Supplementary material

S.1 In-detail methodology to develop the alternatives

The water resources model of the Verde River Basin (the donor basin of the Zapotillo project) and Guadalajara and León (the recipient regions) that we used in the participatory modelling workshop is based on an existing water resources model developed by a team of experts from the United Nations Office for Project Services (UNOPS). This institution was hired by the government of Jalisco in 2014 to develop a model with the intention to improve science-policy processes and resolve the water. This model was developed in WEAP21 software to explore an optimal configuration of the Zapotillo project by developing scenarios with different configurations of dam heights and allocated water to Guadalajara and León (for more information on the history of this model in the context of the conflict consult Godinez Madrigal et al., 2020). We requested and received the complete model by the end of 2017. We thoroughly analyzed the model and systematically documented all its assumptions and what we consider its pitfalls and inconsistencies (Godinez-Madrigal et al., 2020). Based on our own assessment and the calibration and validation described in UNOPS (2017) we decided to invest our resources to improve the model instead of creating a new one.

We implemented two important changes into the model. In the first one, we expanded the system boundaries, and for the second, we developed and included alternative solutions to the Zapotillo project for urban water supply for both cities Guadalajara and León. Related to the first change, whereas the original model considered only the Verde River Basin, we incorporated the main social and hydrological variables occurring in both Guadalajara and León. For Guadalajara we added its main water supply sources: Lake Chapala, local springs and the Calderón dam (total yield: 7 m^3/s) and groundwater (3 m^3/s). We also added the average rainfall of the city and the depletion and recharge rate of the groundwater. In the case of León, we also added its main water supply sources (aquifers, 2.3 m^3/s, and the Palote dam, 0.5 m^3/s), the average rainfall and the depletion and recharge rate of its groundwater resources. Finally, while the original model considered environmental flows only for downstream the Zapotillo dam site; we calculated the environmental flows of the Verde River as a tributary of the Santiago River.

In the second change, we developed five alternative strategies to the Zapotillo project for addressing water scarcity in Guadalajara and León, and one strategy to prioritize environmental flows rather than urban water supply. These strategies were inspired by the interviews with key stakeholders of the conflict and the participatory observation of several stakeholder workshops and meetings during 2017.

Table S1 describes all these strategies and the values we used to run the scenarios. Firstly, we considered the four main configurations of the Zapotillo dam (decommissioned, 60 m height, 80 m height and 105 m height). Then, we considered the combination of these four Zapotillo dam configurations with alternative strategies in the following way: 1) the dam configuration with the implementation of only one kind of strategy (supply augmentation, demand management and water reallocation); 2) the dam configuration with the implementation of two different kind of strategies working simultaneously; and 3) the dam configuration with the implementation of three different kind of strategies working simultaneously. Finally, we ran all those scenarios prioritizing environmental flows.

Given the common resistance of water utilities to innovate, we restricted the simultaneous number of running alternatives to three (from the five we developed). We ran five groups of scenarios. For the first group we combined the alternative strategies with the 105 m dam and allocated the water volume according to the 2007 water allocation agreement (UNOPS, 2017) with and without environmental flows, which resulted in 30 scenarios. For the second one, we combined the alternative strategies with the 80 m dam and proportionally reduced the allocated water volume according to the 2007 allocation agreement with and without environmental flows, which resulted in 30 scenarios. For the third one, we combined the alternative strategies with the 60 m dam and decreased the water allocated in proportion to the reduction in storage volume of the reservoir with and without environmental flows, which resulted in 30 scenarios. For the fourth one, we considered only the combination of alternative strategies to supply water to Guadalajara and León, which resulted in 15 scenarios. And finally, we considered the three dam configurations with and without environmental flows, and without implementing any of the alternatives, which resulted in 3 scenarios. The characteristics we tested for each are shown in the repository for data availability.

Table S1: Summary of all strategies analyzed

New model input parameters	Values	Strategies	Sources of calculated values
Dam´s height and transfer volumes	• 105 m (León (L) = 3.8 m^3/s, Los Altos (A) = 1.8 m^3/s, Guadalajara (G) = 5.6 m^3/s)1 • 80 m (L = 1.7 m^3/s, A = 0.8 m^3/s, G = 3.9 m^3/s) • 60 m (L = 1.6 m^3/s, A = 0. 72 m^3/s, G = 2.6 m^3/s) • Decommissioned dam	Supply augmentation	UNOPS (2017)
Rainfall harvesting and stormwater management	Average historic rainfall for Guadalajara and León, plus the capacity of 50% of households to install rainwater harvesting systems, and cities to develop injection wells and urban trenches and bio-retention ponds.	Decentralized supply augmentation	Garrison et al., 2009; Page et al., 2010; Jarden et al., 2016; Escolero Fuentes et al., 2017; Jiang et al., 2017; Urías-Ángulo 2017; Vanegas 2017; Saraswat et al., 2016; Gleason et al., 2018; Tagle-Zamora et al.

