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International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

Kingdom of Morocco



Ministry of
Equipment and Water

Technical Innovations in Water & WEFH Nexus Data Integration: *Lessons from GC3WEFH and WEN-OKN projects*

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December 1, 2025, 2:30-4pm

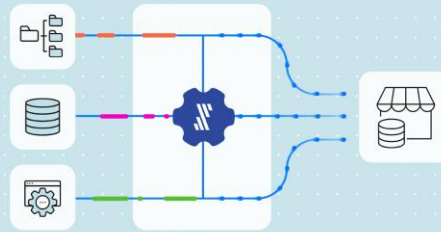
Water-Energy Nexus Open Knowledge Network (WEN-OKN)



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- **Problem:** Water-Energy Nexus is a complex system, but
 - Water and energy are managed in isolation
 - Policy landscape is fragmented
 - Data are siloed

Need a data integration framework!



Proto-OKN

About Projects Presentations Events Proto-OKN PI Portal Contact

Proto-OKN Collaboration

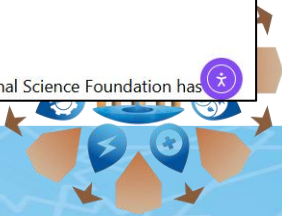
Facilitating the development and deployment of the first-ever Prototype Open Knowledge Network (Proto-OKN) to enable data-driven, artificial intelligence-based solutions and actionable insights that will drive U.S. competitiveness

Explore the Projects Join the Collaboration on Slack

NSF invests \$26.7 million in building the first-ever prototype open knowledge network

[Read the full NSF Press Release](#)

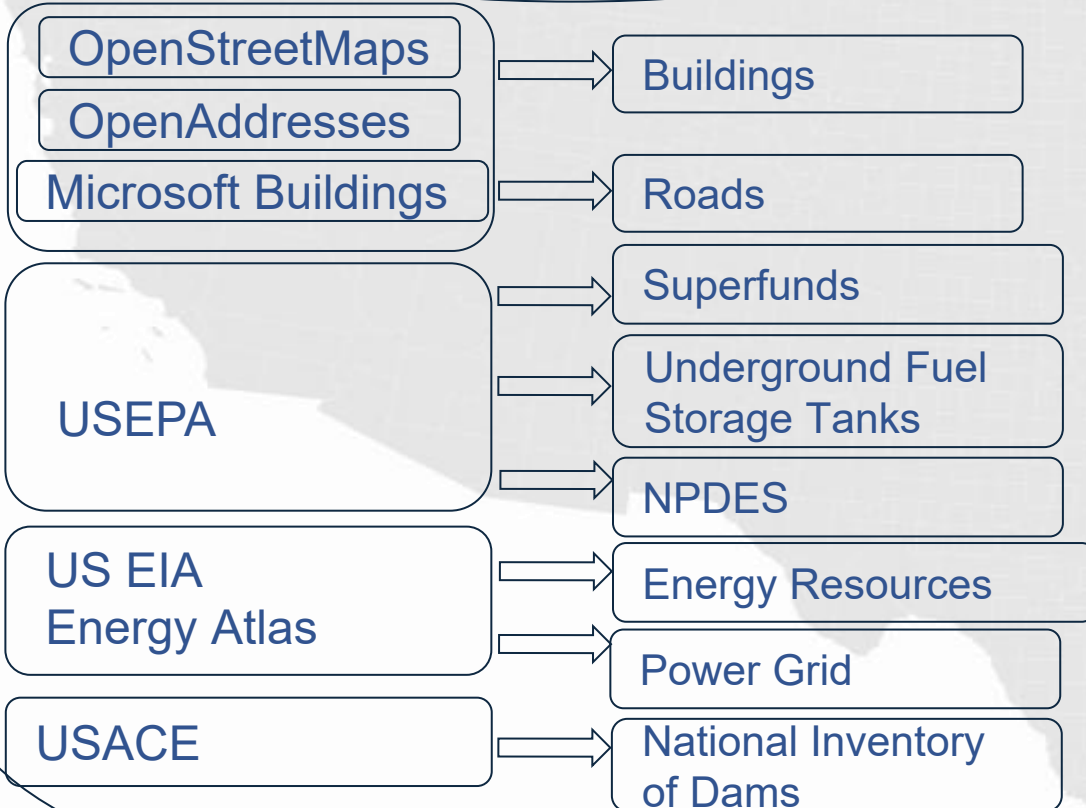
September 26, 2023 – In collaboration with five other U.S. government agencies, the U.S. National Science Foundation has



