THA 2022 International Conference on
Moving Towards a Sustainable Water and Climate Change Management After COVID-19

Organised by:
Collaborative Agencies:
Supported by:
Managed by:

26 - 28 January 2022
09.00 - 16.30 hrs. (GMT+7 Bangkok)

WEEKLY GROUNDWATER PUMPAGE ESTIMATION IN UPPER CENTRAL PLAIN THAILAND VIA ARTIFICIAL NEURAL TECHNIQUE

Tran Thanh Long[1,2*], Chokchai Suthidhummajit[3] and Sucharit Koontanakulvong[3]

Bangkok, Jan 26-28, 2022

Content

Under the water stress in the recent dry years, the farmers in the Upper Central Plain Basin of Thailand have adapted conjunctive water use to meet high demand from rice cultivation. Conjunctive water management is an optimal tool of groundwater pumping guideline under reservoir water release conditions for sustainable development. However, weekly conjunctive water management operation remains difficult practice due to the difficulties on estimations of groundwater pumpage and reservoir water storage due to the complex modeling techniques, consuming time, and survey data.

This study aims to apply an artificial neural network to improve the estimation of weekly groundwater availability under extreme climate scenarios.

First, the weekly historical pumping pattern was calculated via monthly artificial neural networks through groundwater level, reservoir storage, and rainfall.

Second, the weekly groundwater pumping of the Younger Terrace Aquifer was validated through groundwater modeling, obtaining the region's piezometric head.

Third, the available groundwater was estimated based on three scenarios under sustainable drawdown criteria: wet year, drought year, and normal year scenarios.

Finally, the rainfall, groundwater level, and dam storage data from three climate scenarios were re-trained into the artificial neural network for the weekly available groundwater pumping. As a result, the ANN tool could guide properly the region's available groundwater by utilizing the relatively surface water data, less laborious, and cost-effective.