1 The original allocation agreement states that Guadalajara would receive 3.0 m^3/s out of the Zapotillo dam. However, the state water authority calculated that at least 2.6 m^3/s of run-off is generated in-basin downstream of the Zapotillo dam, which besides the 3.0 m^3/s (5.6 m^3/s in total) can be transferred also to Guadalajara.

			2018; Conagua, 2019; Nguyen et al., 2019.
Reclaimed wastewater potential for industries + Reduction of water demand through implementation of water-saving devices	Average of 20% reduction in water demand for Guadalajara and 5% for León (see supplementary material)	Demand Management	Bidhendi et al., 2008; Furumai, 2008; Jimenez-Cisneros and Asano, 2008; Jimenez-Cisneros and Asano, 2015; Sharma & Vairavamoorthy, 2009; Velarde-Flores, 2017.
Reducing physical losses in the urban distribution system	Guadalajara reducing non-revenue water (NRW) from 32.4% to 20% León reducing (NRW32.77% to 15% water demand (see supplementary material)	Demand Management	Farley, 2001; Consejo Tarifario SIAPA, 2016; Molinos-Selante et al., 2016; Sapal, 2016; Liemberger & Wyatt, 2018; Marsalek et al. 2018.
Limits to urban and agricultural growth	Limiting urban growth to 1%/year, and limiting agricultural growth to 0%	Demand Management	INEGI, 2005, 2010, 2015; Martinez-Alier, 2005; Daly & Farley, 2010; Schneider et al., 2010; CEA Jalisco, 2015; IIEG Jalisco, 2017.
Transfer of inter-sectoral water rights	Re-allocate 20% of the volume of current agricultural water rights to the urban sector	Water reallocation	Richter et al., 2013; Richter, 2014; Hoogesteger, 2017.
Environmental flows	Prioritize environmental flows at the discharge to the Santiago fiver basin	Ecological protection	Salinas-Rodriguez, 2011; DOF, 2012

To assess the performance of the scenarios, we developed three meaningful indicators. According to the current objectives of Guadalajara and León, a first indicator is water supply coverage, and a second indicator is the rate of over-exploitation of groundwater. Other objectives are those of the actors opposing the Zapotillo project: avoiding the flooding of Temacapulín and protecting the environmental flows of the Verde River.

For water demand coverage we used the percentages of water demand covered by the hybrid infrastructure systems for both cities. Then, we filtered those systems when the average coverage over the 55 years was more than 95% for both cities.

Then, we assessed the sustainability of aquifers by taking the final result of the aquifer storage capacity and divided it by 55 (the number of years the model runs), to get the average yearly change of storage capacity. Then, we converted that result into the proportion of its current over-exploitation rate. A result of 100% would indicate that the over-exploitation persists at the same current rate, and 0% would indicate the hybrid system reversed the over-exploitation.

Related to the negative effects in the donor basin, for the indicators of unmet water demand and environmental flow requirements, we collected the monthly results and averaged them.

Lastly, we indicate what would be the situation regarding the communities and their potential flooding: a dam decommission, and a 60 m height dam do not flood the communities; an 80 m height dam would require additional infrastructural measures to avoid flooding the communities, such as levees; and, a 105 m height dam would inevitably flood the communities.

S.1.1 Supply augmentation strategies

These strategies consist of centralized and decentralized supply augmentation systems. The centralized system consists of the different operational strategies of the already existing infrastructure of the Zapotillo dam. The decentralized supply systems consist of rainwater harvesting.

For the centralized systems we considered that the Zapotillo dam is already built at 80 meters height and was originally designed to be the water source solely for León. However, the water authorities and state and national governments are proposing to increase its height to 105 meters to supply water for both Guadalajara and León. The communities affected by the dam's reservoir have proposed to restrict its operational use to only 60 meters height to keep the communities from flooding. Other groups of actors have proposed for the decommissioning of the Zapotillo dam.

Table 1 presents the main characteristics of all these operational configurations of the dam. The information on water allocations was calculated under the principle of proportionality of the water allocation agreement (DOF, 1997).

Table 2. Proposed options for the dam variable.

