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Implementation of customized hydropower model for enhancing the hydropower generation in Tanzania

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1. Introduction

- Tanzania, situated on the eastern coast of Africa, is bordered by Kenya and Uganda to the north, Rwanda, Burundi, and the Democratic Republic of the Congo to the west, and Zambia, Malawi, and Mozambique to the south.

- Its strategic location provides access to various rivers and water bodies, making it an ideal location for hydropower generation.

- Tanzania is blessed with numerous rivers, lakes, and water bodies, which contribute to its vast potential for hydropower generation.

- Tanzania is one of the few country in Africa that has many transboundary water resources (**14 in total**)

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Tanzania Hydrological Basins

- Those transboundary water resources are part of the **9 Lake/River basins.**

Those 9 lake/river basins are

1. Pangani Basin
2. Wami/Ruvu Basin
3. Rufiji Basin
4. Ruvuma Basin
5. Lake Nyasa Basin
6. Internal drainage Basin
7. Lake Rukwa Basin
8. Lake Tanganyika Basin
9. Lake Victoria Basin

- Among the 9 Lake/River basins **7 of them are transboundary** while **only 2 (Rufiji and Wami/ ruvu**) are not transboundary.

- **Rufiji is the largest Basin** and most of the hydropower plants are located there

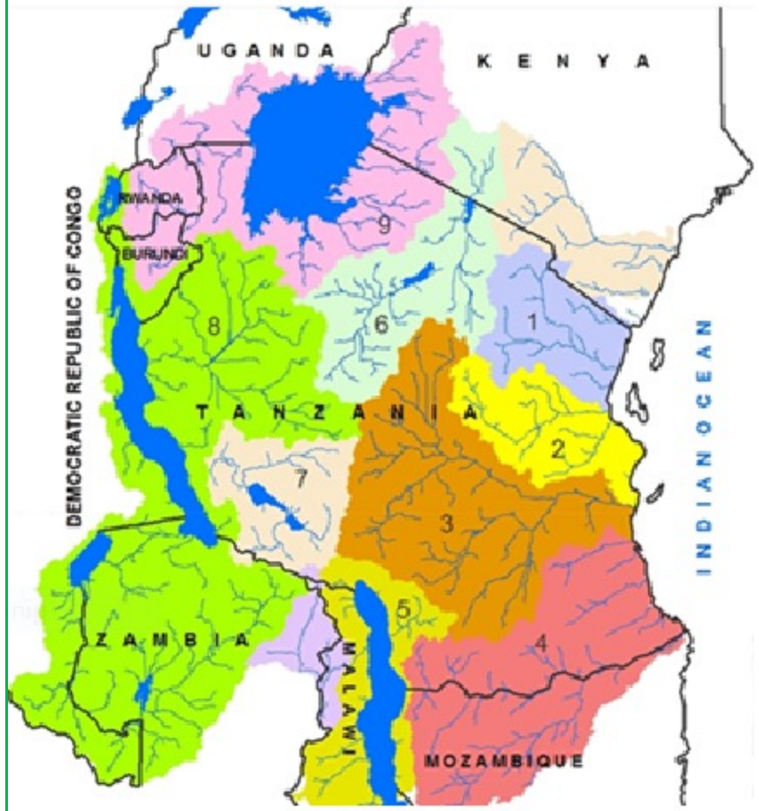

Figure1. Lake/River basins with their associated river channels

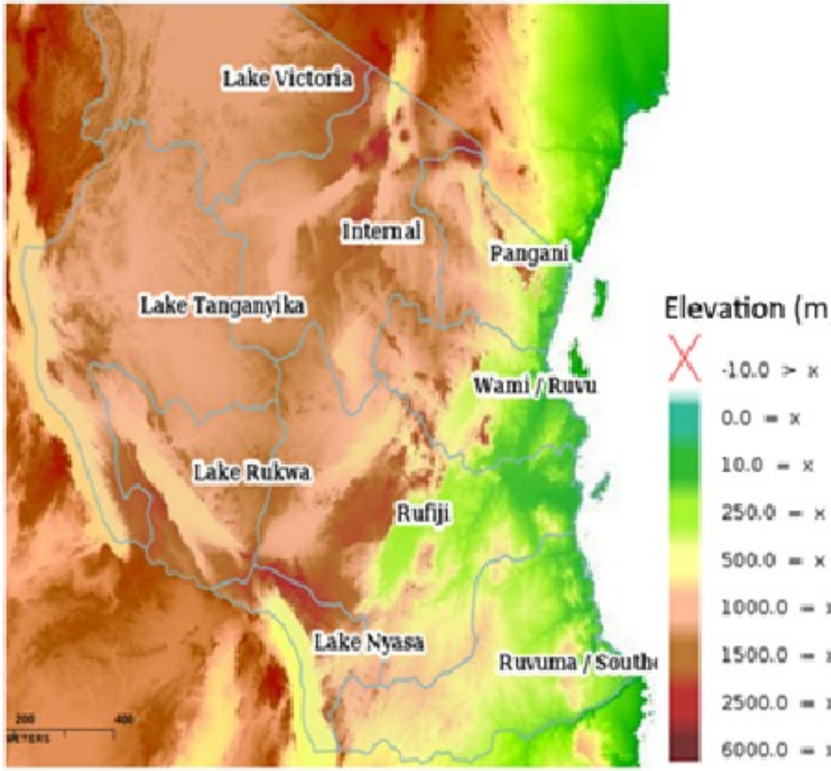

Figure2. Lake/River basins and elevation.

