Supplement of Hydrol. Earth Syst. Sci., 24, 4903–4921, 2020
https://doi.org/10.5194/hess-24-4903-2020-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

Unraveling intractable water conflicts: the entanglement of science and politics in decision-making on large hydraulic infrastructure

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Supplementary material 1. Detailed information of Guadalajara, León and Los Altos.

Table S1: Comparison of water demand and supply for Guadalajara, León and Los Altos (Source: CEA Jalisco, 2018; INEGI 2015; SAPAL, 2018; SIAPA, 2017; UNOPS, 2017)

	Population[1]	Total water supplied and per capita	Water source	Over-exploitation of aquifers[2]
León	1.5 million	2.56 m³/s (81 hm³/year) 140 l/cap/d	– **Aquifers** 2.42 m³/s (76.6 hm³/year) 95.3% – **Palote Dam** 0.13 m³/year (4.2 hm³/year) 4.7%	Deficit in Valle de León and Romita aquifers = 177 hm³/year
Guadalajara[3]	4.2 million	9.97 m³/s (313 hm³/year) 207 l/cap/day	– **Lake Chapala** 5.97 m³/s (188.5 hm³/year) 60% – **Aquifers** 2.72 m³/s (85.8 hm³/year) 27% – **Calderón Dam** 1.1 m³/s (35.4 hm³/year) 11% – **Local springs** 0.14 m³/s (4.6 hm³/year) 2%	Deficit in Atemajac and Toluquilla aquifers = 84.5 hm³/year
Los Altos	0.8 million	4.6 m³/s (146 hm³/year) 493 l/cap/d	– **Groundwater** 1.49 m³/s (46.9 hm³/year) – **Surface water** 3.14 m³/s (99 hm³/year)	Deficit in 17 aquifers = 155 hm³/year

1. This data is from 2015, the latest official data available.
2. The overexploitation counts all aquifer users, including agriculture and industry.
3. We consider only the municipalities of Guadalajara, Zapopan, Tonalá and Tlaquepaque.

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Supplementary material 2. Detailed information on the key actors in the conflict.

Figure 4 show the position of key actors vis-à-vis the Zapotillo dam project. Each actor's position depended on some factors described in Table S2. If an actor is a key and direct stakeholder of the project, lobbied for or against the project, and has publicly condemned or be in favor of the project, it is at the extreme of the spectrum.

Table S2. Detailed information on the key actors in the conflict.

Actor	Sector	Position
Universidad de Guanajuato	Academy	Although the university has not released any public position on the project, many of their academics and research groups have positioned themselves against the project, arguing that the project is not a reliable solution for León´s water scarcity.
Acción Colectiva	NGO	This NGO's area of influence is Guanajuato and promotes democratization of decision-making on water resources. They are against the project because they see it as an imposition.
Guanajuato's government and State water authorities	Government	This actor has been consistently lobbying for the project throughout many administrations since the 1990s.
León municipality and SAPAL	Government	This is León's water utility; it has publicly declared to be in favour of the Zapotillo project, because it considers it central to the city's future water security.
Guanajuato's business associations	Social actor	Most of Guanajuato's business associations have publicly declared their support for the Zapotillo project, arguing that it is instrumental for León´s development.
ITESO (Jesuit University of Guadalajara)	Academy	This university has publicly released their position against the project, arguing that it is not based on principles of Integrated Water Resources Management nor respect to human rights, and that Mexican society should transit to a new water management approach based on demand management, instead of large infrastructure.
Universidad de Guadalajara	Academy	This university has publicly released their position against the project, arguing that the project is unfeasible based on the increasing water scarcity and higher temperatures in the donor basin, as well as the absence of an environmental management plan of the region.
Temacapulín	Social actor	As one of the central actors of the conflict, Temacapulín's representatives have always been against the Zapotillo dam to protect their communities from forced displacement.
IMDEC	NGO	IMDEC is an NGO that has been supporting the affected communities of Temacapulín, Acasico and Palmarejo since the start of the Zapotillo project.
Colectivo COA	NGO	This NGO specializes in legal support for affected communities of large projects. As such, they have provided legal support to Temacapulín, Acasico and Palmarejo.
Animal farmers' associations of Los Altos	Social actor	Some associations from Los Altos have publicly been against the water transfer, arguing that the region is already affected by water scarcity, but not necessarily against the dam. They lack consensus among the many municipalities within the region.
Observatory	Social actor	Although recently created, the Observatory has been adamantly against the water transfer, arguing that the donor basin is already affected by water scarcity and that the region is the most important producer of animal protein in the country. The Observatory's members have changed over time, but some of its core members are representatives of University of Guadalajara, Animal Farmers Associations of Los Altos, representatives of the catholic church from Los

