Rwanda Space Agency

Current and Future Spatial-Temporal Variability of Flood susceptibility in Rwanda

Introduction

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Rwanda Space Agency

Rwanda Space Agency at a glance…

Vision

To develop a globally competitive space ecosystem

Mission

To develop Rwanda's space sector towards social-economic development using space technologies, services and product development.

Foundation (Steps)

- High quality capacity building initiatives – Academically, technically and industrially
- Robust partnership network – Local, regional and international

Background

Kinamba-Gakiriro-Kagugu (27 January 2022)

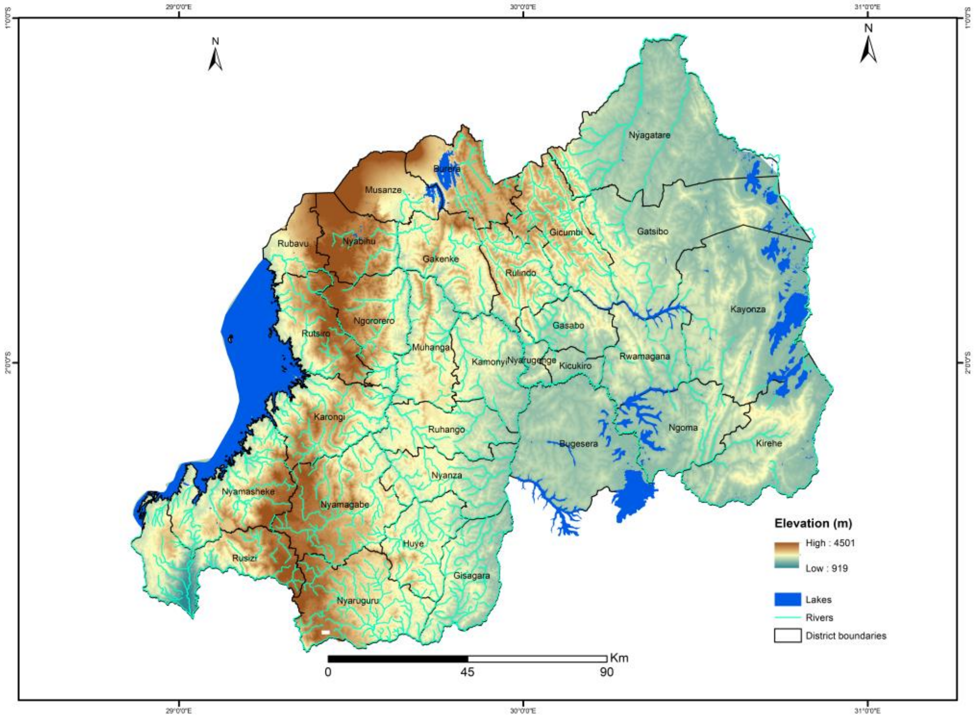
- Floods are one of the most frequent and distressing natural hazards threatening life and economy loss worldwide.
- The Emergency Events Database (EM-DAT) reported 290 major natural disasters worldwide in 2019, of which 49% were caused by floods.
- In terms of mortalities, floods killed the largest amount of people, at more than five thousand, followed by extreme temperature. (https://www.preventionweb.net/files/73363_2019globalnaturaldisasterassessment.pdf).
- The Ministry in charge of Emergency Management of Rwanda has ranked floods as the second disaster in Rwanda, which have killed many people in 2021 after landslides, and they are the first disaster which damage the crops at the high extent area.

Cont’

- In Rwanda, researchers have conducted studies about geo-environmental disaster management with significant emphasis on the description of hazards but scarce attention has been paid to flood susceptibility prediction under the tremendous global warming (climate change). Therefore the objectives of this study are:
- To assess the monthly flood susceptibility index in Rwanda based on the baseline period (1981 - 2017).
- To evaluate the spatial and temporal variability of the future flood susceptibility based on General Circulation Models (GCMs) of Coupled Model Intercomparison Project Phase 5 (CMIP 5) under the Representative Concentration Path (RCP) 2.6 (optimistic) and 8.5 (pessimistic) scenarios
- To guide and inform decision and policy makers in the relocation process, land use planning and sustainable environmental management toward flood resilience building in Rwanda.