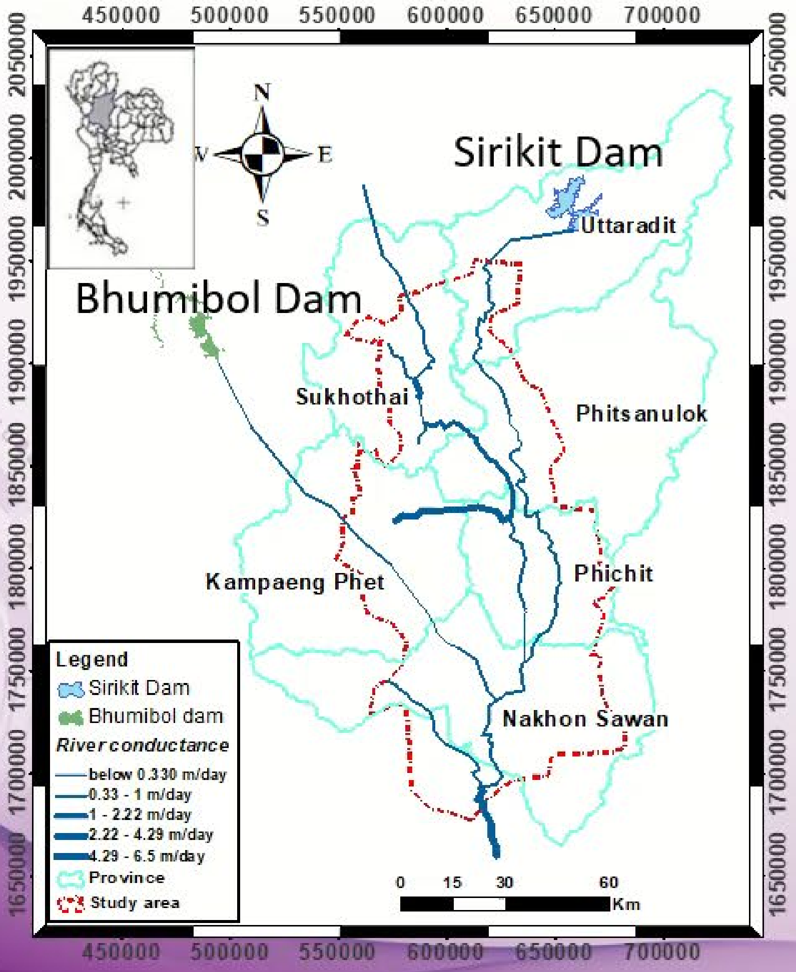
THA 2022 International Conference on

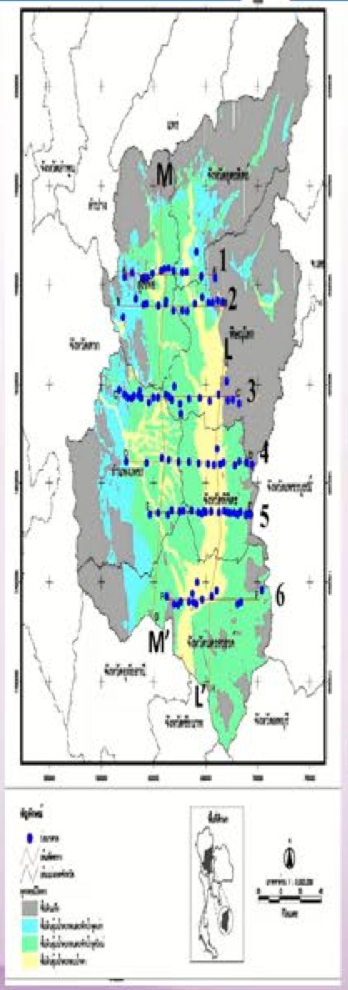
Moving Towards a Sustainable Water and Climate Change Management After COVID-19

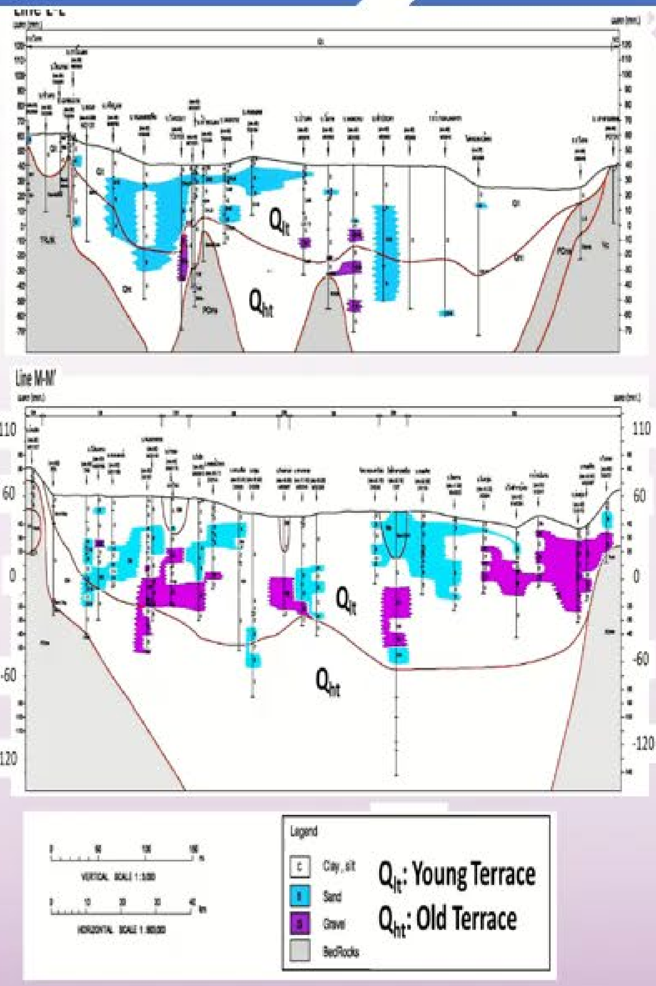
26 - 28 January 2022 09.00 - 16.30 hrs. (GMT+7 Bangkok)

