United Nations Educational, Scientific and Cultural Organization

University Twinning and Networking Programme

13 CLIMATE ACTION

UNESCO Chair on Water, Disaster Management and Climate Change

the UNESCO International Water Conference, during 13 and 14 May 2019

Chulalongkorn University

Thailand

Chair holder: Assoc. Prof. Dr. Sucharit Koontanakulvong

http://project-wre.eng.chula.ac.th/watercu_eng/

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Current areas of activity

- Water Security Assessment in ASEAN
- Vulnerability and Risk assessment due to Climate Change
- PERSIANN-CCS Estimation for Water and Disaster Management
- Climate Change Impact Assessment on Groundwater Management for sustainable development

Future Activities to address the SDGs

- Water-Energy-Food NEXUS's data base and model development for Sustainable Development
- Flood and Drought Monitoring and Warning System with application from Remote Sensing Images
- Sustainable Groundwater Management under Climate Change
- THA2019 International Conference on Water, Disaster Management and Climate Change
- Smart System for Dam Operation

Education 2030

Water Security and Sustainability
Thailand's Water Security Situation in the context of world and ASEAN

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Abstract

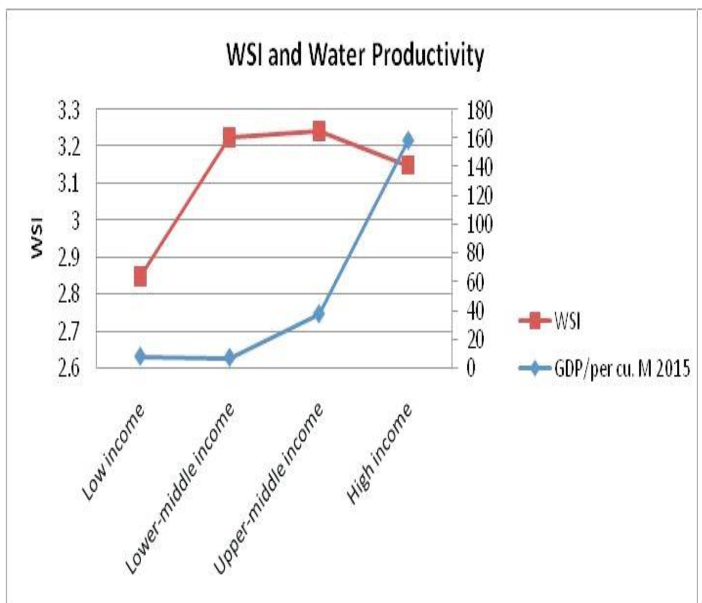
Worlds nowadays focus on SDG goals to be set as country benchmark for socio-econ-environmental development.The successful countries for sustainable water security depend on efficiency of integrated water management, water productivity and provision of water supply and sanitary services. Water security index was another issue that had been proposed to monitor the national socio-economical development which comprised of household, urban water, economic water (including irrigation water), river health and resilience. The study proposed the water security definition and assessed the water security status of Thailand by using water use status and correlated with gross domestic product per capita, water productivity, Government effectiveness (as governance), political stabilities in various countries of the world, Asia and ASEAN which helped to understand the competitiveness and the strength, weakness and potential of water resources development of Thailand compared with the rest of the world and ASEAN countries and their initiatives needed.

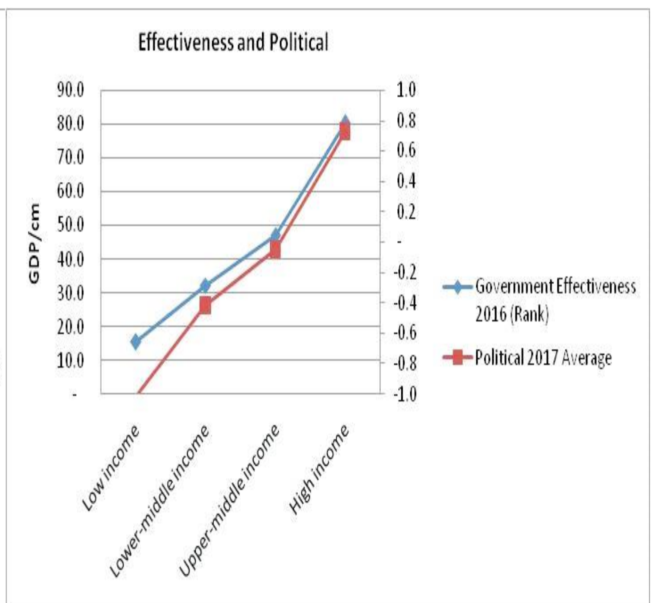
Definition and methodologies

This study determined the water security status from five dimensions, i.e., WS1: basic water (renewable, supply, hygiene), WS2; sufficient water (water supply, consumption, agricultural water), WS3:development water (irrigation area, industrial water use, water for energy, water for aquaculture), WS4:water disaster (loss from floods and drought), WS5:water for future (population growth, urban population growth, water footprint) (Sucharit et. al., 2014). The index status analysed were correlated with water use unit (cubic meter per capita), water productivity (US $ per cubic meter of water use), government effectiveness, political stabilities and grouped into four groups of country classified by income per capita of the country. Based on the available data from various sources of the world (World Bank, 2016; ADB, 2016), the index of each country was determined comparatively by weighting equally from each dimensions and ranked by marking equally (1-5 points) of each elements from the average and standard deviation values while the security status in ASIA is based on ADB study (ADB, 2016, 2019; Piyatida et.al., 2019).

Water security status in the world scale

The water productivity, measured by the income per capita and per water use unit, was assessed and compared with the water security index obtained and it showed that more water productivity induced better water security status in the upper middle and high income group due to the loss of water disaster. The government effectiveness and political stability also grows with income per capita stage which reflects the influenced factors of governance and politic to water security.



