Interdisciplinary User Perspective: Leveraging Earth Observation Data to Study Interdependence of Water, Energy, and Food Systems

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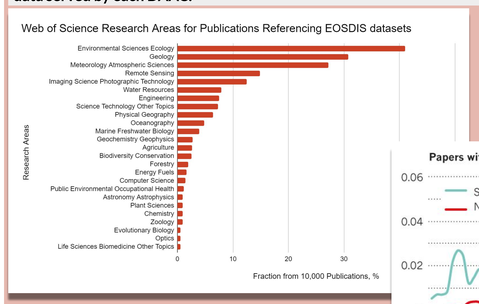
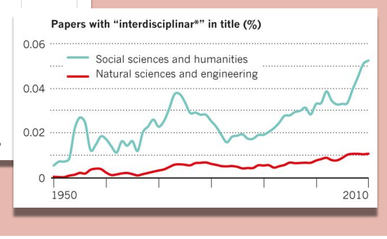
Motivation

As the world is facing large global challenges, researchers are moving away from a traditional way of doing science to a comprehensive and interdisciplinary approach. There is a growing community of interdisciplinary researchers and a need for data providers to think from an interdisciplinary perspective.

The current structures of the NASA Distributed Active Archives Centers (DAACs) are mission- or project-focused, and hence datasets are served with a user community in mind. Because of this, the interdisciplinary research community needs to explore different tools and services customized to the data served by each DAAC.





Water-Energy- Food (WEF)

The global demand for food, water, and energy is on the rise due to factors like urbanization, population growth, economic expansion, and regional conflicts. Given their interconnected nature, our study adopts an integrated Water-Energy-Food Nexus (WEF) approach to explore the interdependencies of water, energy, and food systems in developing country-Nepal as a use case and analyze the impacts of climate change on their consumption. Nepal, situated in Southeast Asia, presents a unique challenge with sparse and hard-to-obtain datasets.

Leveraging NASA's Earth Observation data hosted in the Earthdata Cloud, we accessed long-term observations of the planet at various resolutions and analyzed the WEF nexus at the administrative boundary in Nepal. We combined Earth Observation data, such as NASA's GLDAS (Global Land Data Assimilation System), Black Marble Night Light and demographic data to gain a holistic understanding of the region's water, energy, and food dynamics in the cloud environment.

Water-Energy- Food (WEF) Data

Research Questions

- What relationship exist between energy consumption, hydrometeorology and demographics?
- How have water availability, hydropower generation and consumption, demographics, and crop yield changed in Nepal over the last decade?

Theme	Variables	Collection Name	Temporal span	spatial resolution	temporal resolution	Format	Source	Hosted By
Temperature	Tair_f_inst	GLDAS_NOAH025_M	2000-01-01 to-date	0.25 degree	Monthly	NetCDF4	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1 (GLDAS_NOAH025_3H 2.1)	NASA GES DISC
Water Availability	Rainf_f_tavg							
	Evap_tavg							
	SoilMoi0_10cm_inst							
Energy Consumption	AllAngle_Composite_Snow_Free	VNP46A4	2012-01-01 to date	15 arc second (~500 m)	Yearly	HDF5	VIIRS/NPP Lunar BRDF-Adjusted Nighttime Lights Yearly L3 Global 15 arc second Linear Lat Lon Grid - LAADS DAAC (nasa.gov)	NASA LAADS DAAC
Crop Yield	Cereal Crop Area		2020/21	District	Yearly	pdf	Statistical Information on Nepalese Agriculture	Government of Nepal: Ministry of Agriculture & Livestock Development
	Crop production		2020/22	District	Yearly	pdf	Statistical Information on Nepalese Agriculture	Government of Nepal: Ministry of Agriculture & Livestock Development
Demographics	Population		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Population density		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Household with light from electricity		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Household cooking Fuel- Firewood		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Household cooking Fuel- LP		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Household cooking from electricity		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Household with amenities		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Cereal Production Area		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
	Population in agriculture, forestry, fishery		2021	District	Yearly	excel	National Population and and Housing Census	Government of Nepal: National Statistics office
Energy Production	Available energy of hydropower MWh		2021/2022	Hydropower station	Yearly	pdf	Annual Report	Nepal Electricity Authority

Workflow and Gaps

Workflow

Access Data in Cloud

Access data from the Earthdata Cloud (S3 Bucket)

- GLDAS_NOAH025_M 2.1 (Temp, Precip, Soil Moisture, Evaporation)
- VNP46A4 (Nighttime Light)

Download and clean the demographic data

Subset

Subset data by administrative boundary (district)

