S1 Review of ABM applications

Table S1: Selected relevant existing studies of ABM applications in surface water management and ecological modeling

Topics	Literature	Agent types	Agents' decisions	Agents' goal	Hierarchical agents	Direct agent interaction	Link with other models
Watershed management - Surface water	Barreteau et al. (2004)	farmers	farm activities	simulate cultivating activities	Yes	Yes	No
	Berger et al. (2007)	water users	bid on land/water resources	max incomes	No	Yes	Yes - hydrological model
	Brady et al. (2012)	farmers	farm activities	max incomes	No	Yes	No
	Farolfi et al. (2010)	farms/villages	water demand	simulate water demand	No	No	No
	Giacomoni et al. (2013)	consumers/policy makers	water use/water restrict	simulate water demand	Yes	Yes	Yes - SWAT
	Giuliani and Castelletti (2013)	reservoirs/delta	reservoir operation	max HP/delta preservation	No	Yes	No
	Giuliani et al. (2015)	farm/city	water use	max profit	No	No	No
	Jeuland et al. (2014)	reservoirs	reservoir operation	max profit	No	No	No
	Kanta and Zechman (2014)	households/policy makers	conservation action/policy	simulate water demand	Yes	Yes	No
	Ng et al. (2011)	farmers	crop/BMP choices	max profit	No	No	Yes - SWAT
	Schluter et al. (2009)	farmers/lake/policy makers	water use	max profit	Yes	Yes	No
	Schwarz and Ernst (2009)	households	adoption of new water-related technology	simulate technology diffusion	No	Yes	No
	Yang et al. (2009)	farm/city	water use	max profit/min violation	No	No	No
	Yang et al. (2011)	subbasins	water use/water trading	max profit	No	Yes	No
Ecologic modeling	Bagstad et al., (2013)	carriers/sink/users of ES	carry/affect/use ES	simulate ES flow path	No	Yes	No
	Miller et al. (2014)	waterfowls	search food in foraging patches	simulate different impact on foraging	No	No	No
	Sun and Müller (2013)	farms	land use/land conservation	max profit	No	Yes	No

S2 SWAT model setup

The data used to set up the SWAT models for the two study river basins are shown in Table S2. SWAT is a semi-distributed model. In model setup, the Mekong River Basin is partitioned into 289 subbasins (Fig. S1(a)), and the Niger River Basin is divided into 178 subbasins (Fig. S1(b)). Hydrological response units (HRUs) were defined within subbasins to reflect the spatial variability of land use/land cover and soil. For this study, we defined crop HRUs for rainfed and irrigated upland crops and rice. The initial size of crop HRUs was estimated using cropping area data from International Food Policy Research Institute (IFPRI)'s SPAM database (You et al., 2014), which disaggregates national/sub-national crop production stations to a 5 arc minute grid.

The SWAT models contain customized modules to simulate storage and water surface variations of two major natural water impoundments: the Tonlé Sap in the Mekong River Basin and the Inner Niger Delta in the Niger River Basin. The storage variations of the Tonlé Sap and the Inner Niger Delta were modeled by following the approaches by Kirby et al. (2006) and Thompson et al.(2016), in which statistical relationships were developed to relate the outflow of the Tonlé Sap to streamflows at Kratie and outflow of the Inner Niger Delta at Diré to flows at Ké-Macina and Bénény Kégny. The water surface areas of the two water impoundments were further calculated using volume-surface relationship developed by Manley (2015) and Ogilvie (2017, personal communication).

