REGIONAL WATER TALKS

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VIRTUAL PLATFORM

VIETNAM SESSIONS

TUESDAY | 3 AUGUST 2021

03.00pm - 05.00pm

Moderator & Speaker:

Professor, PhD. Viet-Anh Nguyen
Vice President cum Head of Science and Technology Department, Vietnam Water Supply and Sewerage Association (VWSA);Professor in Water and Wastewater Engineering, Hanoi University of Civil Engineering (HUCE)

Speakers

PhD. Tran Anh Tuan
Vice President of Vietnam Water Supply and Sewerage Association- Head of Policy Department, Former General Director, Deputy General Director of Technical Infrastructure Agency, Ministry of Construction.

PhD. Duong Du BUI
Director of Water Resources Monitoring Department, National Center for Water Resources Planning and Investigation (NAWAPI), Ministry of Natural Resources and Environment (MONRE), Vietnam., Chair (Water, Ecology & Fisheries) of US-ASEAN S&T Fellow Association

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PhD. Tran Anh Tuan
Vice President of Vietnam Water Supply and Sewerage Association- Head of Policy Department
Former General Director, Deputy General Director of Technical Infrastructure Agency, Ministry of Construction

Topic

Investment Policy for Clean Water Supply in Urban areas in Vietnam

INVESTMENT POLICY FOR CLEAN WATER SUPPLY IN URBAN AREAS IN VIETNAM

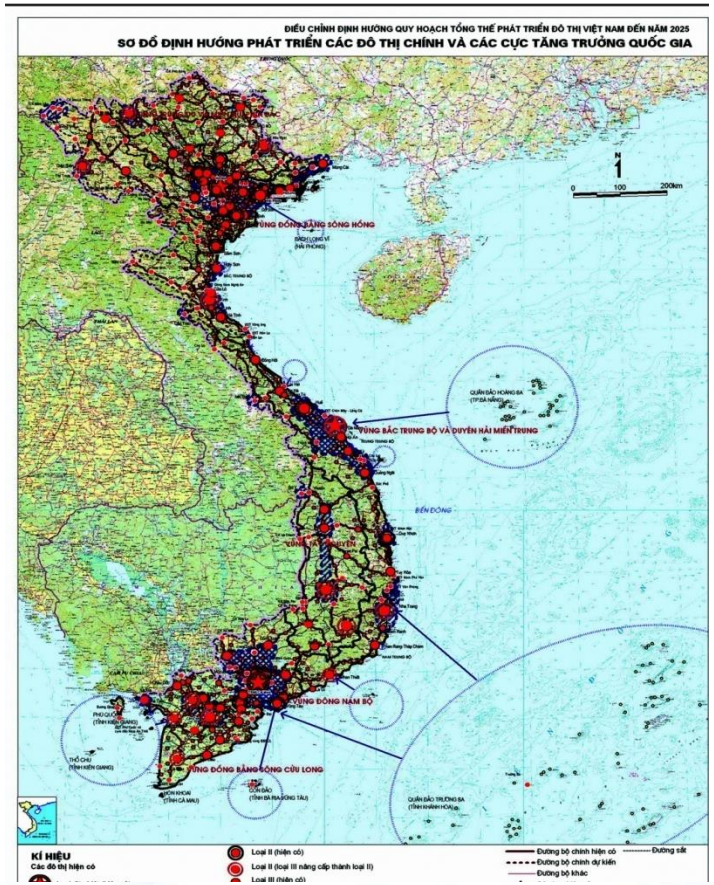
PhD. Tran Anh Tuan
Vice Chairman of Vietnam Water Supply and Sewerage Association (VWSA)
Email: *trananhtuan738926@gmail.com*

Information Classification: General

1. VIETNAM WATER SUPPLY OVERVIEW

1.1. Water supply capacity

- Clean water is a special, essential and irreplaceable product that ensures the lives and health of people and production.
- In Vietnam, the total capacity of urban water plants is about 10.6 million m3/day; the rate of water supply reached 89%; the average loss of revenue was 19%.
- In rural areas, the percentage of people using hygienic water has increased to 88.5%.
- Climate change, saltwater intrusion, drought, and pollution of water sources are potential risks to water supply safety, not only for Vietnamese cities but also for countries in the region and the world.

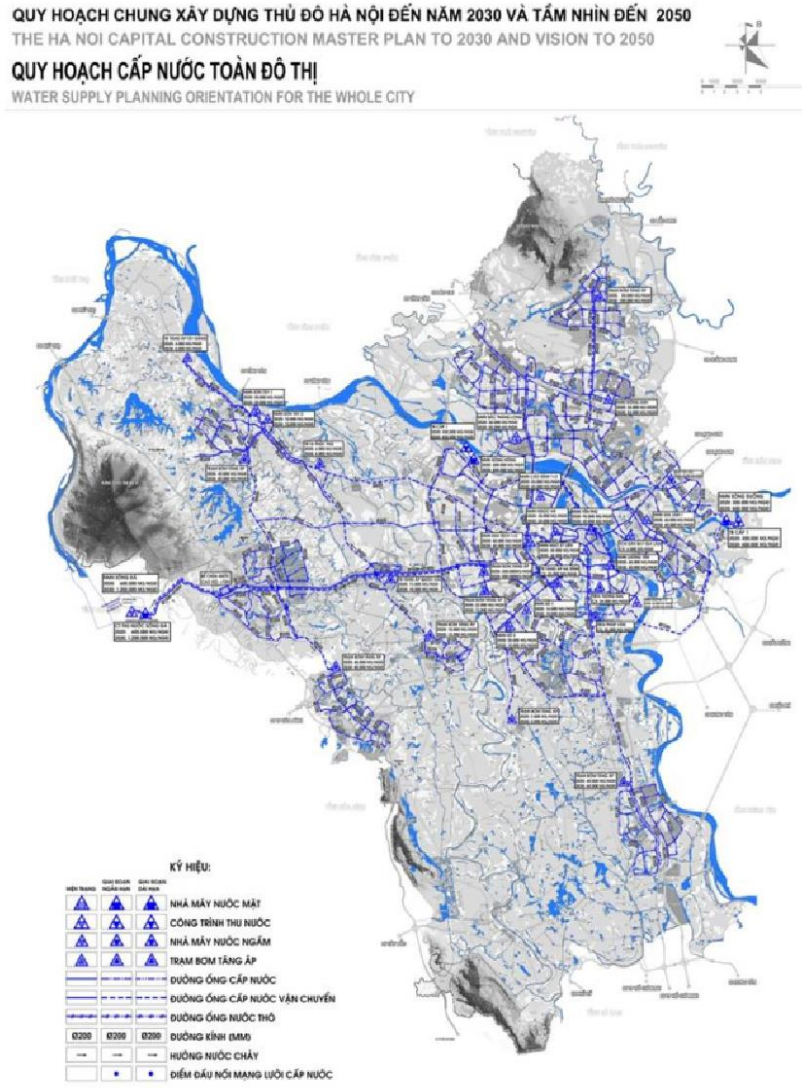


1.2. Urban water supply planning.

- Vietnam has over 860 urban areas, the urbanization rate is about 40% (35-36 million people living in urban areas).
- The planning of water supply is a content of the technical infrastructure system which is displayed in urban planning projects.

- Main contents: (i) Determination of water source, storage amount, demand for water supply (for living, production, service), location, scale, capacity of key works and water supply network; (ii) List of water supply investment projects in 10 - 20 years.

(Particularly, Urbans types 1 are central cities able to implement a water supply planning project and eligible for setting up water supply projects)



Information Classification: General

1.3. Urban water supply project.

- Urban planning approved: Provincial People's Committees organize planning, formulation and approval of urban water supply projects in phases (10-20 years).

- Provincial People's Committee assigns specialized agencies to invest, search and attract investment sources for water supply projects;

- Investment forms: Bidding - New construction projects or assignment of tasks - Upgrading and renovation projects using local budget).

Information Classification: General

2. LEGAL DOCUMENTS RELATED TO INVESTMENT IN WATER INDUSTRY

2.1. LAW-granting documents

The institutional framework for development of water supply and drainage has improved state management, created conditions for enterprises to invest, mobilize capital sources, and encourage the participation of all economic sectors: Construction Law, Law on Urban Planning, Law on Water Resources, Law on Enterprises, Amended Investment Law, Law on Pricing, etc.

2.2. The guiding documents under the law such as Decrees, Circulars, ...

Decree 117/2007ND-CP on production, supply and consumption of clean water, Decree 124/2011/ND-CP, Decree 37/2010/ND-CP Preparation, appraisal and approval of urban planning.

Circular No. 08/2011/TT-BXD guiding the implementation of ensuring safe water supply, etc.

- Documents on clean water supply are only available at the Decree level, which are too long (over 10 years) and not suitable for development practice; are being reviewed and revised to meet the reality and the development trend of the country.

2.3. Specialized law:

The Law on Management of Clean Water Supply is expected to be built in the list of programmes and projects under the Government's action program for the period of 2021 - 2025.

Information Classification: General

2.2. Regulations on investment and development of water supply in the Decree on production, supply and consumption of clean water.

➢ Selecting a water supply unit

- The water supply unit may act as a partial or synchronous investor in all items of the water supply system for the purpose of wholesale and retail of clean water.

- Units that are providing water supply services may continue to provide water supply services in the locality.

- For a new area or need to change the water supply unit that does not meet the service quality and water supply development plan, the selection of investment and business units is conducted through bidding and the specific conditions of each local.

- Water supply works according to the water supply planning's approval, are announced and called for investment and organized for bidding to select investors according to the provisions of law.

- A water supply project is divided into several stages, the water supply unit that has invested in the previous stage may be appointed as the investor in the next phase if it meets the capacity conditions and has a reasonable economic - technical proposal.

Information Classification: General

- Encourage and create conditions for organisations and individuals to actively research and register as investors in investment and development projects on water supply.

➢ Authority to select water supply unit:

- Provincial-level People's Committees shall organise the selection of water supply units with the participation of localities in the water supply regions.

- The Ministry of Construction shall organise the selection of water supply units for clean water supply works with inter-provincial scope of water supply with the participation of relevant provinces.

- The Ministry of Agriculture and Rural Development shall organise the selection of water supply units for rural water supply works with inter-provincial scope of water supply with the participation of relevant provinces.

Information Classification: General

➢Using land in water supply activities.

- Prioritise the land fund for the construction of water supply works based on actual needs and development requirements in each period according to the approved water supply planning.

- The local government shall organise the management and protection of the identified land fund in service of the approved water supply works;

- Exemption from land use levy and land rent for water supply works: water exploitation and treatment works, pipelines and works on the network; works to support the management and operation of water supply systems.

Information Classification: General

➢Equitization of water supply enterprises

- The equitization of state-owned enterprises (SOEs) was piloted from 1990 to 1991 and officially implemented in 1992 with the achieved strategy being basically completed by 2020.

- Equitization and divestment are not the goal but the method for innovation; is a model of governance, calling for investment capital, and renewing technology to ensure the effective operation of enterprises.

- As for water supply enterprises (water supply and drainage companies) which have been equitized since 2005, up to now, 90% of urban water supply enterprises have switched to joint stock companies;

Information Classification: General

➢Plan to divest capital of water enterprises

- Currently, there are 54 enterprises operating in the field of water supply and drainage under the People's Committees of provinces and cities that do not have a policy to continue to divest (of which 27 state-owned enterprises hold 65% or more, 13 state-owned enterprises) countries hold 50%-65%, 14 state-owned enterprises hold less than 50%).

- The equitization of water supply enterprises has made a positive change in corporate governance, reducing the investment burden from the state budget, expanding service coverage, managing and exploiting the system. The water supply and drainage system is improved, workers' incomes are stable, and corporate profits are guaranteed. Customers enjoy better service quality.

- Some water supply enterprises are monopolizing in the scope of water supply, putting more emphasis on profits than developing water supply systems for areas with low water supply demand, or when urbanization has not yet developed.

Information Classification: General

➢ **Clean water prices.**

(On June 18, 2021, the Ministry of Finance issued Circular No. 44/2021/TT-BTC)

- Price bracket for daily life clean water; principles and methods of determining the price of daily life clean water (for daily life purposes and for other purposes).

- Applies to agencies, organisations and individuals that appraise, submit and decide on daily life clean water prices in accordance with law; clean water supply units and customers using daily-life clean water.

- Clean water prices are calculated correctly, fully accounting for reasonable and valid production cost factors in the process of exploitation, production, distribution, consumption and profit; consistent with water quality, economic-technical norms, supply-demand relationship of clean water, natural conditions, socio-economic development conditions of the locality; harmonise lawful rights and interests of clean water supply units.

- The average retail price of clean water decided by the People's Committees of the provinces and centrally run cities must be consistent with the prescribed clean water price bracket.

Information Classification: General

INVESTMENT POLICY FOR CLEAN WATER SUPPLY FOR URBANS IN VIETNAM

➢ Clean water price bracket (not including value-added tax -VAT)

No	Type	Minimum Price (VND/m^3)	Maximum (VND/m^3)
1	Special cities, grade 1 cities	**3.500**	**18.000**
2	Urban grade 2, grade 3, grade 4, grade 5	**3.000**	**15.000**
3	Rural Areas	**2.000**	**11.000**

➢ Retail price of clean water (VAT not included)

No	**Group of customers using clean water for living purposes**	**Amount of clean water used/month**		**Factor of calculating maximum price to average price (Hi)**
		Level(m^3/Meter/Month)	Symbol	
Group **1**	Residential Household	- Lower than 10 m^3/Meter/tháng - From over 10 m^3 - 20 m^3/Meter/Month - From over 20 m^3 - 30 m^3/Meter/ Month - Over 30 m^3/Meter/ Month	SH1 SH2 SH3 SH4	**0,8** **1,0** **1,5** **2,5**
Group **2**	Administrative agencies; business units-public; schools, hospitals, medical examination and treatment establishments (public and private); serve a public purpose (non-profit).	Actual use	HCSN	**1,2**
Group **3**	Organizations and individuals that produce material	Actual use	SX	**1,5**
Group **4**	Organization, Business Individuals, Service	Actual Use	KD	**3**
Retail price average clean water				**1,0**

Information Classification: Ge

3. Investment in water supply projects of inter-provincial scale

(Planning water supply in the Mekong Delta to 2030, with a vision to 2050 - Decision 2140/QD-TTg - November 8, 2016 - in response to climate change and saline intrusion)

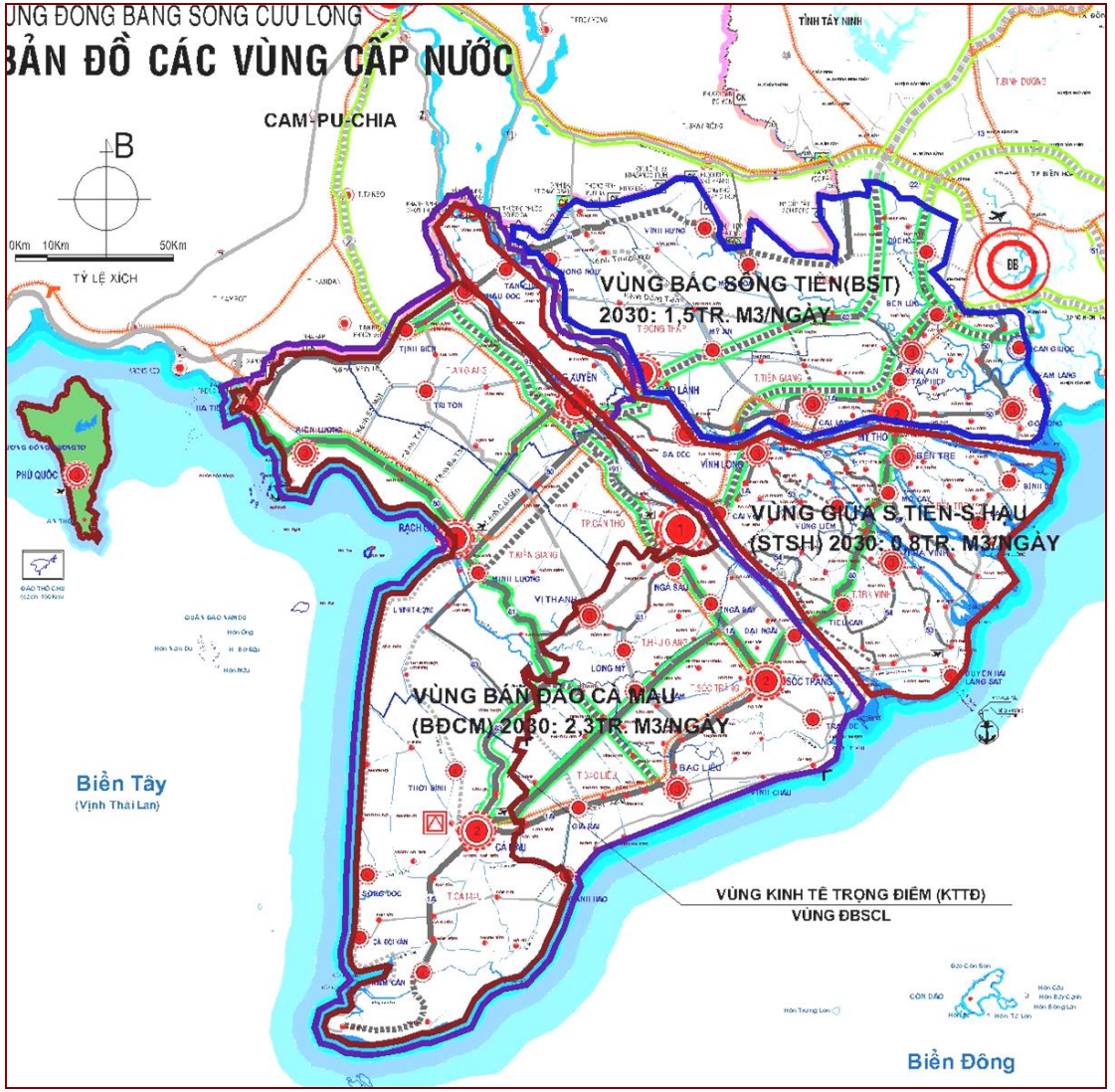
- Scope: Mekong River Delta, total area about 40,604.7 km2, including Can Tho City and 12 provinces (Long An, Tien Giang, Ben Tre, Dong Thap, Vinh Long, Tra Vinh, Hau Giang, An Giang, Soc Trang, Kien Giang, Bac Lieu and Ca Mau);

- Population until 2030: Total population is 18 -19 million people, in which urban population is 6.5-7.5 million people;

-Total water demand (2030): 3.27 million m3/day (urban 1.89 million m3/day, concentrated rural areas: 0.75 million m3/day; Industrial zone: 0.63 million m3/day).