Materials and Methods

Study area



- Hilly and mountainous
- Altitude: 919-4501m
- Area: 26338 Km^2
- Population: 13,527,079
- Density:525 per Km^2

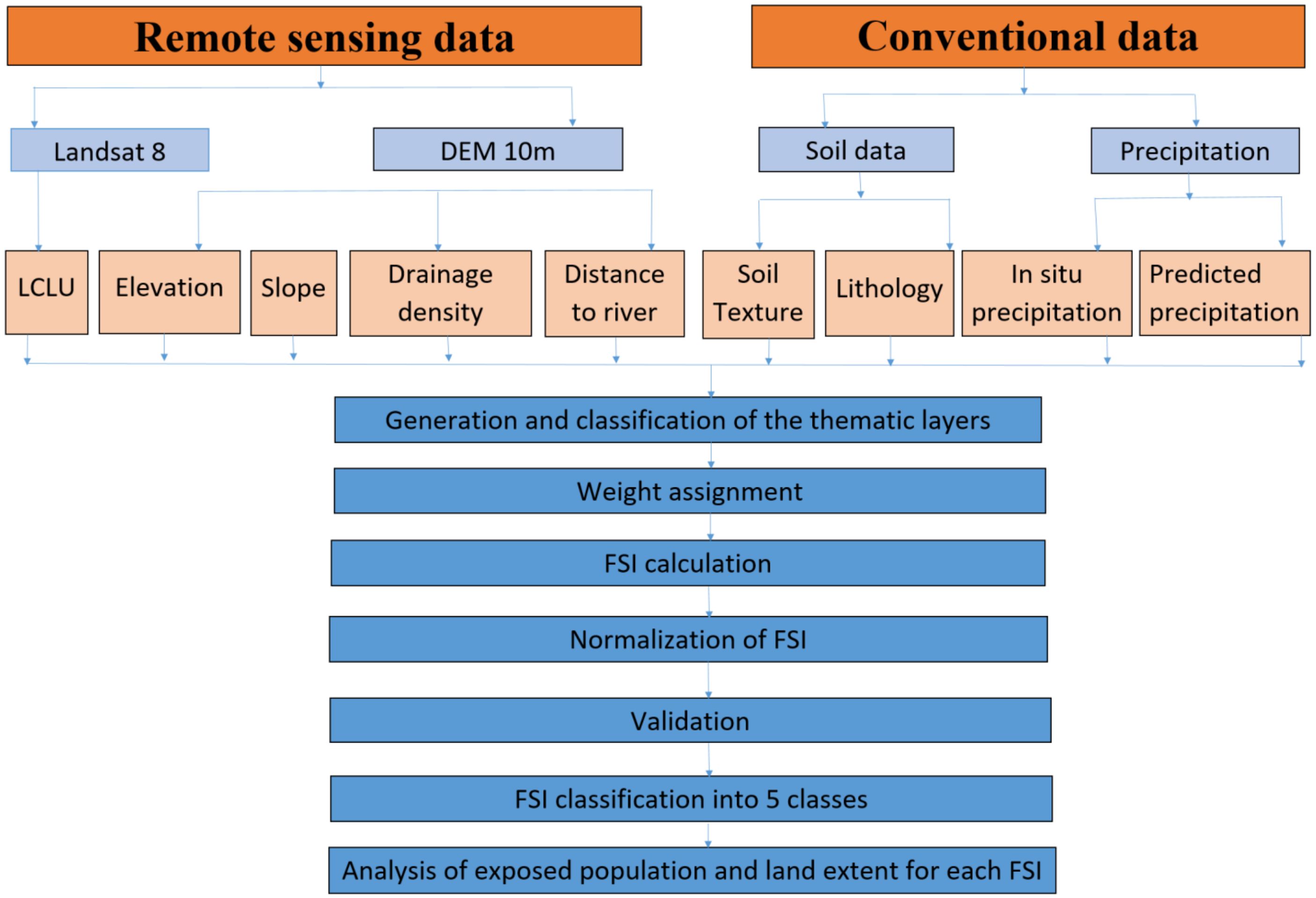
- Lakes: 128,190 ha
- Rivers: 7,260 ha
- Marshlands: 77.000
- 22,300: springs