Organised by: Collaborative Agencies: KWRA JICA EGAT Supported by: THAIWATER Sponsor: CKPower Managed by: informa markets

I. INTRODUCTION | **II. OBJECTIVE/ STUDY AREA** | III. STUDY THEORIES AND PROCEDURES | IV. RESULTS | V. CONCLUSIONS







Weekly groundwater level monitor

↓

ANN toolbox in monthly GW pumping

↓

Weekly River stage | Weekly land recharge | Weekly groundwater pumping

↓

Regional groundwater modeling

↓

Verifed regional groundwater modeling ← Maximum rainfall pattern from historical (1993-2016); Minimum rainfall pattern from historical (1993-2016); Average rainfall pattern from historical (1993-2016)

↓

Evaluated flow budget and available groundwater each scenarios

↓

Training ANN tool for estimation groundwater pumping and prediction groundwater available via monitor groundwater

↓

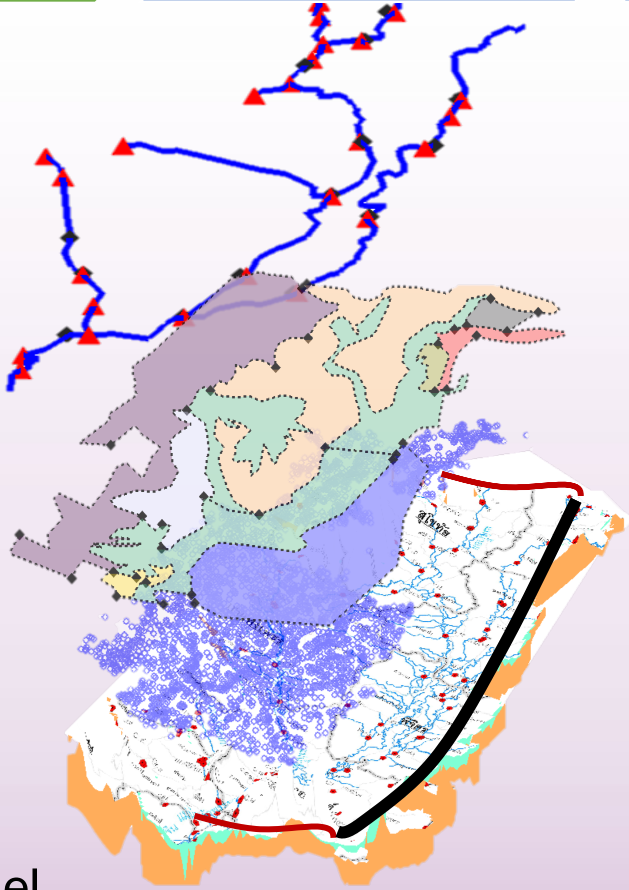
Estimate groundwater pumping with certain criteria groundwater level/ Rainfall/ Dam storage

Conceptual groundwater modeling

River recharge=conductive*(h_{river}-h_{GW})

Land recharge =recharge ratio*effective rainfall

Weekly groundwater use=well * pump rate



Regional groundwater model
grid-size 2 km X 2 km.

