

Towards SWIM Narratives for Sustainable Water Management

**Raúl Alejandro Vargas Acosta¹, Luis Garnica Chavira²,
Natalia Villanueva Rosales¹, Deana Pennington³**

¹Department of Computer Science, ³Department of Geology, The University of Texas at El Paso

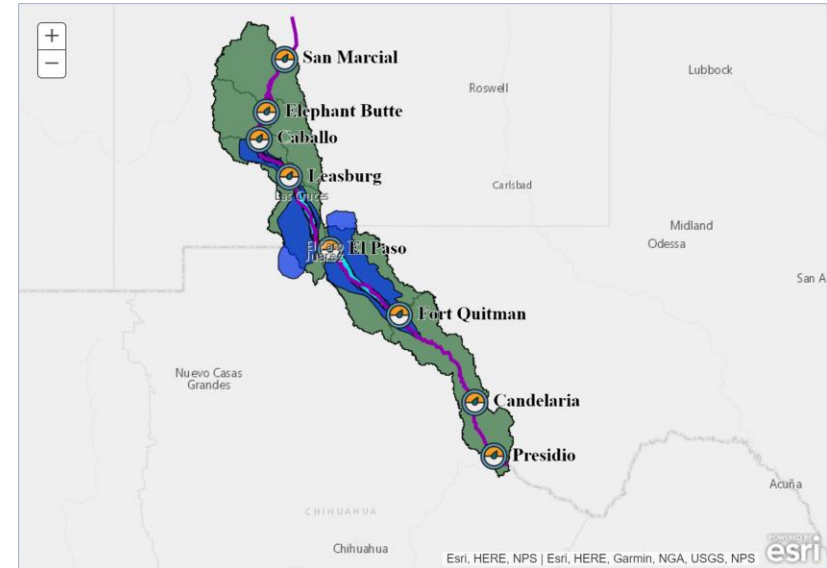
²Git Gud Consulting SAS

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Water Sustainability in the US Southwest

- **Research Fields:** Economy, Hydrology, Climatology, Computer, Environmental, Earth Science, and Civil Engineering.
- **User Roles:** Farmers, Policy Makers, Citizens, Academics
- **Regions:** New Mexico, Texas, Chihuahua (MX)
- **Institutions:** UTEP, NMSU, UNM, UACJ, MTU, TAMU



Source: middleriogrande.org

Sustainable Water through Integrated Modelling Framework (SWIM)

- **Expose** water sustainability models on the Web.
- Clearly identify the sources and processes used for data **manipulation** for model consumption.
- **Describe** the science behind the models.


Sustainable Water through Integrated Modelling Framework (SWIM)

Step 1 Scenarios Step 2 Customize Step 3 Review and Run Model Outputs Model Performance

Water Inflows Policy Population Technology Next >

Select a base water supply scenario by clicking on the image option.

Simulated Observed Inflows at San Marcial Gauge



Time Range: Uses observed historical inflows from 1994 to 2013. Inflow remains static after 2013, i.e. 2013 average inflow is repeated up to 2033.

Description: Custom percentage of observed annual average flow past the pair of gauges at San Marcial.

0% 100% 150%

Simulated Observed Inflows + Extended Drought



Time Range: Uses observed historical inflows from 1994 to 2013. Appends 20 years of synthetic drought from 2014 up to 2033.

Description: The extended drought is defined as the three-year sequence of San Marcial flows at the end of the baseline period (2011-2013), repeated over and over for the 20 years following 2013.


Moderate Stress Climate Scenario



Time Range: From 1995 up to 2033.

Description: Simulated annual average flow corresponding to the location of Elephant Butte Reservoir, generated by the US Bureau of Reclamation using a climate change simulation from the HadGEM2 global climate model driven by historical climatic boundary conditions through 2005, and future climate (2006 onward) driven by the RCP6.5 scenario of greenhouse gas concentrations. The simulated climate then is coupled to

Big Stress Climate Scenario



Time Range: From 1995 up to 2033.

Description: Appended values of extended drought flows (the observed sequence of annual flows from 2011-2013 repeated over and over) to the HadGEM2-simulated flows for 1994-2013.