CONUS Scale Data Architecture

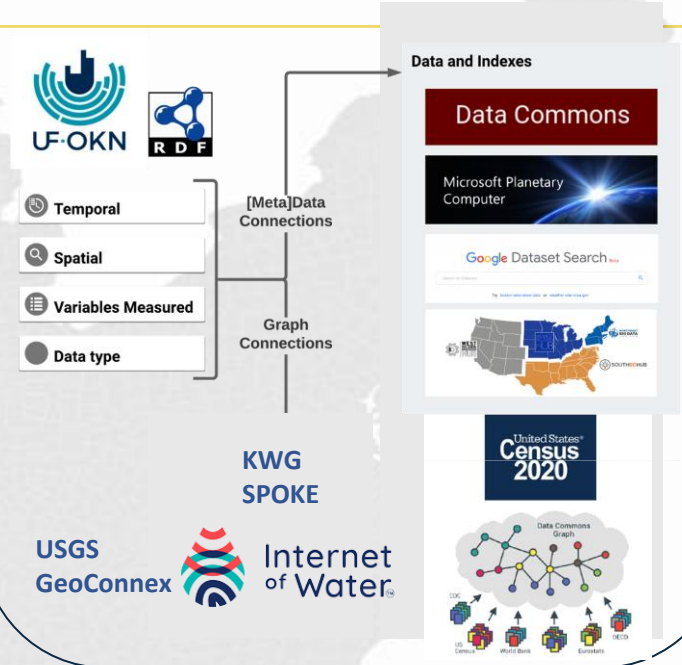
Urban Multiplex Inventory (UrMI)

- Federal and other open sources
- Seeds CONUS OKN for social, environmental, technological systems



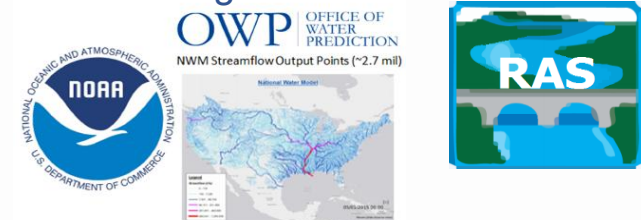
Connections

- Discovery, connections, analytics
- Impacts



Flood Forecasting & Hydrology Services

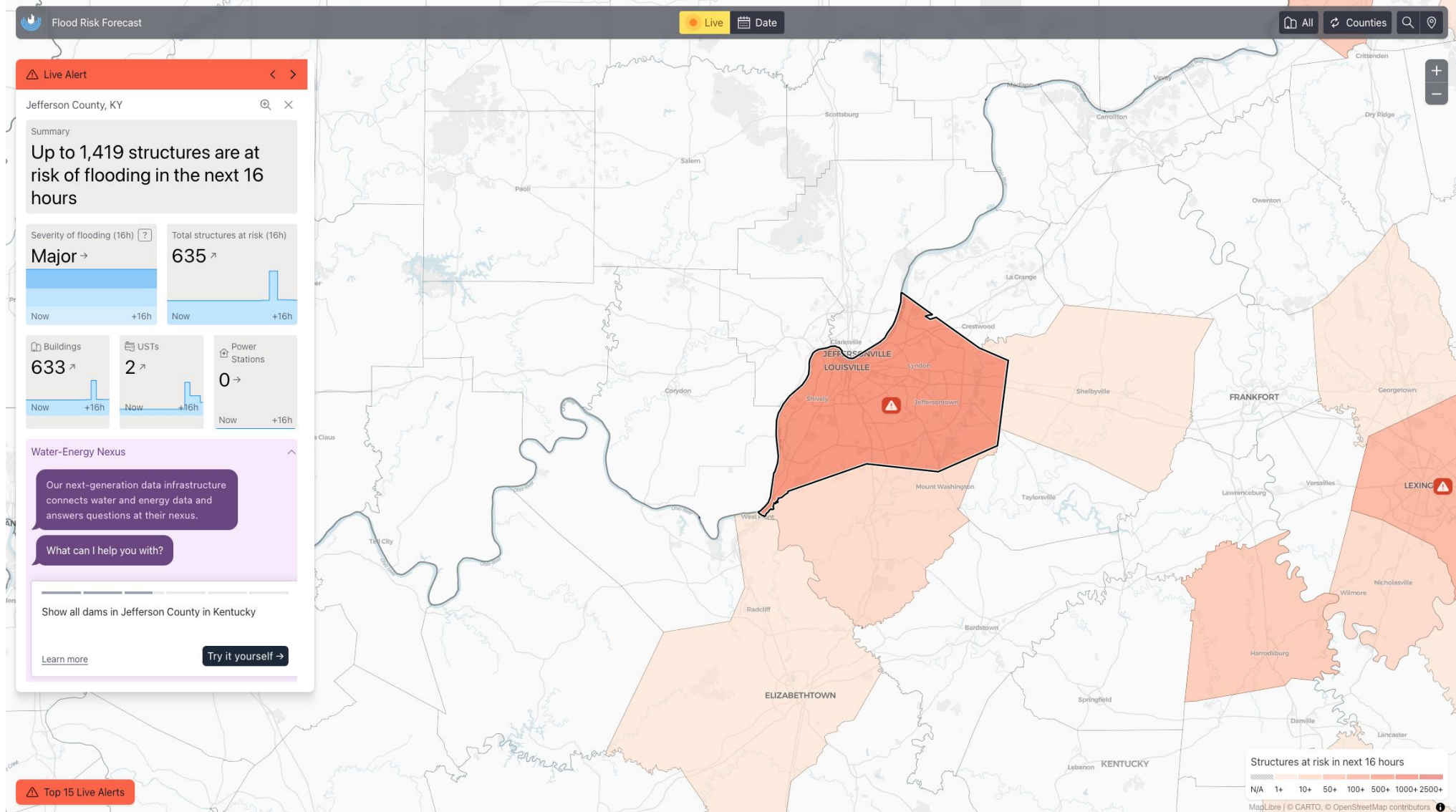
- NOAA, USGS hydrography, streamflows
- NOAA Climate Hazards
- Design flood risk



Questions at Nexus of Water-Energy

- **Water supply:** What are the current and future threats to water availability to meet water and energy needs
- **Water and energy demand:** How much is being used, where and for what purpose
- **Threat:** What are the current and future threats to water and energy infrastructure?
- **Rules/regulations:** Which rules/regulations currently support integrated thinking about water/energy?