SDS	**LRS**	**LDS**	**SRS**	**Average precipitation**		**Average temperature**	
				Rainy(mm)	Dry(mm)	Rainy	Dry
Dec-Feb	Mar-May	Jun-Sept	Sept-Nov	110-200	10-20	14-26 (^{0}C)	19-27 (^{0}C)

SDS: Short dry season
LDS: Long dry season
SRS: Short rainy season
LRS: Long rainy season

Cont's

Flowchart for the identification of Flood Susceptibility Index (FSI)



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Assigned weight and rank scores for the layer

Factor (unit)	Class	Flood hazard	Class Rank	Factor weigh(%)
Precipitation (mm/month)	< 55 55_70 70 - 85 85- 100 >100	Very low Low Moderate High Very high	1 2 3 4 5	**19.57%**
Distance to river(m)	>140 <140 <105 <70 <35	Very low Low Moderate High Very high	1 2 3 4 5	**16.06%**
Elevation(m)	>4400 <2500 <1500 <500 <50	Very low Low Moderate High Very high	1 2 3 4 5	**14.20%**
Slope (degree)	>40 <40 <30 <20 <10	Very low Low Moderate High Very high	1 2 3 4 5	**13.99%**
Land cover/Land use	Forestland Grassland/Cropland Wetland Settlement Water body	Very low Low Moderate High Very high	1 2 3 4 5	**11.07%**

Factor (unit)	Class	Flood hazard	Class Rank	Factor weigh(%)
Drainage density(km/km2)	<0.1 <0.4 <0.7 <1 >1	Very low Low Moderate High Very high	1 2 3 4 5	**10.57%**
Soil Texture	Loam Clay loam Sandy clay loam, Sandy clay Silty loam, Silty clay loam, Silty clay Clay	Very low Low Moderate High Very high	1 2 3 4 5	**8.89%**
Lithology	Volcanic ash Schist Organic Acid metamorphic rock, Migmatite Quartzite, Gneiss. Granite, Basic igneous rock, water Basalt, Colluvial, Fluvial, Lacustrine	Very low Low Moderate High Very high	1 2 3 4 5	**5.65%**

Cont’s

Satellite images and formulas used in this study

- **FSI** = (“Precipitation" * 19.57%) + (“Soil_texture" * 8.89%) + ("Lithology" * 5.65%) + (“LCLU" * 11.07%) + (“Elevation" * 14.2%) + ("Dist_to_river" * 16.06%) + ("Slope" * 13.99%) + ("Drainage_density" * 10.57%)