Tanzania Hydrological Basins

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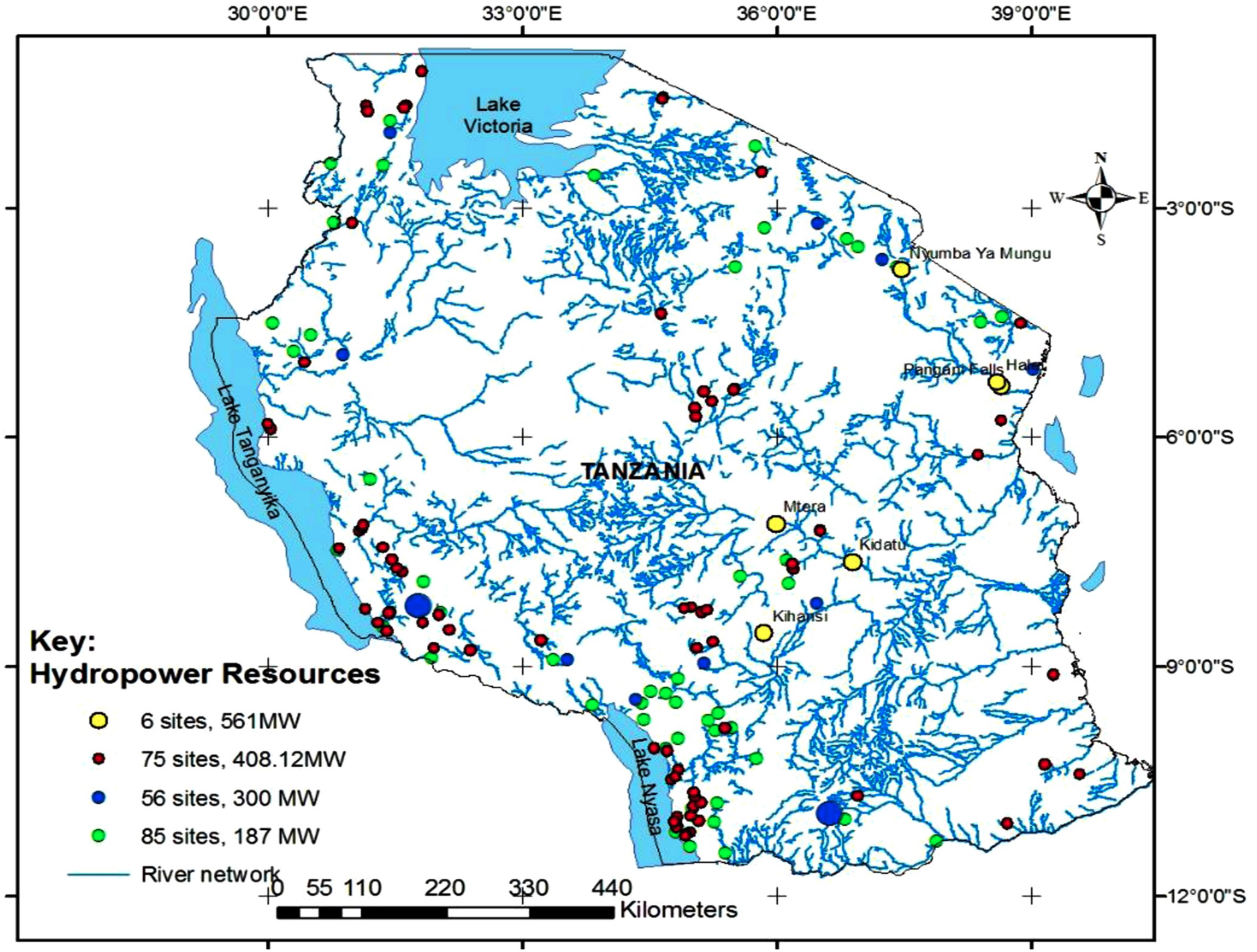
Several studies have indicated that Tanzania is the country that has many area where the small hydropower plants can be established.

Some of those studies include.

Ombeni J Mdee et al 2018 (as shown in the map)

Baraka KIchonge, 2018 (Indicated **75 small hydropower plant sites**)



Despite of having many water resources with various promising area for establishing new hydropower plants but still the **dependence of hydropower generation in Tanzania decreased from 96% in 2003 to 34% in 2015.**

Initiatives in enhancing hydropower generation in Tanzania

As part of its initiative to enhance hydropower production, Tanzania is currently undertaking the Julius Nyerere Hydropower Project, which is expected **to generate an impressive capacity of 2,115 MW.** This project reflects Tanzania's commitment to expanding clean and renewable energy sources for sustainable development.

1. Introduction: Objective of CS6

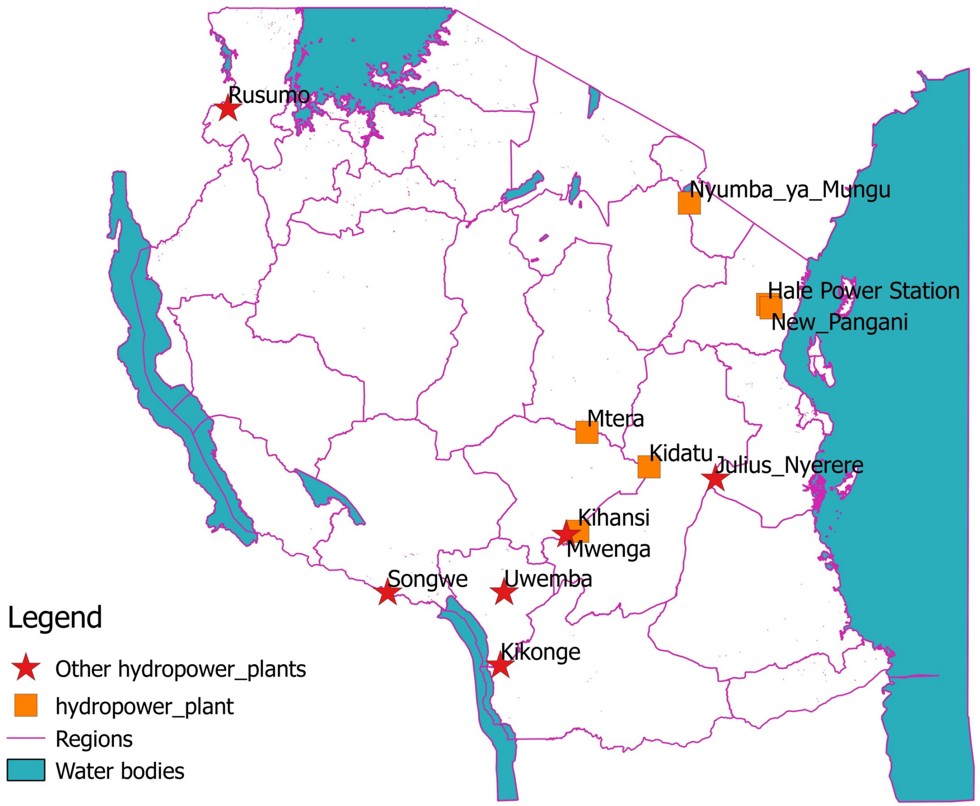
Despite of initiative taken in Tanzania;

Tanzania's hydropower sector is vulnerable to climate variability and change, highlighting the need for strategies that consider climate factors to ensure sustainability and resilience.