	Decommissioning the Zapotillo dam	Zapotillo dam 60 m	Zapotillo dam 80 m	Zapotillo dam 105 m
Storage capacity	none	146 m^3	520 m^3	990 m^3
Operational storage	none	130 hm^3	411 hm^3	911 hm^3
Minimum volume	none	58.3 m^3	58.3 m^3	58.3 m^3
Situation with Temacapulín Acasico and Palmarejo	The communities are spared	The communities are spared	Acasico and Palmarejo are flooded, and to spare Temacapulín 10 m dikes need to be built	All communities are flooded

For decentralized systems we considered rainwater harvesting. The rainwater harvesting strategy is based on Gleason-Espíndola et al. (2018), who calculated Guadalajara's potential for rainwater to be 21 hm^3/year. In the case of León, Tagle-Zamora et al. (2018) calculated León's potential to be 9.7 hm^3/year. This difference is due to the precipitation patterns and the number of households currently counting with cisterns. However, this potential for rainwater harvesting is constrained by a marked seasonal precipitation pattern in just five months of the year (June, July, August, September and October).

Stormwater harvesting has also been proposed as a strategy by local university researchers in Guadalajara (Urías-Ángulo 2017; Vanegas-Espinoza 2017). Moreover, IMTA, the technical branch of the Mexican water authority compiled a book of all the pilots that are currently tested around the country to promote this technology as a viable solution to groundwater recharge (Escolero et al., 2017).

S.1.2 Water demand management strategies

Three strategies were selected: a) wide installation of water saving devices in urban households for Guadalajara and León; b) reduce physical losses in the urban water distribution system of both cities; and c) limit the urban growth of Guadalajara and León, as well as the agricultural production of Los Altos.

The first strategy was proposed by Conagua in a workshop in November 2018. (i.e., Sharma and Vairavamoorthy, 2009). We consulted national and international studies on the potential for decreasing water demand in urban settings through water-saving devices (Bidhendi et al., 2008; Sharma and Vairavamoorthy, 2009; Velarde-Flores, 2017), and also consulted the costs of such devices in the Mexican market (Gobierno de la Ciudad de México, 2009). We estimated that a wide adoption of these devices could reduce 20% total water demand for Guadalajara, but only 5% for León.

Reclaimed wastewater has already been adopted by the water utilities from Guadalajara at a very low scale, with industries reusing wastewater equivalent to 0.13% of its total water demand; and León with a large scale reuse of wastewater by farmers, industries and watering green urban areas equivalent to 23% of its total water demand. Therefore, the larger potential for reclaimed wastewater lies in Guadalajara. Since reclaimed wastewater can only be reused for non-human consumption and restricted to industries and irrigation (Furumai, 2008; Jimenez-Cisneros and Asano, 2008; Jimenez and Asano, 2015).

The second strategy, reducing physical losses, was lobbied by NGOs and researchers from the University of Guadalajara. Guadalajara and León have more than 32% rate of physical losses (Consejo Tarifario SIAPA, 2016; Sapal, 2016). A natural strategy would be to reduce the physical losses in the distribution system before considering supply augmentation schemes. To design a coherent alternative we reviewed literature and material from Liemberger & Wyatt (2018) and Marsalek et al. (2008), as well as official data from SIAPA (2020) and SAPAL (2016) to find the costs for the strategy. We found that Guadalajara and León currently perform passive physical losses reduction based on reported (and visible) bursts characterized by large flow rates and short run times. What has been unattended are unreported bursts, which are non-visible, smaller but with a long run-time (Liemberger & Wyatt, 2018). These invisible leaks are only detected through an active program through specialized equipment. Water utilities can reach a level of 20% of physical losses if a combined approach of pressure management, pipe repair, and district-metered areas are employed (Farley, 2001; Molinos-Senante, Mocholí-Arce and Sala-Garrido, 2016).

Finally, during the stakeholder workshop in 2017, Temacapulín's activists complained that the unrelenting urban growth from Guadalajara and León demanded natural resources from the nearby rural areas. Therefore, as an effort to stop the negative effects to rural areas, the cities must have a limit to growth. This idea was in line with the idea of degrowth by ecological economics scholars (Daly & Farley, 2010; Martinez-alier, 2005; Schneider et al., 2010).

Therefore, we developed this strategy based on limiting the population growth of Guadalajara and León by 1 %/year. We used official data (INEGI, 2005, 2010, 2015; CEA Jalisco, 2015; IIEG Jalisco, 2017) to get the current population trends of both cities.