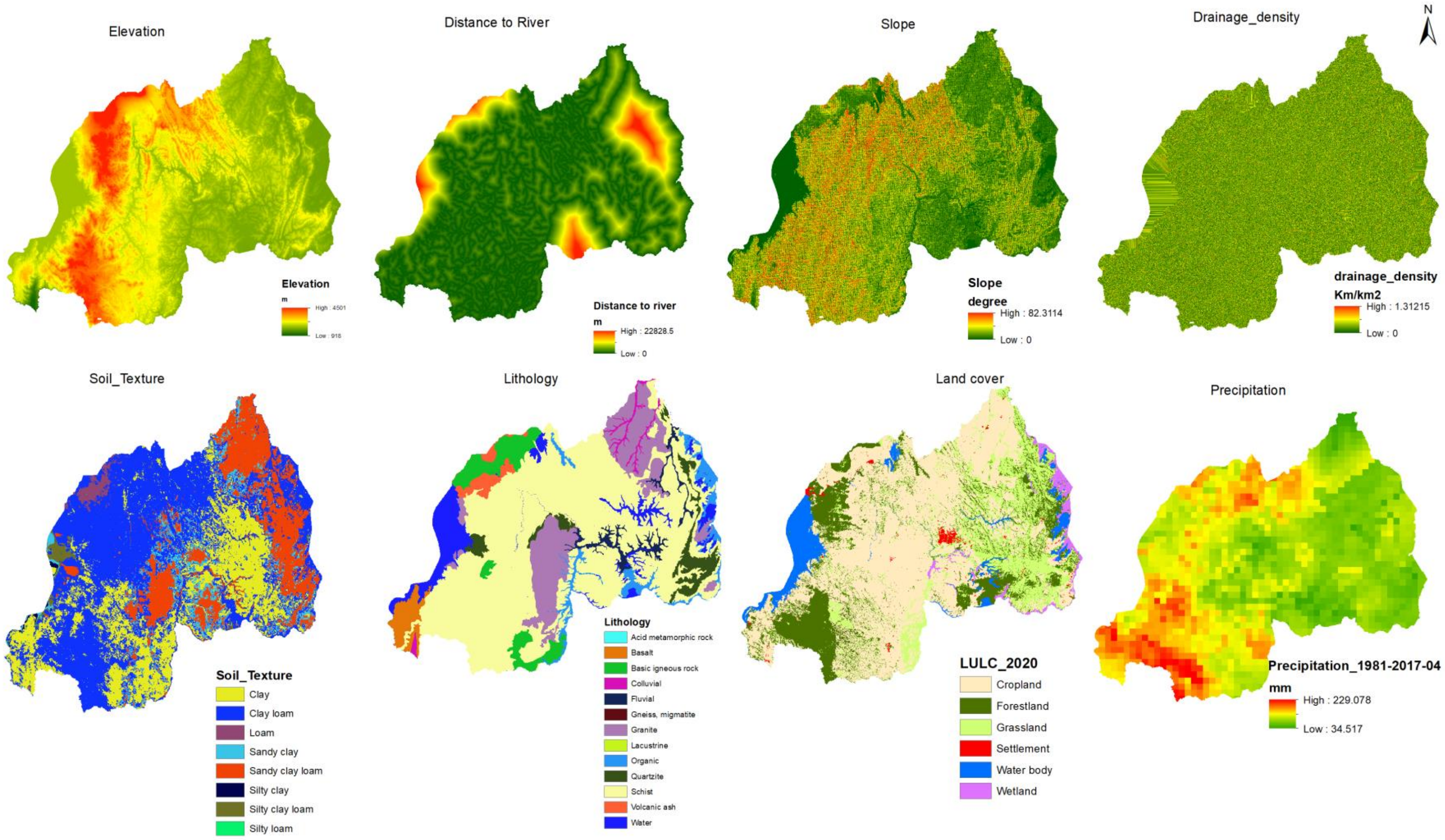
- **FSI Normalization ranged from** 0 **to** 1 = (FSI – FSI_{min}) / (FSI_{max} - FSI_{min})

- Normalized Difference Water Index(**NDWI**) using Sentinel-2 = **(B03-B08/B03+B08)**

- Sentinel-1: To extract waterbodies in observed area
- Landsat 8 for Land Cover classification

Cont’s

The factors used to calculate the Flood Susceptibility Index(FSI)