The Case study 6 under the FOCUS-Africa Project aims to develop a cutting-edge hydropower model that will incorporate climate parameter and hence better planning of the hydropower generation in Tanzania.

The hydropower model will focus on six main hydropower plants (Shown on the map with rectangle shape) with a data spanning from 2008 to 2022.

LIST OF HYDROPOWER PLANTS IN TANZANIA



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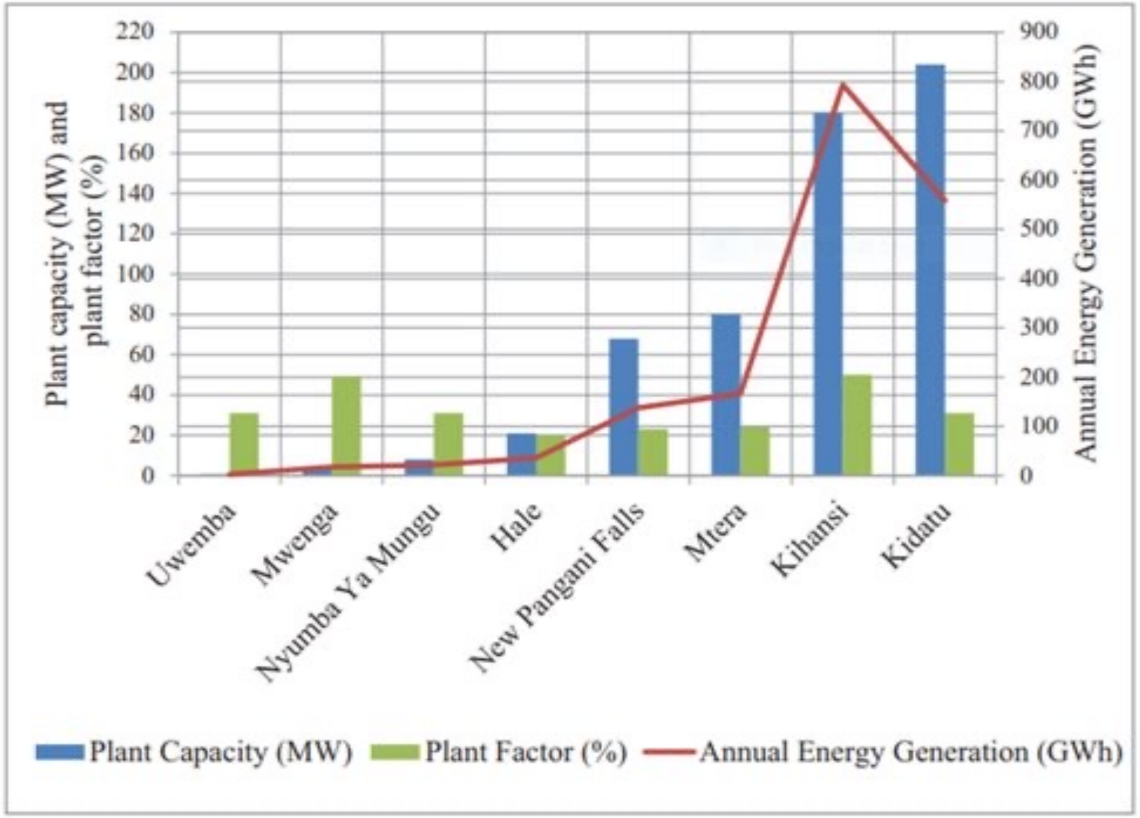
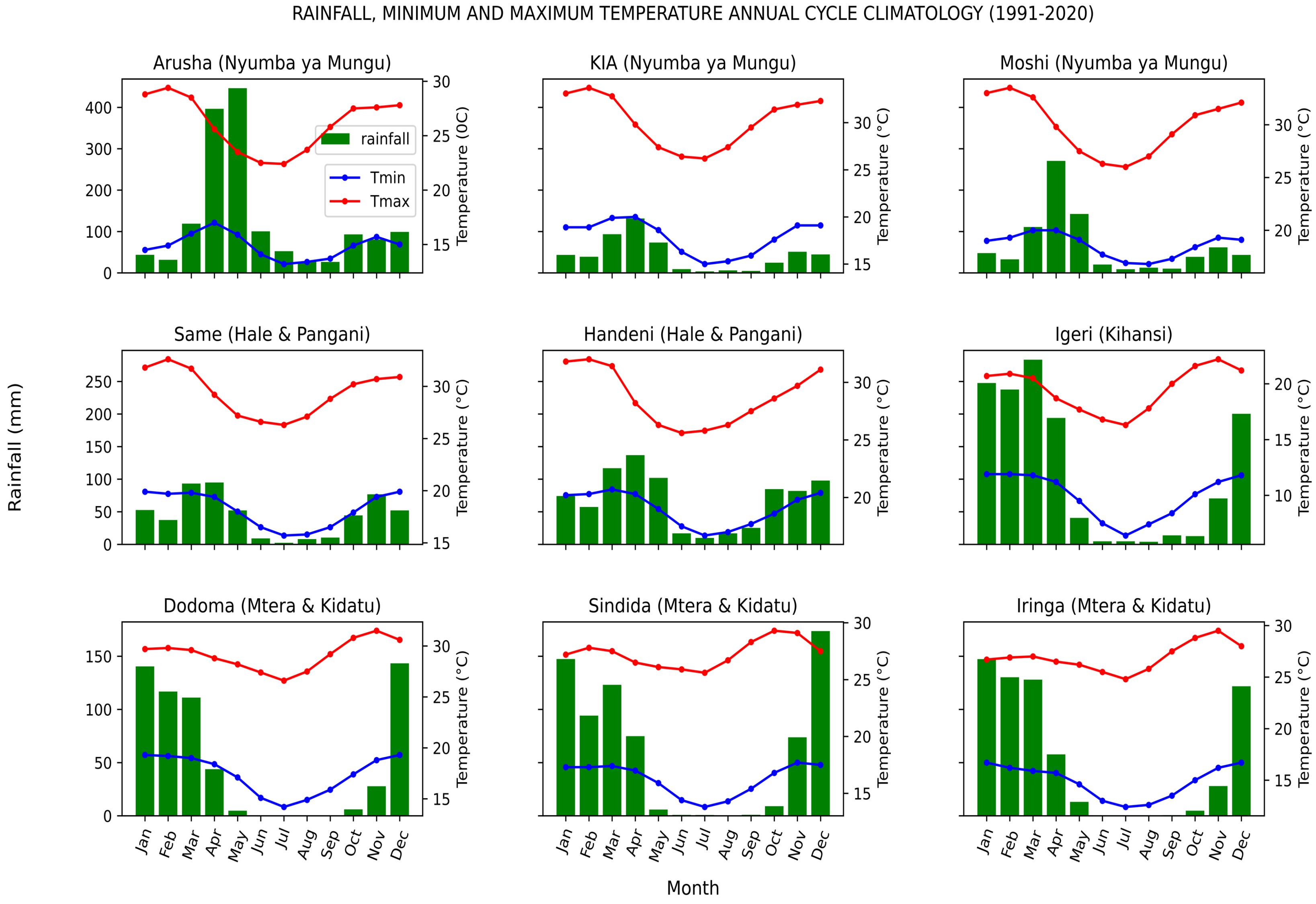
Hydro Power plants considered