S.1.3 Water reallocation

We investigated two different kinds of inter-sectoral water transfers: one based on Richter *et al.* (2013) and Richter (2014) who drew from international experiences on urban-rural partnerships, where the basic principle is that cities fund irrigation modernization and the saved water would we transferred to the cities. However, according to Hoogesteger (2017; 2018), irrigation modernization rarely reduces water consumption, therefore a better strategy would be to buy water rights from farmers. We operationalized this strategy by reducing 20 % agricultural water use to make it available for urban use.

S.1.4 Securing ecological flows

Since the original plan of Guadalajara is to take water from the Verde River at the point where it discharges to the Santiago River, there was a social concern of communities downstream the Santiago River that this would impact water quality and have negative ecological effects. We therefore developed a minimum river flow from the official norm (DOF, 2012).

References

Bidhendi, G. N. et al.: Role of Water-Saving Devices in Reducing Urban Water Consumption in the Mega-City of Tehran, Case Study: A Residential Complex, Journal of Environmental Health, 70(8), pp. 44–47, 2008.
CEA-Jalisco (2015)
Conagua: SMN-CG-GMC-SMAA-Climatología, 2019.
Consejo Tarifario SIAPA: Oferta y demanda actual y futura de agua potable en el AMG: Presentación al Consejo Tarifario del SIAPA, 2016.
Daly, H. E. and Farley, J.: Ecological Economics: Principles and Applications. Island Press, 2010.
Escolero Fuentes, O., Gutiérrez Ojeda, C., and Mendoza Cazares, E. Y. (eds.): Manejo de la recarga de acuíferos: un enfoque hacia Latinoamérica. Jiutepec, Morelos: Instituto Mexicano de tecnologías del Agua, 2017.
Farley, M. Leakage Management and Control: A Best Practice Training Manual. Geneva, Switzerland: WHO, pp. 1–169. Available at: http://whqlibdoc.who.int/hq/2001/WHO_SDE_WSH_01.1_pp1-98.pdf, 2001.
Furumai, H.: Rainwater and reclaimed wastewater for sustainable urban water use, Physics and Chemistry of the Earth, 33(5), pp. 340–346. doi: 10.1016/j.pce.2008.02.029, 2008.
Garrison, N., Sahl, J., Dugger, A., & Wilkinson, R.: 'Stormwater Capture Potential in Urban and Suburban California'. Natural resources defense council technical report, 2014.
Gleason-Espíndola, J. A., Cordova, F. & Casiano-Flores, C.: 'The importance of urban rainwater harvesting in circular economy: the case of Guadalajara city harvesting', Management Research Review. doi: 10.1108/MRR-02-2018-0064, 2018.
Godinez-Madrigal, J., Van Cauwenbergh, N. and van der Zaag, P.: 'Unravelling intractable water conflicts: the entanglement of science and politics in decision-making on large hydraulic infrastructure, Hydrology and Earth System Sciences, 2020.
Hoogesteger, J.: An elite technology? Drip irrigation, agro-export and agricultural policies in Guanajuato, Mexico, in Venot, J.-P., Kuper, M., and Zwarteveen, M. (eds) Drip Irrigation for Agriculture: Untold Stories of Efficiency, Innovation and Development. New York: Routledge, pp. 151–166, 2017.
Hoogesteger, J.: The Ostrich Politics of Groundwater Development and Neoliberal Regulation in