- Water supply zones:

- (I) North of Tien River; (II) Middle of Tien River, Hau River; (III) Southwest Hau River



Information Classification: General

➢Interprovincial water supply projects.

Invest in building 5 water plants for 3 regions (2025-2030).

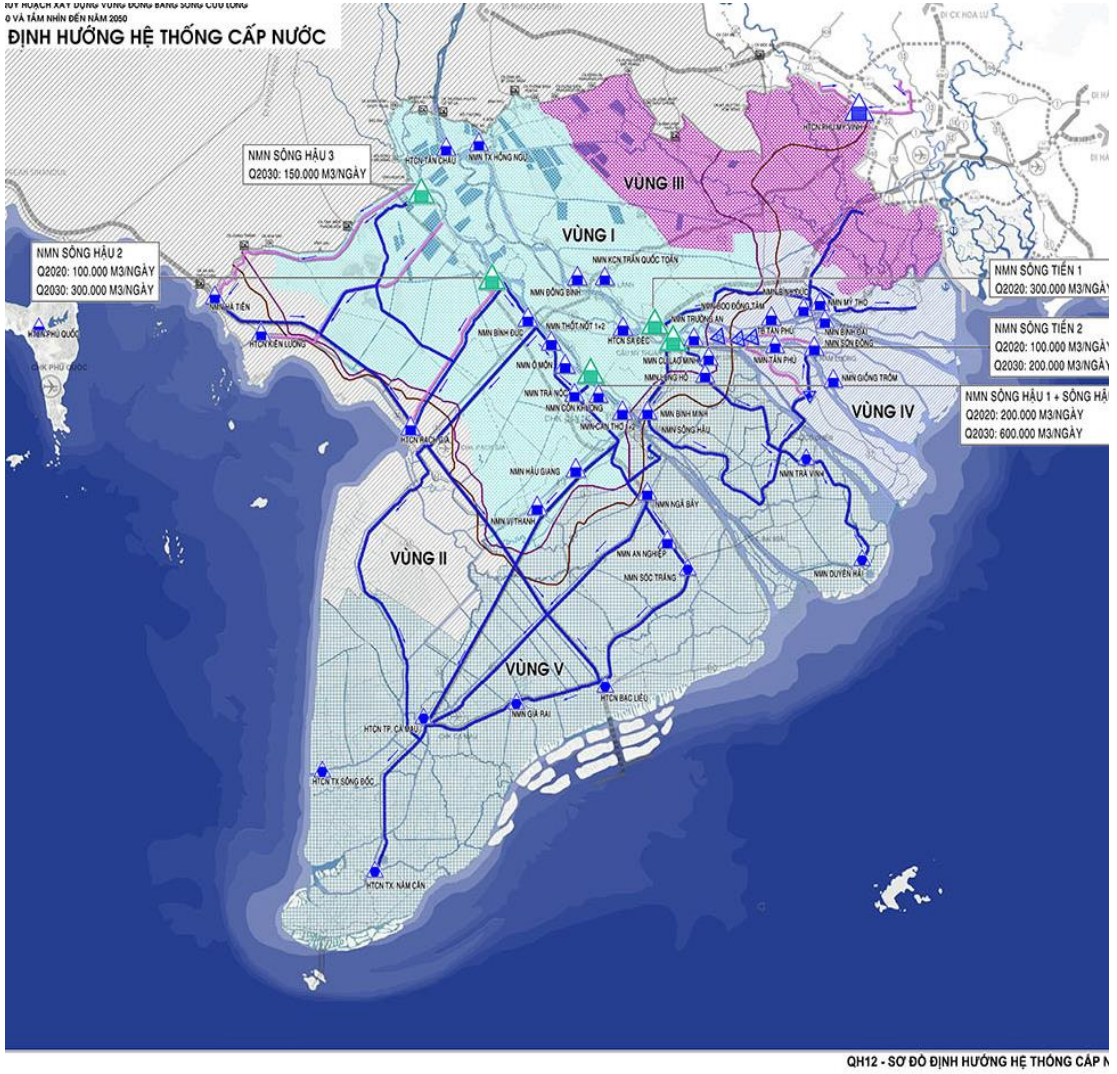
1) Region I: Tien River water plant (Tien Giang): 100-300 thousand m3/day;

2) Region II: Tien 2 River water plant (Vinh Long): 200-300 thousand m3/day;

3) Region III: invest in 3 water plants:

- Hau 1 River water plant cluster (O Mon): 400-600 thousand m3/day; and water plant in Hau Giang: 100 thousand m3/day);

- Hau 2 River water plant (Chau Thanh): 200-300 thousand m3/day;
- Hau 3 River water plant (Chau Doc): 100-150 thousand m3/day



➢Surface water sources: Hau River and Tien River: Only exploiting groundwater for areas with difficult water sources on a small and local scale.

Information Classification: General

4. Investment proposal for enterprise's water supply project for the Mekong Delta region

-**Project objective**: supplying fresh water (raw water) for water plants of 3 provinces of Tien Giang, Long An, and Ben Tre;

- Surface water source: upstream of Tien River at Cai Be, Tien Giang)

- Capacity of Phase I (2025): **300 thousand m3/day;**
- Phase II (2030): **600 thousand m3/day;**
- Estimated funding sources:
- Phase I: **2300 billion VND**-enterprise capital - form of calling for investment;

➢ **Proposed update:** Partial adjustment of the water supply master plan in the Mekong Delta to 2030, with a vision to 2050. Approved by the Prime Minister in Decision No. 287/QD-TTg dated March 2, 2021

Information Classification: General

Thus, it can be seen that the need to invest in water supply projects in Vietnam is very necessary, especially large-scale projects with inter-provincial service scope in order to solve problems of safe water supply. Response to climate change, saltwater intrusion and drought have been complicated not only in Vietnam but also in the region.

Information Classification: General

Thank you for listening!

Information Classification:

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Topic

Policies in municipal wastewater management in Vietnam

POLICIES IN MUNICIPAL WASTEWATER MANAGEMENT IN VIETNAM

Hanoi – 03 August 2021

PROF. DR. VIET-ANH NGUYEN

Vice President, Vietnam Water Supply and Sewerage Association (VWSA),

Director, Institute of Environmental Science & Engineering (IESE), Hanoi University of Civil Engineering

Email: anhnv@nuce.edu.vn; vietanhctn@gmail.com.

Information Classification: General

VIETNAM URBAN WATER

- 07/2021: **850** cities and towns; **39.3%** population (MOC, 2020).
- Total urban water supply capacity: **10,6** million m^3/day.
- Urban population served with tap water: **89%**.
- Non-revenue water: **19%** (from 6% to 27%; reduced from 31% in 2010).
- Average water consumption: **110** l/cap/day (33…213 l/cap/day)

Information Classification: General

VIETNAM URBAN WASTEWATER

- **70%** of HHs have access to piped drainage/ sewerage systems
- **15%** of collected drainage/ sewerage treated by centralized WWTPs
- **54** municipal WWTPs currently in operation, with total capacity **~1,181,380 m^3/day**.
- **77** municipal WWTPs in planning/construction, with total capacity 1.5 million m^3/day
- **90%** of HHs have septic tank as a preliminary treatment step (only black wastewater passes through septic tank, in most of cases)
- **4%** of septage disposed satisfactorily

WW treatment technologies applied: CAS, AO, A^2O, SBR, OD, TF, Stab. Ponds, CEPT, etc.

- Investment over last 5 years for urban wastewater: **>USD 1 billion** (**USD 220 million/year**) (>80% is ODA, rest is from state budget)
- Financial need for 100% urban wastewater treatment: **USD 8-10 bio**.

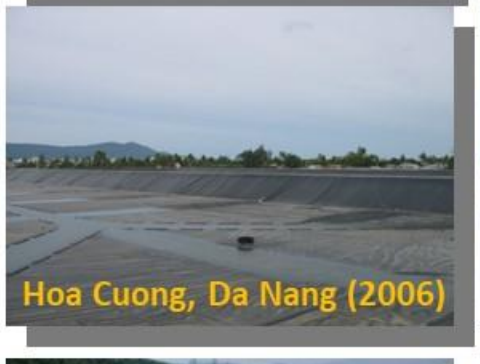
Information Classification: General


Truc Bach, Ha Noi (2005)


Kim Lien, Ha Noi (2005)

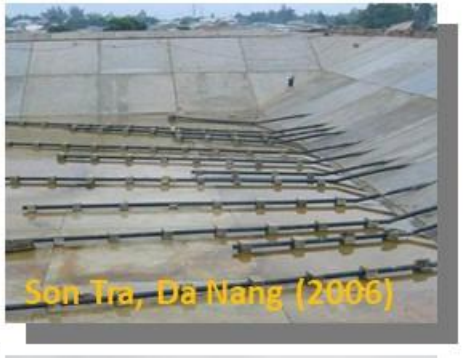

Da Lat, Lam Dong (2006)

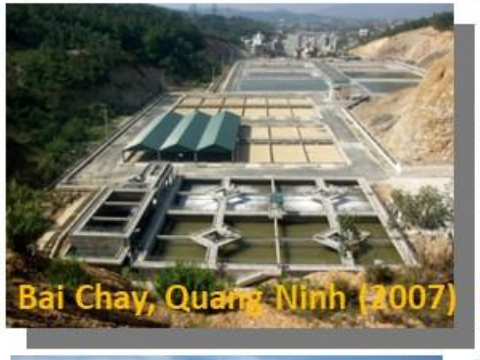

Buon Ma Thuot, Dak Lak (2006)


Hoa Cuong, Da Nang (2006)

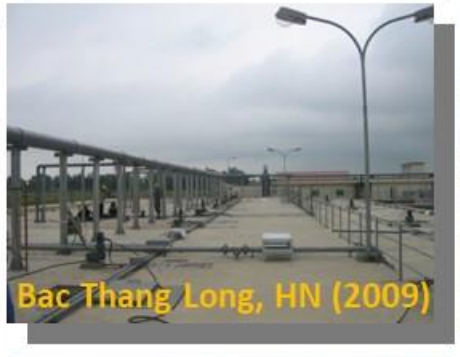

Phu Loc, Da Nang (2006)


Ngu Hanh Son, DN (2006)


Son Tra, Da Nang (2006)


Bai Chay, Quang Ninh (2007)


Binh Hung Hoa, HCMC (2008)


Bac Thang Long, HN (2009)


Ha Khanh, QN (2009)

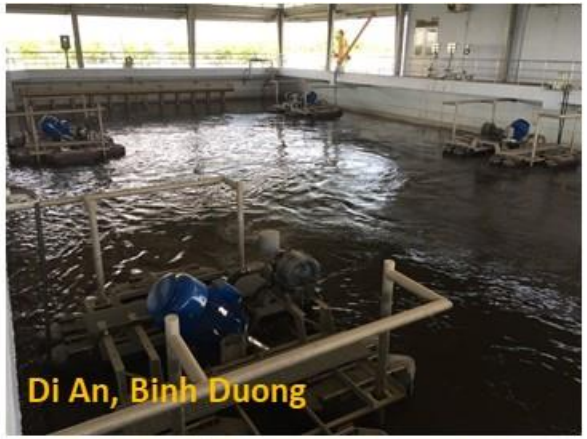

Nam Vien, PMH, HCMC (2009)


Binh Hung, HCMC (2009)


Bac Giang (2010)


Yen So, Ha Noi (2012)

Information Classification: General



Information Classification: General

VIETNAM POLICIES ON WASTEWATER MANAGEMENT

1. LAW OF PLANNING (2017, 2018)
2. LAW OF CONSTRUCTION (2014)
3. LAW OF ENVIRONMENT (2020)
4. LAW OF WATER RESOURCES (2012)
5. LAW OF INVESTMENT (2020)

1. Decree 80/2014/ND-CP on Drainage, sewerage and wastewater treatment
2. Decree 53/2020/ND-CP on Environmental protection fee
3. Decree 40/2019/ND-CP on Environmental protection
4. Other Decrees

1. Circular 04/2015/TT-BXD guiding Decree 80
2. Circular 13/2018/TT-BXD guiding Wastewater service tariff
3. Circular 20/2021/TT-BTC guiding Water tariff
3. Other Circulars

Provincial legal documents

- Technical Norms, Codes, Standards
- Decision 589/2016/QD-TTg of Prime Minister on Revision of Urban and Industrial sewerage and drainage orientation to 2025, vision to 2050
- Decision 622/2017/QD-TTg of Prime Minister on Agenda 2030 for SDGs

Information Classification: General

VIETNAM URBAN WASTEWATER MANAGEMENT

- Most of collection system are **Combined sewerage and drainage**.
- **Separate sewerage systems**: in core centers of Buon Ma Thuot, Da Lat, Hue, Vung Tau, Thai Hoa, Binh Duong, Can Tho cities; and in new urban developments (compulsory).
- **Main challenges:**
  - Sanitation strategy and specialized wastewater planning
  - Household connection coverage;
  - Urban flooding;
  - Sludge management;
  - Septic tank and fecal sludge management;
  - Source of funding (Capex)
  - Cost recovery (Opex)