Hydropower plant	Installed capacity (MW)	Plant factor/ performance (%)	Annual generation (GWh)	Generation type
Kidatu	204	31	558.34	Reservoir
Kihansi	180	50	793.49	Run-of-river
Mtera	80	24	166.68	Reservoir
Hale	21	20	36.11	Run-of-river
New Pangani	68	23	137.2	Reservoir
Nyumba ya mungu	8	31	21.53	Reservoir



Climatological characteristics

The meteorological stations situated in the hydropower plant catchment area together with their rainfall and temperature annual cycle.



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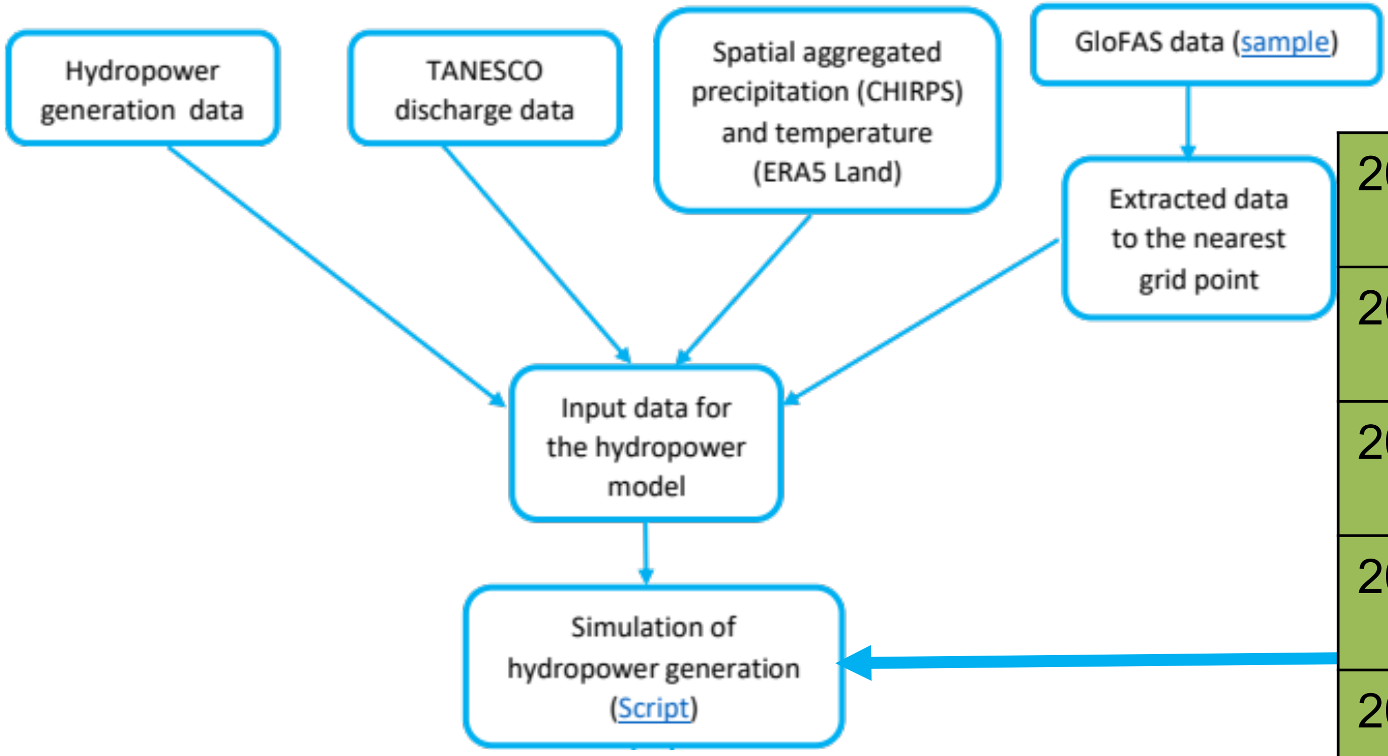
Methodology