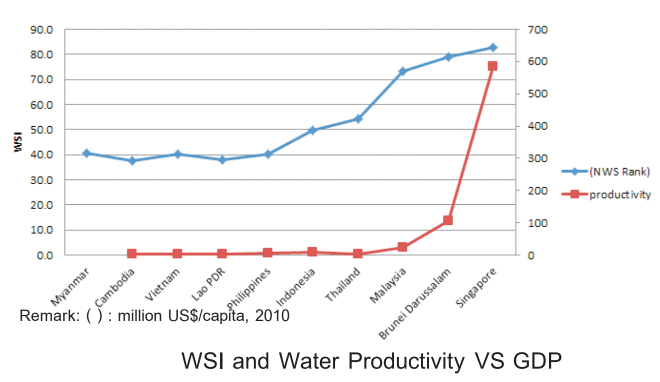


Acknowledgement

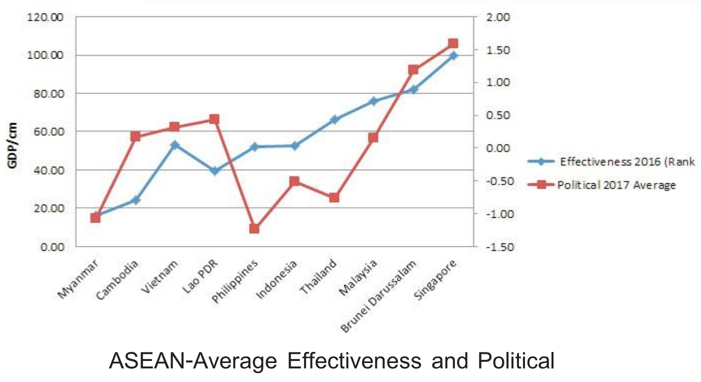
The authors would like to express sincere thanks to NRCT-TRF Spearhead Research Program on Water Resources Management for their research funding and to Chulalongkorn University for her supports for working place and utility provision.

Thailand and ASEAN

The water security status of Thailand, compared with the world, Asia and ASEAN regions were investigated with the ranking in each dimension as shown in Table 1. Within ASEAN countries, the water use, water productivity(Suthidhummajitet.al., 2019) and water security status of each country VS country GDP per capita were assessed comparatively and it showed that Thailand has the highest water use unit, moderate lower water productivity and moderate in water security ranking.



WSI and Water Productivity VS GDP



ASEAN-Average Effectiveness and Political

Table 1 Water Security of Thailand compared with the rest of the world

Elements	World		Asia		ASEAN		Thailand
	average	ranking	average	ranking	average	ranking	
Gross domestic product : Population	14,260	88	9,546	14	11,117	4	5,980
Water productivity (GDP/cm)	81	132	49	20	82	6	4
Government Effectiveness	48.70	59	46.34	13	56.30	2	66.3
Political stability index	-0.05	118	0.14	32	0.03	8	-0.76
National Water Security Index by Economy (NWS Score) (full score: 25)	15.8	23	16.7	12	17	5	17.3

Remark: 1) Gross domestic product Population: World Bank (2016), 2) Water productivity (GDP/cm) : World Bank (2015), 3) Government Effectiveness : World Bank (2016), 4) Political stability index : World Bank (2017), 5) National Water Security Index by Economy: ADB 2016, * Sucharit 2014.

National Water Management Strategies

Thailand had set up long term National Strategic Plan and water resources management is an important issue out of 23 issues (NESDB, 2019). The concept of water security was used of the framework and target setup on water security, water productivity, water governance with counter initiatives in lined with SDGs, i.e.,

Group 1 to reduce loss via issues of flood and drought (SDG 13), urban water (SDG 11),

Group 2 to induce more value added and participation via issues of water productivity (SDG 9) and water governance (SDG 16),

Group 3 to upgrade quality of life via issues of environmental water (SDG 6), watersanitary (especially in the rural areas) (SDG 6).

Conclusions

This study showed the status of water security of Thailand compared with the rest of the world. Thailand has strengths on clean water and sanitation water accessibility and water for development due to the investment in the past. However, water use status in fresh water renewable, agricultural sector, i.e., low efficiency, high water footprint, low productivity, water resilient, urban water seemed to be a weakness compared with other countries. Water governance is comparatively in good handled. Based on the National Master Plan on water resources management, the urgent issues are to reduce loss, to enhance more value added and to improve quality of life to comply with SDG 6.

References

ADB (2016) ASIAN Water Development Outlook, ISBN 978-92-9257-543-4 (Print), 978-92-9257-544-1 (e-ISBN), Publication Stock No. RPT168317-2

ADB (2019) Asian Water Development Outlook 2020, Asia Pacific Water Forum, Report on 1st Coordination Workshop, 27 and 28 February 2019.

Piyatida H., et. al., Water security, Water Productivity, Water Resilience Assessment for Water Masterplan Preparation, Progress report, Feb 2019 (in Thai).

NESDB, Master Plan under National Strategic Plan, Water System Management, Report No. 19, 2019 (in Thai).

Sucharit Koontanakulvong, PiamchanDoungmanee and PiyatidaHoisungwan. "Thailand's Water Security Situation in the context of world and ASEAN." Hydrological Sciences and Water Security: Past, Present and Future (from Proceedings of the 11th Kovacs Colloquium, Paris, France, June 2014). IAHS Publ. 366, (2014): 2 pp. (IAHS Press doi:10.5194/piahs-366-117-2015)

Suthidhummajit S. and Koontanakulvong S.The study report of Water Balance Analysis, Water Accounting and Water Productivity, 2019.

Suthidhummajit S. and Koontanakulvong S., Evaluation of Water Productivity of Thailand and Improvement Measure Proposals, Proc. KWRA, May 2019.

World Bank, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD, 2016

((Note The material is distributed in the session of Water Security in the UNESCO International Water Conference during 13 and 14 May 2019 at UNESCO Headquarters in Paris, France).

Improved Irrigation Demand Estimation via Soil Moisture Data from Satellite Images

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Abstract Nowadays, the development of optimum irrigation efficiency has been becoming more and more important with a primary role of controlling rate and time of irrigation water to meet crop water demand, while constraining losses and preserving water resources (Alhammadi and Al-Shrouf 2013). The soil layer and actual value of soil moisture content (SMC) at any given time must be known before any decisions on improving irrigation management can be made. In recent years, satellite surface soil moisture has tended to be more widely available (Champagne et al. 2016). In the study, the irrigation demand is estimated by using satellite images, LANDSAT. The Enhanced Vegetation Index (EVI) and Temperature Vegetation Dryness Index (TVDI) values are estimated from the plant growth stage and soil moisture to estimate near real-time irrigation demand. The derived irrigation demand estimation will help water allocation for irrigation and dam operation to meet the water demand of stakeholders more effective and efficient.

Definition and methodologies

The EVI2 and TVDI values were calibrated and verified with the field plant growth stages and soil moisture field data in the year 2017-2018. The irrigation demand in the irrigation project is then estimated from the plant growth stage and soil moisture in the Thor Thong Daeng Irrigation Project, Kamphangphet Province. With the estimated irrigation demand, the dam operation will manage the water supply in a better manner compared with using the past operational average data

Soil moisture sensor data

A soil moisture estimation model is established by using a collection of soil moisture observation and remote sensing data. A stepwise multiple regression approach was used to assess the relationship between observed soil moisture data and remote sensing data, i.e., TVDI were used as independent variables. The model can be computed by a regression formula as follows:

$$\text{Estimated soil moisture} = a + b(\text{TVDI})$$

where the estimated soil moisture is given as a percentage (%), and a, b are the coefficients of the regression lines of the TVDI.