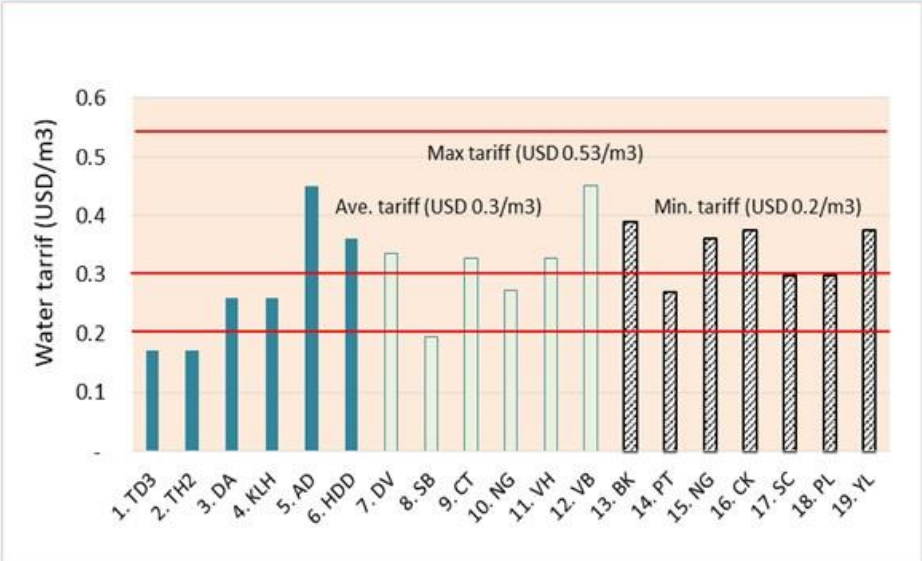
Information Classification: Gen

SYSTEM OPERATOR AND WASTEWATER TARIFF

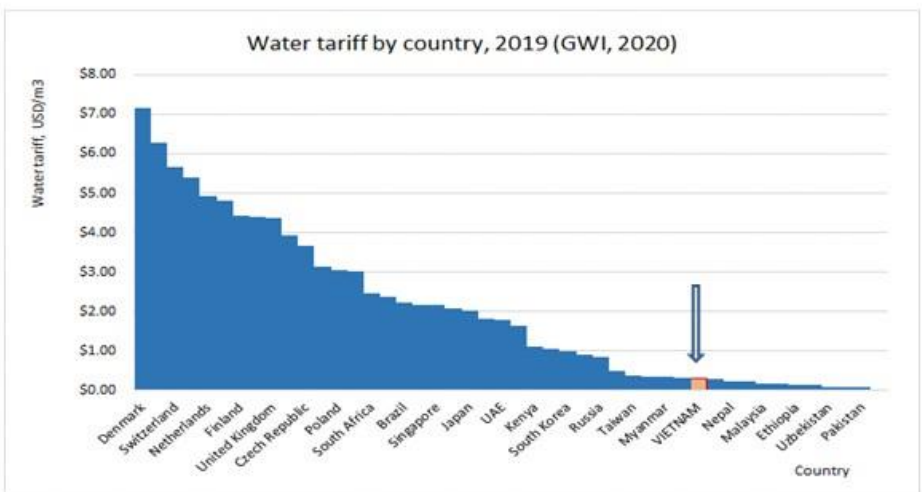
- By 2020: **26/63 provinces have O&M Contracts** for Urban wastewater system management.
- **Private Wastewater Companies are Contractors in 10 cities:** Hanoi, HCMC, Bac Ninh, Da Nang, Vinh, Nha Trang, Cao Lanh, Hau Giang, Hai Phong, Ba Ria – Vung Tau.
- **Wastewater tariffs:**
  - **22/63** provinces have issued Wastewater tariffs (varying in cities).
  - In general, wastewater tariffs are still lower than expenditures.
  - **Wastewater tariff/Water tariff = 10 (most of cases) – 25% (Da Nang city).**
  - Cities with high tariffs: Bac Ninh (1,500 VND/m^3), Sac Trang (2,600 VND/m^3), Da Lat (2,900 VND/m^3), ...
  - HCMC (June 2021) has set roadmap for wastewater tariff increasing for 5% per year: from 15% (present) to 25% (2025).

Information Classification: Ge

WATER TARIFF



(Nguyen V-A, Tran THH, 2020)



- Lowest tariff: **0.17 USD/m³** in 2.TH2, wholesale contract.
- Average domestic water tariff in 2018: 7,162 VND/m³ (**0.3USD/m³**), ranging from minimum value of 4,629 USD/m³ (**0.2 USD/m³**) to maximum value of 12,481 VND/m³ (**0.53 USD/m³**).

- *No. 1-6: with capacity ≥100,000 m³/day;*
- *No. 7-12: with capacity from 10,000 to <100,000 m³/day;*
- *No. 13-17: with capacity <10,000 m³/day.*

- **(Calculated) OPEX for wastewater management: USD 0,21 – 0.42/m³**

Information Classification:

VIETNAM POLICIES IN URBAN WASTEWATER MANAGEEMNT IN A COMING DECADE (cont.)

- Application of **O&M Contract bidding** for service quality and efficiency.
- Development of policies for **mobilizing of private investors** in wastewater sector.
- Preparation of **Law of Water Supply and Law of Wastewater** (~2025).

ATI, MOC, 2020

Information Classification: Gen

VIETNAM POLICIES IN URBAN WASTEWATER MANAGEEMNT IN A COMING DECADE

- Application of O&M Contract bidding for service quality and efficiency.
- Development of policies for mobilizing of private investors in wastewater sector.
- Preparation of Law of Wastewater (2025).

ATI, MOC, 2020

Information Classification: Gen

BUSINESS OPPORTUNITIES

- Intensive development;
- (Recovery after pandemic);
- Urban water consumption (forecast) by 2025: 14 - 15 million m^3/day, by 2030: 20 - 22 million m^3/day.
- Needs in new technologies in wastewater collection, treatment, sludge treatment, resource recovery, smart system management solutions, etc.

Information Classification: General

BUSINESS OPPORTUNITIES

- **Law of PPP Investment (2020)**;
- Encouraging investment in **5 sectors**: Transportation; Electricity network and power plant; Irrigation; ***Water supply, wastewater, solid waste management***; Medicine, education and IT infrastructure.
- Minimum investment amount: VND 200 billion (USD 9 million).

PPP Contract types
(Vietnam PPP Office, 2019)

Information Classification:

BUSINESS OPPORTUNITIES

- Investment procedure

Solicited Projects
(proposed by Authorized State Agencies)

- **Pre-Feasibility Study Report** (developed, appraised, approved ***by Authorized State Agencies***)
- **Feasibility Study Report** (developed, appraised, approved ***by Authorized State Agencies***)
- **Tendering**
- **Contract signing and Implementation**

Unsolicited Project
(Proposed by investors)

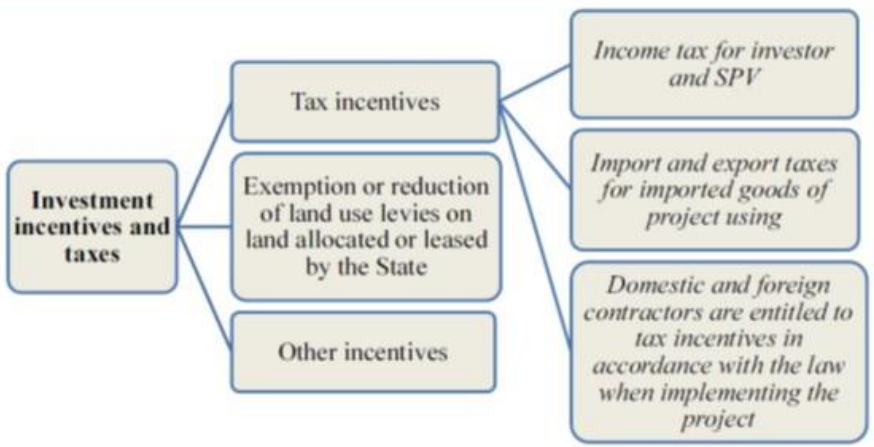
- **Pre-Feasibility Study Report** (developed ***by an Investor***; appraised and approved by ASA)
- **Feasibility Study Report** (developed ***by an Investor***; appraised and approved by ASA)
- **Tendering**
- **Contract signing and Implementation**

Note:

1. There is a separate and shortened procedure for PPP projects of small scale (with total investment less than 2 million USD).
2. Projects proposed by investor still have to go through procurement process. However, the project proponent will be entitled to incentives in procurement process.

- Incentives and Guarantees for PPP investors

PPP Contract types
(Vietnam PPP Office, 2019)



Information Classification: General

BUSINESS OPPORTUNITIES FOR SMEs

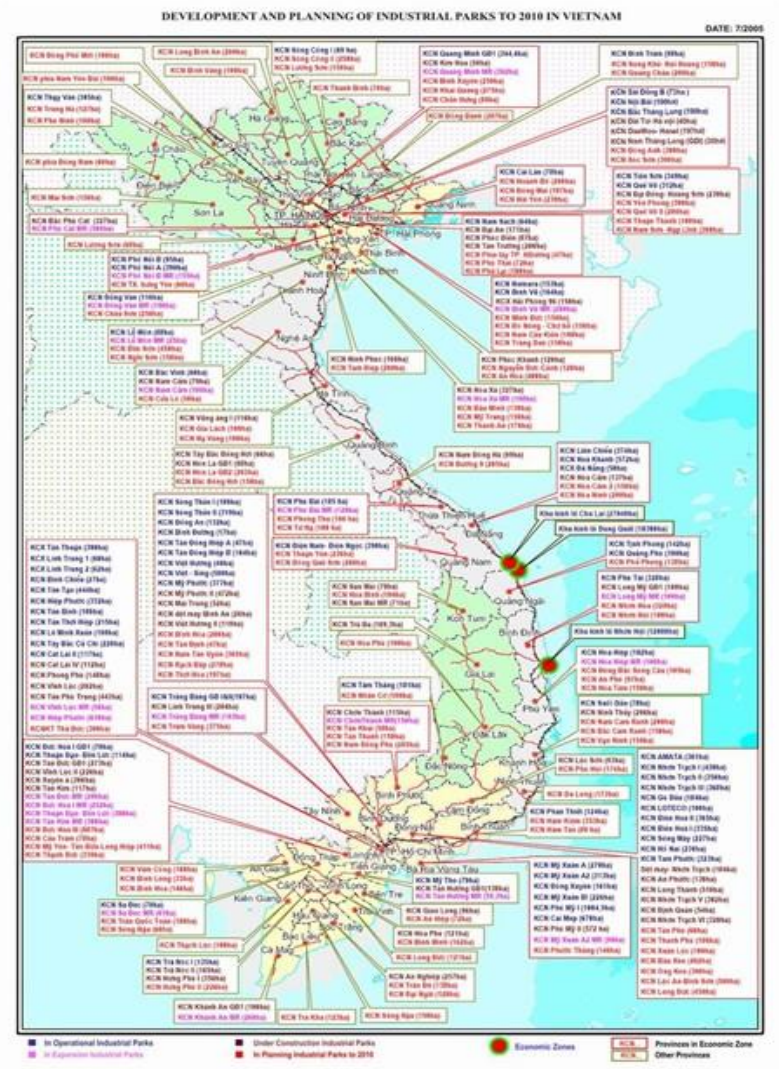
- Private sector participation in large projects:
  - BOO, O&M projects
- Private sector in Decentralized wastewater management
  - Private sector is a key player
  - New urban development/ Real state projects: Project owner, Contractor/Supplier
  - Cost recovery is assured
- Private sector in Industrial wastewater management
  - Private sector is a key player
  - Big market: ~ 300 Industrial parks
  - New effluent standards (2021-2022): more strict
  - Eco-industrial park (Decree 82)

VIETNAM INDUSTRIAL WASTEWATER MANAGEMENT

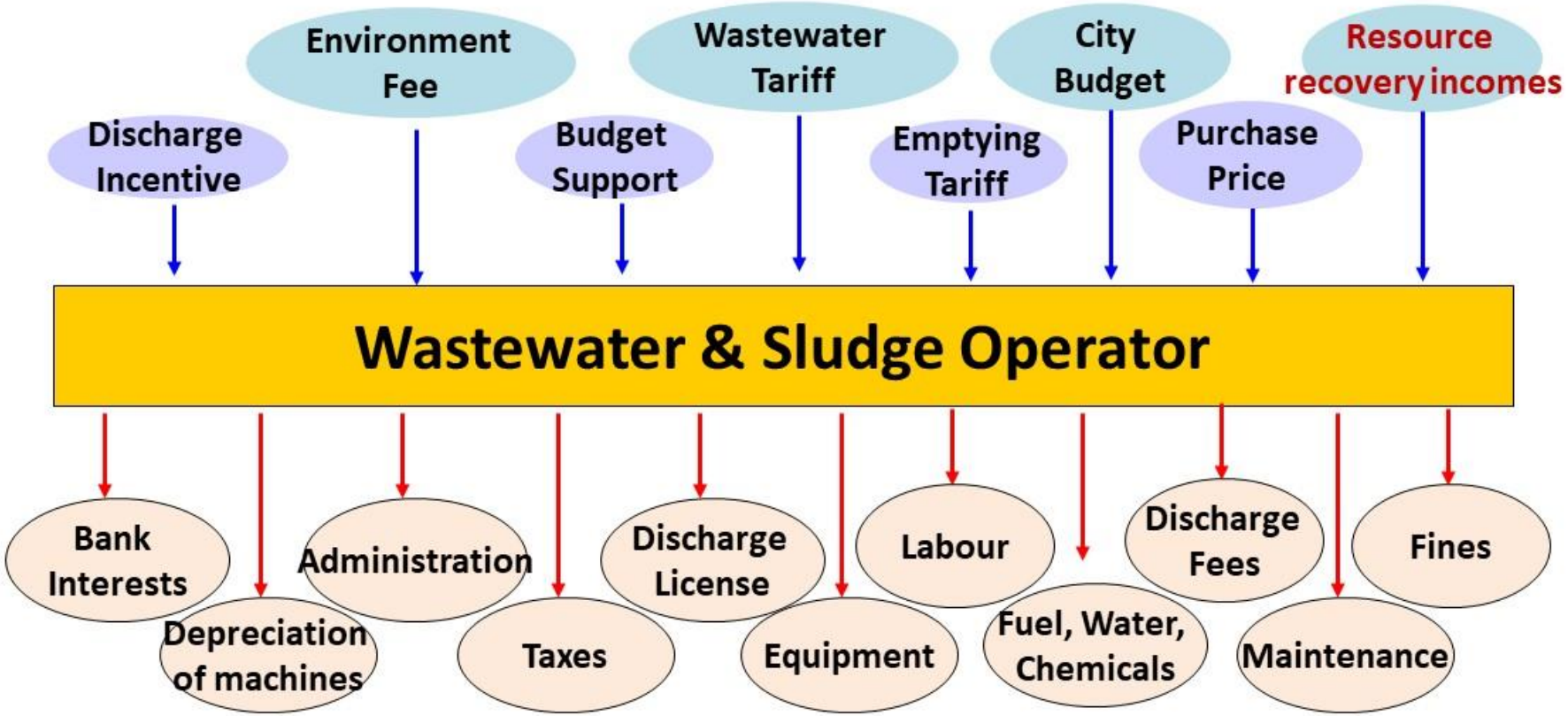
- **326 IPs** have been established (2020). 251 IPs are in operation. Occupation ratio 73%.
- CETPs are at 220 IPs **(=88%)** (increased from 30% in 2005).
- Ratio of IPs with CETPs: 20%...100%.

- Total amount of wastewater generated from IPs: **905,000 m^3/day** (VEA, 2018).
- **80%** CETPs at IPs are considered meeting effluent standards (JICA, May 2018).
- Among in operation IPs, there are 107 IPs with area >200ha.

- **587 Industrial clusters** have been formed, among which: 55 ICs with CETPs (2018).
- **> 5,000 handicraft villages**.



MONEY FLUXES IN WASTEWATER SYSTEM OPERATION



Improved water and sanitation help to improve life quality and make profits!