SIMULATION OF HYDROPOWER GENERATION



Leave 1 out approach

2008	Predict 2008	Training period			
2009	Training period	Predict 2009	Training period		
2010	Training period		Predict 2010	Training period	
2011	Training period			Predict 2011	Training period
2012	Training period				Predict 2012

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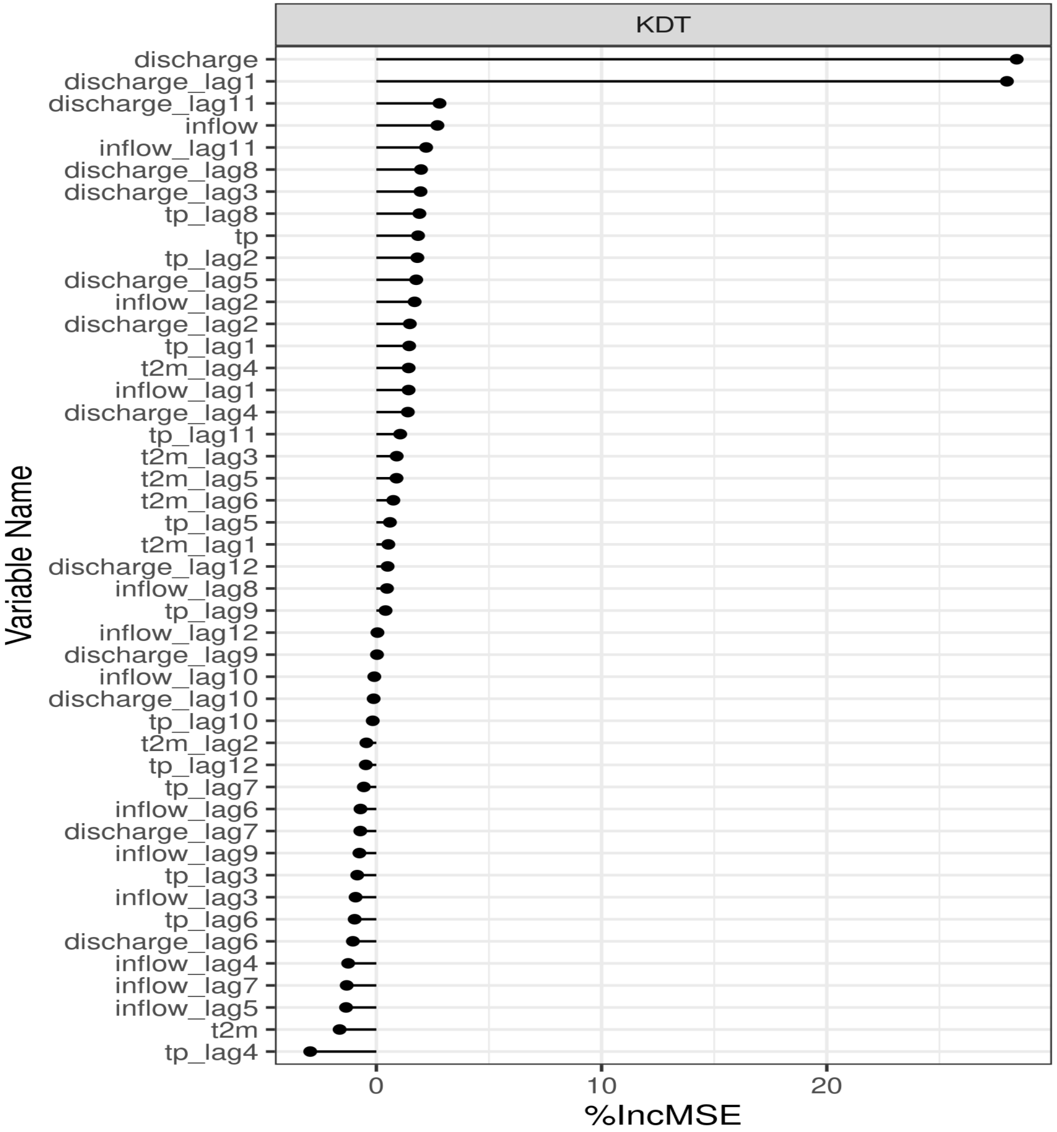
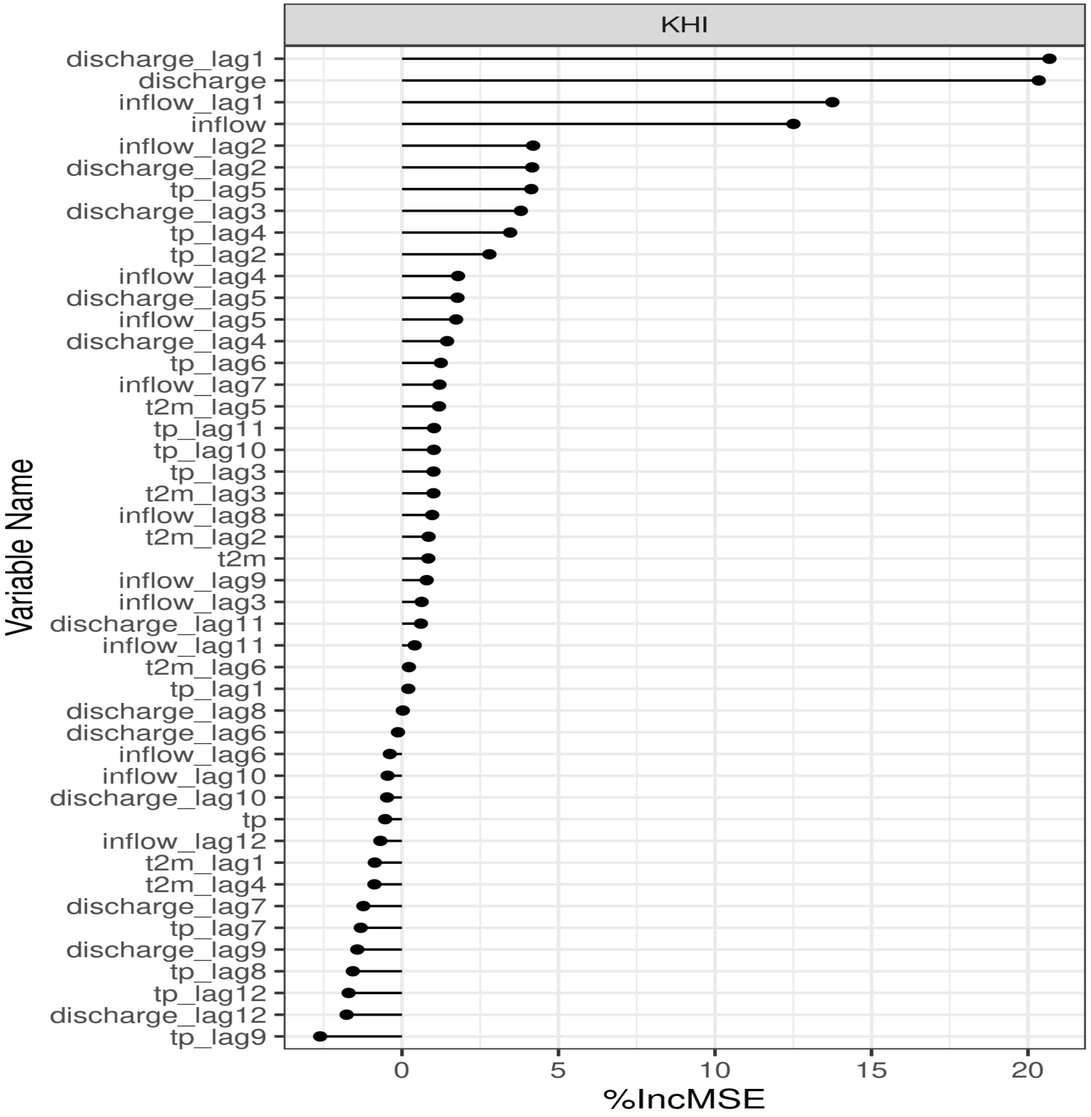
Importance variable assessment