Real-Time Flood Risk Forecasts



Demo



Find all dams on Ohio river



Your request has been processed.



Find all dams located upstream of the power station dpjc6wthc32 along the Muskingum river



Your request has been processed.

What can I help you with?



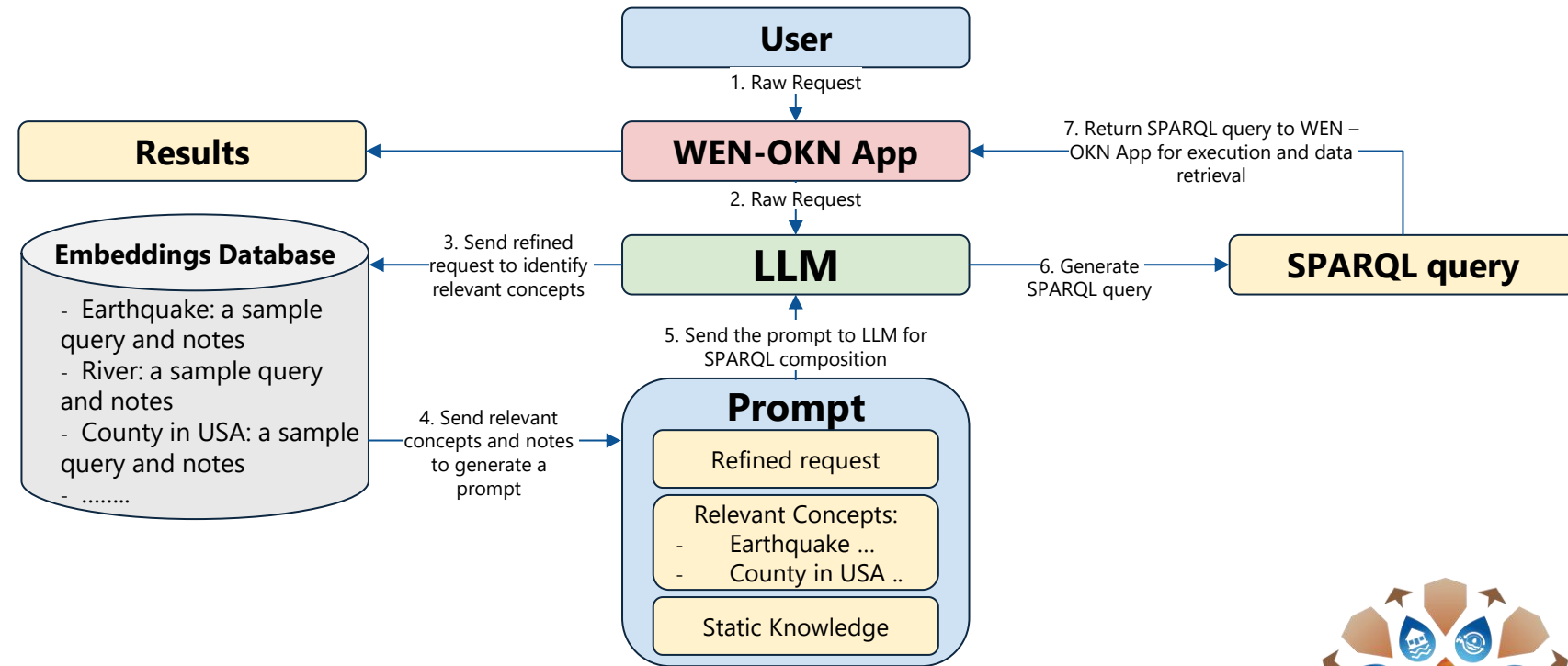
Select a sample query to edit and run as needed





WEN-OKN Integration Framework

- Several Knowledge Graphs and other data sources
 - Urban flooding OKN (UFOKN)
 - KnowWhereGraph (KWG)
 - Internet of Water (IoW)
 - Energy Atlas (ESRI services)
 - Google Data Commons
 - ...
- Queried using federated GeoSPARQL and source APIs
- Query plans are generated by LLM
- Efficient spatial indexing



Global Center for Climate Change and Water Energy Food Health Systems (GC3WEFH): Leveraging AI and Large Language Models



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**GC3WEFH Data Hub:
Navigating nexus datasets with SuAVE**

The screenshot shows the 'GC3WEFH Datasets' interface. On the left, there's a sidebar with 'Dataset Name' and 'Values' sections. The main area displays a grid of dataset thumbnails, including 'Administrative', 'Climate', and 'Environment'. A large grey arrow points from this interface towards the 'Jordan Standardized Precipitation Index' map.

LLM to find, explore and compare health indicators

The screenshot shows search results for 'Jordan'. It lists three items: 'Levant (Lebanon, Israel, Jordan, Syria, Palestine) 1:50,000 (PDR 1510, PDR 1521, MDR 499, GSGS 8061) maps index', 'Jordan Average Household Size', and 'Jordan Purchasing Power per Capita'. Each item includes a small map thumbnail and a description of the data layer.