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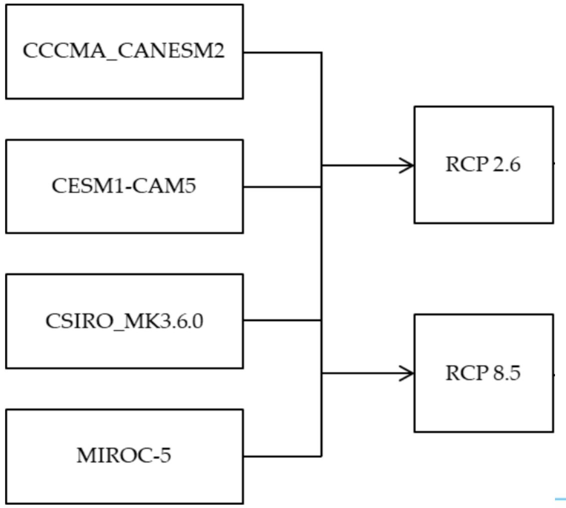
The details of the four GCMs applied in this study

Model	Country	Institute	Resolution
CCCMA_CANESM2	CANADA	Canadian Centre for Climate Modeling and Analysis	2.8◦ × 2.8◦
CESM1-CAM5	USA	Community Earth System Model Contributors	1.25◦ × 0.9◦
CSIRO_MK3.6.0	AUSTRALIA	Commonwealth Scientific and Industrial Research Organization	1.875◦ × 1.875◦
MIROC-5	JAPAN	Model for Interdisciplinary Research On Climate	1.4◦ × 1.4◦

Integrated of climate change scenarios



We used the average of CCCMA_CANESM2, CESM1-CAM5, CSIRO_MK3.6.0 and MIROC-5 CMPI5 GCMs because **Ongoma** and **George** noted that are among the top eight models that well simulate rainfall patterns for the East African region.