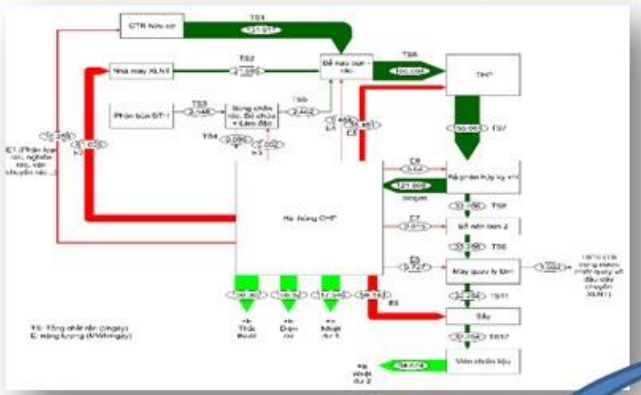
Information Classification: C

SUSTAINABLE URBAN DRAINAGE SOLUTIONS (SUDS)

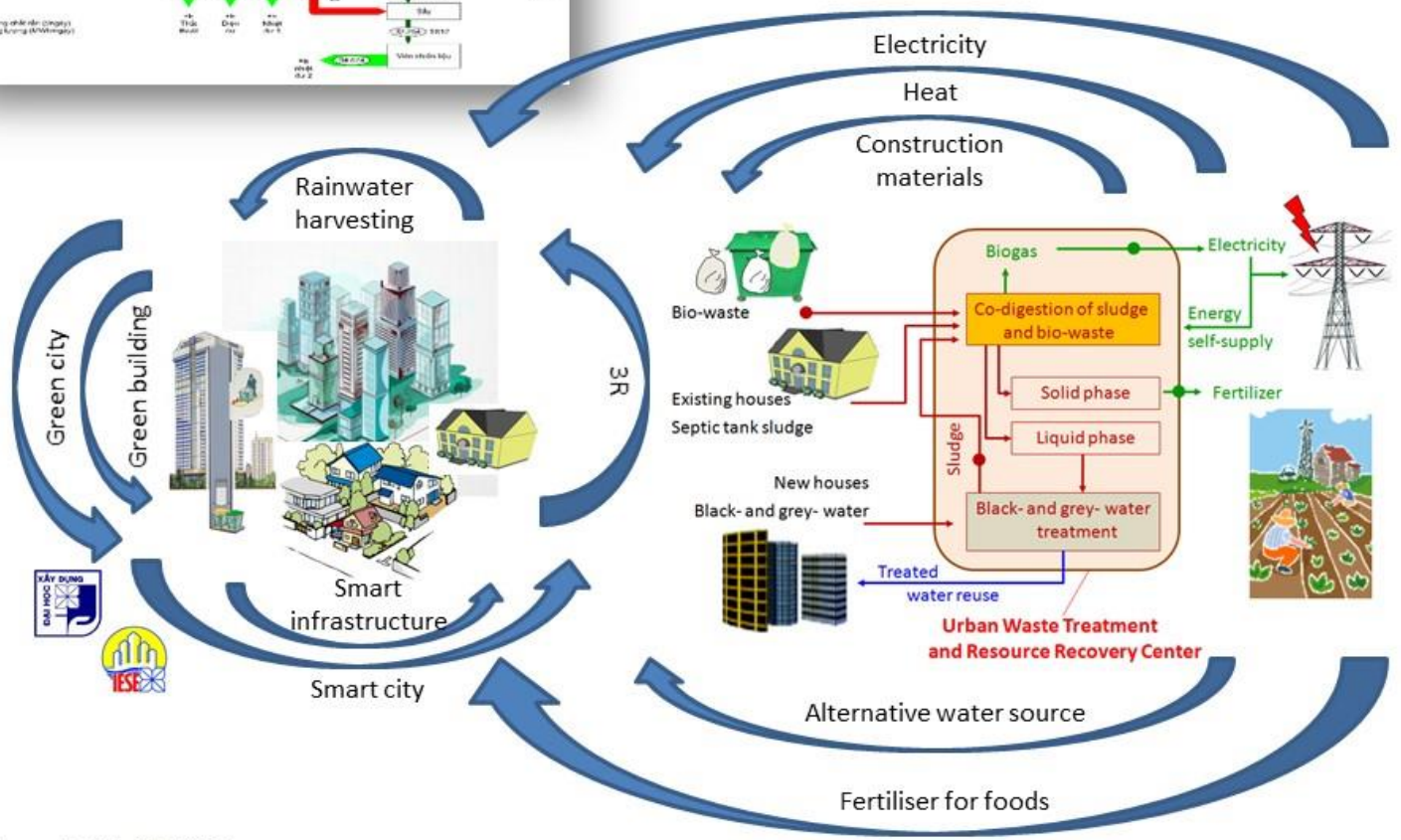
Eco-Park urban area, 500 ha, Hung Yen prov.

Information Classification: General

CIRCULAR ECONOMY WITH RESOURCE RECOVERY FROM WASTES IN A SMART - GREEN CITY



CASE STUDY FOR A URBAN DISTRICT OF HANOI CITY



Information Classification: General

CONCLUSIONS AND RECOMENDATIONS

1) Vietnam Water & Wastewater Industry is in the **intensive development period**: expansion of service area, and, improvement of service quality, with different stakeholders involved.
2) Government has been developing **policies**, and looking further for more **suitable measures** to involve **Private sector participation**.
3) **Potential market in Wastewater management**: to combat hot issues in wastewater collection and treatment, fecal sludge and solid waste treatment. System efficiency, resource recovery from waste in green urban centers and eco-industrial parks have emerging interests, and these topics are highly encouraged by the Government.

Information Classification: General

THANK YOU VERY MUCH !

- **Prof. Dr. Viet-Anh Nguyen**
- Vice President, Vietnam Water Supply and Sewerage Association (VWSA),
- Director, Institute of Environmental Science & Engineering (IESE), Hanoi University of Civil Engineering
- Email: anhnv@nuce.edu.vn; vietanhctn@gmail.com.

Information Classification: General

REGIONAL WATER TALKS

Organised By informa markets

VIRTUAL PLATFORM

VIETNAM SESSIONS

TUESDAY | 3 AUGUST 2021

03.00pm - 05.00pm

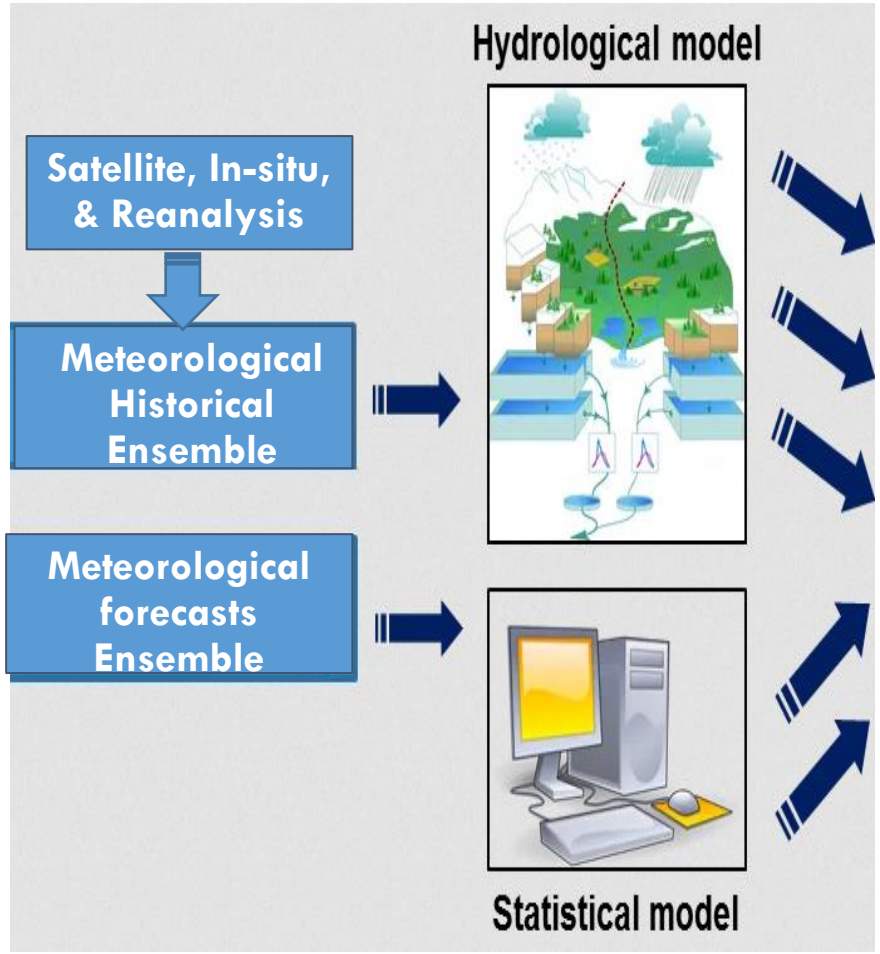
Speaker

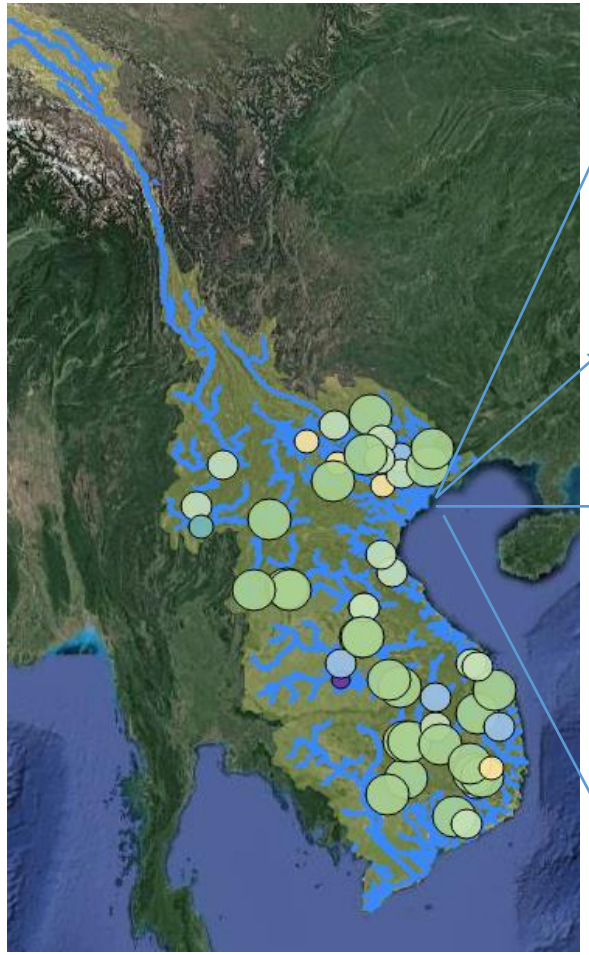
PhD. Duong Du BUI
Director of Water Resources Monitoring Department, National Center for Water Resources Planning and Investigation (NAWAPI), Ministry of Natural Resources and Environment (MONRE), Vietnam
Chair (Water, Ecology & Fisheries) of US-ASEAN S&T Fellow Association

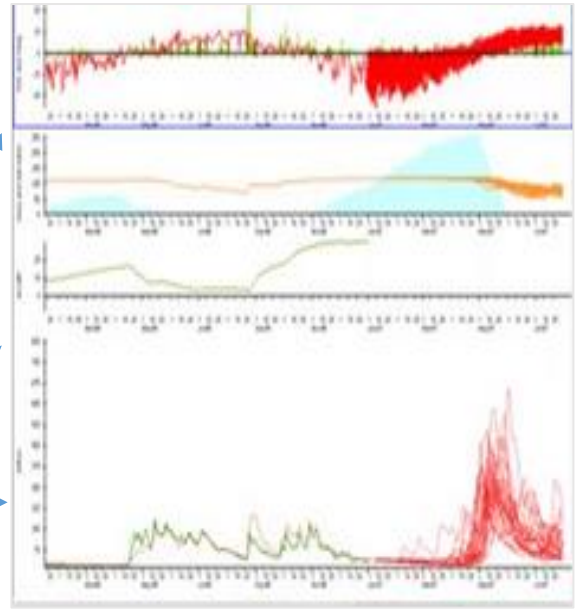
Topic

Multi-basin Operational Water Model and data Services for Vietnam and Mekong region

Multi-basin operational water model and data services for Vietnam and Mekong region







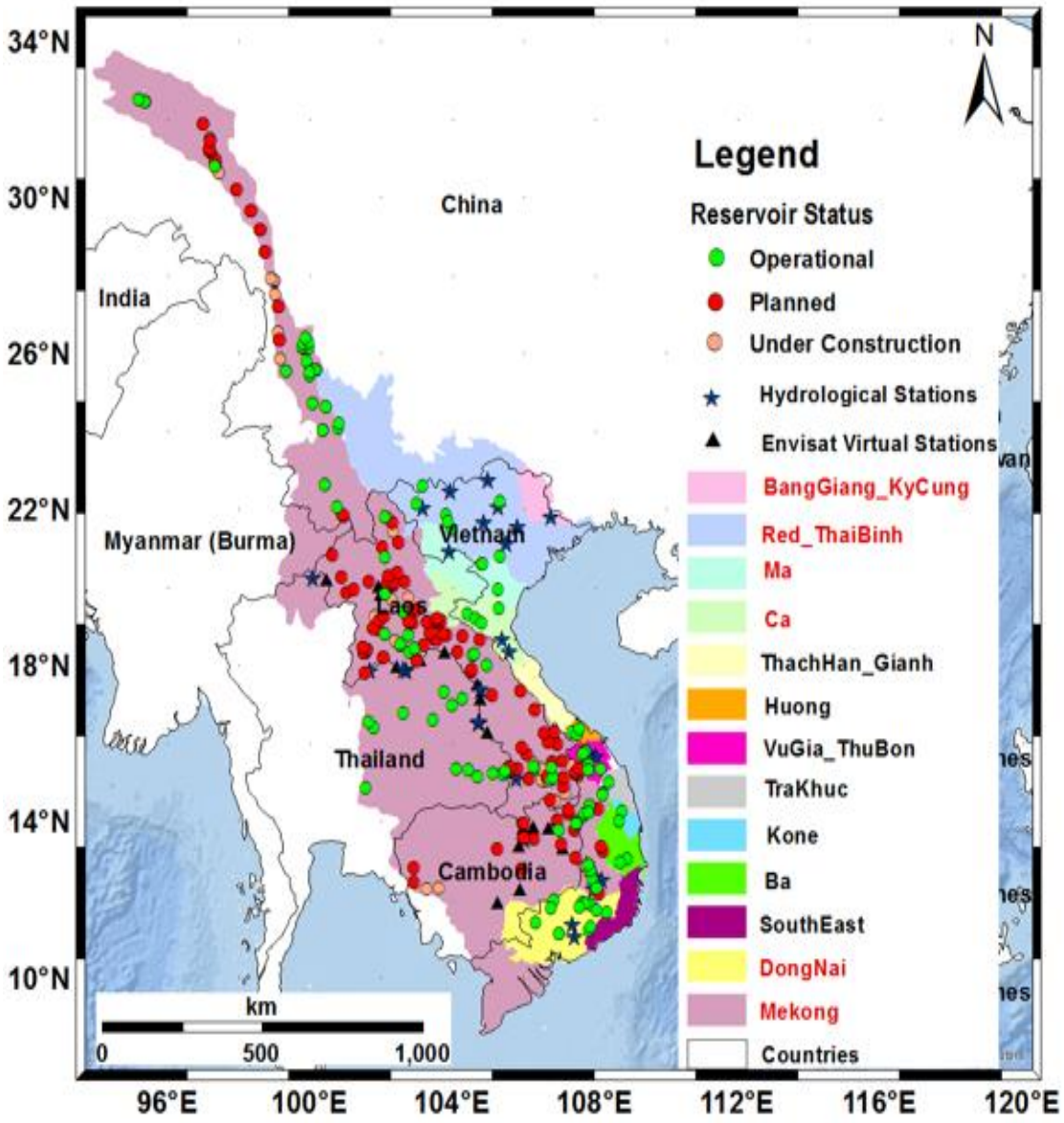
Ensemble forecasts

End Users

Dr. Duong Bui: NAWAPI Director of Water Res Monitoring & Coordinator of Vietnam Water Cooperation Initiative-VACI at Ministry of MONRE, Vietnam
Water Chair of US-ASEAN S&T Fellow Association (duongdubui@gmail.com)