Specific head boundary
No flow boundary

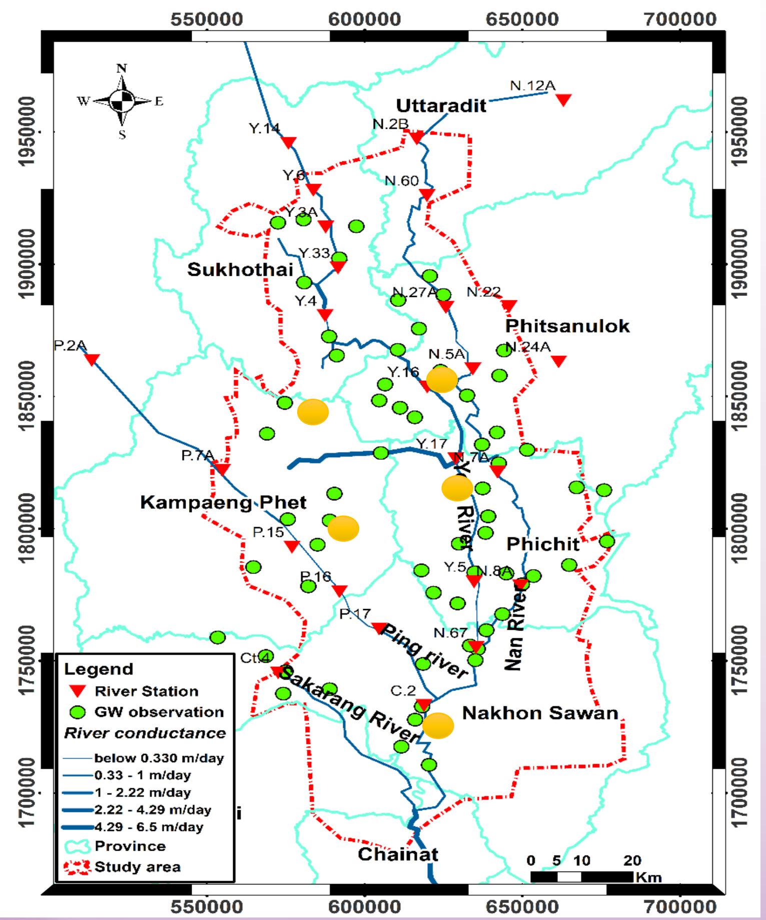
Monitoring network

Monitor runoff: 15 stations

Monitor GW: 112 monitoring wells

The conductance varies 0.2 to 6.5 m^2/day/m

- Automatic monitoring well



Criteria estimation available groundwater pumping

The **available groundwater pumping was estimated in three scenarios**

The drought year (rain <1000 mm like year 2016),

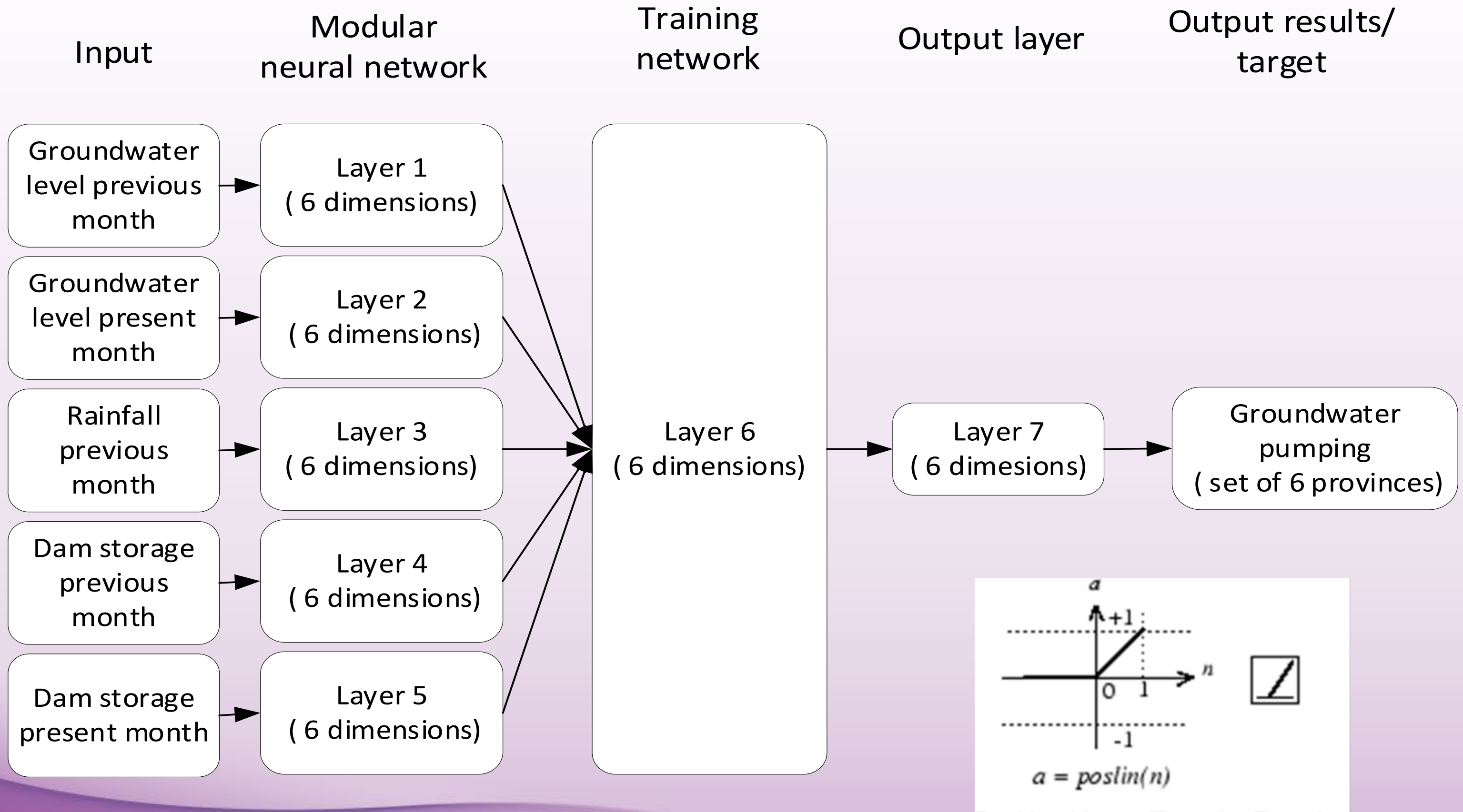
The normal year (1000< rain <1400 mm like year 2009),