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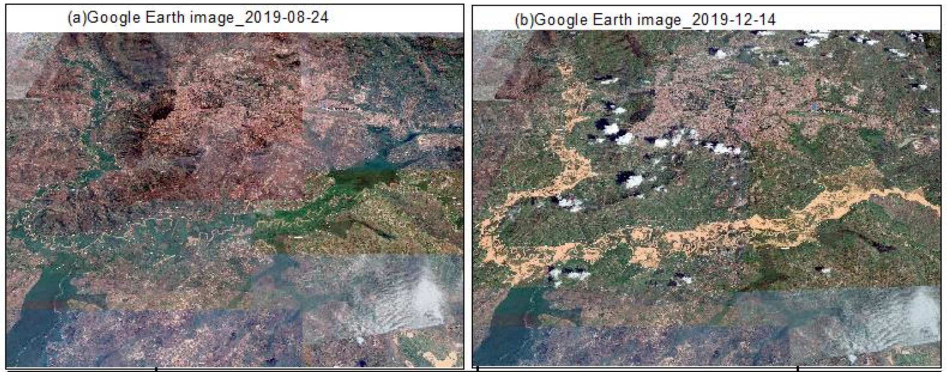
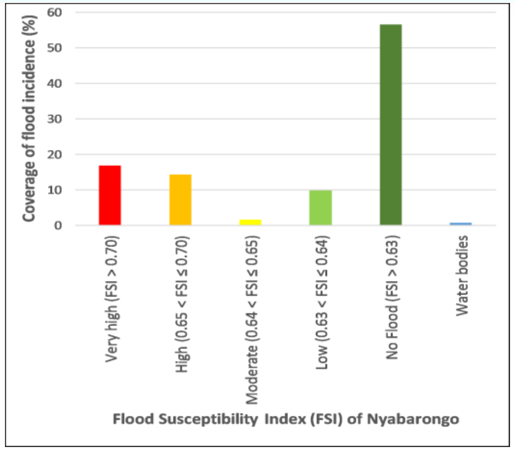
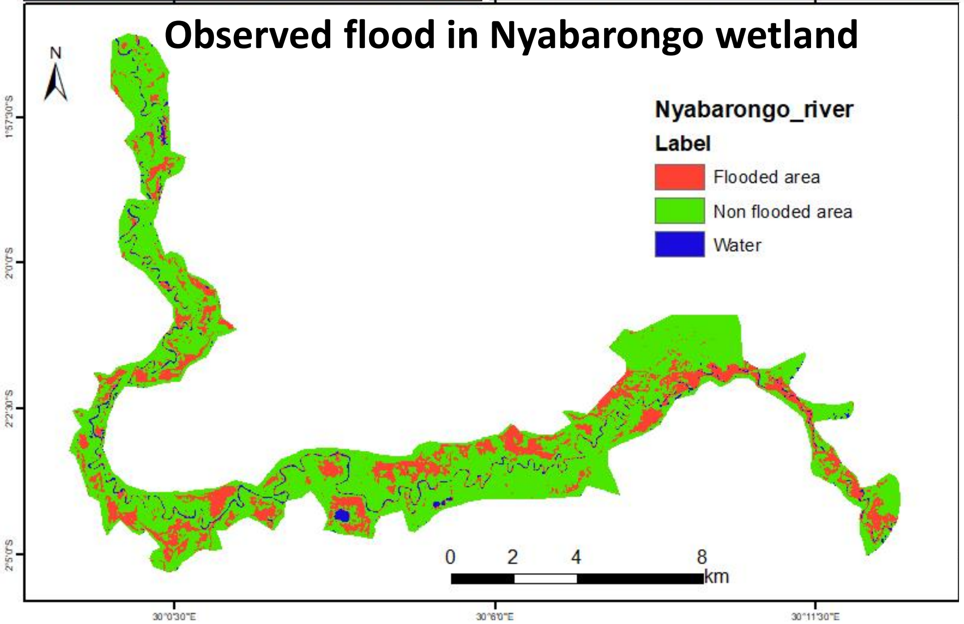
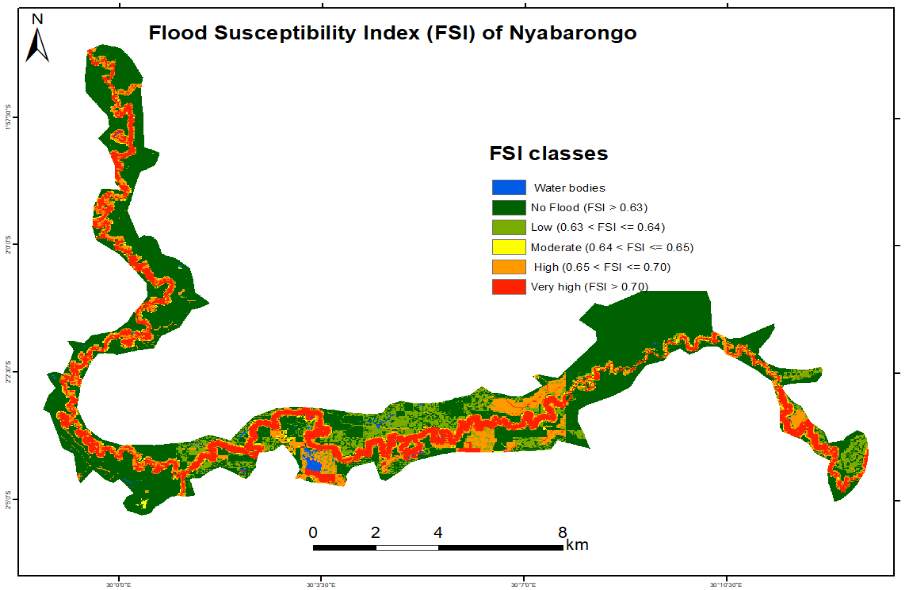
Validation of FSI in Rwanda