		Altos, business and industry associations, local universities (ITESO, UNIVA), and civil society organizations.
Universidad Panamericana	Academy	This university has publicly released their position in favour of the project, arguing that it is key to the water security for Guadalajara, León and Los Altos.
Universidad Autónoma de Guadalajara	Academy	This university has publicly released their position in favour of the project, arguing that domestic use has priority over other kinds of uses.
Chamber of the industry of construction of Jalisco	Social actor	This actor has publicly released their position in favour of the project, arguing that the benefit of the majorities should prevail over the benefit of the minorities.
College of civil engineers of Jalisco	Social actor	This actor has publicly released their position in favour of the project, arguing that it is the only feasible solution to guarantee water supply to Guadalajara, León and Los Altos.
SIAPA	Government	Guadalajara's water utility has publicly declared its support to the project as a key element in the city's water security.
Jalisco's government and State water authority	Government	Its position has changed over time from supporting different configurations of the Zapotillo project, but always supported the project.
Conagua	Federal government	The official position has changed from implicitly favoring the project to being neutral when the latest administration and presidency took over (December 2018).
IMTA	Government	The official position has changed from implicitly favoring the project to being neutral when the latest administration and presidency took over (December 2018).
Municipality of Cañadas de Obregón	Government	This is the municipality where the Zapotillo dam is located. Because the duration of local administrations lasts only three years, there has been many administrations throughout the conflict. Some mayors have shown support for the communities of Temacapulín, Acasico and Palmarejo, while others have remained neutral, or at least kept a low profile.

Supplementary material 3. Detailed information of the UNOPS´ Verde River Basin model.

UNOPS model of the Verde River basin is developed in WEAP software. This is a water planning software, functioning with the principle of water balance accounting. The software analyses the diverse water supply sources, as well as the withdrawal and transmission to water demand nodes. To start the analysis the software needs a "time frame, spatial boundary, system components and the configuration of the problem." (WEAP, 2020). The software uses two main features to analyze the water resources system. One, called 'Current accounts' analyses the present water demand, resources and supplies based on economic, demographic, hydrological trends to present a snapshot of a business-as-usual scenario. The other explores scenarios to evaluate different strategies such as supply augmentation or demand management.

To create the model, it is necessary to delimit the area and establish the system boundaries. UNOPS first delimited the study area to that of the Verde River Basin, which was 21,495 km^2. The main natural variables that condition the models is percolation, precipitation, run-off, evapotranspiration, infiltration and interflow, while the variables derived from manmade interventions are reservoirs, groundwater draft, water transfers, water demand, derived flows and return flows. UNOPS used the data of Table S3 to fill these variables. The basic parameters used by WEAP are the monthly variation of demand, climate data, and then uses the MABIA water balance method to compute the water balance. This method is based on the two-bucket structure that processes the root zone as the top bucket and what is below the root zone as the bottom bucket (representing groundwater). The model proceeds to process 8 necessary steps to compute the water balance: 1) reference evapotranspiration, 2) soil water capacity, 3) basal crop coefficient, 4) evaporation coefficient, 5) potential and actual crop evapotranspiration, 6) water balance of the root zone, 7) irrigation, and 8) yield. Groundwater is calculated through nodes that compute the natural recharge flows (the top bucket), demand returns, infiltration losses from aqueducts and reservoirs and river recharges as flows that replenish the groundwater storage, and groundwater draft and base flows are computed as flows that deplete groundwater storage.

Then, since the software is configured to create semi-distributed models, UNOPS created 18 sub-regions that were characterized by a similar climate by using data mentioned in Table S3 through GIS extrapolation procedures. To ascertain the validity of all this sub-regions, UNOPS integrated the following data layers of all 18 sub-regions: 1) the hydrographic network, 2) the artificial regulation and monitoring system (dams, sluices and hydrometric stations), 3) the overlaps of the limits of aquifers with the density of surface and groundwater extractions, 4) soil and land cover characteristics, and the climatic distribution within the basin (UNOPS, 2017).

For the first layer, UNOPS used specialized algorithms to process in a digital elevation model a hydrographic network. For the second layer, the model used CONAGUA´s observed data of 7 reservoirs (flows, volume and storage levels) and 8 hydrometric stations; this data was used to calibrate the model. For the third layers, CONAGUA´s georeferenced database of water rights (REPDA) was used to determine hotspot areas of groundwater draft. With the fourth layer the model was able to process the relation with the upper and bottom buckets of the MABIA water balance method, and used SGM´s, SSN´s, INEGI´s and CONAFOR´s data for the soil characteristics, and CLCICOM´s and INIFAP´s data for the climatic distribution.

Table S3. UNOPS´ Verde River Basin model variables (source: UNOPS, 2017).

	Source	Spatial resolution	Temporal resolution
Climate	CLCICOM (CONAGUA-SMN)	315 stations including a buffer of 50 km outside the contour of the basin	Daily (1943-2014)
Hydroclimatology	INIFAP	105 stations including a buffer of 50 km outside the contour of the basin	Monthly (2002-2014)
Hydrometry in rivers and reservoirs	BANDAS (CONAGUA)	Timeseries of 8 hydrometric stations	1941-2016
Groundwater	CONAGUA GRACE (GFZ German Research Centre for Geosciences, Center for Space Research - The University of Texas at Austin and NASA Jet Propulsion Laboratory)	Studies of 21 aquifers of the region. Monthly fields with gravity coefficients at a spatial resolution of 1ºx1º (≈ 11,000 km^2)	1997-2010 2002-2014
Soil and Land cover	INEGI, CONAFOR	Land cover maps 1:50,000, irrigation district maps 1:250,000, and images of SPOT 6 and 7	2012-2016
Water demand	REPDA (CONAGUA)	All georeferenced surface and groundwater rights	2016
Geology	SGM, SSN	Maps 1:50,000 and 1:250,000	2007
Population/returns	INEGI	Population of towns with more than 2,500 people	2010
Digital Elevation Model	CEM v2.0	Raster with resolution of 15m (1:20000)	2013

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