Scientific results hard to understand

Semantics behind the data

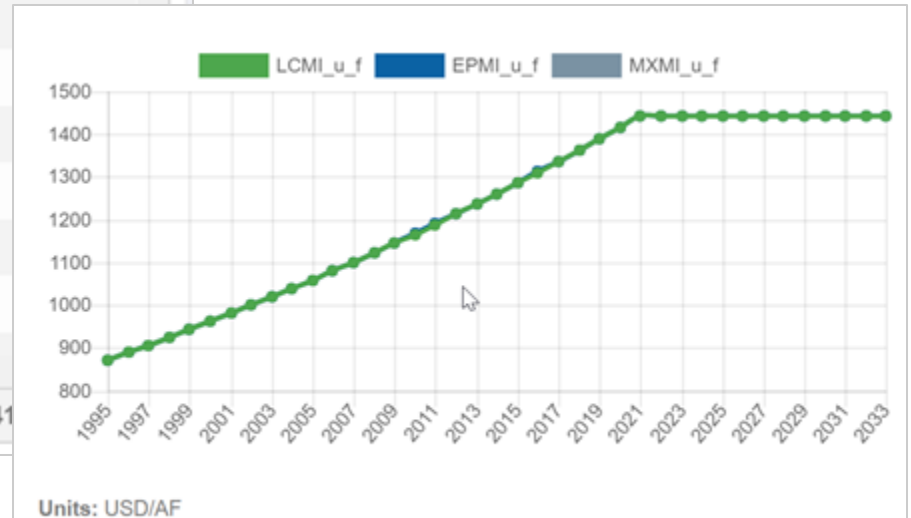
Urban Price

Use Locations:

Urban water price

LCMI_u_f = Las Cruces Municipal and Industrial
 EPMI_u_f = El Paso Municipal and Industrial
 MXMI_u_f = Ciudad Juarez Municipal and Industrial

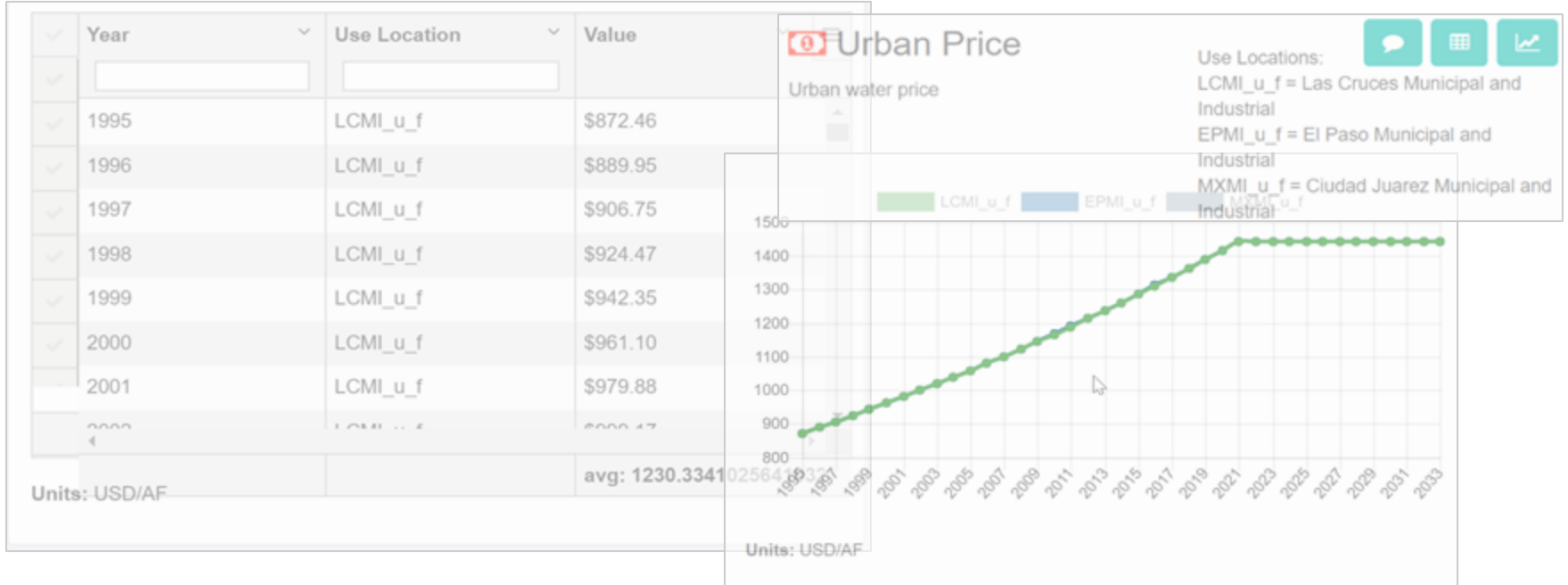
Year	Use Location	Value
1995	LCMI_u_f	\$872.46
1996	LCMI_u_f	\$889.95
1997	LCMI_u_f	\$906.75
1998	LCMI_u_f	\$924.47
1999	LCMI_u_f	\$942.35
2000	LCMI_u_f	\$961.10
2001	LCMI_u_f	\$979.88
2002	LCMI_u_f	\$999.17
Units: USD/AF		avg: 1230.3341