Calculate area-averaged mean by districts

Extract the Historical Electricity Generation of 19 Hydropower stations

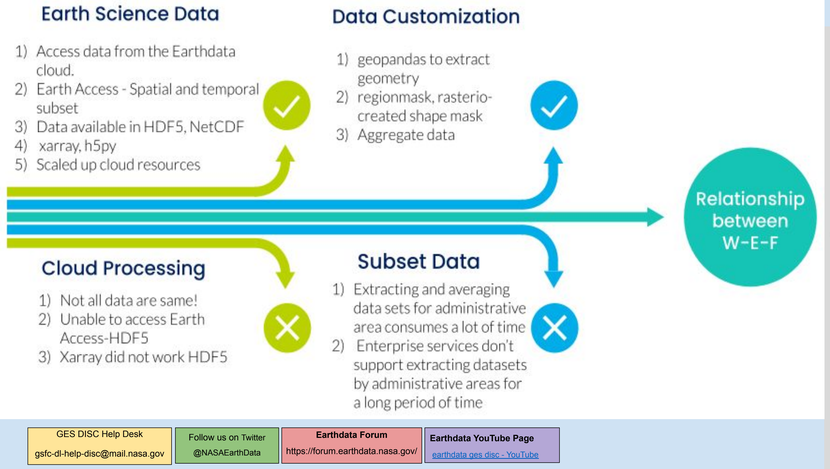
Analysis

Regression and correlation to study the relationship between hydrometeorological data and demographics

Challenges

- Analysis at watershed level was challenging, as demographics datasets are available at administrative boundaries
- Energy generation data was available for hydropower stations, but the distribution datasets are not available publicly

What worked, what did not

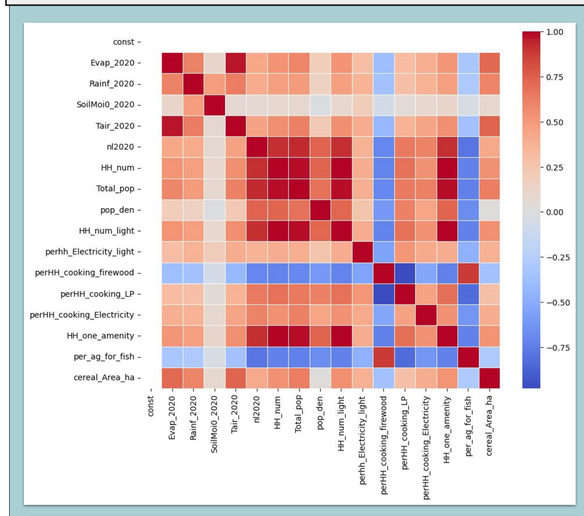


GES DISC Help Desk: gsfc-dl-help-disc@mail.nasa.gov | Follow us on Twitter: @NASAEarthData | Earthdata Forum: https://forum.earthdata.nasa.gov/ | Earthdata YouTube Page: earthdata ges disc - YouTube

Preliminary Observations

- Rainfall, number in household, population size, & households with lights are statistically significant in predicting night light, as indicated by p-value <0.05.
- Although cereal production area indicates less built up area, it is insignificant as indicated by p-value >0.05
- Future investigation to study the relations between energy production and hydro-meteorological parameters and how W-E-F dynamics have changed over time.

Preliminary Results



OLS Regression Results

Dep. Variable:	nl2020	R-squared:	0.913
Model:	OLS	Adj. R-squared:	0.891
Method:	Least Squares	F-statistic:	41.41
Date:	Mon, 04 Dec 2023	Prob (F-statistic):	1.11e-25
Time:	05:04:50	Log-Likelihood:	-546.90
No. Observations:	75	AIC:	1126.
Df Residuals:	59	BIC:	1163.
Df Model:	15		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	5221.9707	7146.041	0.731	0.468	-9077.224	1.95e+04
Evap_2020	4.011e+06	3.72e+07	0.108	0.915	-7.05e+07	7.85e+07
Rainf_2020	1.209e+07	6.48e+06	1.867	0.067	-8.69e+05	2.51e+07
SoilMoi0_2020	-17.4941	29.864	-0.586	0.560	-77.253	42.264
Tair_2020	-18.6168	29.070	-0.640	0.524	-76.786	39.552
HH_num	1.2731	0.706	1.802	0.077	-0.140	2.686
Total_pop	0.0057	0.001	4.165	0.000	0.003	0.008
pop_den	0.0256	0.139	0.184	0.855	-0.252	0.303
HH_num_light	-1.2819	0.700	-1.831	0.072	-2.682	0.119
perhh_Electricity_light	2.4444	3.554	0.688	0.494	-4.668	9.557
perHH_cooking_firewood	2.4571	13.615	0.180	0.857	-24.786	29.701
perHH_cooking_LP	4.0070	13.967	0.287	0.775	-23.942	31.956
perHH_cooking_Electricity	-64.0541	216.075	-0.296	0.768	-496.420	368.311
HH_one_amenity	-0.0050	0.040	-0.125	0.901	-0.086	0.076
per_ag_for_fish	-9.3395	7.701	-1.213	0.230	-24.750	6.071
cereal_Area_ha	-0.0054	0.004	-1.367	0.177	-0.013	0.003

Omnibus:	13.000	Durbin-Watson:	1.896
Prob(Omnibus):	0.002	Jarque-Bera (JB):	29.597
Skew:	-0.459	Prob(JB):	3.74e-07
Kurtosis:	5.937	Cond. No.	4.45e+11

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.