The flood year (rain>1400 mm like year 2011).

The criteria is maximum available groundwater pump:

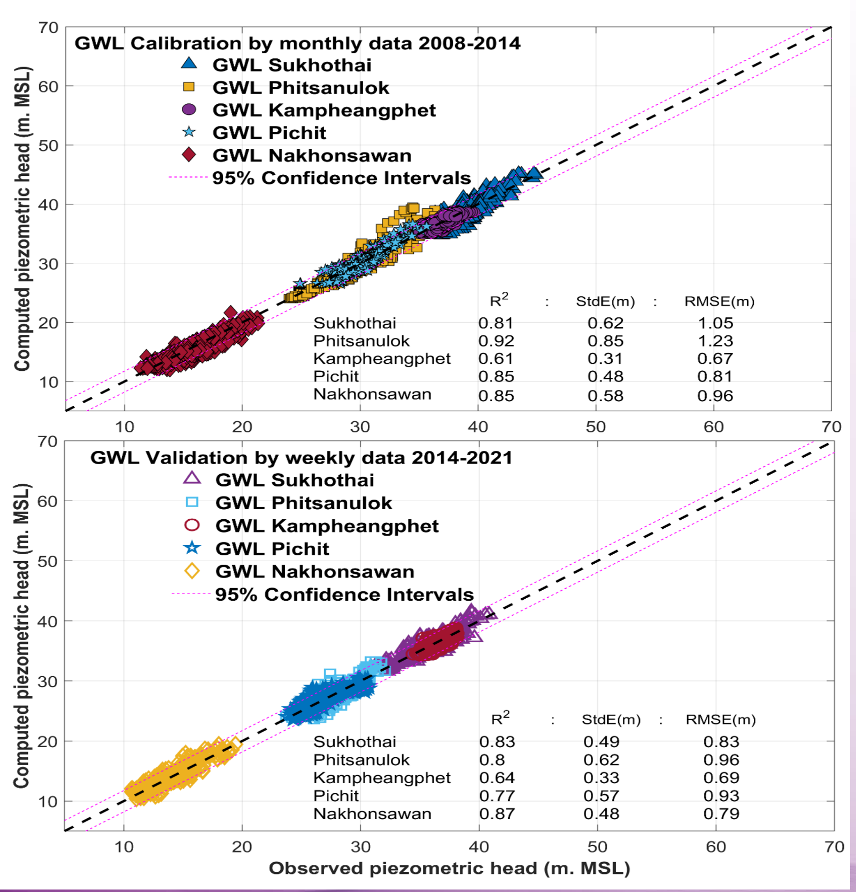
The drawdown of automatic monitor well is not below surface 20 meters. Except the Sukhothai station, the groundwater can not below 13meters, since the monitor station is far from the groundwater drawdown hotspot. When the groundwater level at Sukhothai station meet the drawdown 13 meters below the surface, the lowest drawdown of Sukhothai reach to 20 meters depth.