The screenshot shows the 'Jordan Health Data' LLM interface. It includes a 'Map LLM' section with a map of Jordan and a table of data. The table has columns for 'Date', 'Temperature (C)', 'Avg Avg (C)', 'Wind (km/h)', 'Prec (mm)', 'Total Prec (mm)', 'Vis (km)', and 'Daily weather summary'. Below the table, there are buttons for 'Ajlun', 'Amman', 'Aqaba', 'Baqqa', 'Mafraq', 'Tafilah', and 'Zarqa'.

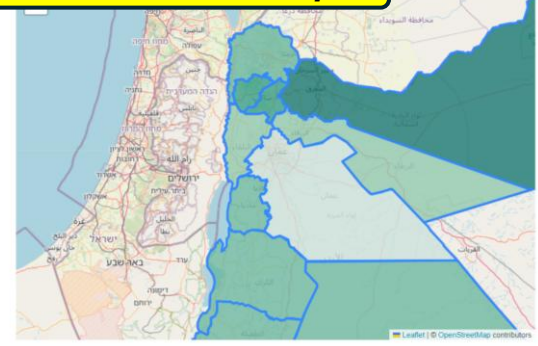
Jordan Standardized Precipitation Index



Daily summary at 13:00 UTC, (15:23 mean solar time)
Time interval: 50 days before 2023/03/02

Date	Temperature (C)	Td Avg (C)	Hi: (C)	Low: (C)	Wind (km/h)	Dir: (Dir)	Prec (mm)	Total Prec (mm)	Vis (km)	Daily weather summary
03/02	26.8	11.2	18.0	2.7	35.3	WSW	2.5	927.0	0.0	0.0
02/21	24.8	12.0	18.4	1.4	20.6	SE	6.1	930.1	0.0	0.0
02/28	23.0	10.8	17.3	1.2	29.9	ESE	8.8	933.7	0.0	0.4
02/27	22.4	8.8	15.0	3.0	5.0	ESE	5.3	932.8	0.0	0.8
02/26	19.4	7.5	12.4	5.3	65.5	WSW	3.2	929.1	0.0	0.0
02/25	17.8	6.6	11.1	5.8	71.8	W	3.2	927.1	0.0	1.6
02/24	15.1	6.2	10.3	4.8	70.5	WNW	5.6	926.2	0.0	6.2
02/23	21.0	6.6	11.7	5.0	66.2	WNW	7.9	925.6	0.0	1.8
02/22	19.9	5.2	10.8	4.7	69.9	WNW	3.9	928.1	0.0	0.0
02/21	19.0	7.2	11.5	3.0	60.0	W	9.5	929.2	0.0	1.1
02/20	18.4	5.5	11.5	1.0	46.5	ENE	1.9	932.0	0.0	0.0
02/19	17.6	4.2	10.6	0.7	49.8	SE	2.1	934.9	0.0	0.2
02/18	15.7	3.4	9.4	0.2	55.8	ESE	0.7	931.6	0.0	0.2
02/17	14.5	2.7	7.3	1.9	70.9	SSW	2.3	935.5	0.0	3.2
02/16	10.4	2.5	6.2	1.7	73.8	W	5.1	931.2	0.0	4.9
02/15	12.5	3.6	7.6	0.7	63.2	W	6.0	926.5	0.0	1.9
02/14	12.4	2.4	6.7	1.2	69.3	ENE	3.7	929.2	0.0	4.2
02/13	10.8	1.8	6.6	1.4	71.9	W	3.2	931.1	0.0	3.4
02/12	10.2	1.8	6.9	1.0	67.4	WSW	3.0	927.6	0.0	3.9
02/11	11.0	1.4	5.6	1.1	65.0	ENE	5.1	928.9	0.0	1.8
02/10	10.4	1.7	5.5	1.2	75.0	ENE	2.5	931.6	0.0	3.4
02/09	7.5	3.0	4.4	1.7	82.7	W	6.8	933.6	0.1	5.8

Online interactive maps



The screenshot shows the 'DHS Program' interface. It displays a list of surveys for Jordan, including 'Jordan Standard DHS, 2017-18'. The interface includes a sidebar with 'Survey Summary' and 'Survey Characteristics' sections. A map of Jordan is shown in the background.