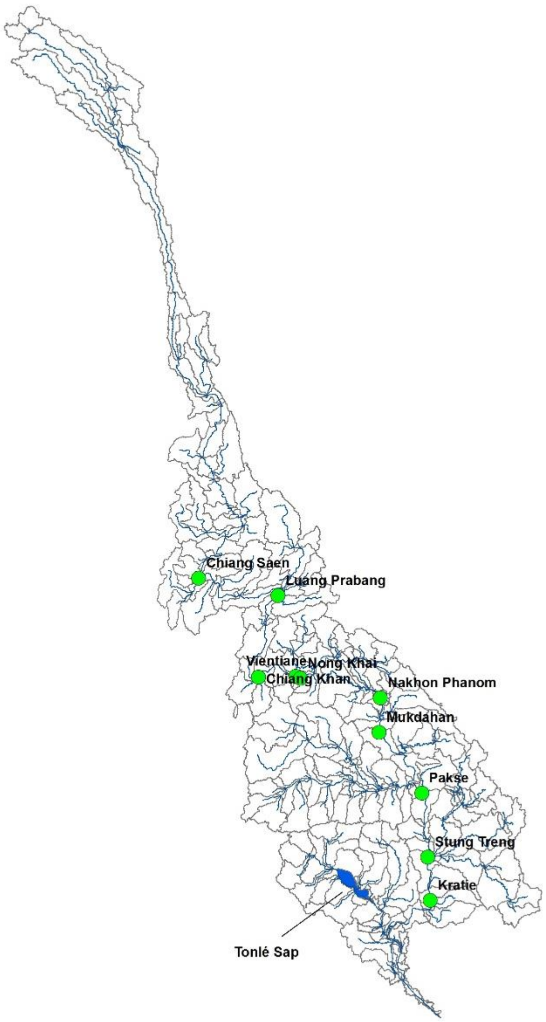
Table S2: Data for SWAT model setup

Category	Data
Elevation	HydroSHEDS[1]
Land use/land cover	GLC2000[2] & SPAM 2005[3]
Soil	Soil Map of the World[4]
Precipitation	Mekong: APHRODITE[5] Niger: NCEP-CFSR[6] (monthly totals were corrected using monthly precipitation data in CRU TS v. 4.00[7])
Temperatures/solar radiation/relative humidity/wind speed	NCEP-CFSR

1. Source: The SHuttle Elevation Derivatives at multiple Scales (HydroSHEDS) database http://www.hydrosheds.org/
2. Source: Global Land Cover (GLC) 2000 database. European Commission, Joint Research Centre. http://forobs.jrc.ec.europa.eu/products/glc2000/glc2000.php
3. Source: Spatial Production Allocation Model (SPAM) database for 2005, IFPRI. http://mapspam.info/
4. Source: FAO/UNESCO. http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/
5. Source: Asian Precipitation-Highly Resolved Observational Data Integration Towards the Evaluation of Water Resources (APHRODITE) project. http://www.chikyu.ac.jp/precip/english/conditions.html
6. Source: National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR); downloaded via global weather database for SWAT https://globalweather.tamu.edu/
7. Source: Climatic Research Unit - University of East Anglia. http://www.cru.uea.ac.uk/data

S3 Sub-basin Delineation

(a) **Mekong**



(b) **Niger**

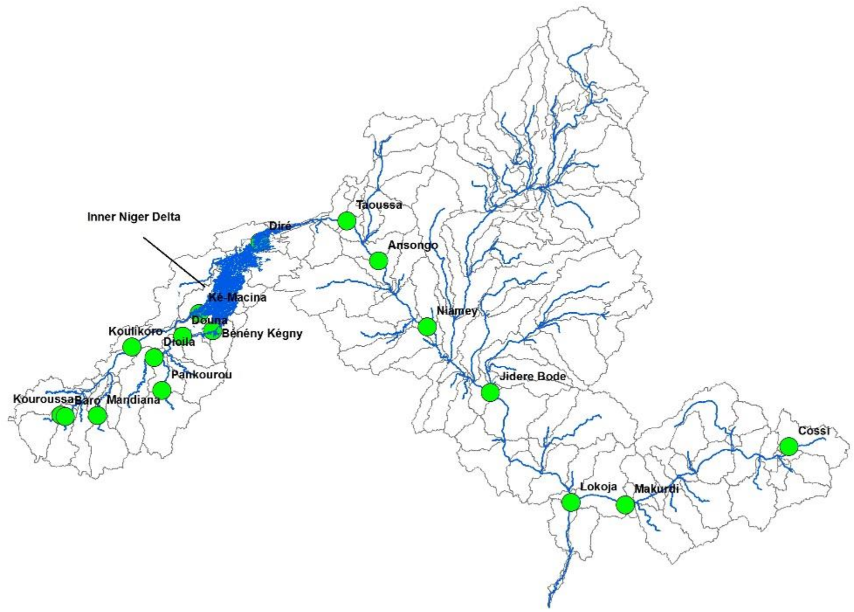


Figure S1 Watershed delineation schemes and locations of streamflow stations used in model calibration/validation

S4 Model Calibration and Validation

The SWAT-Mekong model was calibrated and validated using daily streamflow data from 10 gauging stations, while for the Niger River basin, model calibration and validation was conducted on a monthly basis. The data were obtained from L'Institut de recherche pour le développement (IRD), Niger Basin Authority (NBA) and Global Runoff Data Centre (GRDC). The calibration/validation periods and the model fits achieved by the SWAT model in both case studies are shown in Figures S2 and S3, and Table S3 (a) and (b).