Source: middleriogrande.org

SWIM narratives

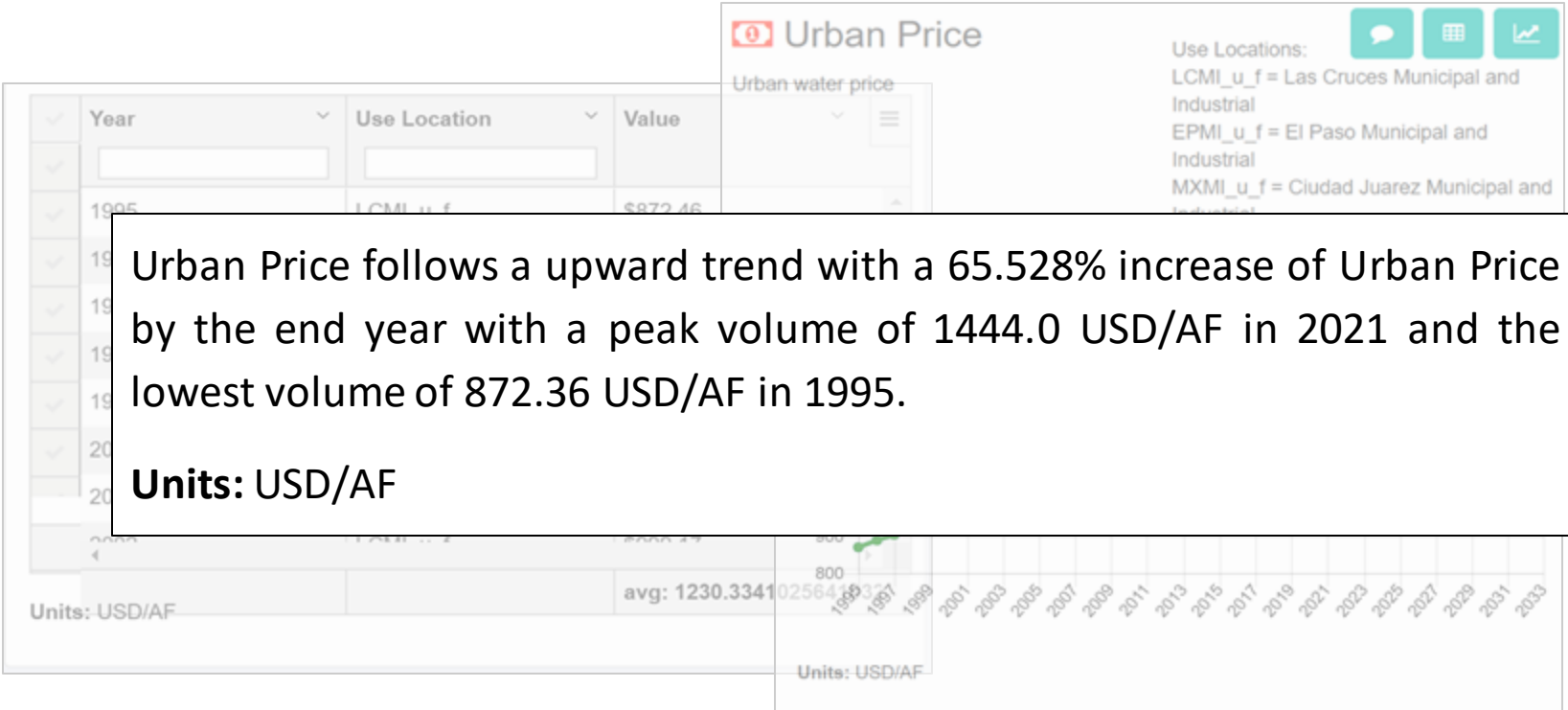
Customizable human-readable data explanations



*Inspired by Yolanda Gil and Daniel Garijo (2017) [1].