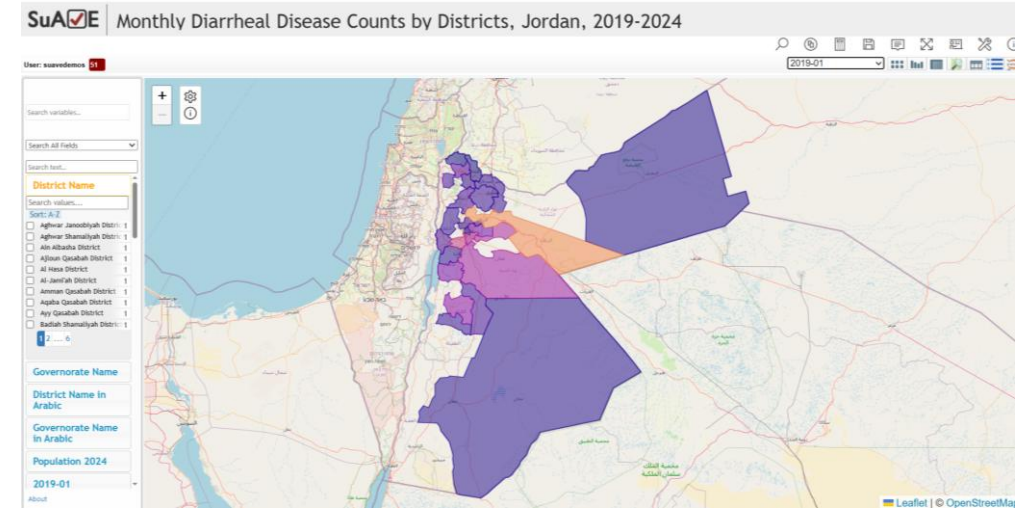


The Health Dimension of the Nexus



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- Health outcomes depend on climate change variables – but this relationship is not well understood in Jordan and elsewhere
- Many intervening WEFH factors!
- Information on individual exposures not available



What we have is 

Patient id	Gender	Age	Governorate	Diagnosis	Date	Allergy	Health Facility id	Health facility type	Health facility
xxxxxx	MALE	1	Madaba	FUNCTIONAL DIARRHEA	XX/XX/2019	\0	194	Comprehensive Center	East Madaba Comprehensive Center
xxxxxx	FEMALE	0	Zarqa	INFECTIOUS DIARRHEA NOS	XX/XX/2019	\0	228	Comprehensive Center	Amiryye Comprehensive Center
xxxxxx	MALE	0	Karak	DIARRHEA	XX/XX/2019	\0	278	Comprehensive Center	South Mazar Comprehensive Center
xxxxxx	FEMALE	58	Amman	Irritable bowel syndrome with diarrhea	XX/XX/2023	\0	371	Comprehensive Center	Naser Comprehensive Center
xxxxxx	MALE	1	Amman	Diarrhea, unspecified	XX/XX/2022	\0	281	Comprehensive Center	Wadi Al-Ser Comprehensive Center
xxxxxx	MALE	25	Mafraq	Other intestinal Escherichia coli infections	XX/XX/2022	\0	108	Hospital	AL-Mafraq Hospital



Challenges (1)



1. Hospital-based aggregation only (not individual addresses) - **prevents accurate estimation of personal exposure to climate variables.** Also, patients may seek care outside their home area
2. Multiple mediating pathways of climate impacts within the WEFH nexus, as **climate typically influences health indirectly**
3. Localized interventions (e.g., improved water treatment, heat-health alerts, vector control) can attenuate or amplify health outcomes - but these mitigation efforts aren't captured yet. Hence, hard to differentiate whether lower disease rates reflect **lower exposure or successful mitigation.**



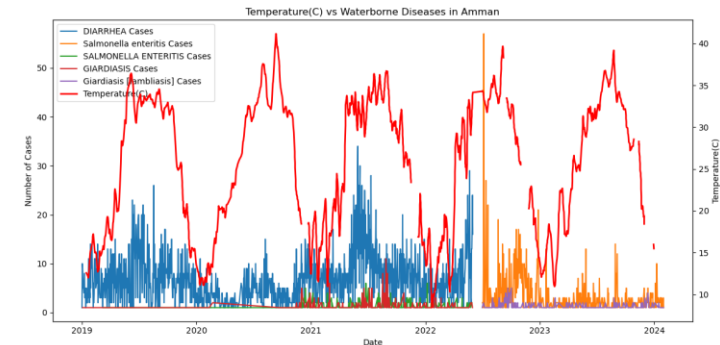
Challenges (2)

4. Spatial and temporal misalignment of climate and health data

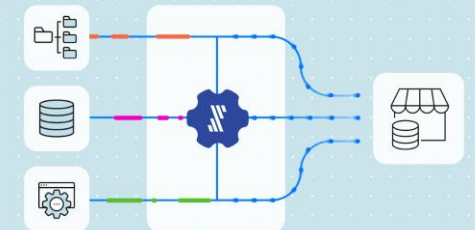
- Climate data – by stations or model-generated grids; health outcomes – by hospitals, administrative units.

5. Comprehensive changes in disease codes over time

- ## 6. Climate, environmental, healthcare, and demographic datasets typically reside with different entities – each using different **formats**, **collection frequencies**, **quality control procedures**, and **confidentiality protocols**.



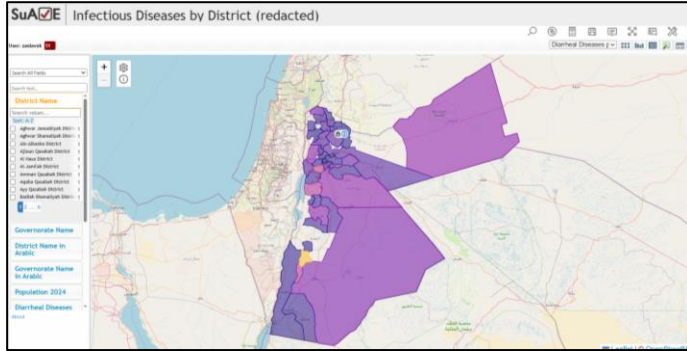
Need a data integration framework!