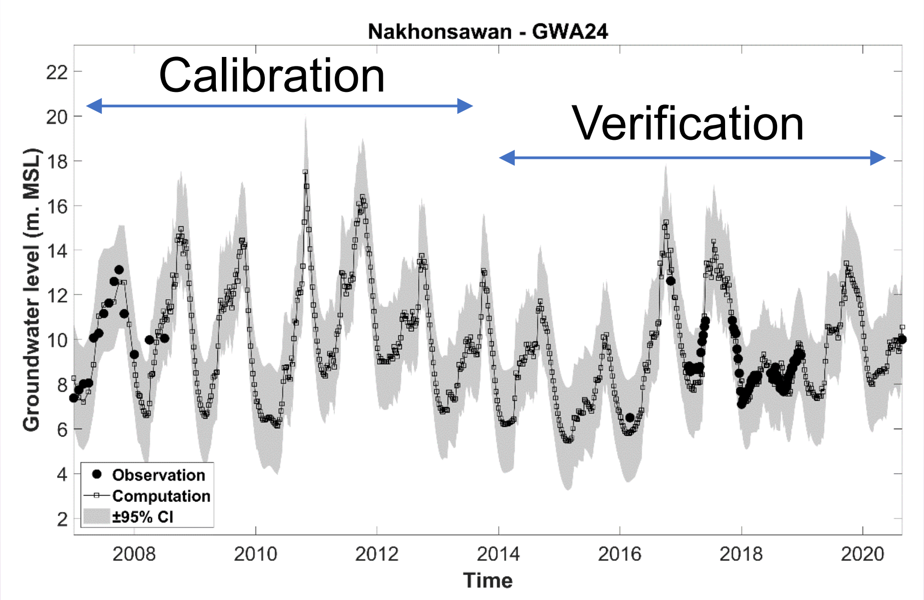
Modular neural network



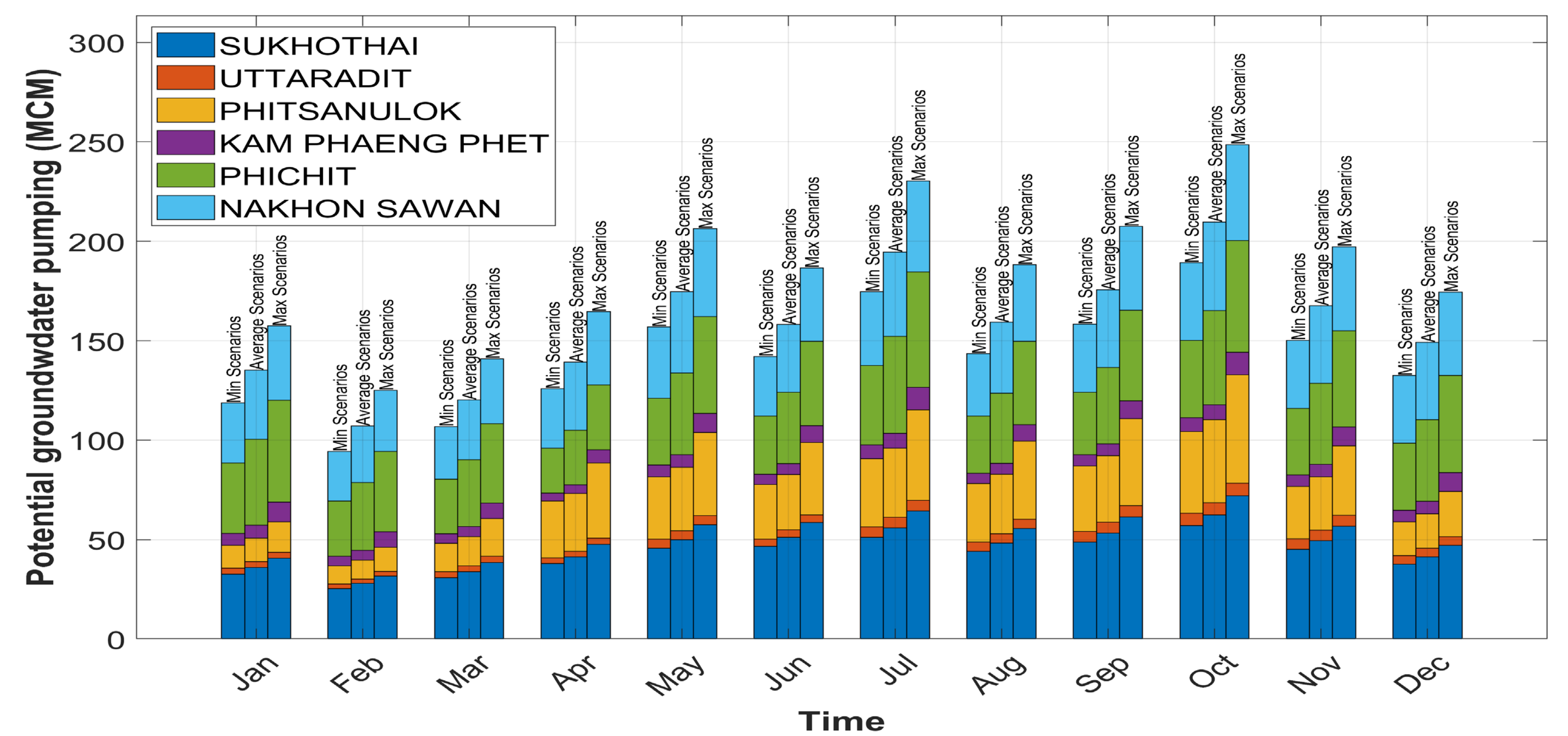
Positive Linear Transfer Function

Calibration and verification GW modeling

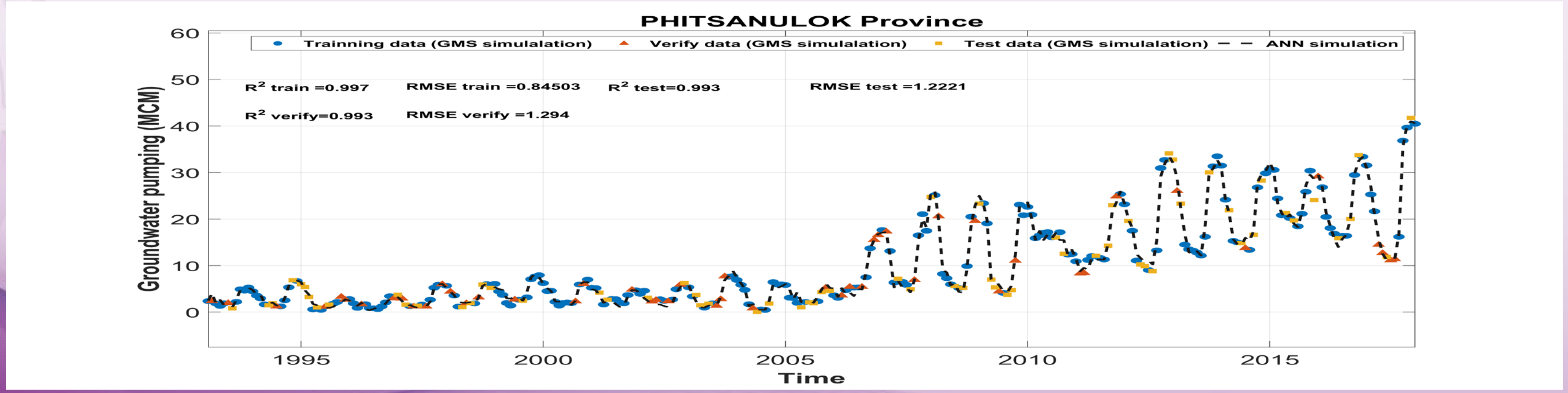




Available groundwater pumping in region



#	Name	Description	Neurons in preprocess layer	Neurons in hidden training layer	Neurons in output layer	R^2	RMSE
1	MNN_1	Without pre-processing data	0	24	5	0.95	3.09
2	MNN_2	Pre-processing groundwater level only	24	10	5	0.95	2.06
3	MNN_3	Pre-processing rainfall only	24	10	5	0.94	3.22
4	MNN_4	Pre-processing dam storage only	24	10	5	0.93	3.4
5	MNN_5	Pre-processing all data (rainfall, GWL, dam storage)	24	24	5	0.98	2.53
6	MNN_6	Pre-processing all data plus one hidden layer	24	24/24	5	0.99	1.32
7	MNN_7	Pre-processing all data plus two hidden layers	24	24/24/24	5	0.28	4.19



Under the sustainable groundwater drawdown criteria, the weekly available groundwater pumping was estimated more properly and make the monthly groundwater budget is more reliable

Province	Utaradit	Sukhothai	Phitsanulok	Khampeangphet	Pichit	Nakhonsawan
Available GW pumping monthly	2-6MCM	25-70MCM	10-54 MCM	4-11MCM	22-59MCM	28-48MCM