Information Classification: General

Motivation

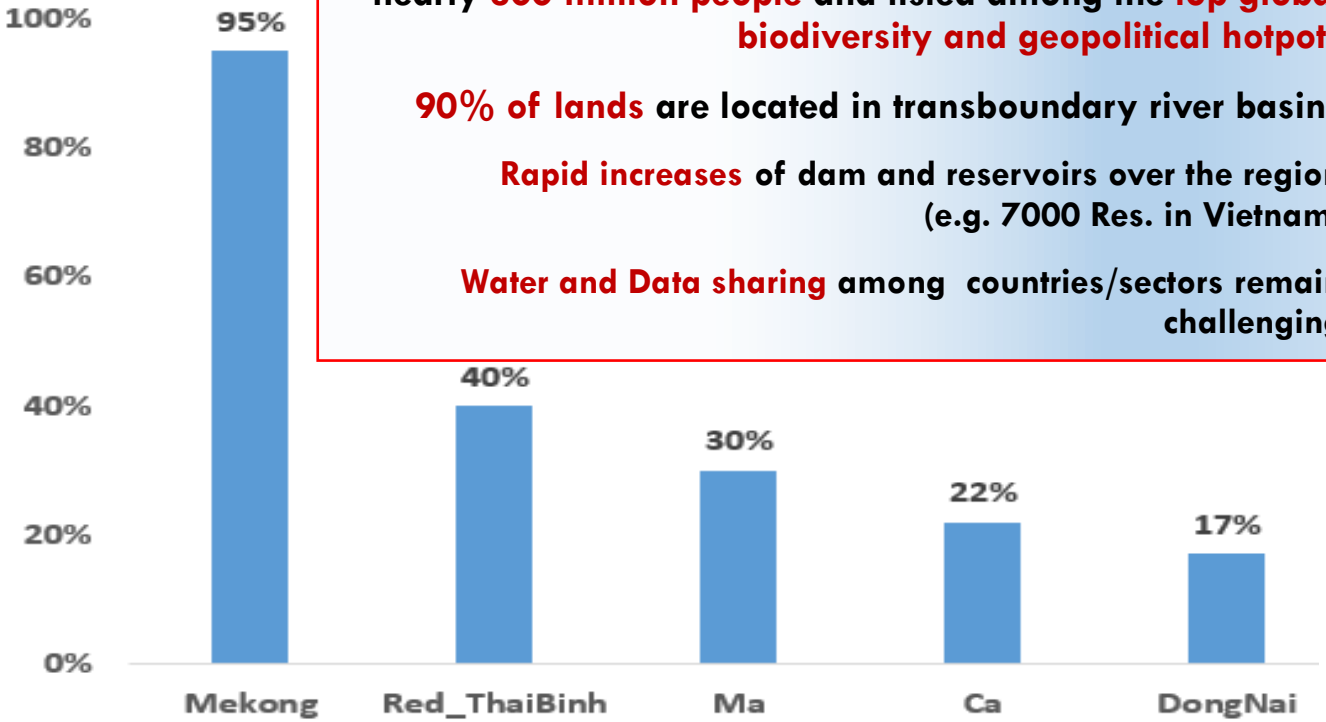


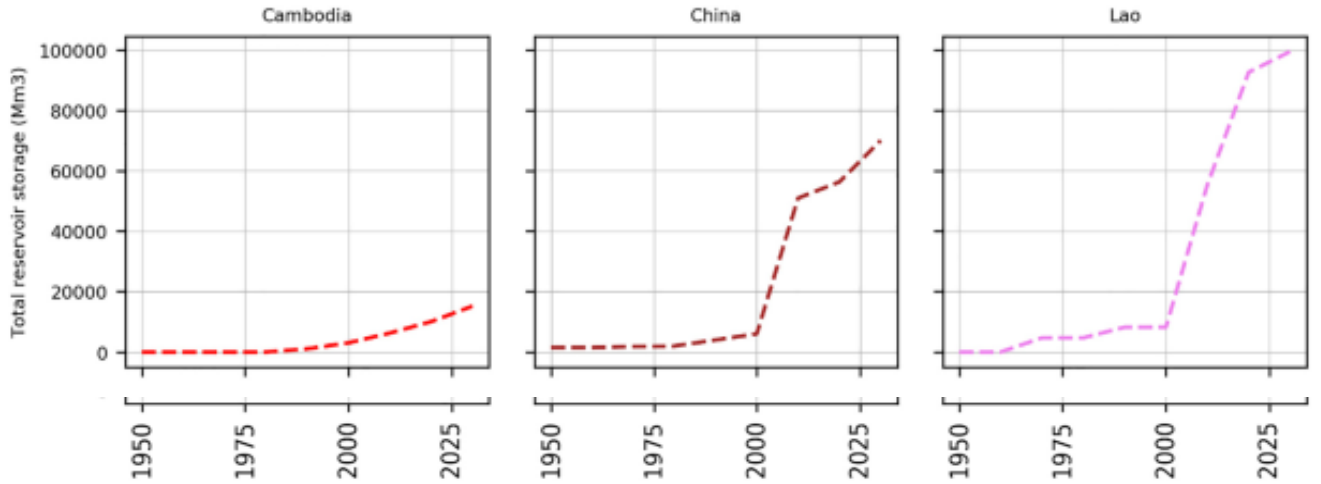
Greater Mekong region provide rich ecosystem services for nearly **300 million people** and listed among the **top global biodiversity and geopolitical hotpots**

90% of lands are located in transboundary river basins

Rapid increases of dam and reservoirs over the region (e.g. 7000 Res. in Vietnam)

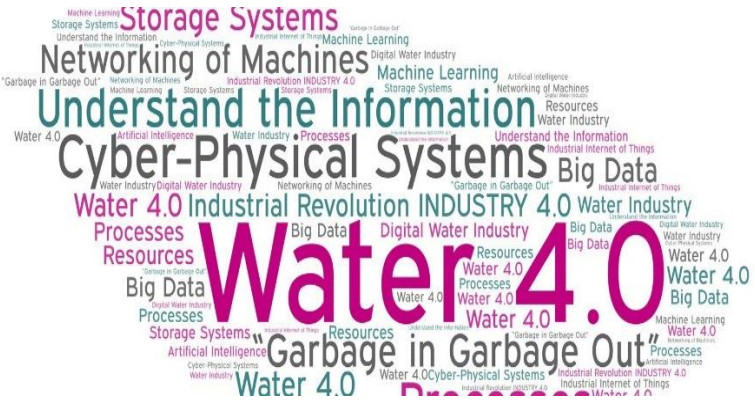
Water and Data sharing among countries/sectors remain challenging

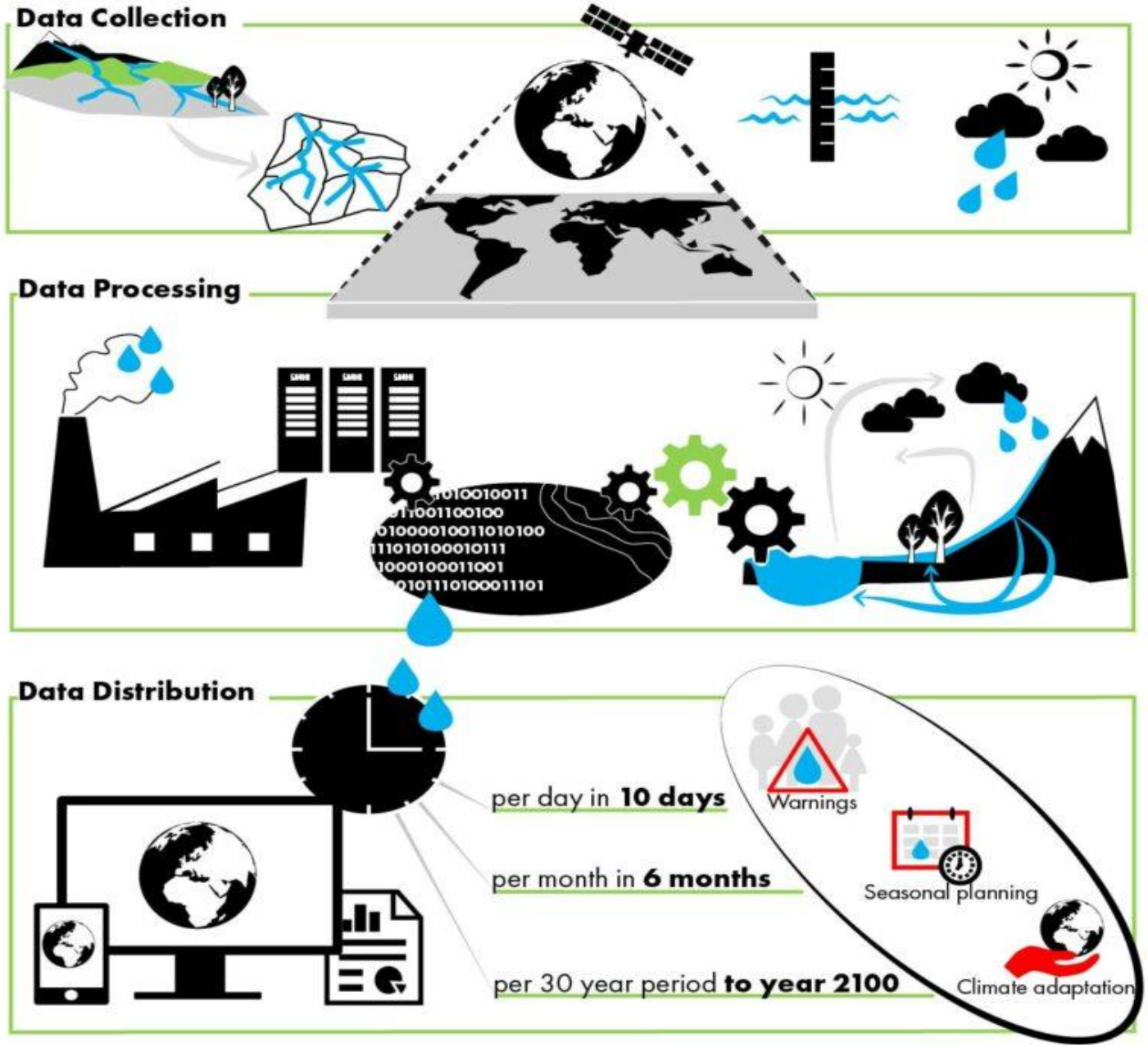




Evolution of the total reservoir storage per country (2020 and 2030 levels are projections G. Bussi et al 2021.

Overall Approach





Information Classification: General

3. Input Database for GM_HYPE Model

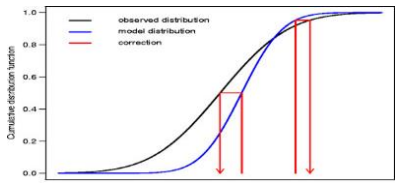
Data type	Source and resolution	Reference
Topography (Flow accumulation, flow direction, digital elevation, river width)	SRTM (3 arcsec) HYDRO1k (30 arcsec) GWD-LR (3 arcsec) **National database**	USGS UGGS Yamazaki et al., 2014 **BIG DREAM project (NAWAPI)**
Floodplains and Lake	Global Lake and Wetland Database (GLWD)	Lehner and Doll, 2004
Reservoirs and dams	Global Reservoir and Dam database v1.1 (GRanD) **In-situ data (WL, inflow, outflow, bathymetry, In Vietnam)** **Satellite data (WL, Storage change, bathymetry, outside Vietnam)**	Lehner et al., 2011 **BIG DREAM project (NAWAPI)** **Du et al 2021**
Land Cover characteristics	ESA CCI Landcover v1.6.1 epoch 2010 (300m)	ESA Climate Change Initiative – Land Cover project
Precipitation	MSWEP (0.25° grid, 1979 – 2014) ++ TRMM 3B42 (0.25° grid, 2001 – 2015) HydroGFD (0.5° grid, 1961 – 2015) GPM IMERGF-V6 ++ ERA-5 In-situ precipitation (576 stations, 1975 – 2011) ++ **GM-Force V1.0 (0.25, 1980-2020)**	Beck et al. 2017 Huffman et al., 2006 Berg et al., 2018 BIG DREAM project (NAWAPI) Bui etc al. 2021
Temperature	NCEP CFSv2 (0.25° grid,1979 – 2020) ++	Berg et al., 2018 Saha et al., 2011
Potential Evapotranspiration	MOD16A2 (8-day 1 km, 2001 – 2010)	Mu et al., 2016
Streamflow observations Suspendered Sediment observations	**Nearly 100 Stations (daily, 1980 - 2019) ++** About 10 stations **daily, 1980 - 2019) ++**	BIG DREAM project (NAWAPI)
Observations of streamflow and water level in Mekong	12 Stations (daily, 1980 – 2007) ++	Mekong-SEVIR project (ADPC)
Envisat-derived Water Level	17 Virtual Stations (daily every 35 days, 2002-2019) ++	Okeowo et al., 2017; Lee et al., 2009; Chang et al., 2019; Kim et al., 2019

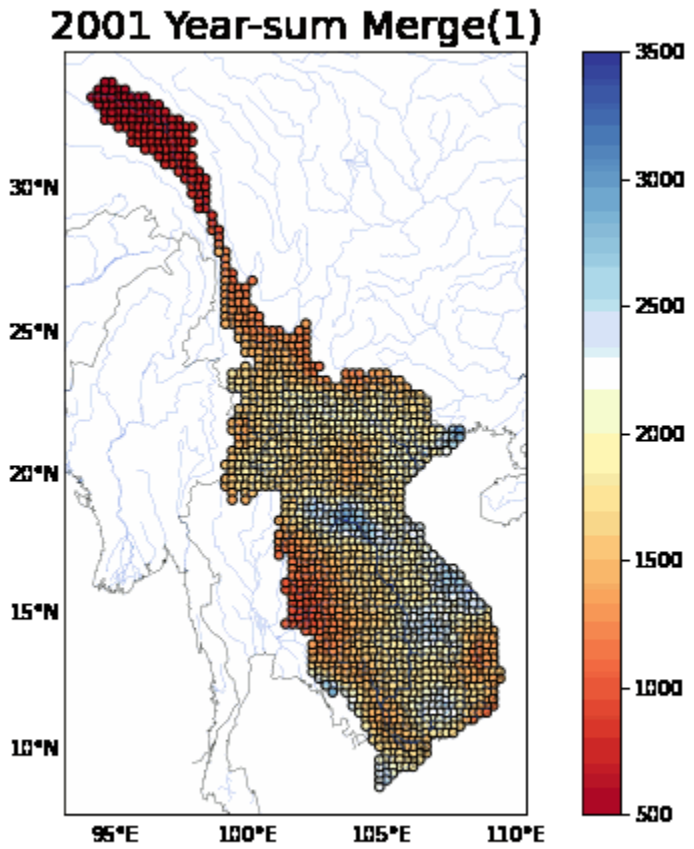
Information Classification: General

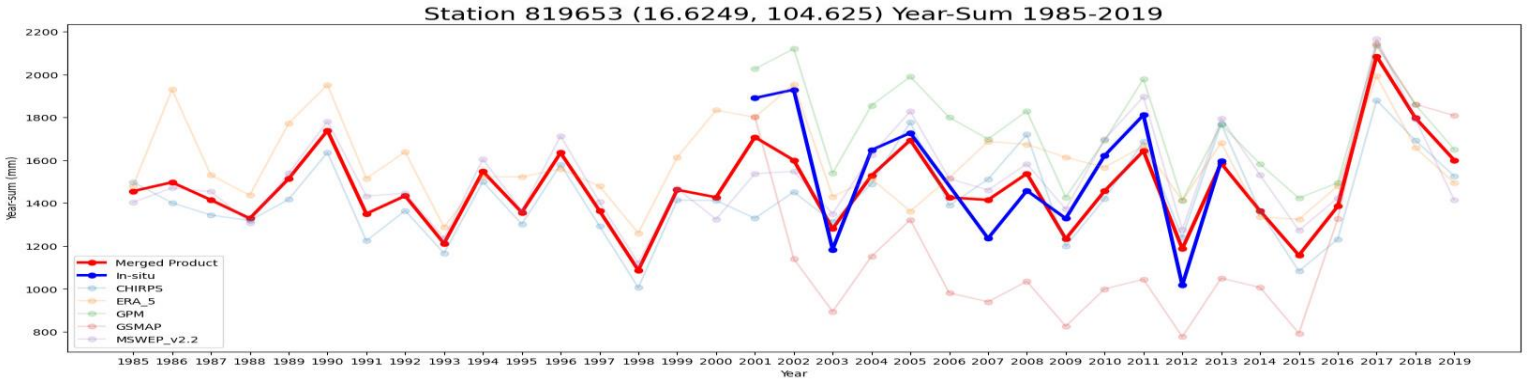
Constructing GM-Force Precipitation dataset (0.25Deg, daily, 1980-now, Near-Realtime)

- **Gauge**:
  - 576 in-situ P stations across the region
  - 1990-2017 (mostly to 2011)
- **Satellite** (40 years till now)
  - GPM
  - GSMAP
  - CHIRPS
- **Reanalysis** (40 years till now)
  - ERA-5
  - MSWEP v2
- **Forecast Data** (16days, Seasonal, realtime update)
  - NCEP/NOAA
  - ECMWF
  - UKMO

