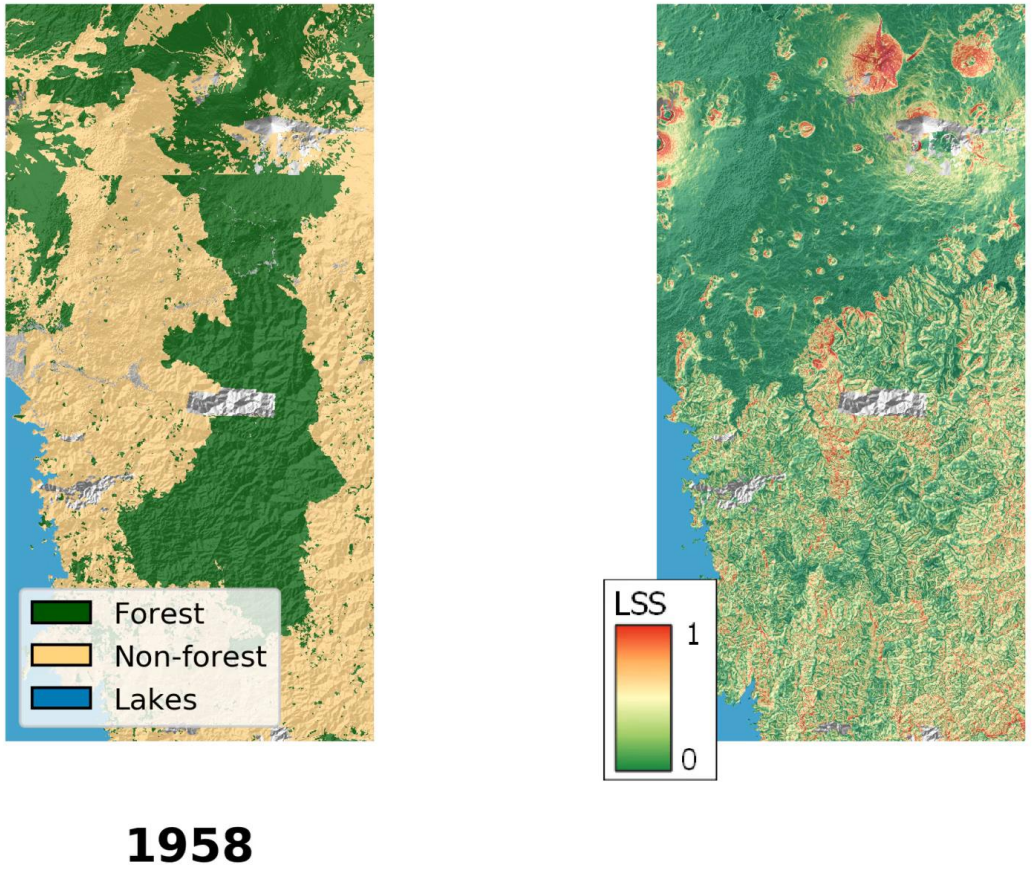
2. Link forest cover to landslide susceptibility

- 4,367 shallow landslides
- Logistic regression
- Dynamic land cover variable
  - Includes the 15 year post-deforestation wave