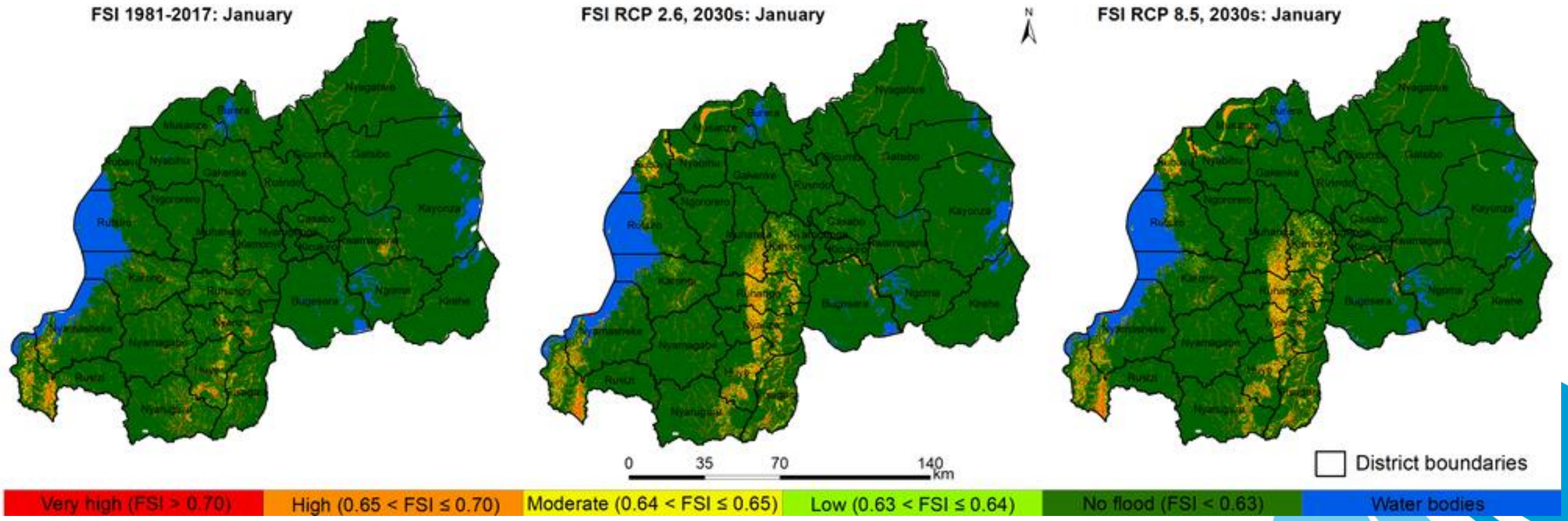
Observed flood in Nyabarongo wetland





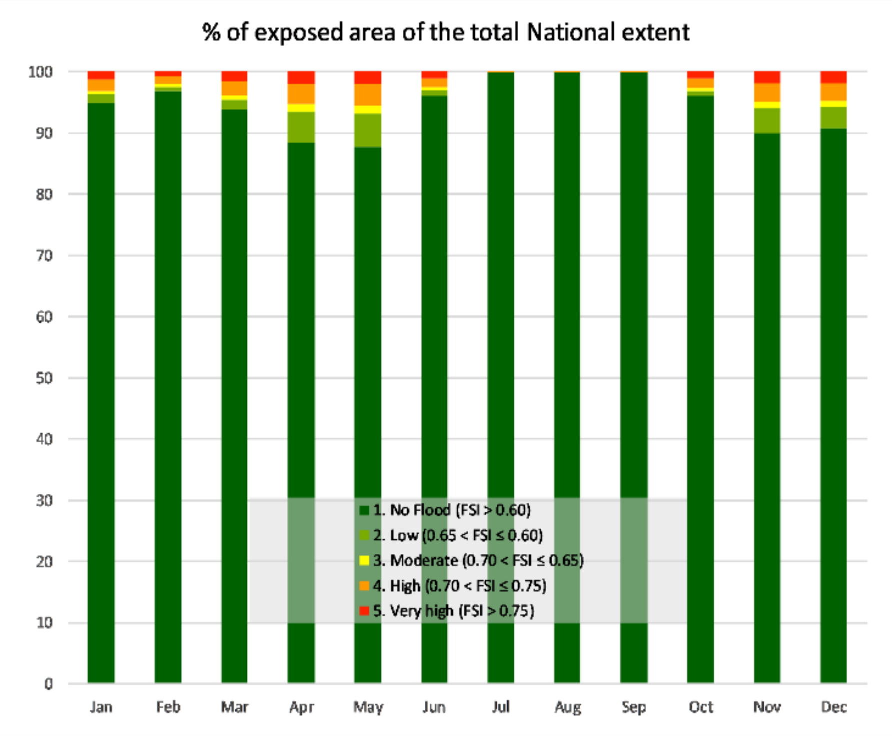
Results

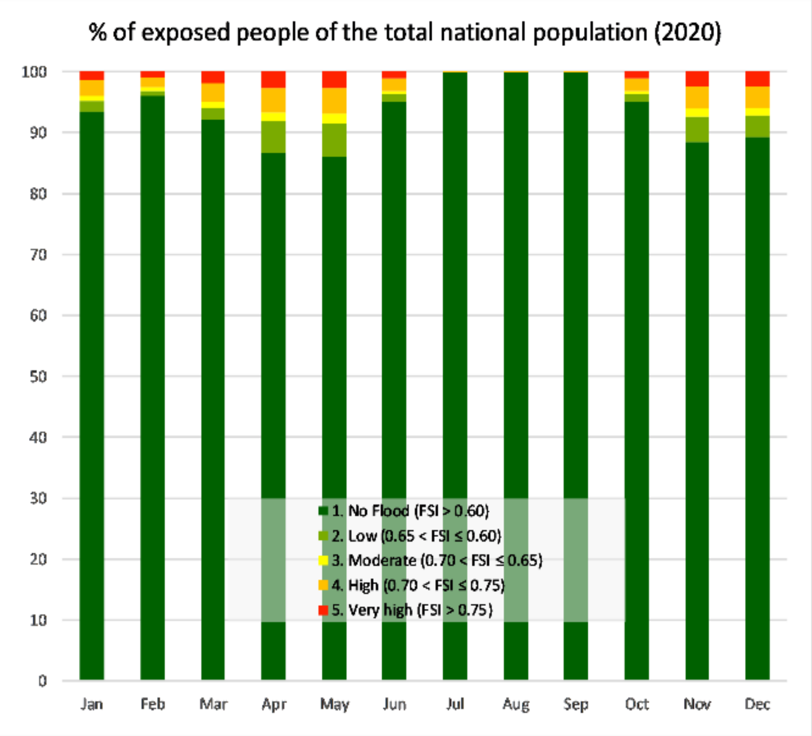
Comparison of current and future predicted Flood Susceptibility Index (FSI) in Rwanda



Cont’s

The extent of exposed area and population to flood(current)





- The precipitation prayed a vital role on flood.
- The rainy season (April, May, November, and December) is the time when many people and areas are exposed to floods.

Results

- The Rwanda is mostly dominated by ridges and plateaus including the Congo Nile with a topographic feature that is entirely hilly.

  The rain water originating from the ridges, flows towards the valleys which cannot effectively absorb and accommodate all the water owing to the increase in solid wastes from anthropogenic activities that clog culverts, water drainage systems within the area.

- It showed that the eastern province is the part of the country with low flood susceptibility, this can be justified by the topographic nature and the geomorphological aspect of the country.

- The areas with abundance of rainfall fell into highly susceptible classes. After modeling Flood Susceptibility Index, we perceived that the Distance to river and rainfall revealed a negative spatial correlation with flood occurrences.

Results

The next steps of this research

- To collect more flood incidences to accurately validate this model in Rwanda.
- Flood forecasting based on Meteo Rwanda’s forecasted rainfall.
- Analysis of exposed areas and population at district level.

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THANK YOU