Bias corrected & Merged

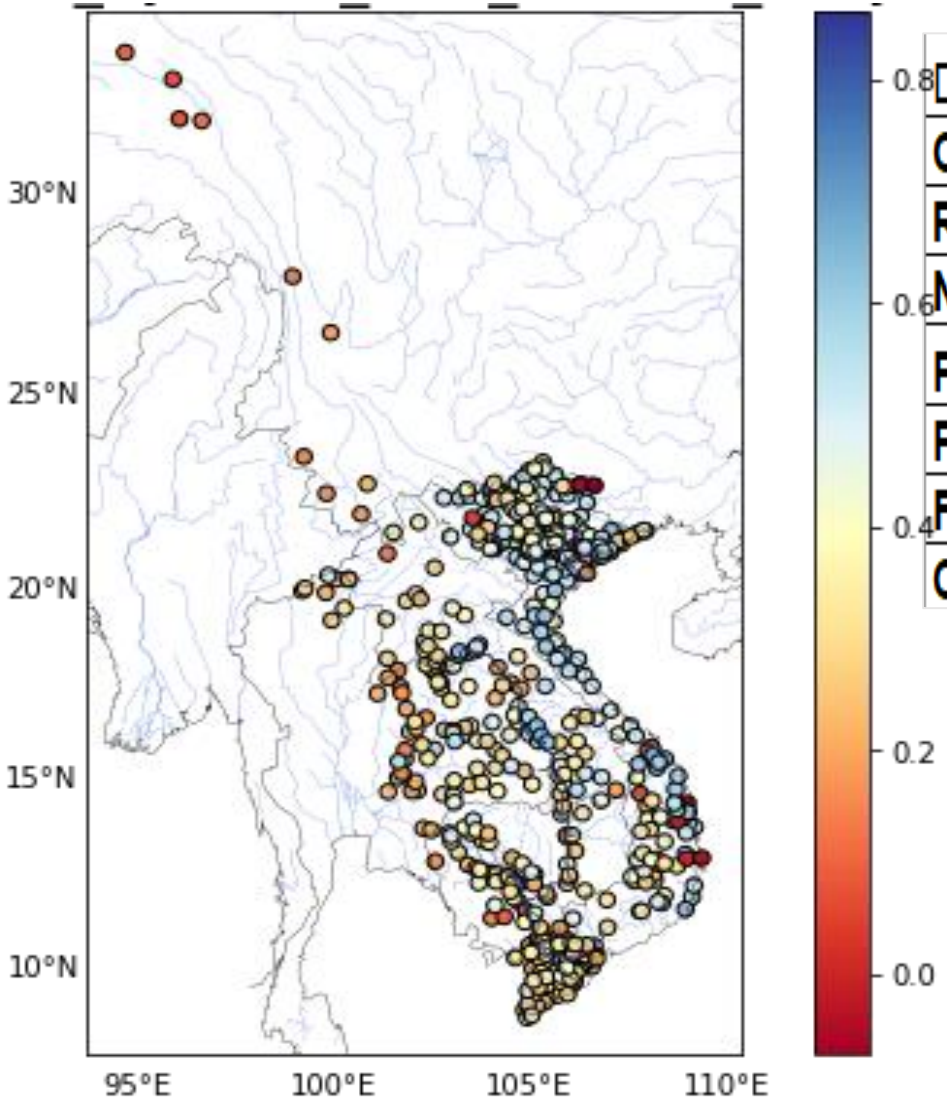






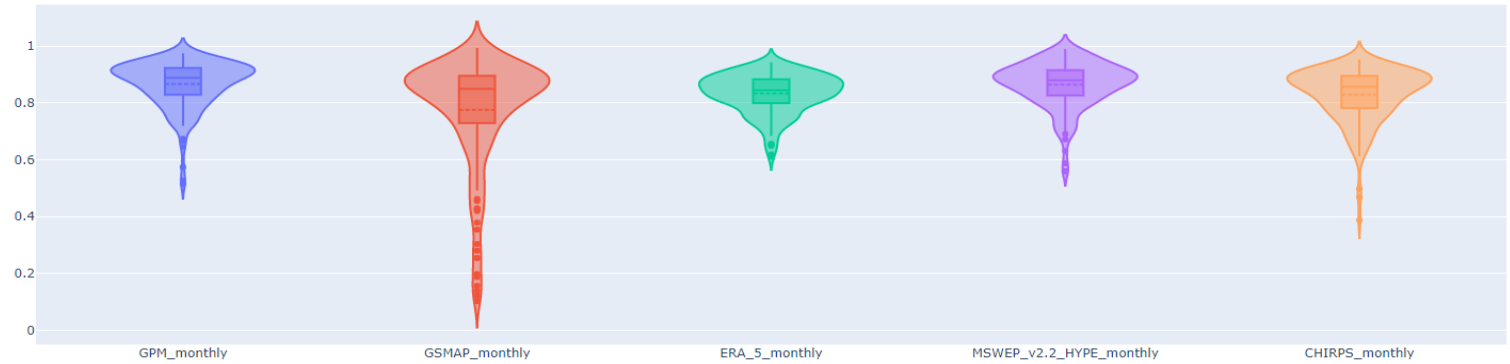
Information Classification: General

Constructing GM-Force Precipitation dataset (0.25 Deg, daily, 1980-now. Near-Realtime)



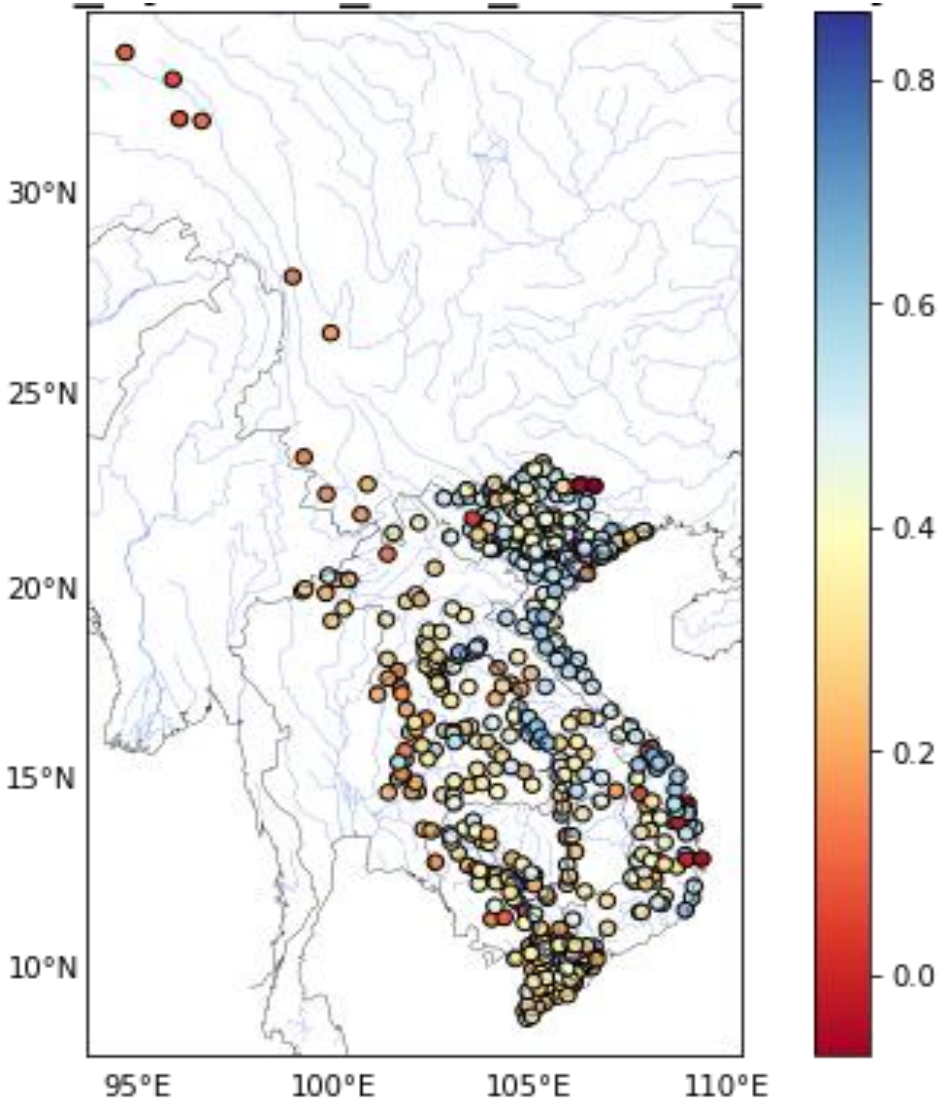
DAILY	GM-Force	GPM	GSMAP	CHIRPS	MSWEP_V2	ERA_5
CC	0.382 (0.13)	0.273 (0.11)	0.299 (0.12)	0.277 (0.1)	0.302 (0.12)	0.323 (0.12)
RMSE	12.945 (3.68)	15.926 (3.85)	13.8 (3.89)	14.876 (4.26)	14.735 (3.85)	13.591 (3.6)
NSE	0.054 (0.32)	-0.478 (0.58)	-0.075 (0.35)	-0.291 (0.83)	-0.251 (0.51)	-0.05 (0.37)
PBIAS	-5.505 (30.06)	-14.015 (33.09)	18.014 (31.71)	-9.964 (34.6)	-2.982 (32.42)	-13.563 (34.04)
POD	0.993 (0.02)	0.807 (0.12)	0.915 (0.06)	0.52 (0.13)	0.883 (0.06)	0.987 (0.02)
FAR	0.638 (0.09)	0.523 (0.11)	0.575 (0.1)	0.46 (0.12)	0.526 (0.11)	0.631 (0.09)
CSI	0.361 (0.09)	0.418 (0.08)	0.407 (0.09)	0.35 (0.08)	0.444 (0.1)	0.367 (0.09)

Performance Metrics (compared to in-situ P) of V-Force dataset (40 years, 1980-2020, 0.25 Deg.) among other Precipitation products



Information Classification: General

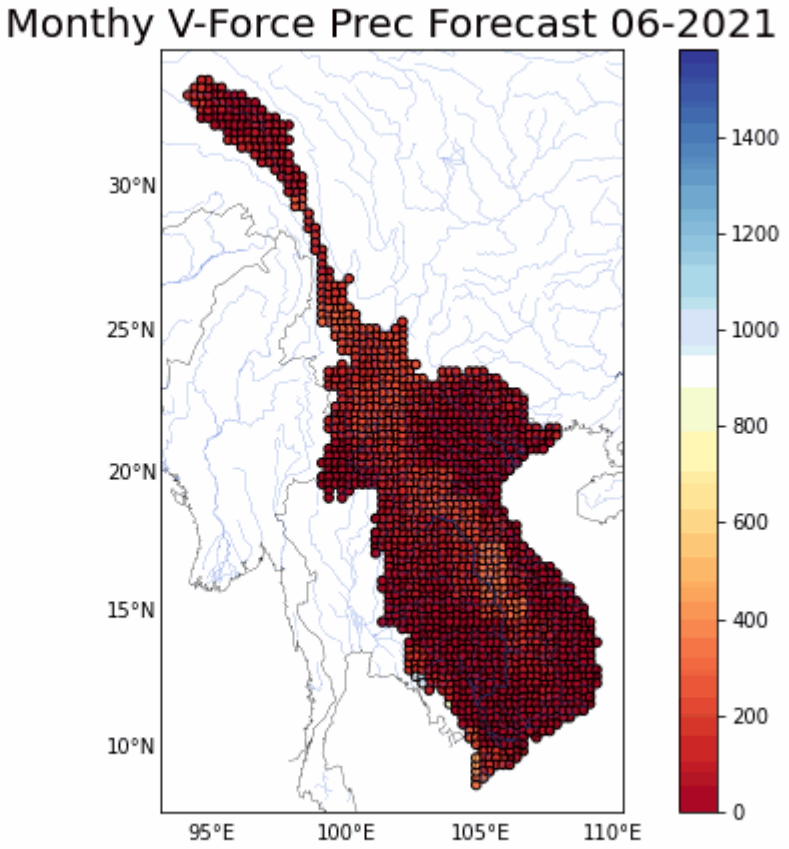
Constructing GM-Force Precipitation dataset (0.25 Deg, Hourly, 1980-now. Near-Realtime)



Daily (from Hourly)	GPM	ERA_5	GSMAP	V-Force
CC	0.389 (0.1)	0.39 (0.08)	0.372 (0.12)	0.447 (0.09)
RMSE	14.522 (3.85)	12.993 (3.59)	13.054 (3.83)	12.643 (3.53)
NSE	-0.181 (0.27)	0.073 (0.11)	0.055 (0.19)	0.118 (0.15)
PBIAS	-10.792 (20.93)	-10.857 (22.21)	19.191 (27.11)	-11.529 (20.22)
POD	0.831 (0.12)	0.992 (0.01)	0.927 (0.05)	0.993 (0.01)
FAR	0.507 (0.11)	0.626 (0.09)	0.568 (0.1)	0.629 (0.09)
CSI	0.438 (0.08)	0.372 (0.09)	0.416 (0.1)	0.37 (0.09)

Information Classification: General

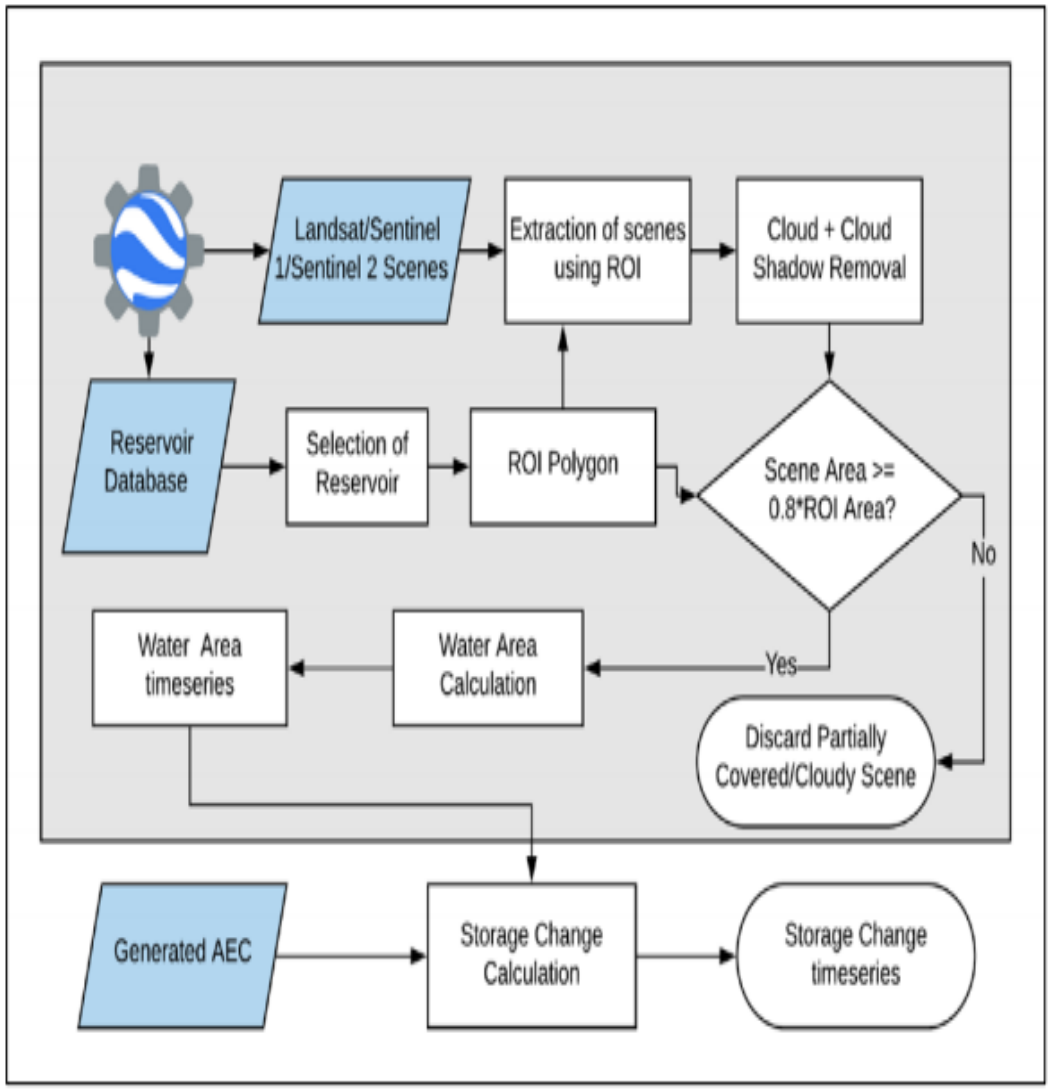
Constructing seasonal forecast ensemble (0.25 Deg, daily, up to 06 month ahead, 1980-now. Near-Realtime)