The decline of Gishwati forest is expected to increase landslide susceptibility



1958

Main menu

3. Link hazard to susceptibility

- Calibrate hazard~susceptibility
- Apply to the annual susceptibility maps

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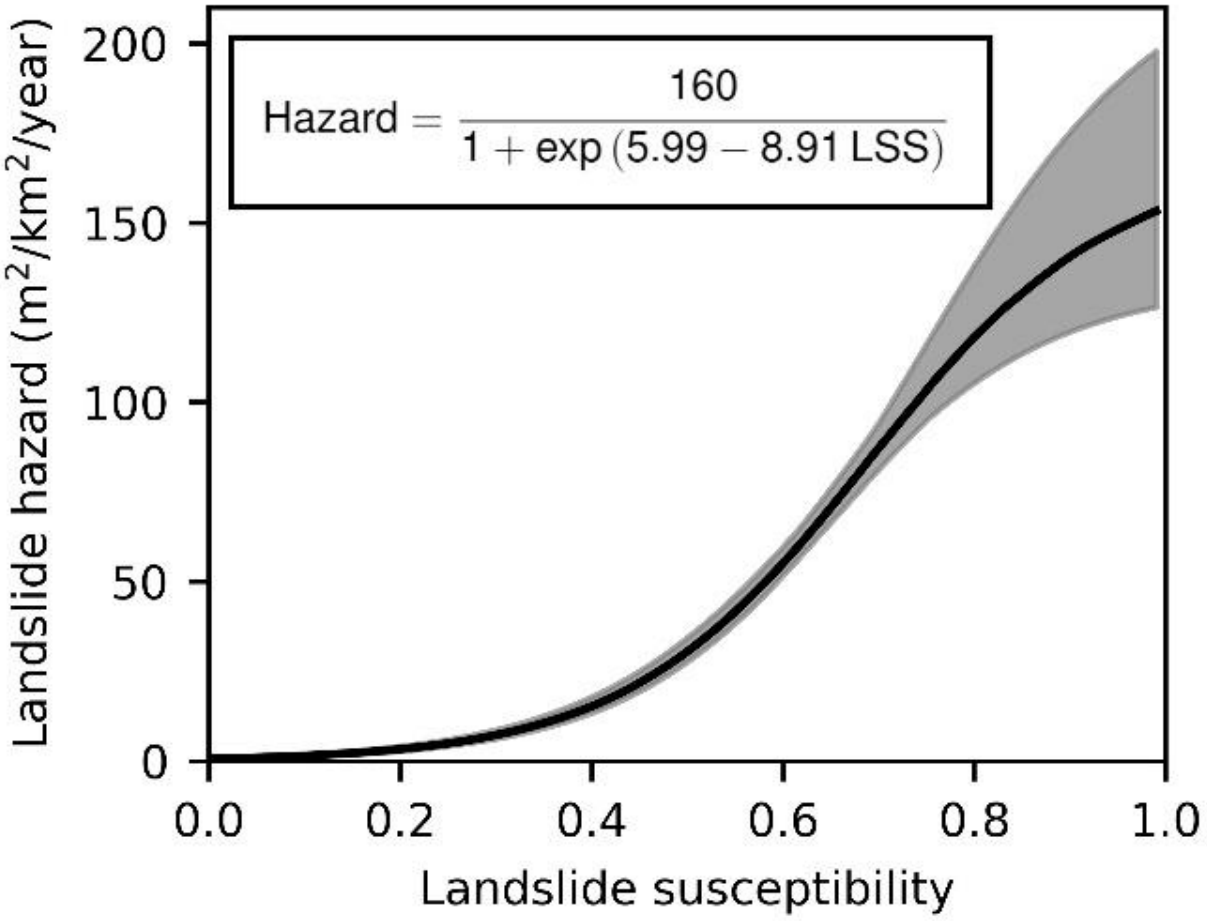

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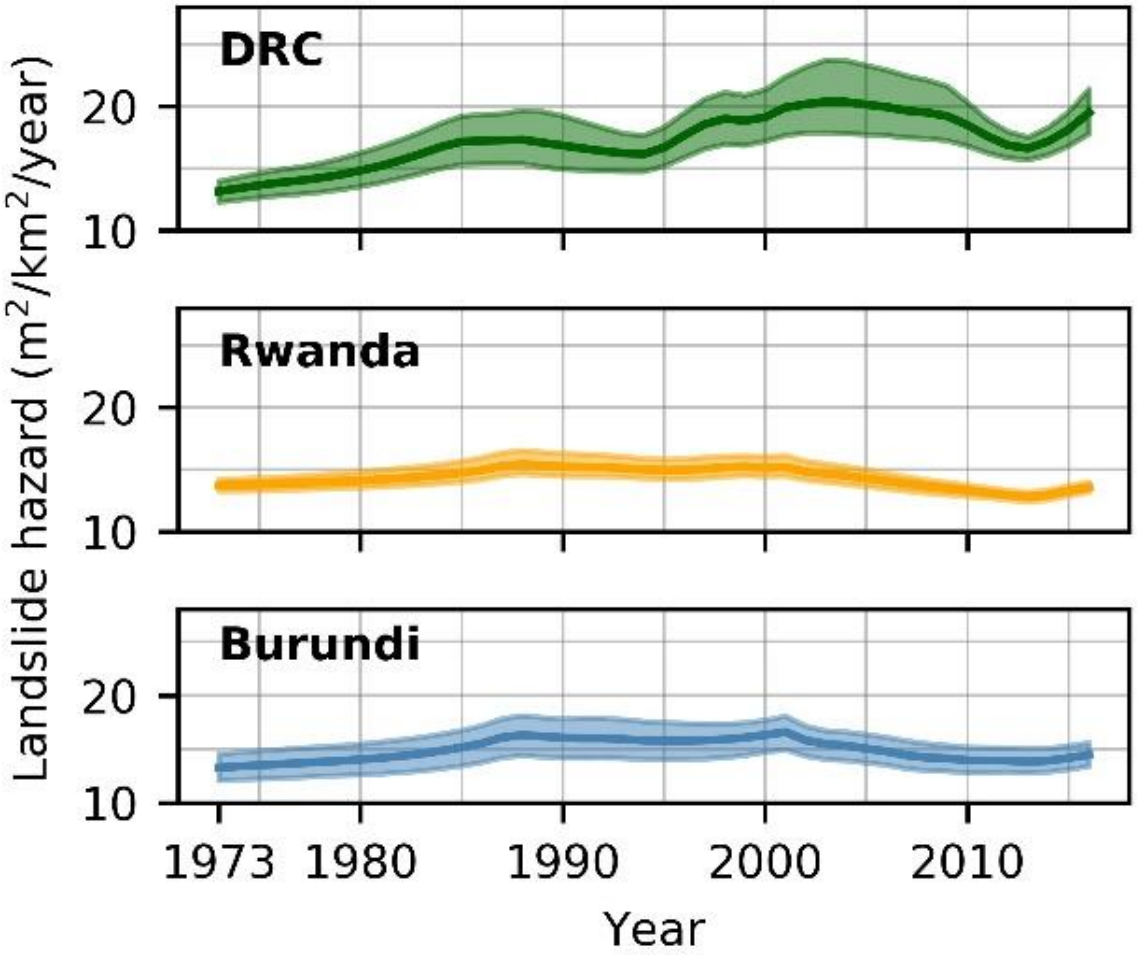
3. Link hazard to susceptibility