Source: middleriogrande.org

SWIM narratives



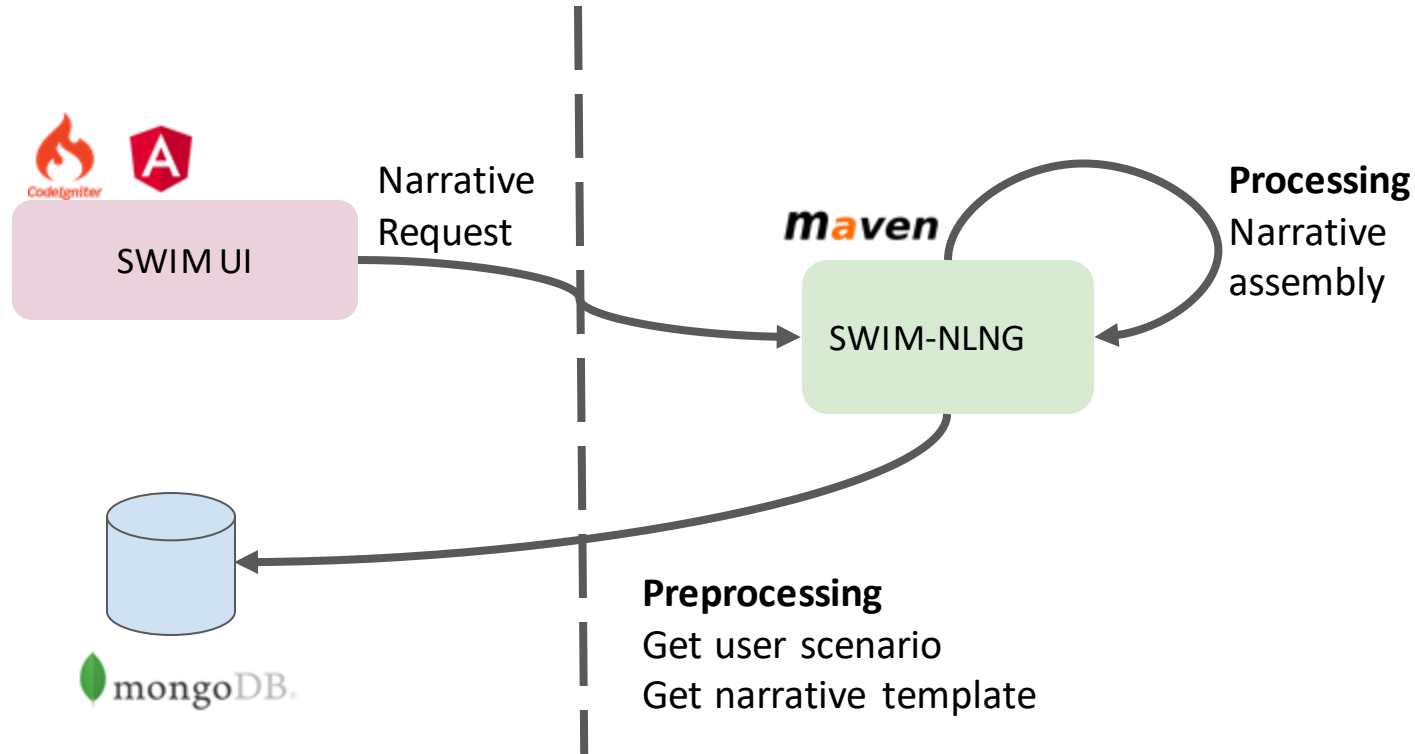
Urban Price follows an upward trend with a 65.528% increase of Urban Price by the end year with a peak volume of 1444.0 USD/AF in 2021 and the lowest volume of 872.36 USD/AF in 1995.