Mexico. Water Alternatives, 11(3), 2018.
IIEG Jalisco: Alcanza área metropolitana de Guadalajara los 5 millones de habitantes. Available at: https://iieg.gob.mx/strategos/alcanza-area-metropolitana-de-guadalajara-los-5-millones-de-habitantes/, 2017.
INEGI: II Conteo de Población y Vivienda 2005. Accessed on 28 February 2020. Available at: http://www.beta.inegi.org.mx/proyectos/ccpv/2005/default.html, 2005.
INEGI: Censo de población y vivienda 2010. Accessed on 28 February 2020. Available at: http://www.beta.inegi.org.mx/proyectos/ccpv/2010/, 2010.
Jarden, K., Jefferson, A. J. & Grieser, J. M.: Assessing the effects of catchment-scale urban green infrastructure retrofits on hydrograph characteristics. Hydrol. Process. 30, 1536–1550, 2016.
Jiang, C.,Li, J.,Li, H.,Li, Y.,Chen, L.: Field Performance of Bioretention Systems for Runoff Quantity Regulation and Pollutant Removal. Water, Air, & Soil Pollution. 228 (12), 2017.
Jimenez-Cisneros, B. and Asano, T. Water reclamation and reuse around the world, in Jimenez-Cisneros, B. and Asano, T. (eds) Water Reuse: An International Survey of current practice, issues and needs. London: IWA Publishing, 2008.
Jimenez, B. and Asano, T.: Water Reuse: An International Survey of current practice, issues and needs, Water Intelligence Online. doi: 10.2166/9781780401881, 2015.
Liemberger, R. and Wyatt, A.: Quantifying the global non-revenue water problem. Cape Town: Miya, 2018.
Marsalek, J. et al.: Urban Water Cycle Processes and Interactions: Urban Water Series - UNESCO-IHP, (78), p. 152. Available at: https://books.google.com/books?id=UXJXJgQCVUwC&pgis=1, 2008.
Martinez-alier, J.: Los conflictos ecológico-distributivos y los indicadores de sustentabilidad, Martinez-Alier, J., Temper, L., Del Bene, D., & Scheidel, A. (2016). Is there a global environmental justice movement? The Journal of Peasant Studies, 43(3), 731-755, 2005.
Molinos-Senante, M., Mocholí-Arce, M. and Sala-Garrido, R.: Estimating the environmental and resource costs of leakage in water distribution systems: A shadow price approach, Science of the Total Environment. Elsevier B.V., 568, pp. 180–188. doi: 10.1016/j.scitotenv.2016.06.020, 2016.
Nguyen, T. T. et al.: Implementation of a specific urban water management - Sponge City, Science of the Total Environment. Elsevier B.V., 652, pp. 147–162. doi: 10.1016/j.scitotenv.2018.10.168, 2019.
Page, D., Dillon, P., Vanderzalm, J., Toze, S., Sidhu J., Barry, K., Levett, K., Kremer, S., and Regel, R.: Risk assessment of aquifer storage transfer and recovery with urban stormwater for producing water of a potable quality, Journal of environmental quality 39, no. 6 2029-2039, 2010.
Richter, B. et al.: Tapped out: how can cities secure their water future?, Water Policy, 15, pp. 335–363. doi: 10.2166/wp.2013.105, 2013.
Richter, B.: Chasing Water. Island Press. doi: 10.5822/978-1-61091-537-3, 2014.
SAPAL: Agua Siempre y Para Todos: Informe de Resultados 2013-2016. León. Available at: http://www.sapal.gob.mx/media/files/1456268400-Informe Consejo 2013-2016.pdf, 2016.
Salinas-Rodríguez, S. A.: Guía rápida para la determinación de caudales ecológicos. Aproximaciones hidrológicas. Available at: http://www.conagua.gob.mx/CONAGUA07/Contenido/Documentos/GUIA.pdf, 2011.
Saraswat, C., Kumar, P., & Mishra, B. K.: Assessment of stormwater runoff management practices and governance under climate change and urbanization: An analysis of Bangkok, Hanoi and Tokyo. Environmental Science & Policy, 64, 101-117, 2016.
Schneider, F., Kallis, G. and Martinez-Alier, J.: ‘Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue’, Journal of Cleaner Production. Elsevier Ltd, 18(6), pp. 511–518. doi: 10.1016/j.jclepro.2010.01.014, 2010.
Sharma, S. K. and Vairavamoorthy, K.: ‘Urban water demand management: Prospects and challenges for the developing countries’, Water and Environment Journal, 23(3), pp. 210–218. doi: 10.1111/j.1747-6593.2008.00134.x, 2009
SAPAL: Agua Siempre y Para Todos: Informe de Resultados 2013-2016. León. Available at: 865 http://www.sapal.gob.mx/media/files/1456268400-Informe Consejo 2013-2016.pdf, 2016.
SIAPA: Data on Guadalajara’s water supply since 1988. Data obtained through transparency procedures, 2020.
Tagle-Zamora, D., Azamar-Alonso, A. and Caldera-Ortega, A.: ‘Cosecha de agua de lluvia como alternativa para la resiliencia hídrica en León, Guanajuato: una reflexión desde la nueva cultura del

agua', Expresión Económica, (40), pp. 5–24, 2018.
UNOPS: 14. Análisis de Escenarios de Modelación. Available at: http://201.131.6.193:8001/JaliscoSostenible/informe/, 2017.
Urías-Ángulo, A.: Hidrología urbana con criterios de sustentabilidad en desarrollos habitacionales de Tlajomulco de Zúñiga, Jalisco. ITESO, 2017.
Vanegas-Espinoza, L.: Pozos de inyección profunda: recarga artificial de acuíferos con aguas pluviales y disminución de inundaciones en el AMG. Tesis de maestría. ITESO: Tlaquepaque, 2017.
Velarde-Flores, M. E.: 'Modelos de estimación de consumos de agua en vivienda. Ahorros por ecotecnias hidrosanitarias y prácticas para la sustentabilidad hídrica (ZMG 2015-2017)', 2017.