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Result and Discussion

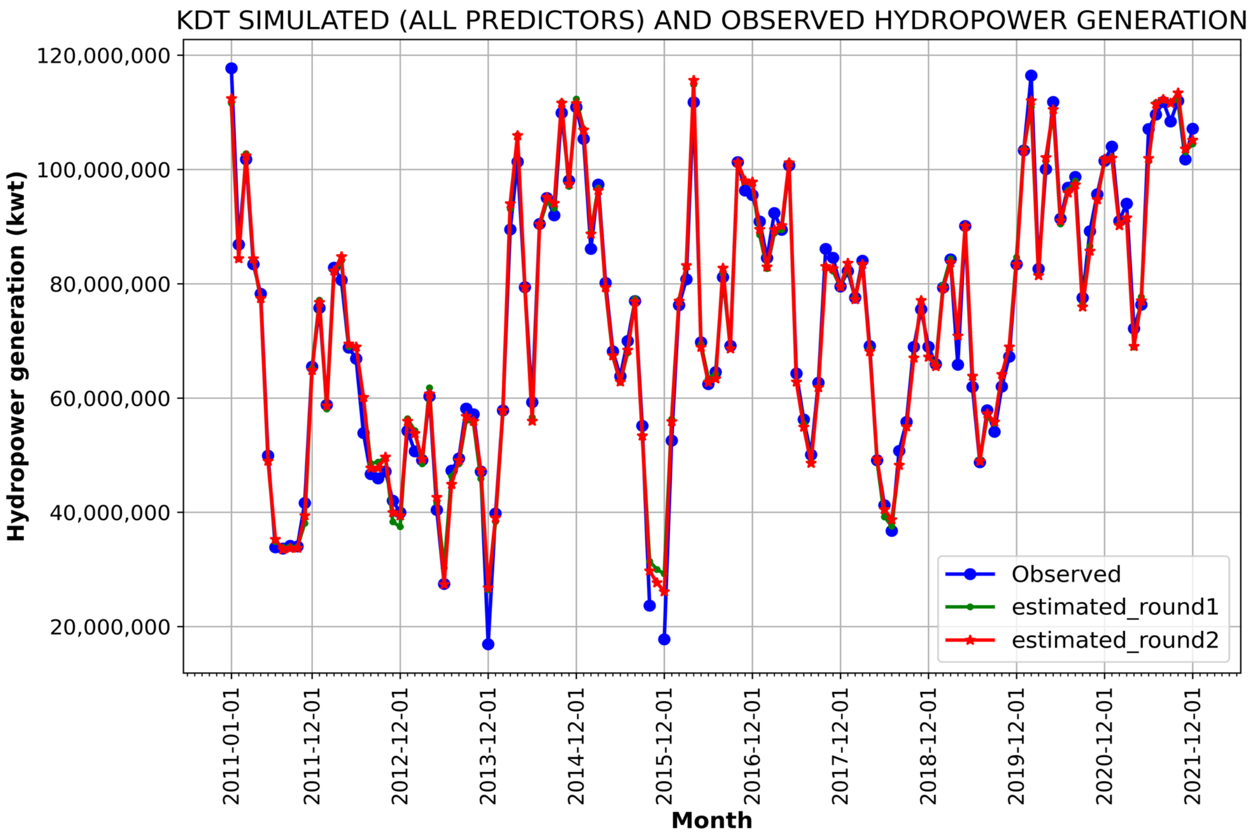
Simulation using Precipitation and temperature