The function was verified by comparing observed soil moisture content (SMC) at two observed locations in Phitsanulok Province with estimated SMC which was applied the function and TVDI values. Six Landsat 8 images were used to estimated TVDI and SMC at two locations. The estimated values of SMC presented a good correlation with observed values (adj-R2 = 0.5876) (as in Figure 1).

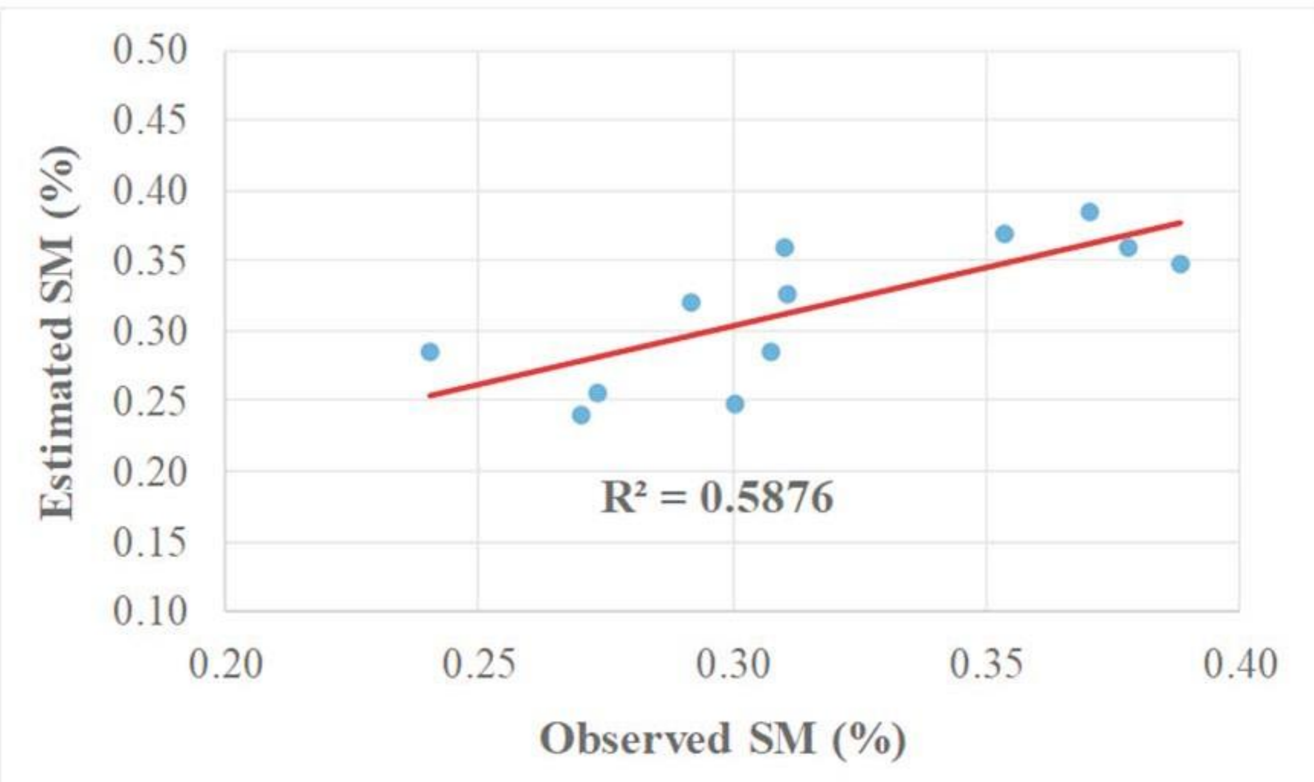

Figure 1. Calibration results of observed and estimated SMC

References

- Alhammadi, M, and A Al-Shrouf. 2013. 'Irrigation of sandy soils, basics and scheduling. Agricultural: crop production', InTech Book Series.
- Allen, Richard G, Luis S Pereira, Dirk Raes, and Martin Smith. 1998. 'Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56', FAO, Rome, 300: D05109.
- Champagne, and et al. 2016. 'Satellite surface soil moisture from SMOS and Aquarius: Assessment for applications in agricultural landscapes', International Journal of Applied Earth Observation and Geoinformation, 45: 143-54.
- Chen, Shulin, Zuomin Wen, Hong Jiang, Qingjian Zhao, Xiuying Zhang, and Yan Chen. 2015. 'Temperature vegetation dryness index estimation of soil moisture under different tree species', Sustainability, 7: 11401-17.
- Gao, Zhiqiang, Wei Gao, and Ni-Bin Chang. 2011. 'Integrating temperature vegetation dryness index (TVDI) and regional water stress index (RWSI) for drought assessment with the aid of LANDSAT TM/ETM+ images', International Journal of Applied Earth Observation and Geoinformation, 13: 495- 503.

Irrigation demand estimation

Crop water demand is defined here as "the depth of water needed to meet the water loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment".

This water can be supplied to the crops in various ways such as by rainfall, irrigation or a combination of irrigation and rainfall. In this study area, part of the crop water need is supplied by rainfall and the remaining part by irrigation. In such cases, the irrigation water demand is the difference between the crop water need (ET crop) and that part of the rainfall which is effectively used by the plants (Pe) as the following formula:

$$IWD = ETcrop - Pe = Kc*ETo - Pe$$

where Pe is effective rainfall and ETo is reference crop evapotranspiration which can be calculated based a three-stage procedure of Allen et al. (1998).

Besides, total water demand of irrigation area can be estimated by using EVI2 coefficient to define growth stage and NDVI to distribute crop area. Table 1 shows the estimation of the irrigation water demand of the whole irrigation area. The estimated demand is highest in March due to heading and ripening period of paddy. During the logging and harvesting period in April, the demand increased to about 65 MCM/month. 2018

Table 1 Irrigation water demand estimation during dry season

Month	Monthly rainfall (mm)	Ce	Effective rainfall (m)	ETo (mm/d)	Kc	ET_{crop} K_c*ET_o (m)	Area (m^2)	Irrigation demand MCM
January	3.21	0.00	0.000	3.26	1.07	0.105	5.84E+08	61.30
February	14.16	0.80	0.011	3.91	1.37	0.161	5.84E+08	87.46
March	15.34	0.80	0.012	4.35	1.44	0.187	5.84E+08	102.19
April	48.61	0.80	0.039	5.01	1.01	0.152	5.84E+08	65.94

Efficiency improvement potentials

Based on the water loss from agricultural fields due to evapotranspiration and conveyance, irrigation water demand for the command area was calculated from January to April 2018. In this study, the net irrigation water demand was computed on monthly.