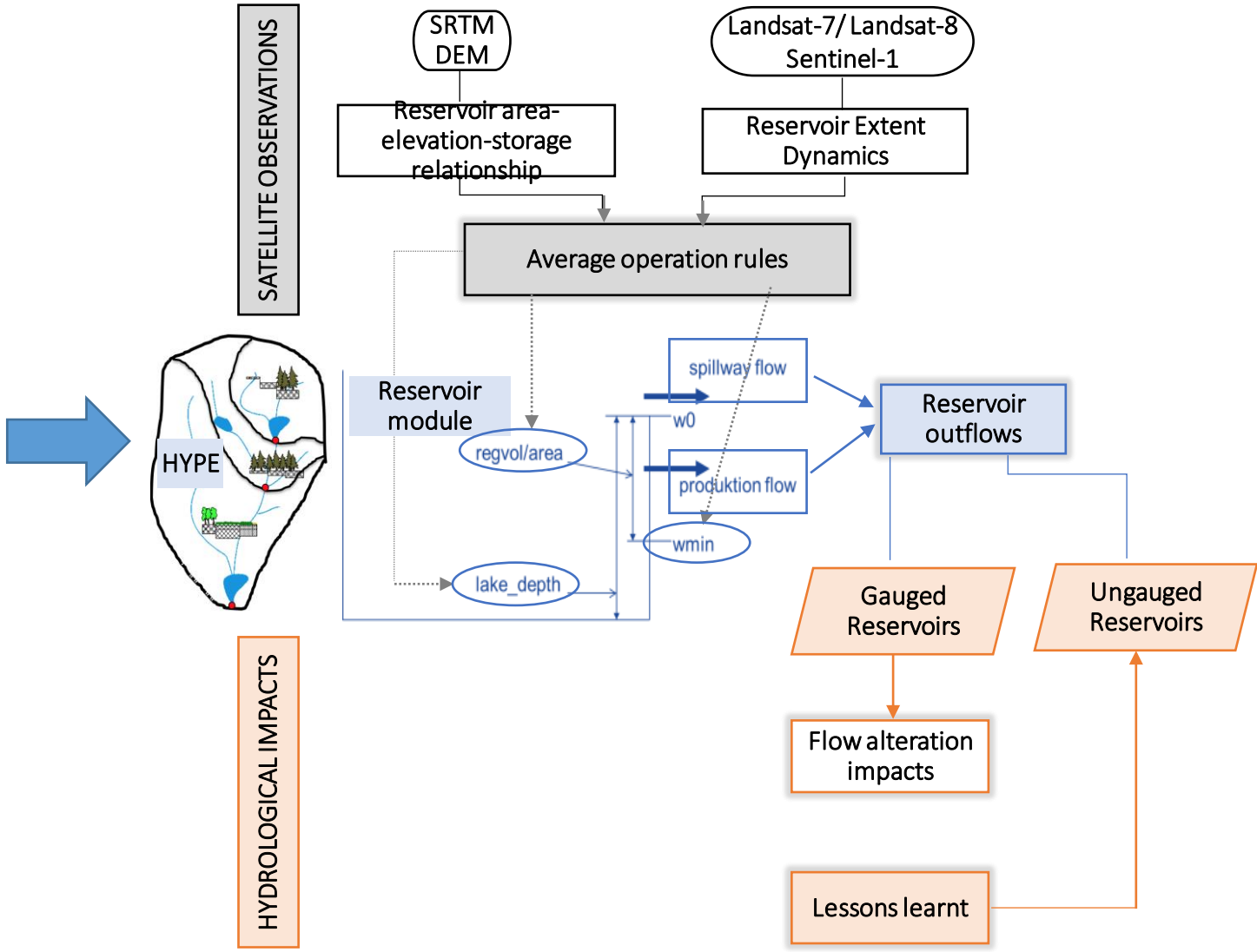


Daily	ECMWF	NCEP	UKMO
CC	0.078 (0.06)	0.076 (0.06)	0.105 (0.07)
RMSE	15.645 (4.57)	14.887 (4.5)	15.034 (4.55)
NSE	-0.423 (1.01)	-0.29 (1.07)	-0.28 (0.63)
PBIAS	5.889 (50.41)	7.34 (48.04)	7.204 (43.26)
POD	0.834 (0.06)	0.876 (0.06)	0.983 (0.01)
FAR	0.628 (0.09)	0.645 (0.09)	0.649 (0.09)
CSI	0.344 (0.08)	0.336 (0.08)	0.349 (0.09)

Information Classification: General

Monitoring essential variables for reservoir operation *(i.e. water extend, bathymetry, operation rules, in-outflow, sediment)* using Satellite Tech & GM_HYPE

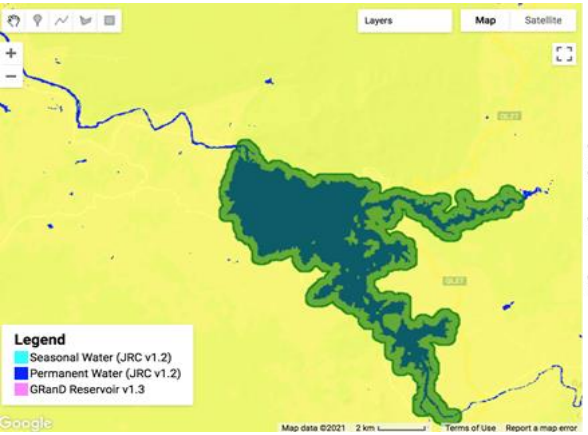


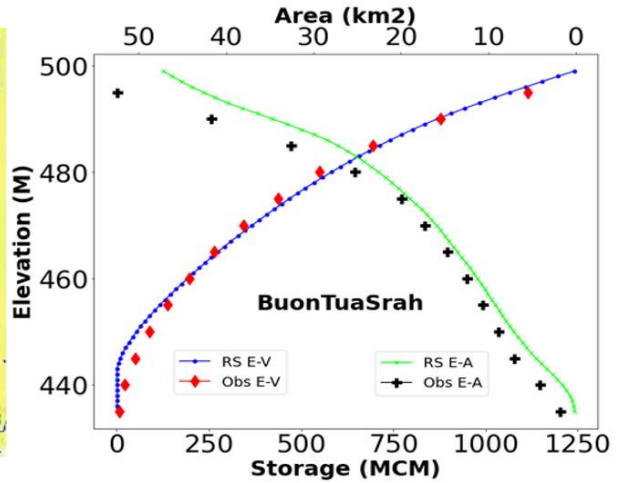


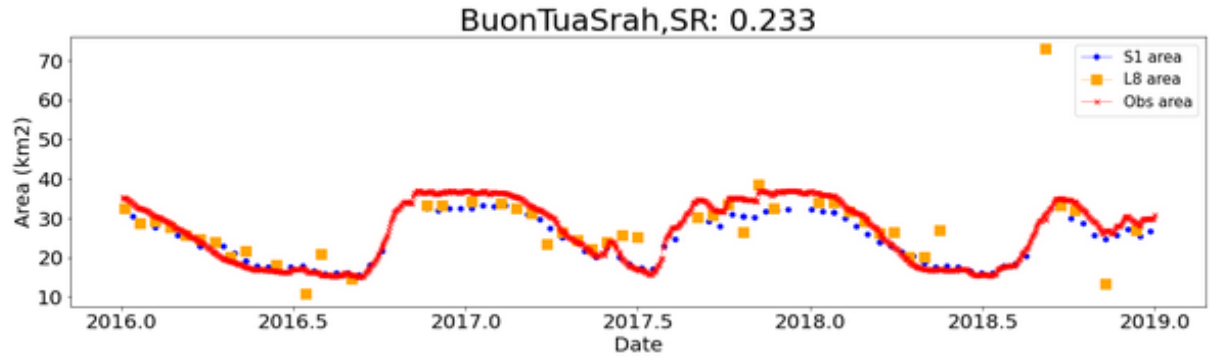
Tien et al 2021

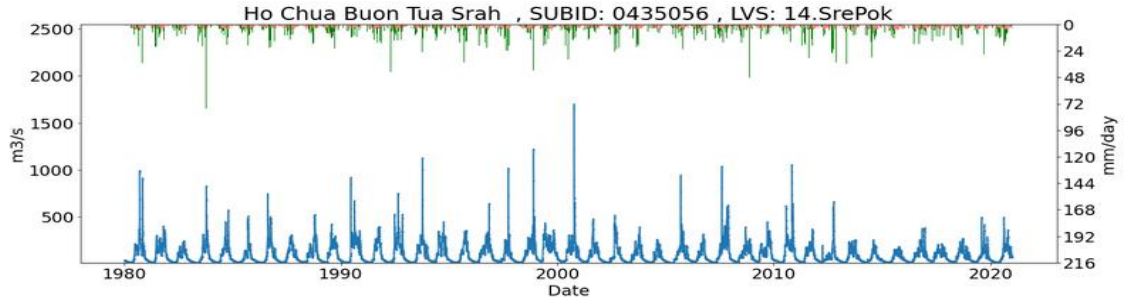
Information Classification: General

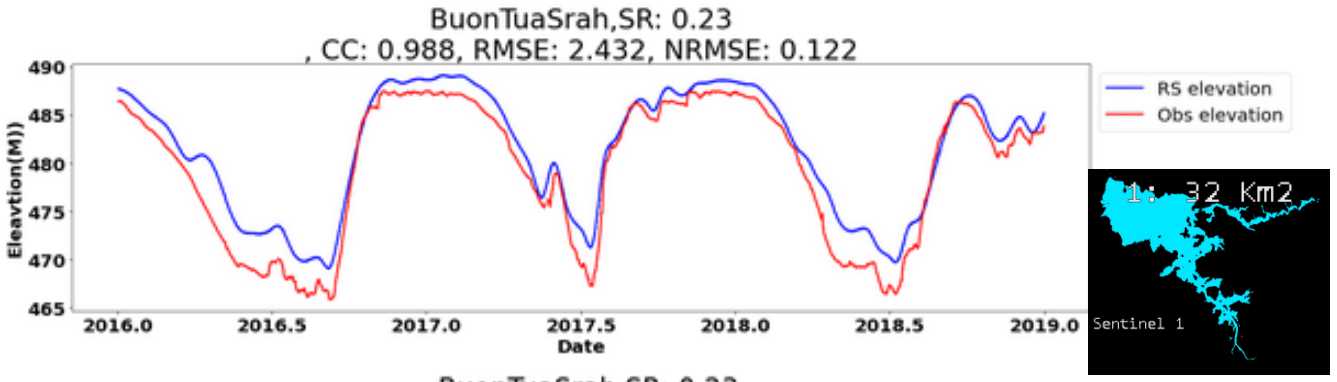
Monitoring essential variables for reservoir operation *(i.e. water extend, bathymetry, operation rules, in-outflow, sediment)* using Satellite Tech & GM_HYPE