Hospital Service Areas (HSA) for Joint Analysis of Health and Climate Data



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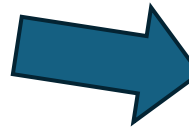
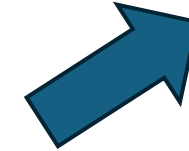
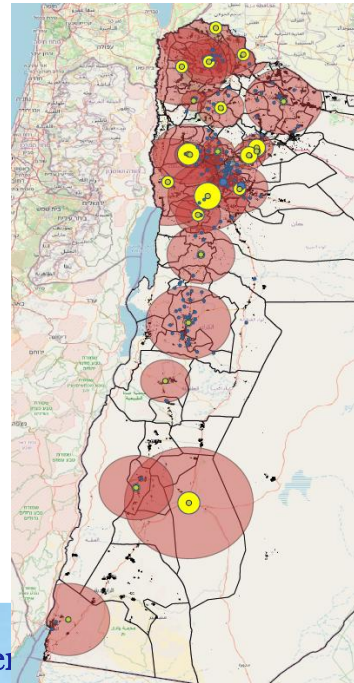
1. Interactive mapping and exploratory data analysis
Outlier detection and data cleaning, disease classification



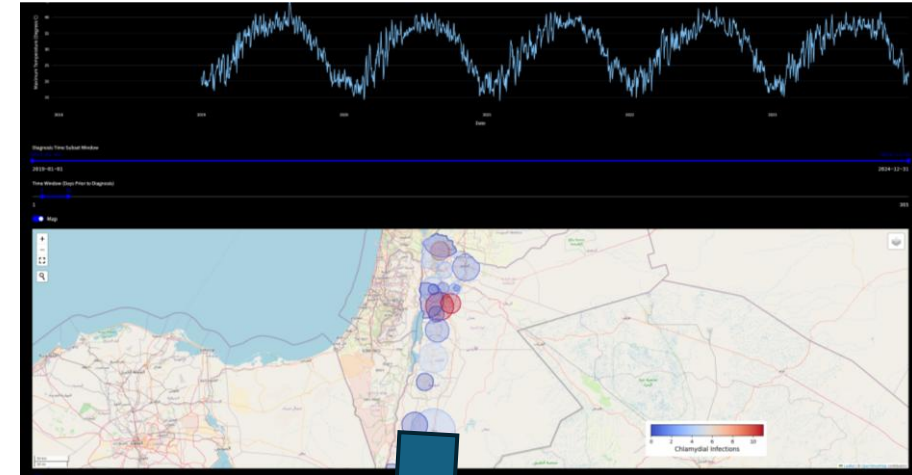
2. Defining hospital service areas and organizing patient data by the service areas



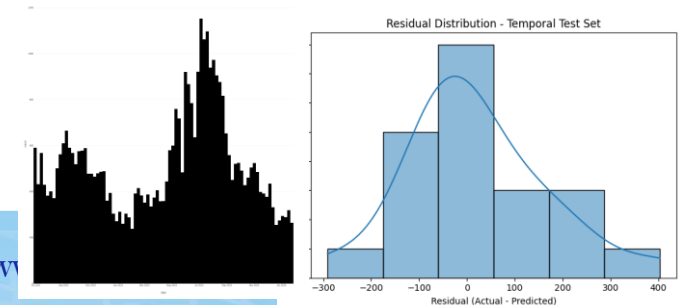
3. Deriving population and climate indicators by the service areas