Table 2 Comparison of irrigation supply and demand ratios

Time	Irrigation demand MCM	Water supply MCM	Net Demand - Supply MCM	Ratio of Supply/Demand	Soil moisture
Jan-18	61.30	77.5	-16.20	0.72	27%
Feb-18	87.46	60	27.46	0.51	38%
Mar-18	102.19	75	27.19	0.47	40%
Apr-18	65.94	0	65.94	0.00	30%

Conclusions

To improve irrigation efficiency, demand and cultivation area estimation is very crucial. In this study, the satellite data provided the cultivation area, plan growth, and demand via ground data verification. The derived irrigation demand estimation will help water allocation for irrigation and dam operation to meet the water demand of stakeholders more effective and efficient.

Acknowledgement

The authors would like to express sincere thanks to NRCT-TRF Spearhead Research Program on Water Resources Management for their research fundings, thanks to RID-Thor Thong Daeng Irrigation Project, Kamphengphet Province, GISTDA for their assistances for field data provision, satellite images and to Chulalongkorn University for her supports of working place and utility provision.

(Note The material is distributed in the session of Water and Technological Innovation in the UNESCO International Water Conference during 13 and 14 May 2019 at UNESCO Headquarters in Paris, France).

ANN applications to Dam Operation Improvement

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Abstract

The dam plays essential role in long-standing strategy to secure a reliable source of water for a wide variety of human activities. Although numerous extensively studies have been done on optimal dam operation via stationarity and past hydrological experience, the effective decision making of release becomes more challenge under the effects of both climate variability and human responses since severe floods and droughts occurred more frequently. Besides, the prediction of real-time dam operation still remains obstacle in effective transmission of precipitation information, consuming computation time and memory capacity

. To improve adaptive dam operation, this study attempted to develop new tools for dam release decision making by generating the inflows and release of the Bhumidol Dam, Thailand by two separate ANN model utilized the upstream rain gauge stations in the past 10 years daily rainfall data.

Definition and methodologies

Since ANN with one hidden layer is sufficient to solve all problem of the hydrologic process , the architecture of each ANN for hydrology process model consists one input layer, one hidden layer, and one output layer (Figure 1). The best network's configuration (number of nodes, weights, biases) was defined through the performance of fitting among the neural network predicted values and the desired outputs. The training of the neural network models was stopped when either the goal of error was achieved or the number of iterations exceeded a prescribed value.

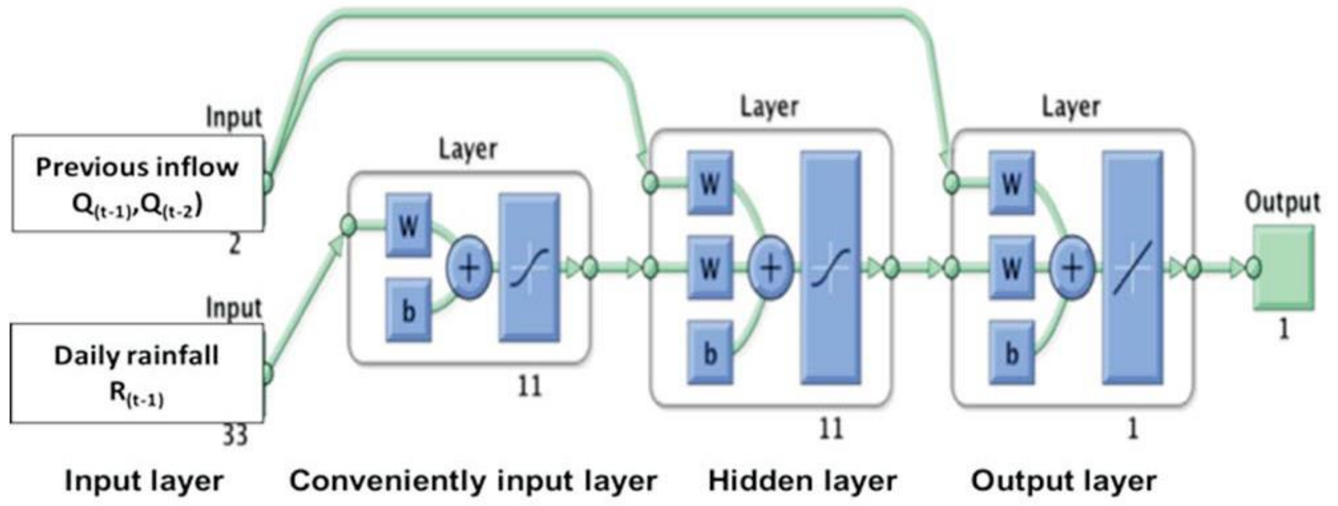

Figure 1. Structure of ANN with conveniently input layer for rainfall-runoff

Rainfall- Dam inflow

According to statistic performance form six combinations of input variables, the combination previous rainfall and two consecutive days of inflow is suitable for rainfall runoff in this study area.. To illuminate this problem, the precipitation was connected to conveniently input layer before transfer to hidden layer (see Figure 1). The performance of ANN was improved when the output was close to peak flow (see Figure 2). The RMSE of ANN with conveniently input layer for calibration and validation are 5.3 and 3.9, respectively. The R2 is 0.92 for training process and is 0.89 for validating process.