According to the good performance, the MNN can reliably predict the available groundwater pumping. Furthermore, the MNN tool could predict available groundwater using relatively fewer input data, less laborious, and cost-effective. Therefore, the MNN tool is a helpful guideline for the available groundwater in the region and may assist in the proper conjunctive management, especially in the crisis drought year. The accuracy of MNN tool could improve via remote sensing data. A future step should set up appropriate policy evaluation/allocation management models based on farmers' water use behavior, the existing irrigation system, the groundwater-well structures and the local groundwater potential.

Acknowledgment

The authors wish to thank the Water Resources System Research Unit, Chulalongkorn University (CU_WRSRU) staff. We also acknowledge the assistance of the RID and Upper Central plain officers for providing helpful information on the study area.

References

Koontanakulvong, S., 2008, groundwater potential in Plaichumpol Irrigation Project [in Thai].

Koontanakulvong, S., and Suthidhummajit, C., 2015, The role of groundwater to mitigate the drought and as an adaptation to climate change in the Phitsanulok irrigation project, in the Nan basin, Thailand.

Koontanakulvong, S. J. D. o. G. R. C. U., 2006, The study of Conjunctive use of Groundwater and Surface Water in Northern Chao Phraya Basin, Final Report.

Kourakos, G., and Mantoglou, A., 2009, Pumping optimization of coastal aquifers based on evolutionary algorithms and surrogate modular neural network models: Advances in water resources, v. 32, no. 4, p. 507-521.

Suthidhummajit, C., and Koontanakulvong, S., 2011, Climate Change Impact on Ground Water and Farmer's response (The Wang Bua Irrigation Project, Kampheng Phet Province, Thailand: Case Study).

Suthidhummajit, C., and Koontanakulvong, S. J. E. J., 2018, Flow Budget Change of Groundwater System under Climate Change in the Upper Central Plain, Thailand, v. 22, no. 1, p. 289-298.

Vasconcelos, V. V., Koontanakulvong, S., Suthidhummajit, C., Junior, P. P. M., and Hadad, R. M. J. A. W. S., 2017, Analysis of spatial–temporal patterns of water table change as a tool for conjunctive water management in the Upper Central Plain of the Chao Phraya River Basin, Thailand, v. 7, no. 1, p. 245-262.

Q&A

THANH YOU FOR YOUR ATTENTION