Table S3: Nash–Sutcliffe model efficiency coefficient

Mekong

Station	Calibration (1983-1992)	Validation (1993-2007)
Chiang Saen	0.51	0.62
Luang Prabang	0.73	0.80
Chiang Khan	0.70	0.82
Vientiane	0.71	0.82
Nong Khai	0.74	0.82
Nakhon Phanom	0.80	0.84
Mukdahan	0.85	0.84
Pakse	0.82	0.85
Stung Treng	0.82	0.84
Kratie	0.83	0.85

Niger

Station	Calibration (1985-1994)	Validation (1995-2010)
Ansongo	0.88	0.50
Baro	0.80	0.33
Beneny Kegny	0.68	0.73
Cossi	0.81	0.08
Dioila	0.71	0.67
Dire	0.87	0.83
Douna	0.73	0.81
Jidere Bode	0.89	0.72
Koulikoro	0.92	0.72
Kouroussa	0.81	0.40
Ke Macina	0.88	0.66
Lokoja	0.86	0.72
Makurdi	0.81	0.87
Mandiana	0.65	0.42
Niamey	0.80	0.28
Pankourou	0.35	0.68
Taoussa	0.85	0.40

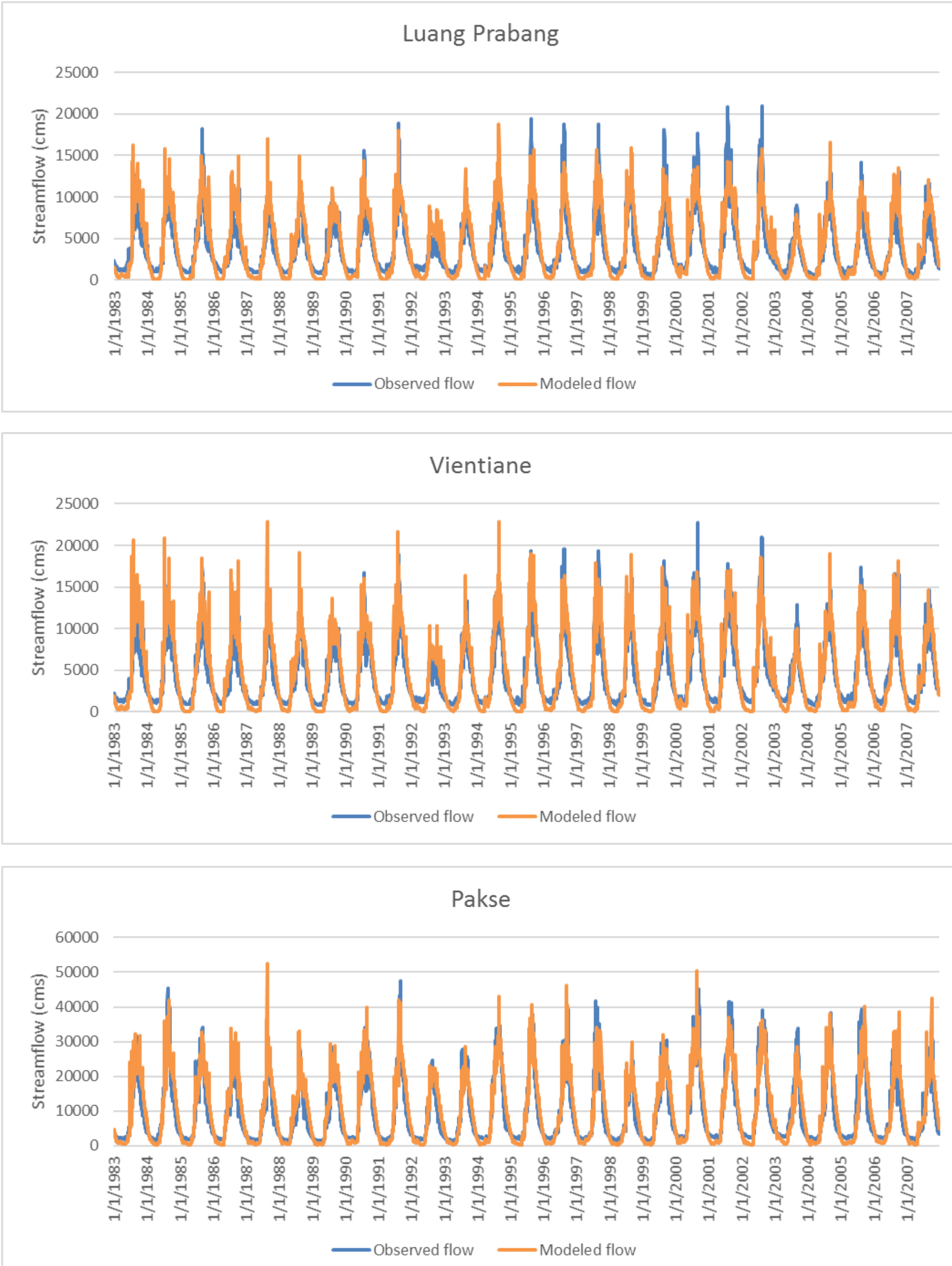


Figure S2: Simulated and observed streamflow at different locations along the Mekong River

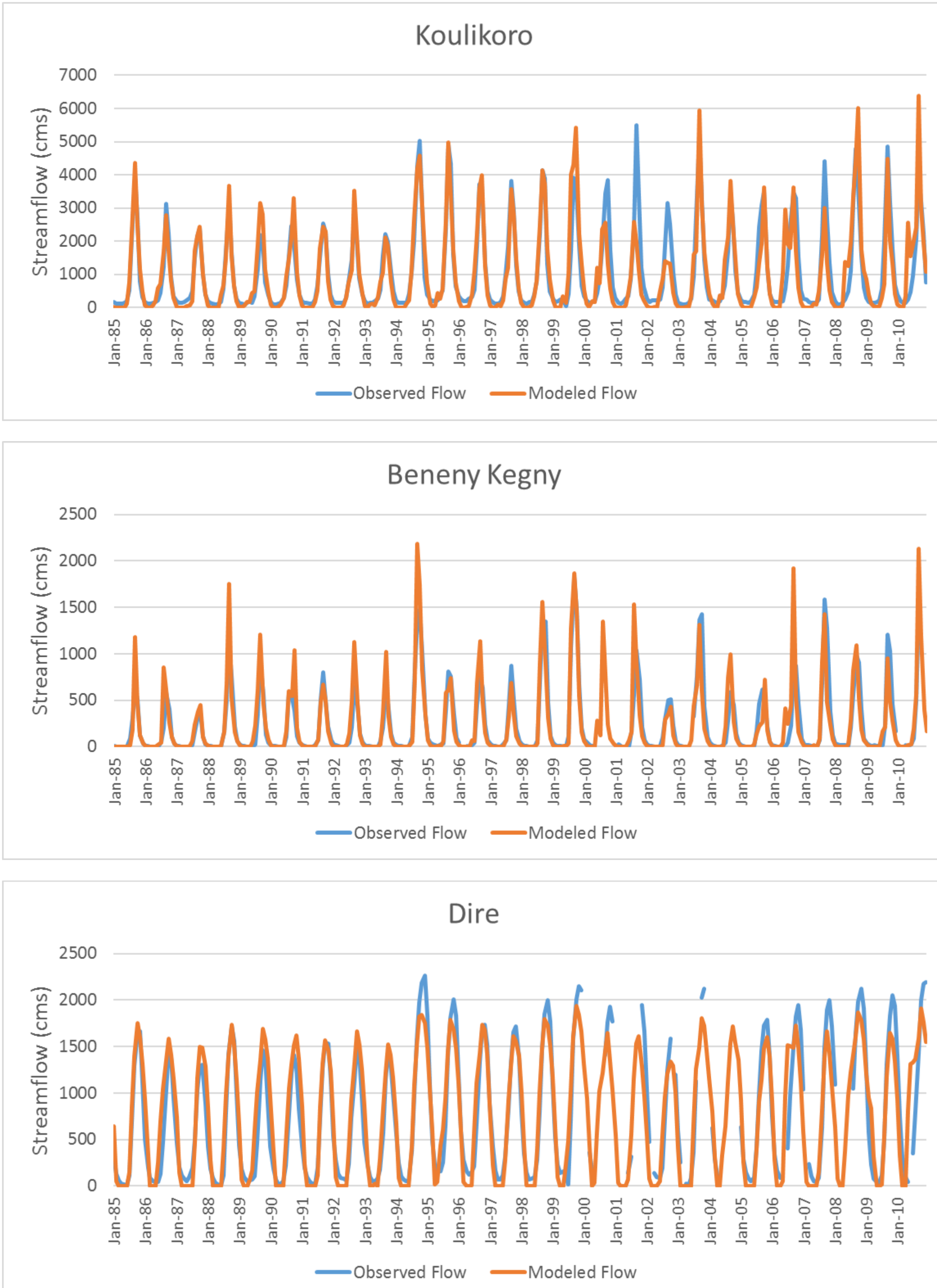


Figure S3: Simulated and observed streamflow at different locations along the Niger River