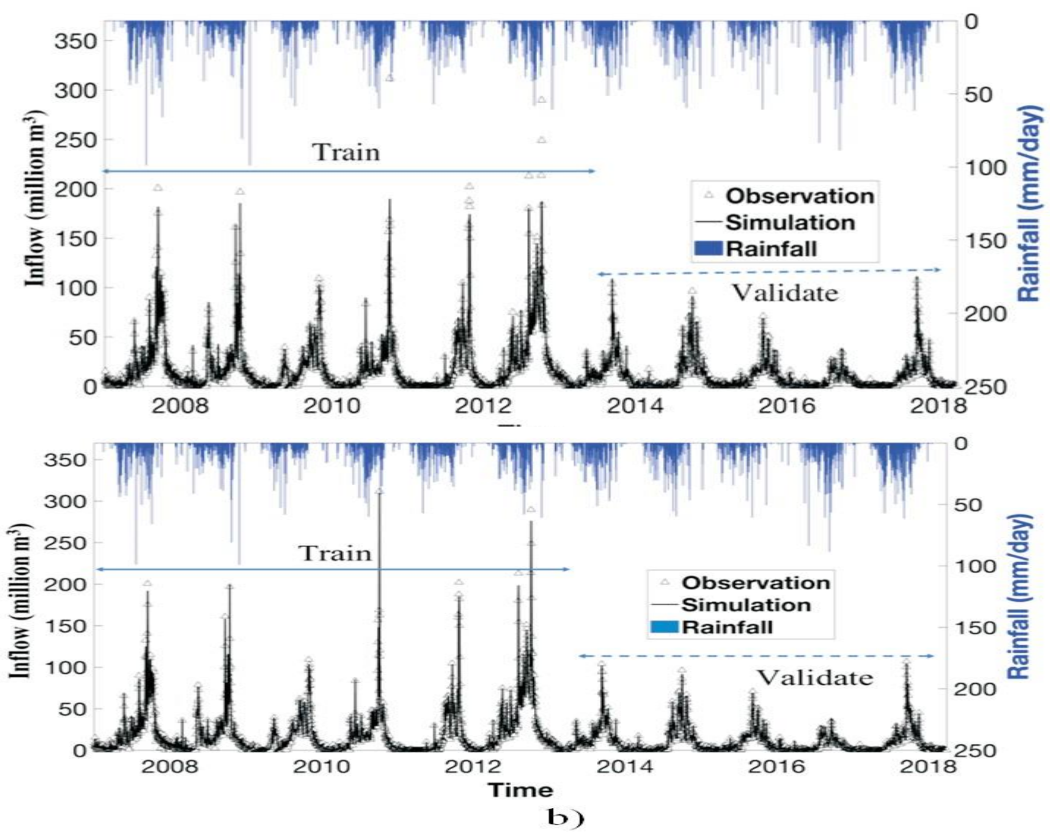

Figure 2. Results inflow of ANN with conveniently input layer

(Note The material is distributed in the session of Water-related Decision-Making in the UNESCO International Water Conference during 13 and 14 May 2019 at UNESCO Headquarters in Paris, France).

Inflow and Dam Release

The combination of two consecutive days of capacity and inflow presented the best performance from six combination variability inputs. The RMSE of calibration and validation are 5.33 mcm, and 3.912 mcm, respectively. The R2 of calibration and validation are 0.92 and 0.95, respectively. Although the simulate could not clarify some immediately high release dam, the ANN is possibility to predict dam release following the current rule curve.

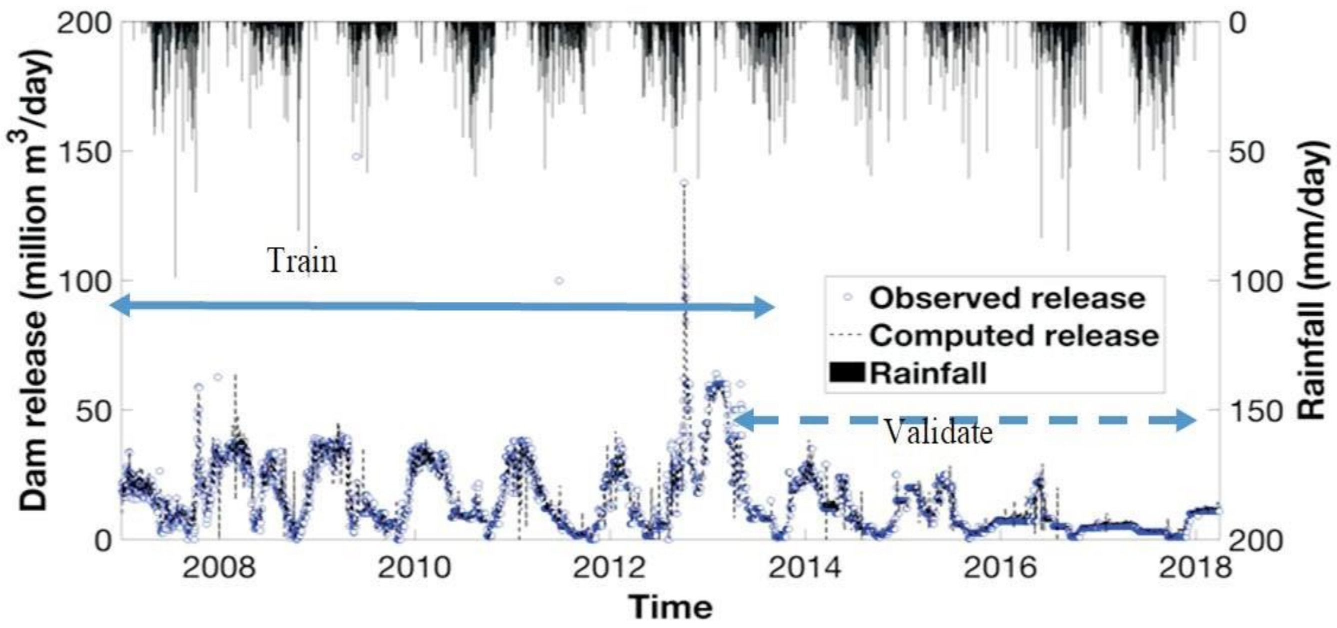

Figure 3. Results dam release following the current rule curve

Possible Improvements for decision making

According to potential application of ANN in hydrologic process, this study propose possible approach to improve water release decision making. The improved water release decision making will be generated from dynamic water demand and optimal ANNs making decision. The procedure shows as following:

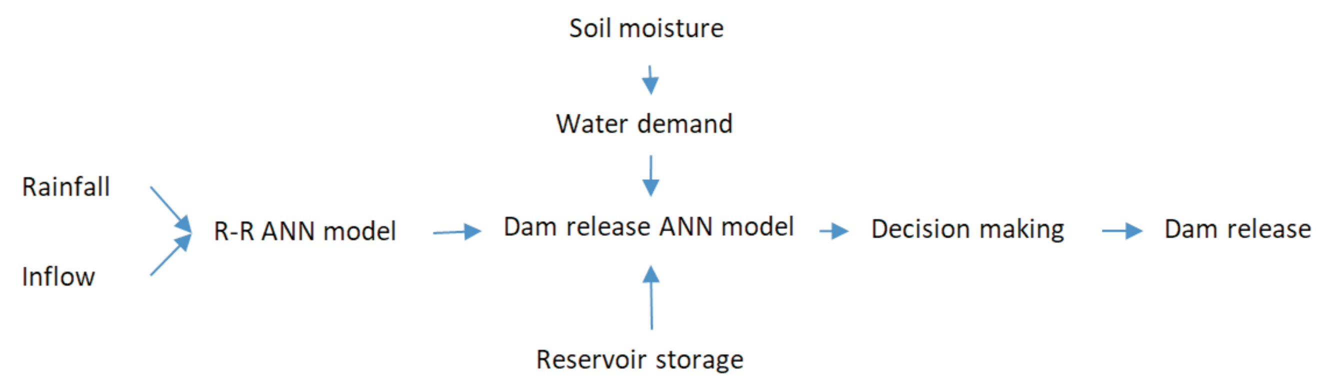

Figure 4. Improved water release decision making will be generated from dynamic water demand and optimal ANNs making decision