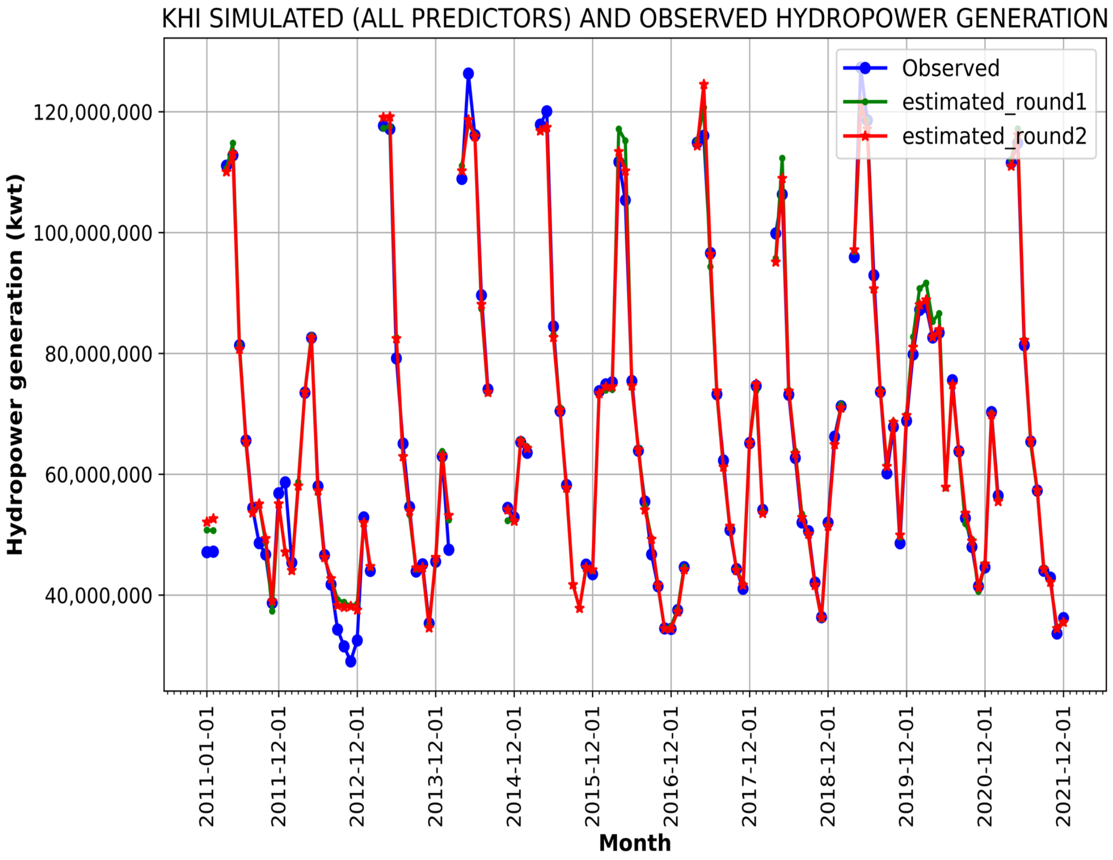
Hydropower plant	simulation	Correlation	Root Mean Square Error (normalized)
Kihansi (KHI) – RoR	Round 1	0.8113	0.2074
	Round 2	0.7646	0.2297
Pangani (NPF) – RES	Round 1	0.3582	0.5324
	Round 2	0.35121	0.5473
Kidatu (KDT) - RES	Round 1	0.3505	0.28590
	Round 2	0.3180	0.2944
Mtera (MTR) - RES	Round 1	0.3599	0.3468
	Round 2	0.3704	0.3541

Simulation using all predictors listed in previous slide

Hydropower plant	simulation	Correlation	Root Mean Square Error (normalized)
Kihansi (KHI) – RoR	Round 1	0.9942	0.0384
	Round 2	**0.9953**	**0.0346**
Pangani (NPF) – RES	Round 1	0.99095	0.0765
	Round 2	**0.9911**	**0.0749**
Kidatu (KDT) - RES	Round 1	0.9945	0.0307
	Round 2	**0.9953**	**0.0282**
Mtera (MTR) - RES	Round 1	0.9756	0.0865
	Round 2	**0.9759**	**0.0847**