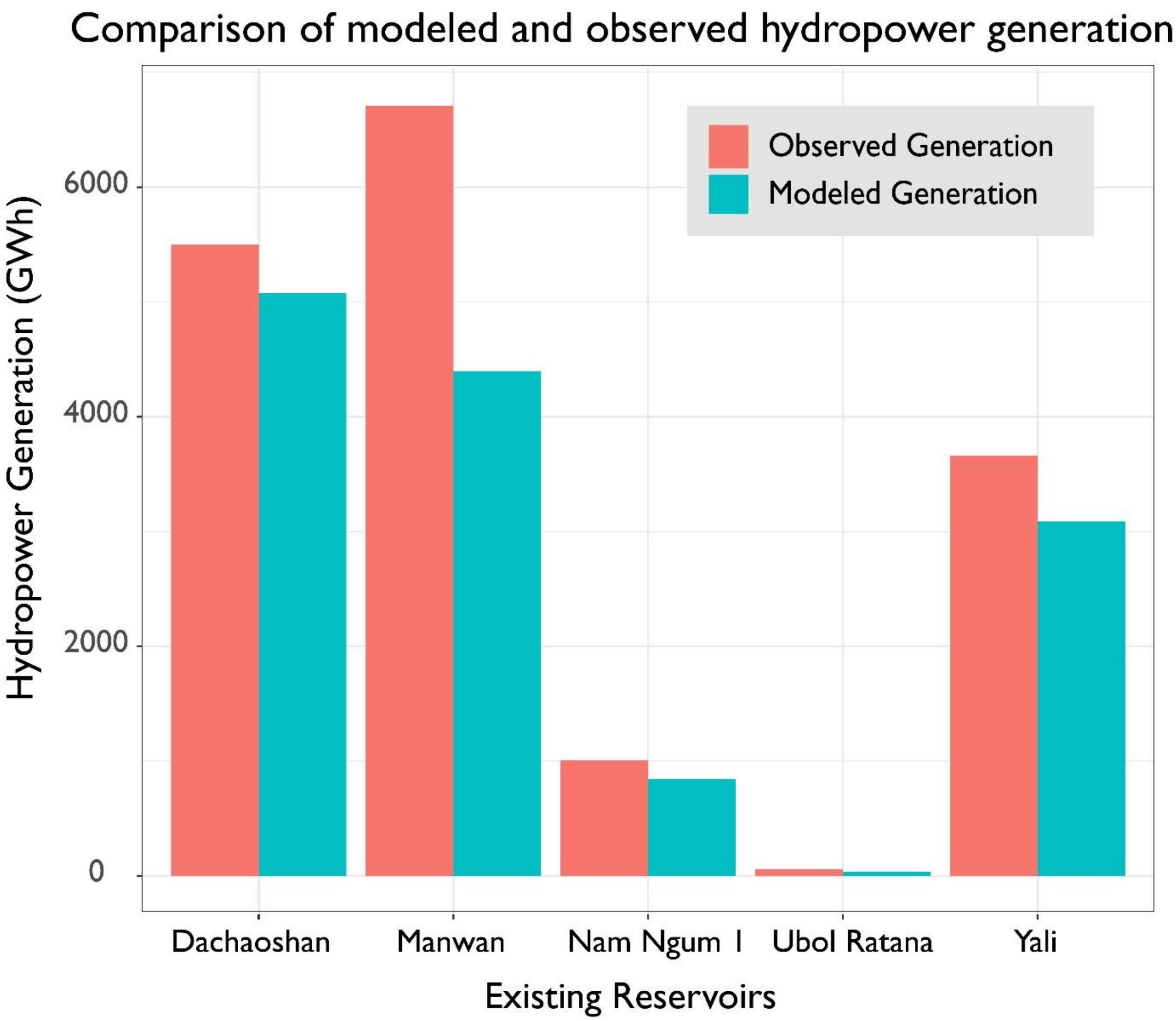


Figure S4: Comparison of simulated hydropower generated using the SWAT module under historic streamflow with observed generation in the Mekong River Basin

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