Units: USD/AF

Narrative components

Language	Spanish and English
User role	Farmers, policy makers, water administrators
Focus area	Urban, environmental
Geographical region	El Paso, Texas; Las Cruces, New Mexico; Ciudad Juarez, Mexico
Model element	Model inputs, model outputs, and scenarios
User scenario	Model run document

SWIM narrative generation



Preprocessing

```
{
  "varLabel": "Surface Water Storage",
  "varName": "water_stocks",
  "varDescription": "Reservoir water storage",
  "varUnit": "KAF/yr",
  "varValue": [
    {"res": "Store_res_s", "t": "1996", "value": 2061.5},
    {"res": "Store_res_s", "t": "1997", "value": 2213.49}
  ]
}
```

Excerpt of an executed scenario serialized as JSON using SWIM's data model. The response contains metadata and result values for the output variable "water stocks."

```
Q1. List<Narrative> outputNarrative = mDataStore.createQuery(Narrative.class).filter("element.name",
varName).asList();
```

R1. `~element_label` follows a `~adjective_trend` trend with a `~percent` `~adjective_behaviour` by the end year `~constant_year` with a peak volume of `~maxValue` `~element_unit` in `~maxYear` and lowest volume of `~minValue` `~element_unit` in `~minYear`.

Query to retrieve narrative template for an output variable and result.

Narratives

Global Average Values

Model outputs compared with outputs from the historical period of 1995-2015

→ Average Total Inflows
Average annual total inflows in thousands of acre feet

Current Run: 466.9 - Historical Run: 582.86

Water Supply outcome causes a **20% reduction** in average inflows to Elephant Butte in comparison to the historical period (1995-2015). Historical averages were 582 KAF/yr and the selected scenario results in **466 KAF/yr** average annual inflow.

Units: KAF/yr

Water Stocks

Reservoir water storage

Output Narrative

Project Storage:
Store_res_s = Caballo/Elephant Butte

Surface Water Storage follows a **downward** trend with a **75% reduction** by the end year **2033** with a peak volume of **2213 KAF** in **1997** and lowest volume of **541 KAF** in **2033**.

Units: KAF/yr

Summary narrative (a) and single output narrative (b)

Current results (1)

- **Specification** of the narrative components.
- One narrative **template** document per model element (scenario, input or output).
- In-house **ontology** for SWIM specific terms.
- Semantically annotated **narrative schema** formatted in JSON-LD.



Current results (2)

- **Stand-alone web service:** Natural Language Narrative Generator (NLNG).
- **Data interpretations** through the ingest of individual model elements (single value or time series), target user metadata and baseline model runs.
- Narrative addition to **SWIM UI**.

Future work

Extension of narrative templates for **different roles**.

Generalization of SWIM narratives.

Evaluation with stakeholders and scientific team.

Expose SWIM's annotated data as **knowledge graphs**, e.g., Cayley.

Predefined user preferences through Machine Learning algorithms.

International, Interdisciplinary Research Team



**Bill
Hargrove**
*Soil and Water
Management*



**Josiah
Heyman**
Anthropologist



**Deana
Pennington**
Geoscientist



**Alex
Mayer**
Civil Engineering



**Frank
Ward**
Economist



**Dave
Gutzler**
Climate Change



**Sarah
Sayles**
*Water Science and
Management*



**Alfredo
Granados**
*Soil Science and
Agronomy*



**Luis
Garnica**
Software Engineering

Availability

Project Website:

<http://purl.org/swim>

SWIM-NLNG Service:

<http://purl.org/swim/services/nlNg>

SWIM Vocabulary (JSON-LD):

<http://purl.org/swim/vocab>

SWIM Terms (OWL):

<http://purl.org/swim/terms>

Backend Source Code:

<https://github.com/iLink-CyberShARE/SWIM-NLNG>



Acknowledgements

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Cyber-ShARE



References

[1] Towards Automating Data Narratives. In Proceedings of the *22Nd International Conference on Intelligent User Interfaces (IUI '17)*, 565–576. DOI:<https://doi.org/10.1145/3025171.3025193>

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