Hydro Power modelling results





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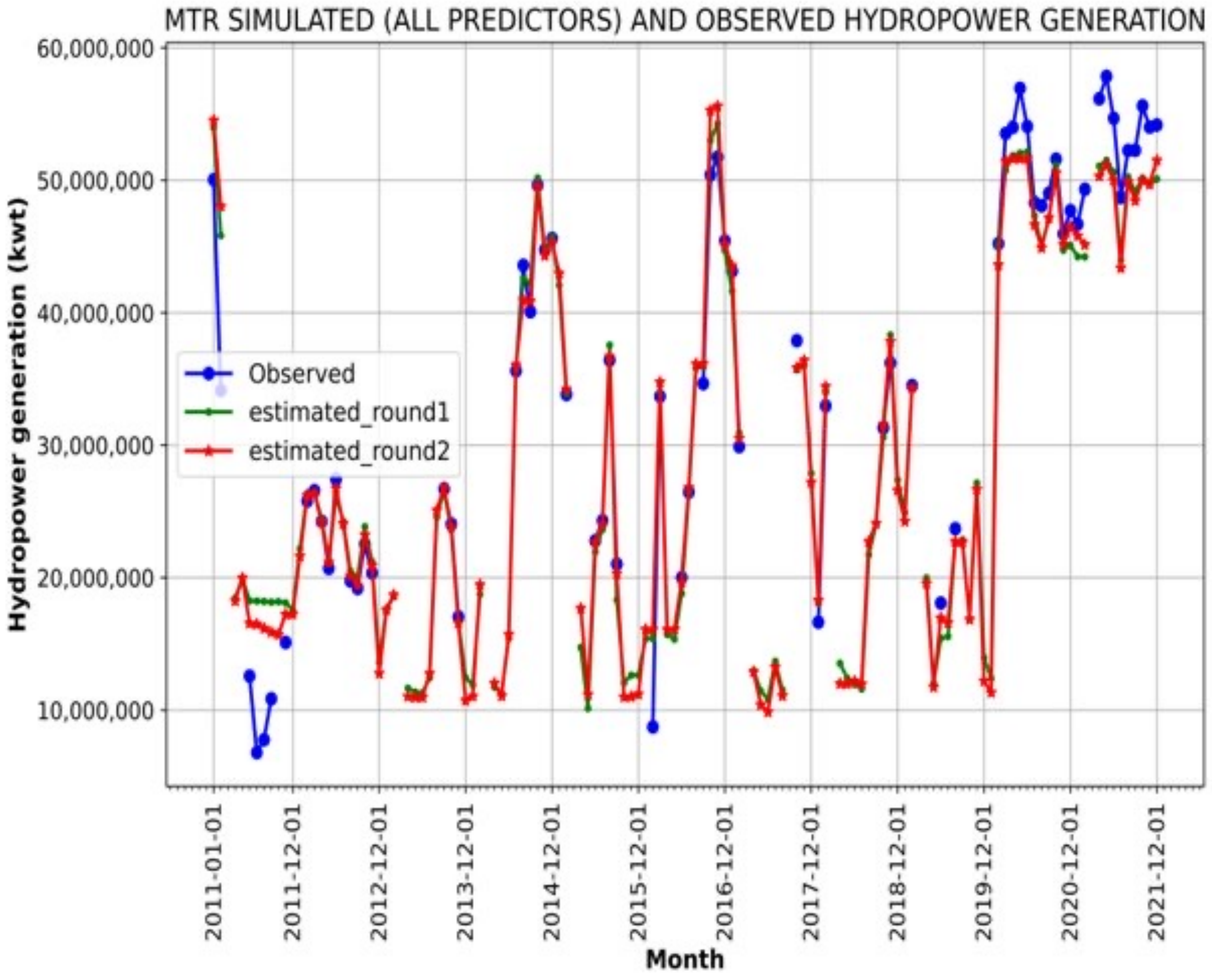
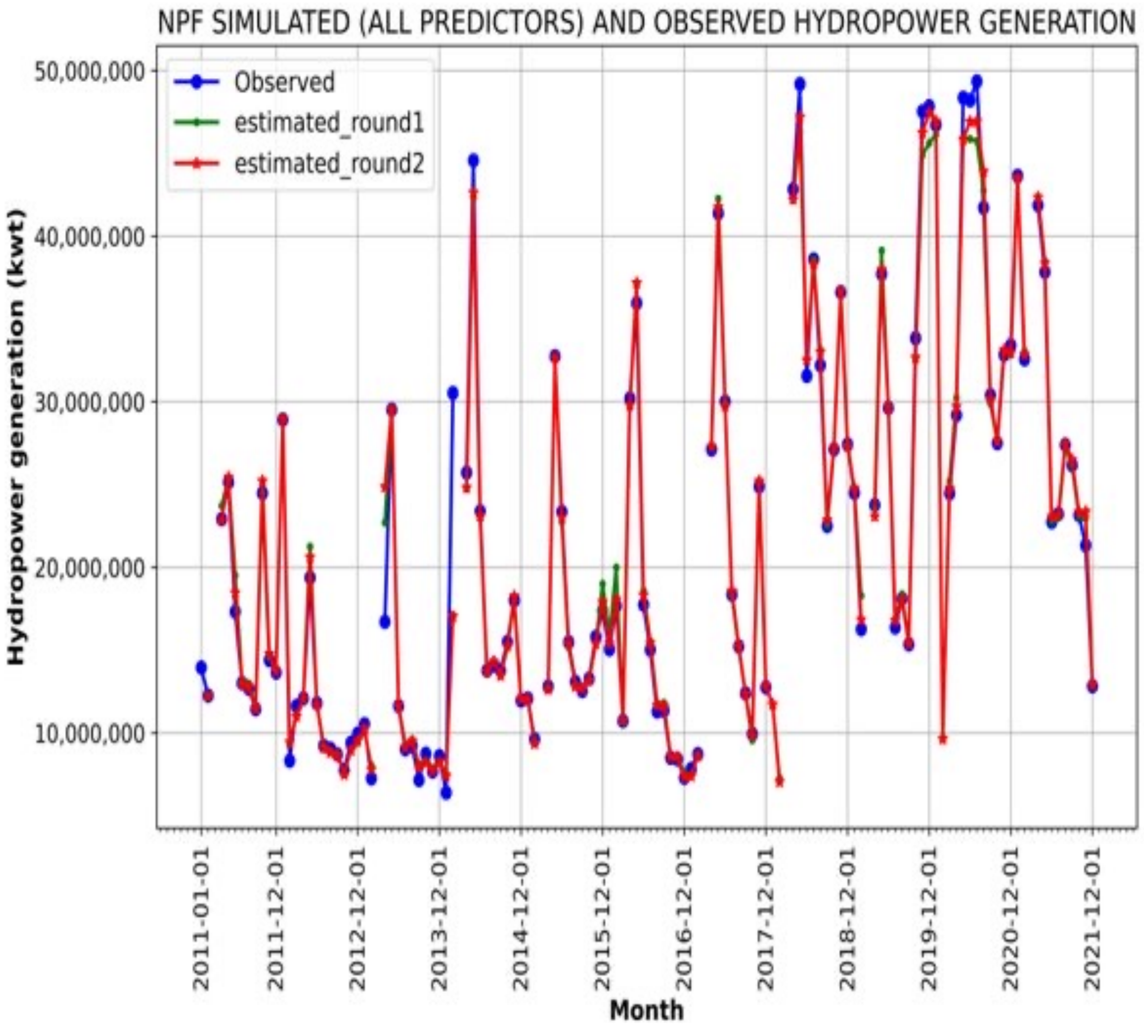
Hydro Power modelling results





Challenges and Limitations

- The performance of reservoir-based hydropower plants, such as Kidatu, Mtera, and Pangani, has exhibited shortcomings in simulating hydropower generation using precipitation and temperature data. **It is plausible that these limitations arise from human operation.**

- Nevertheless, the integration of river discharge data has yielded a remarkable enhancement in the simulation of hydropower generation.

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Conclusion and next steps

- The presented hydropower generation simulation using the random forest model covered the period from 2008 to 2022.
- The next step is to produce seasonal forecast for hydropower generation:
  - This involves bias adjustment of weather forecast models using CDFt based on reference data from CHIRPS for precipitation and ERA 5 land for temperature.
  - This adjustment will improve the accuracy of hydropower generation forecasting and support informed decision-making in the renewable energy sector.

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Thank you