- Hazard highest in the DRC
- Peak around 2001
- Increase in 1988-2001 due to increased deforestation



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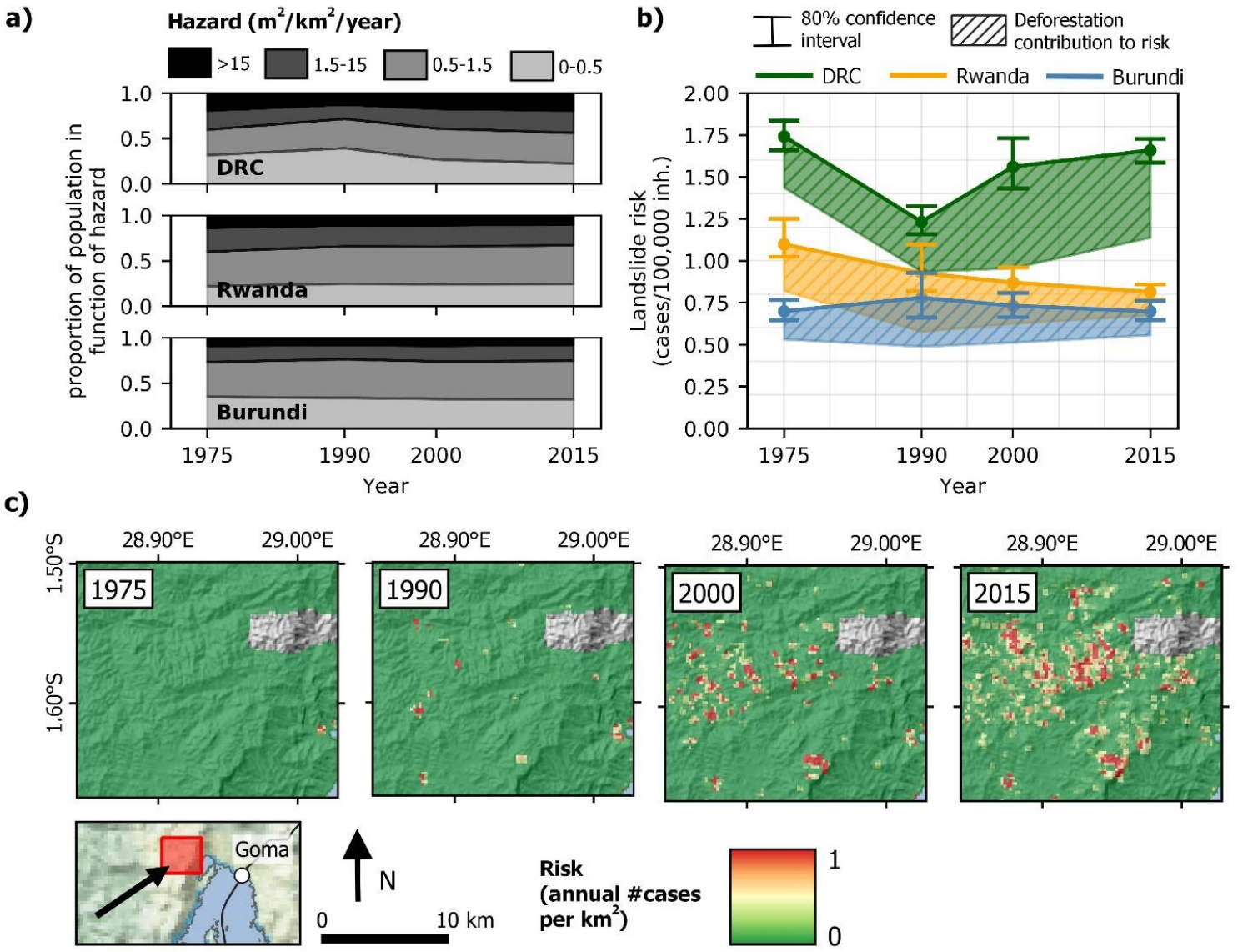
4. Risk = hazard x exposure x vulnerability

- No data on vulnerability, but it is assumed high (~1)
- Exposure ~population grids in 1975, 1990, 2000, 2015 (Global Human Settlement Layer)
- Risk highest in DRC, but only partly due to deforestation



Conclusion

Main menu

Conclusion

- Risk is higher in the DRC
  - Due to deforestation
  - Due to location of people on steeper (hazardous) terrain
    - Refugee influx ➡ population growth ➡ agricultural expansion
    - Mining sector
- What now?
  - Reduce deforestation and incentives to settle in steep terrain
    - Sensibilization
    - Increase productivity in existing cropland
    - Use alternative energy sources other than fuelwood
    - More efficient use of wood (e.g. better stoves)
    - Rely on forest plantations
    - …

Main menu