Conclusions

This study showed potential ANN applications to Dam Operation Improvement. The water release decision making could be developed more adaptive with climate variability and human responses by integrating dynamic water demand and optimal ANNs making decision. However, the inputs of ANN hydrologic process need to be clarified the reliable source water contributions to the inflow and consider scale impact of water demand to avoid redundant parameters which provide inappropriate release decision making.

References

De Vos, N., Rientjes, T., 2005. Constraints of artificial neural networks for rainfall-runoff modelling: trade-offs in hydrological state representation and model evaluation. Hydrology Earth System Sciences Discussions 2, 365-415.
Kolmogorov, A.N., 1957. On the representation of continuous functions of many variables by superposition of continuous functions of one variable and addition. Doklady Akademii Nauk. Russian Academy of Sciences, pp. 953-956.
Vuckovic, A., Radivojevic, V., Chen, A.C., Popovic, D.J.M.e., physics, 2002. Automatic recognition of alertness and drowsiness from EEG by an artificial neural network. 24, 349-360.

Acknowledgement

The authors would like to express sincere thanks to NRCT-TRF Spearhead Research Program on Water Resources Management for their research funding, thanks to EGAT for dam operational data and to Chulalongkorn University for her supports of working place and utility provision.

Water-Energy-Food NEXUS for Socio-Economic Development: Case of Thailand

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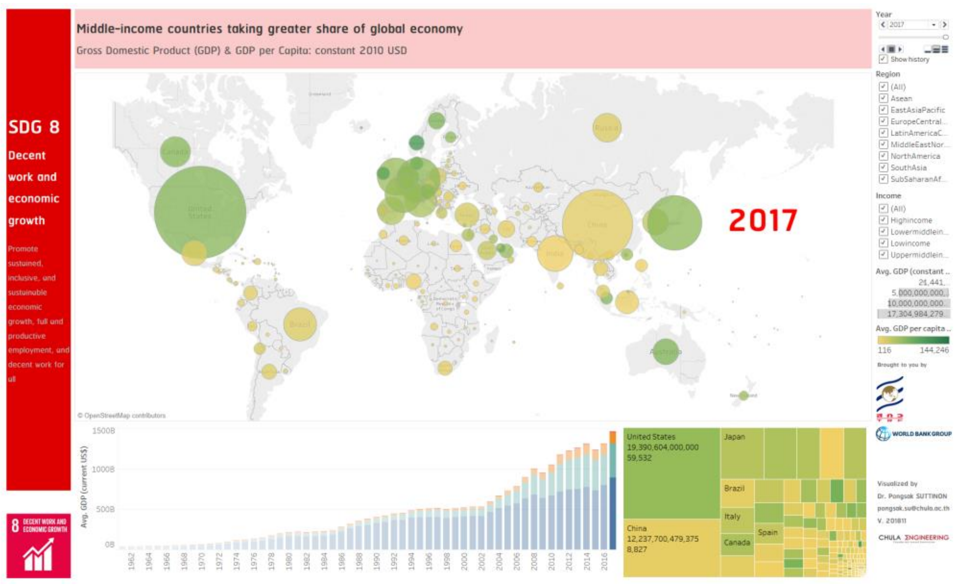
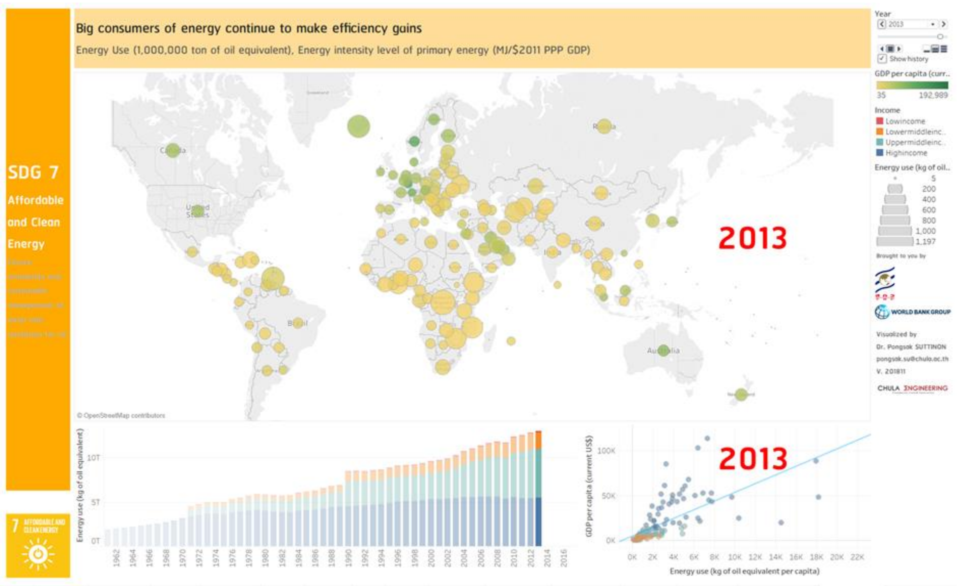
Why WEF NEXUS? Rapid urbanization in our world with regional socio-economic development is vulnerable under resource scarcity. Water, energy and food/land are essential to meet these demands. It is certain that all resources are also intensifying vulnerabilities to future demands. The "Water-Energy-Food NEXUS" approach aims to link socio-economic development and management of water, energy, and food securities by minimizing co-trade-off and optimizing co-benefit. "**Data-Driven-Decision**" is the main issue to support policy makers, developing database for synergies.