4. Extensible platform for linking climate and health data



5. Modeling health outcomes with machine learning



New HSA Delineation Algorithm: Formal Requirements

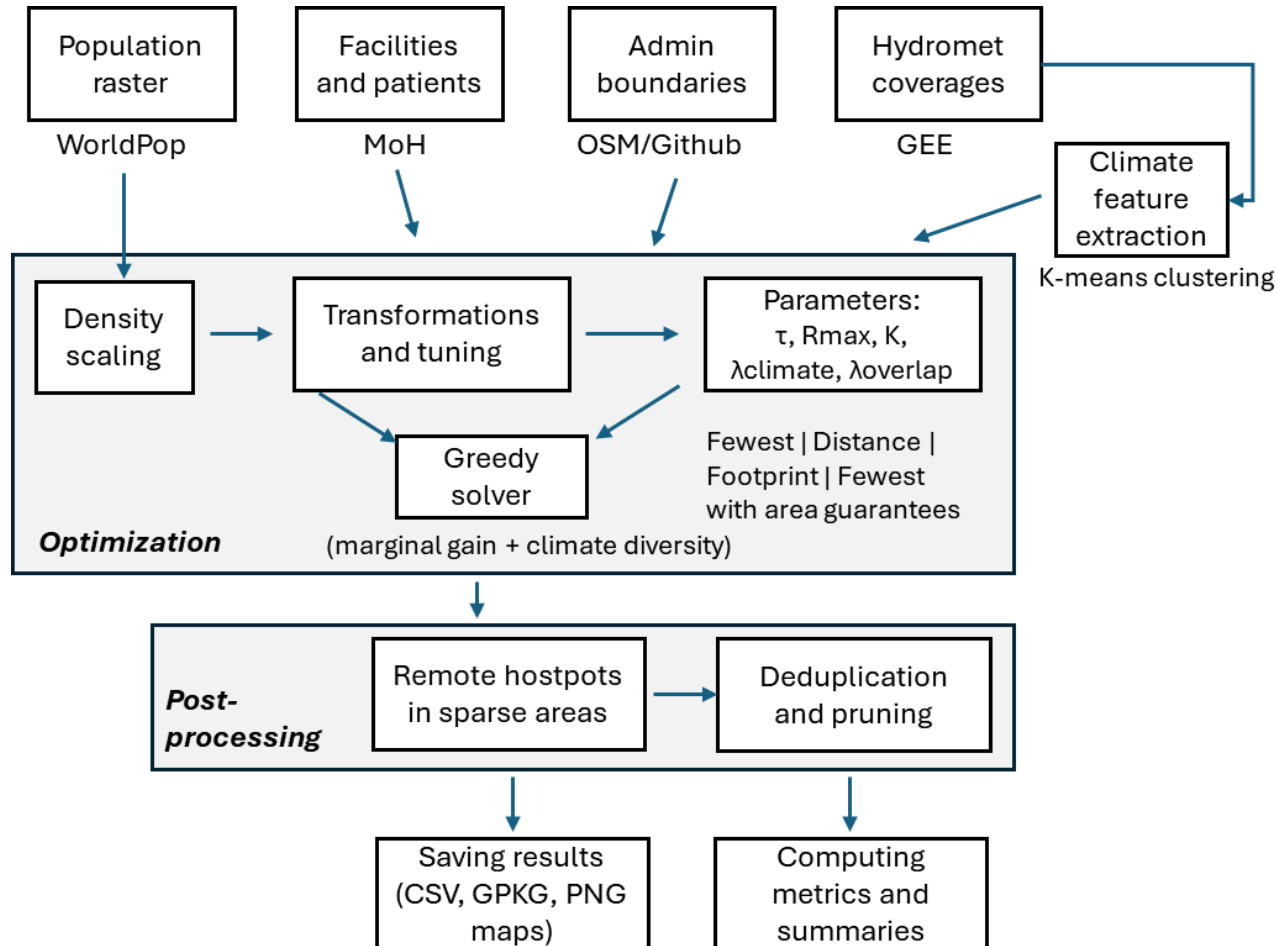


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- **Coverage.** HSAs should collectively cover a high proportion of the national population (typically 90–95%), ensuring broad geographic access to health services.
- **Choice in Dense Areas.** Allow overlapping HSAs in urban contexts where residents may access multiple facilities, reflecting real-world care-seeking rather than enforcing artificial exclusive boundaries.
- **Flexibility in Anchor Selection.** Do not impose hard volume thresholds; allow facilities of varying sizes to serve as anchors if they improve population access, recognizing heterogeneous health infrastructure.
- **Climate Diversity.** Select HSAs that span diverse environmental regimes to enable robust climate-health analyses, ensuring representation across distinct hydro-meteorological conditions.
- **Parameterizable Objectives.** Support multiple utility functions corresponding to different planning scenarios (minimizing facilities, maximizing coverage, minimizing travel distance, ensuring administrative equity), allowing decision-makers to match HSA generation to specific policy contexts.