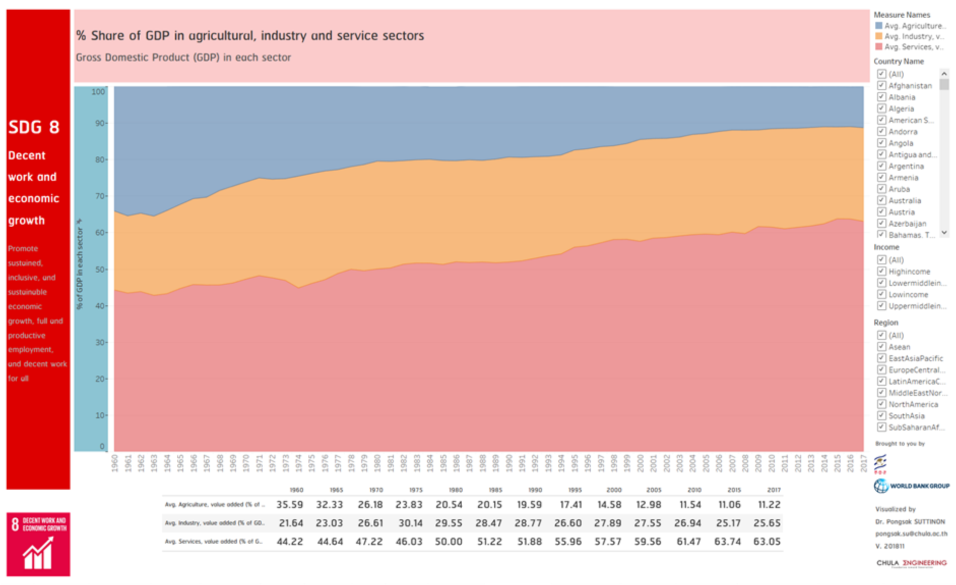
Development of Thailand in the world:

Asian Development Bank concluded that "Asia's march to prosperity will be led by seven economies, two of them already developed and six fast growing middle income converging economies: PRC, India, Indonesia, Japan, Republic of Korea, Thailand and Malaysia" especially in socio-economic terms.



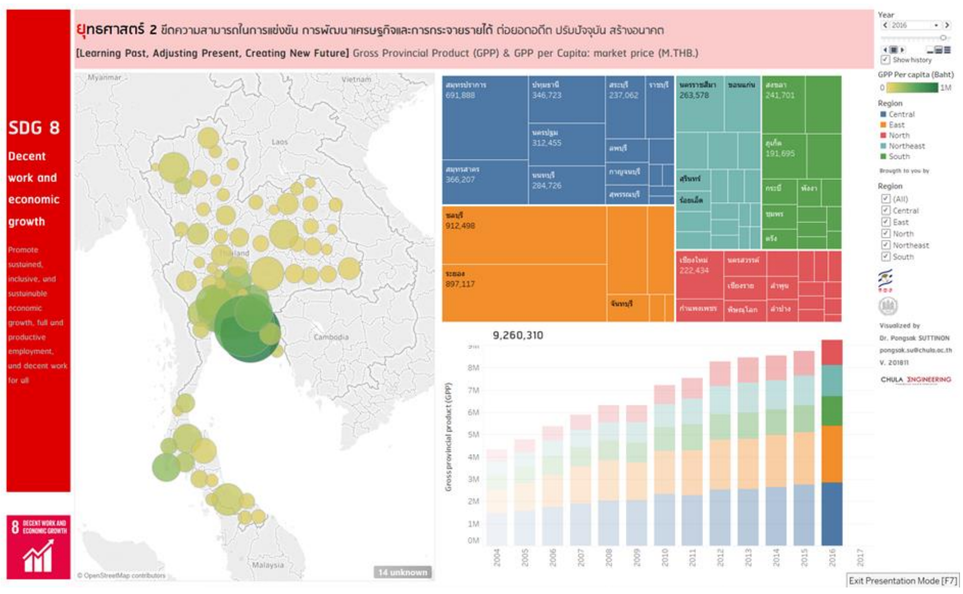
Energy intensity

Energy is the same trend as water issue. High-income country always consumes greater water use per capita. If Thailand would like to be developed country in the near future. We should carefully consider how to manage water, energy, and land in a sustainable way.



Economic structural change

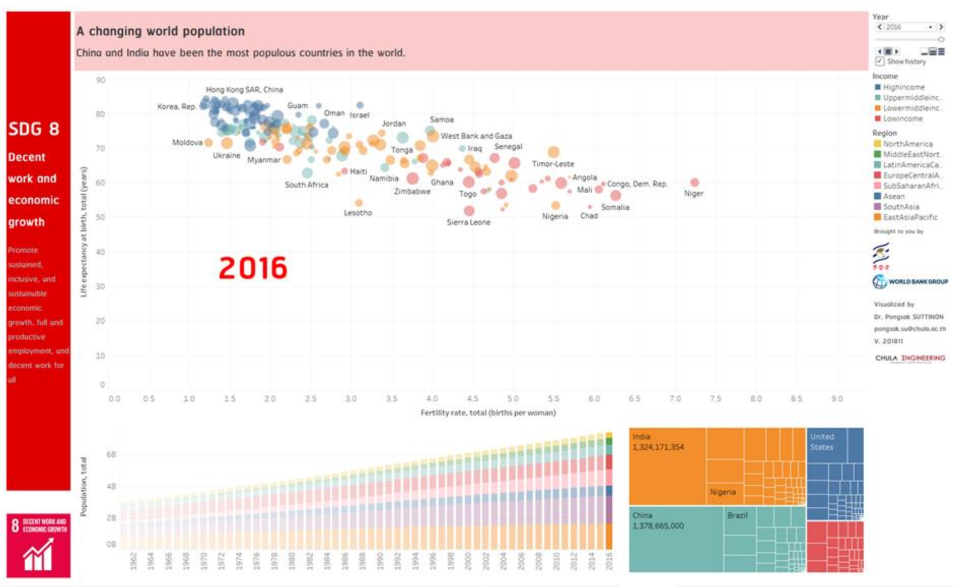
Change of economic structure from the past to present shows that percentage of GDP in agricultural sector is decreasing and service sector is increasing. Thailand is also changing with this trend under concerns of water, energy and food security.



Security in Local level

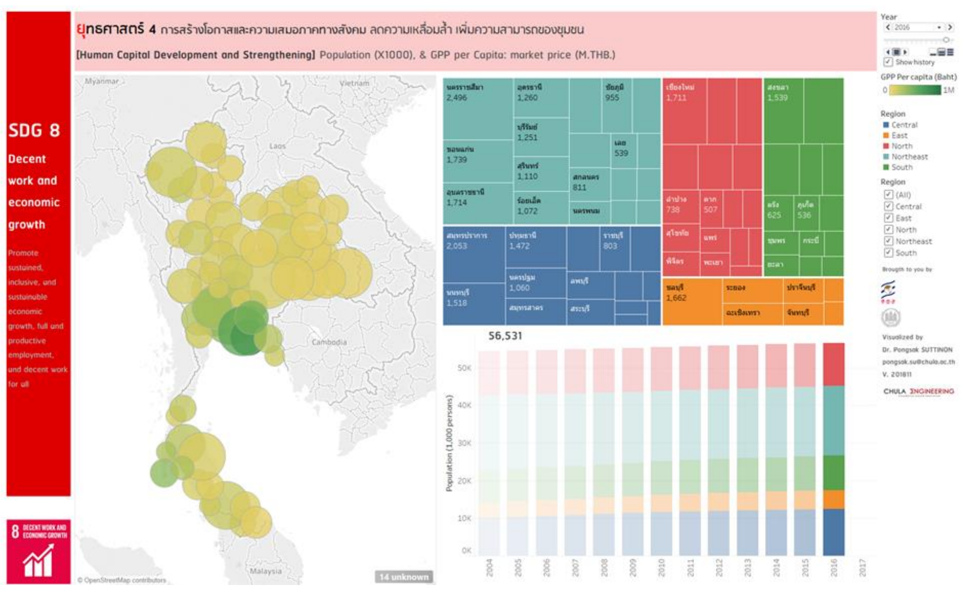
Socio-economic development in each province

For local scale in Thailand, gross provincial product (GPP) and GPP per capita are considered from the past. It is certain that we are growing to be one of developed country in the near future based on national long-term strategy. However, income gap between urban and rural is also expanding. Urbanization may make an inequality issue.



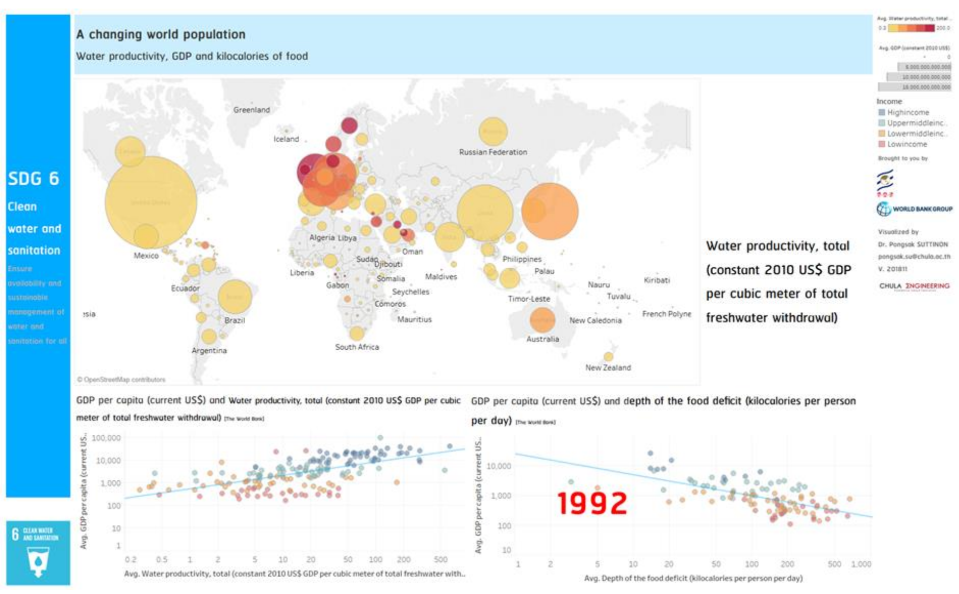
Population change

Ageing society is one of megatrends in our world. Reducing fertility rate with increasing life expectancy are mainly illustrated for all high-income, middle-income and low-income countries.



Population change

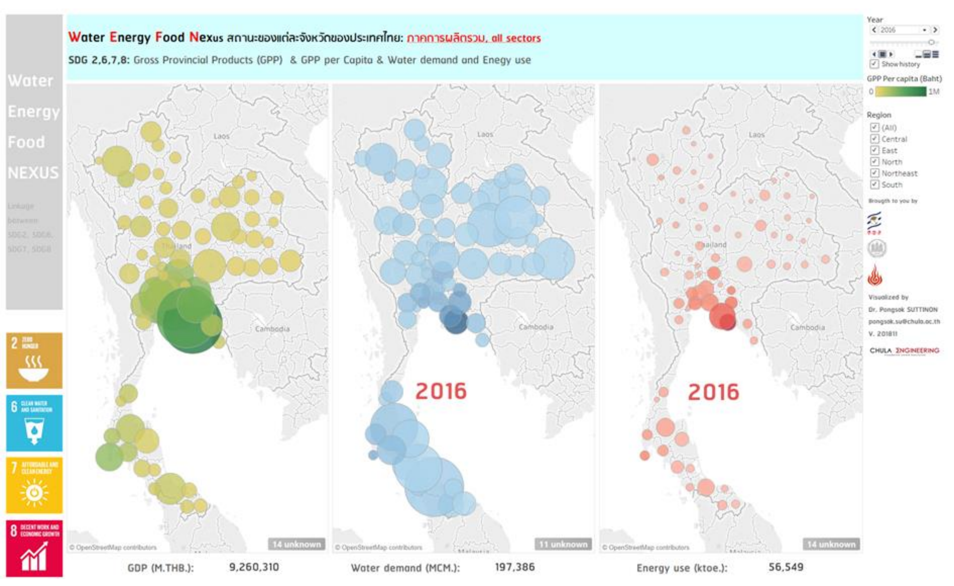
Number of populations in Thailand is still growing with slower rate. National Economic and Social Development Board concludes that ageing society will be an important issue in the near future.



Water productivity

High-income country needs more water use per capita to meet socio-economic development.

Water productivity is a key success for developing economy under limitation of water supply in terms of quantity and quality.



Linkage of socio-economic, water, and energy

Water-Energy-Food/Land NEXUS illustrated how all resources are managed to meet the past development. In the near future, greater productivity and linkage of each resource to socio-economic development is the main issue for policy makers in each level from central government with policy to local community with implementation.

Conclusions and recommendations

The "Water-Energy-Food NEXUS" is an approach to link socio-economic development and management of water, energy, and food securities by minimizing co-trade-off and optimizing co-benefit.

For economic development and urbanization, Thailand needs database and management tool that can integrate socio-economic development and resources.

Acknowledgements

This work was supported by the Thailand Research Fund (TRF).