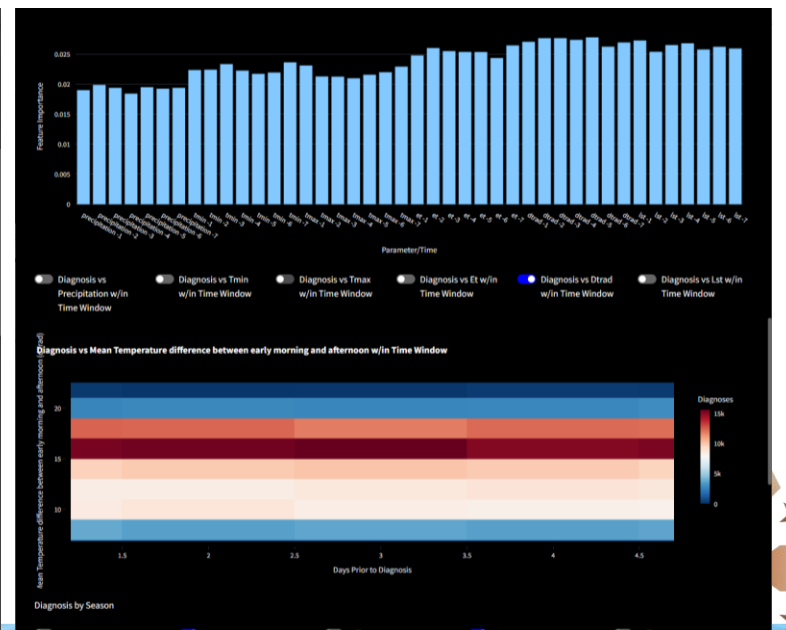
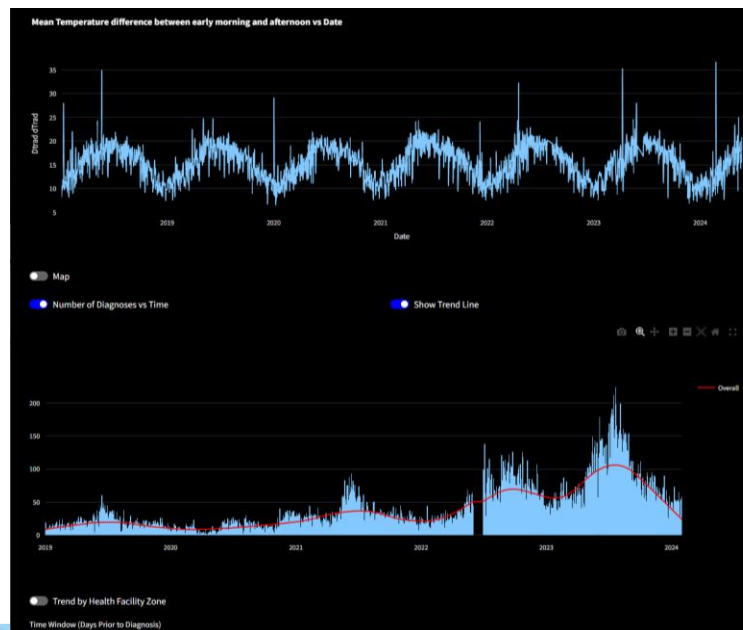
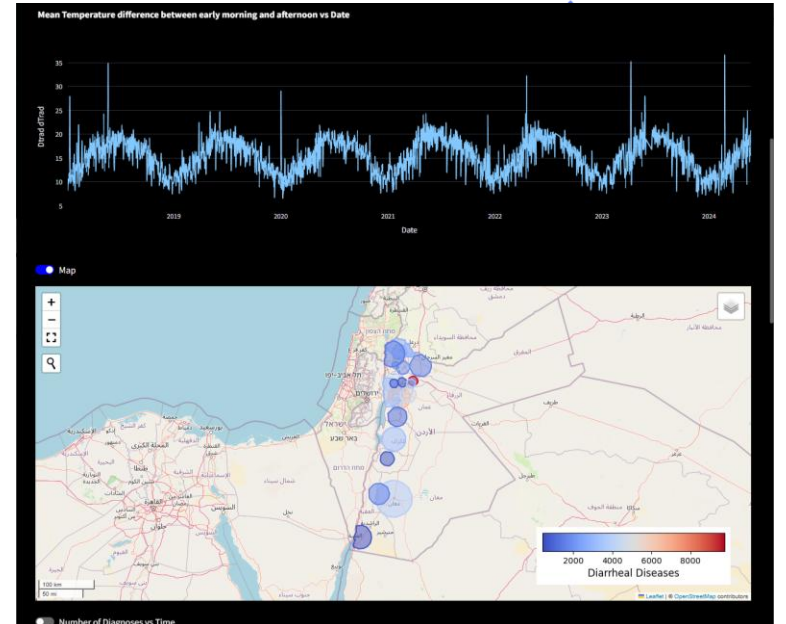
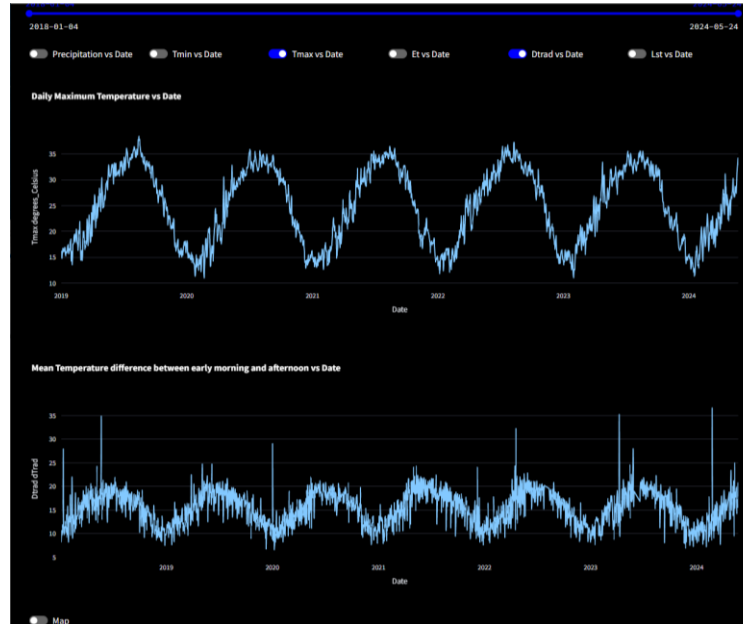
New HSA Delineation Algorithm: Implementation



- Weighted set cover optimization to create a spatial data integration framework balancing multiple factors
- Relying on global datasets, to be applicable across LMIC
- A range of scoring functions (minimum set cover; maximum coverage; minimal radius, stratified selection)



Prototype Information System Linking Climate and Health data by HSAs



Different Projects – Common Lessons



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- Data integration framework is a key challenge in nexus projects, with data from different agencies and systems, with misaligned spatial grids, temporal resolutions, data formats, etc.
- Key ingredients of a solution:
 - Easy to use standards-compliant catalogs and data access
 - Focus on data semantics
 - Integration framework tuned to specific project challenges
 - Careful application of generative AI – to ensure reproducible and explainable science
 - Modular and flexible architectures, using free open-source modules, region-agnostic



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Thank you!

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Support from the US National Institutes of Health, Fogarty International Center (award 1P20TW012709-01) and the US National Science Foundation PROTO-OKN program (award 2135943) is gratefully acknowledged

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