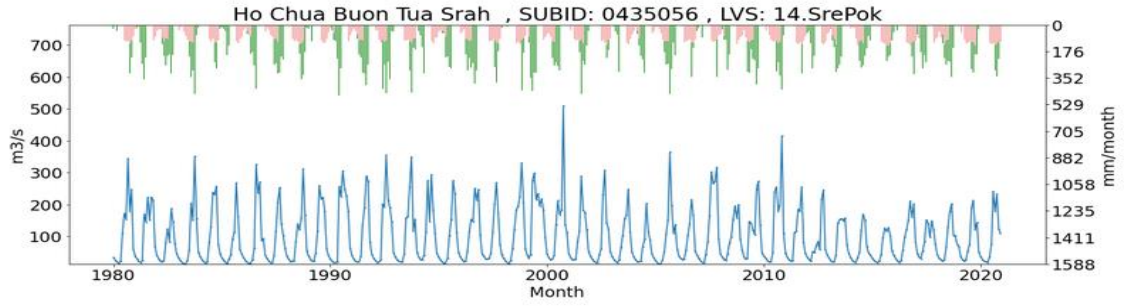


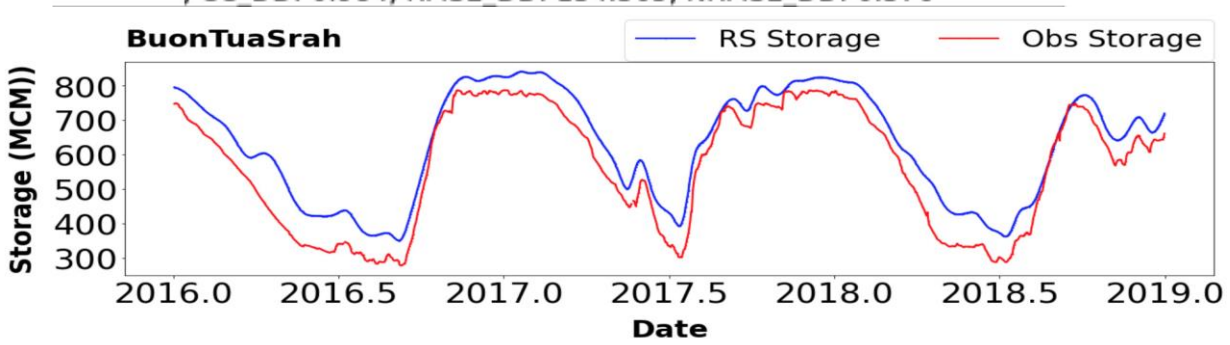






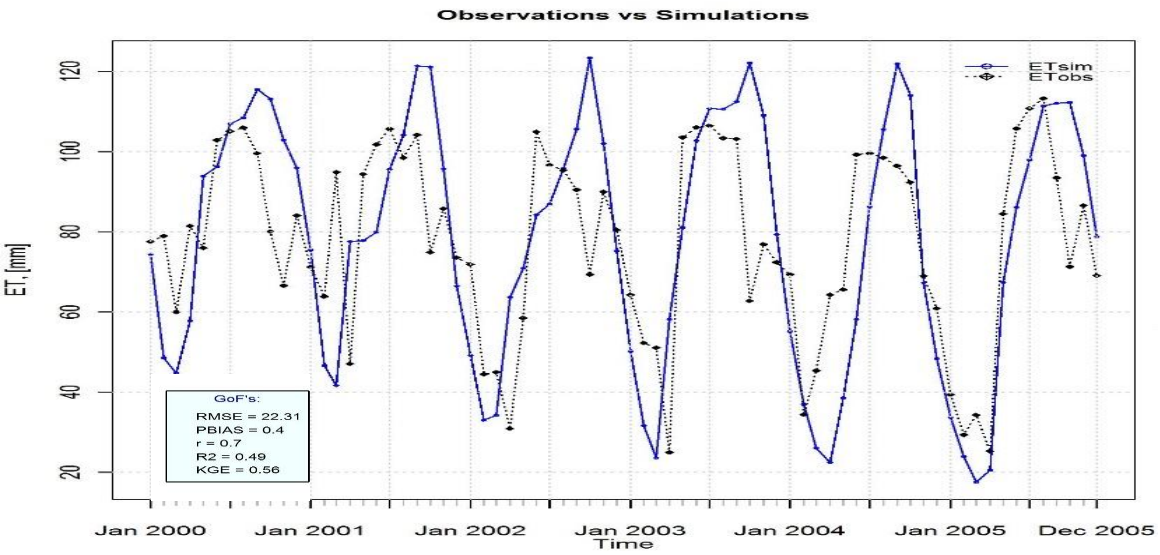


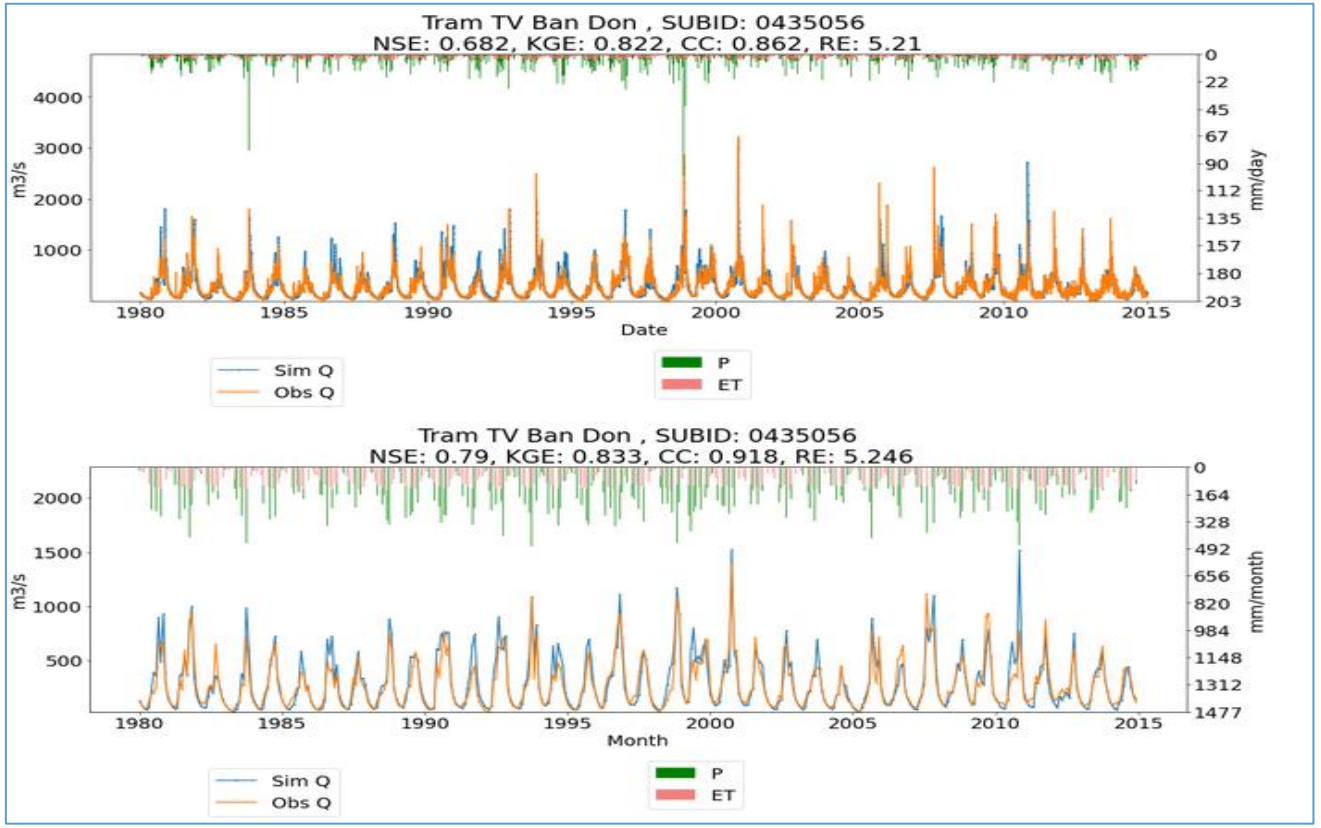


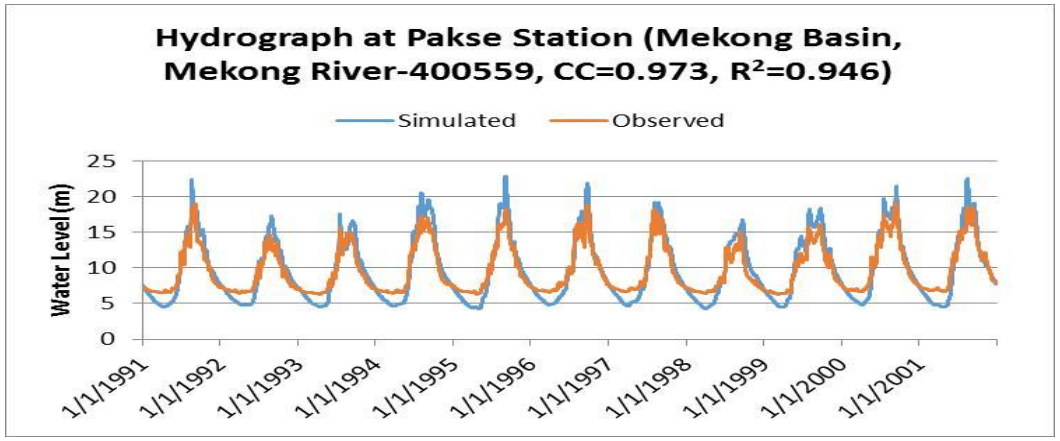


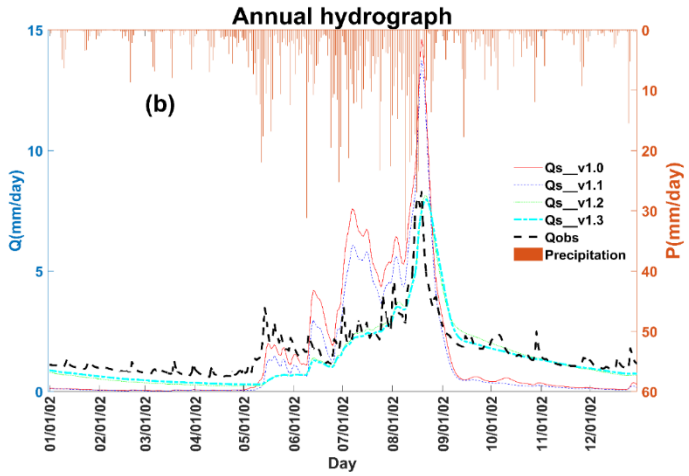
Information Classification: General

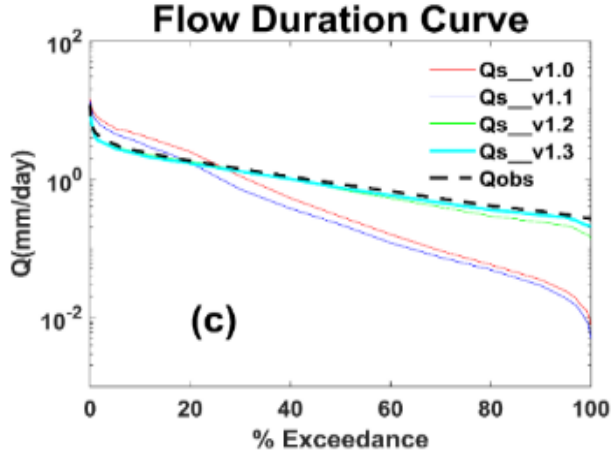
Model performance in "Natural" (before dam) condition







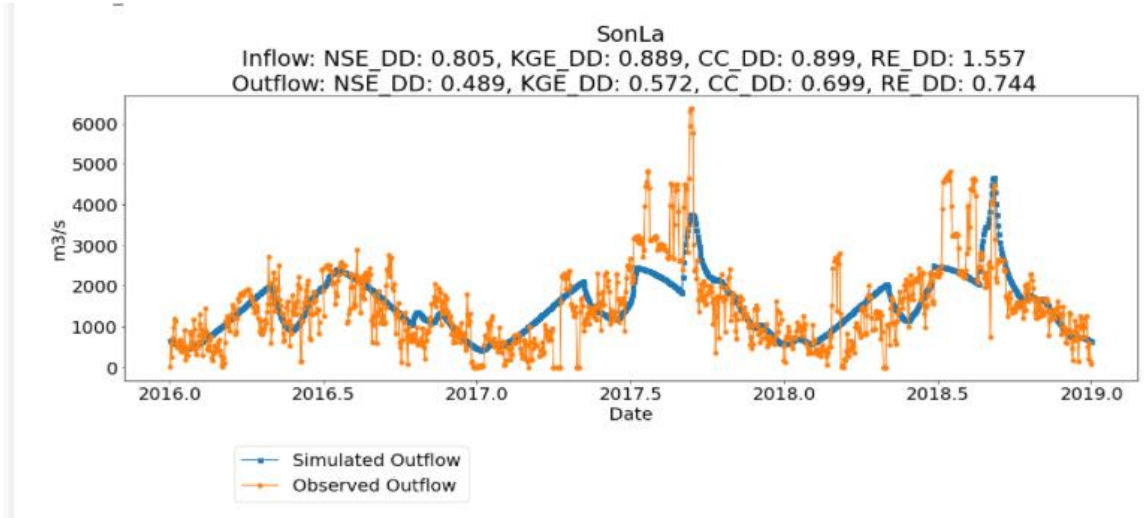


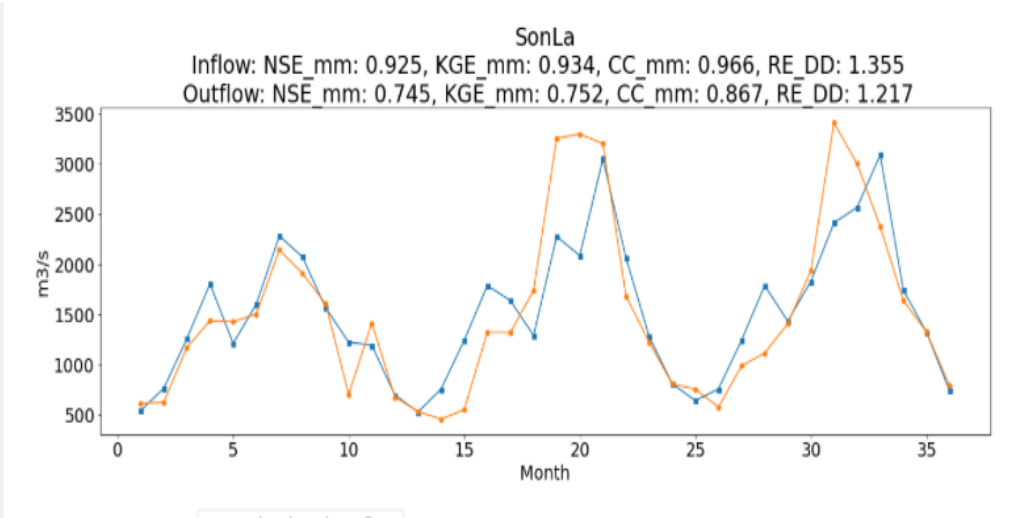


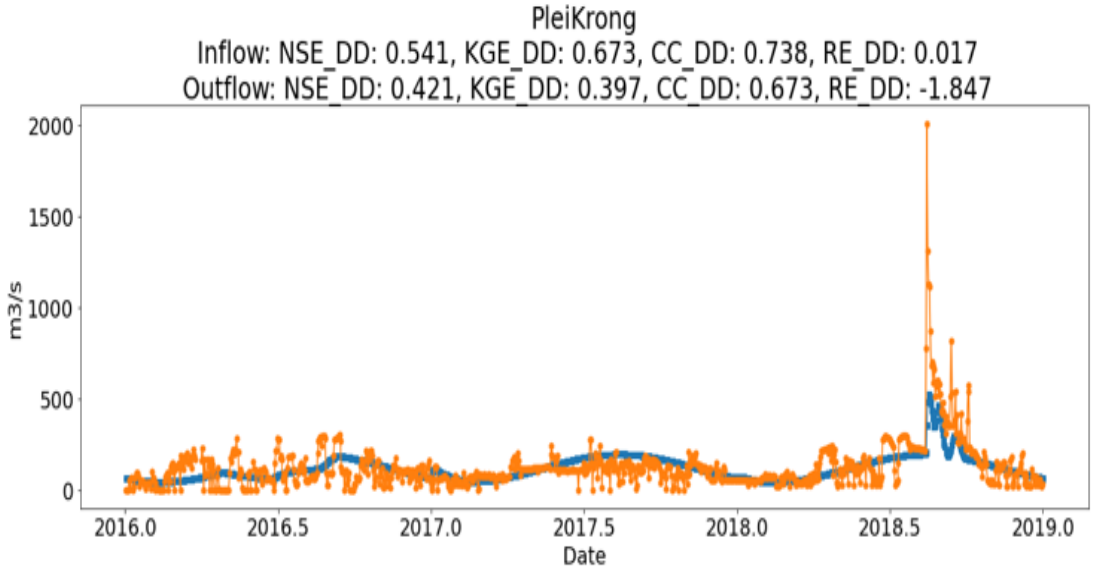
Du et al., 2020

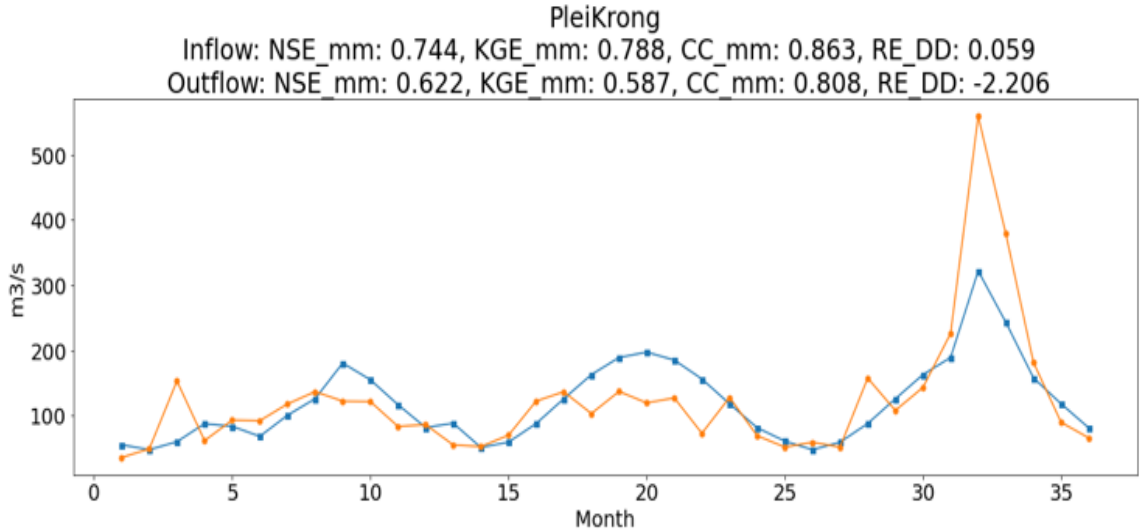
Information Classification: General

Model performance in regulated condition (i.e. dam and reservoirs)





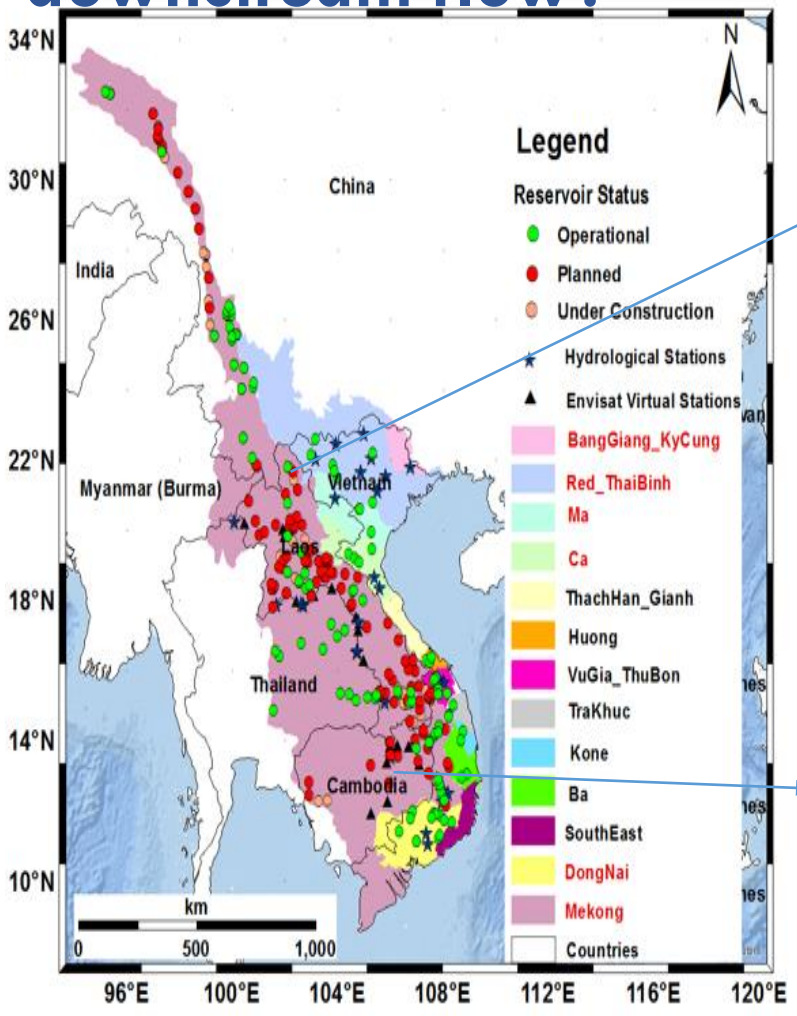


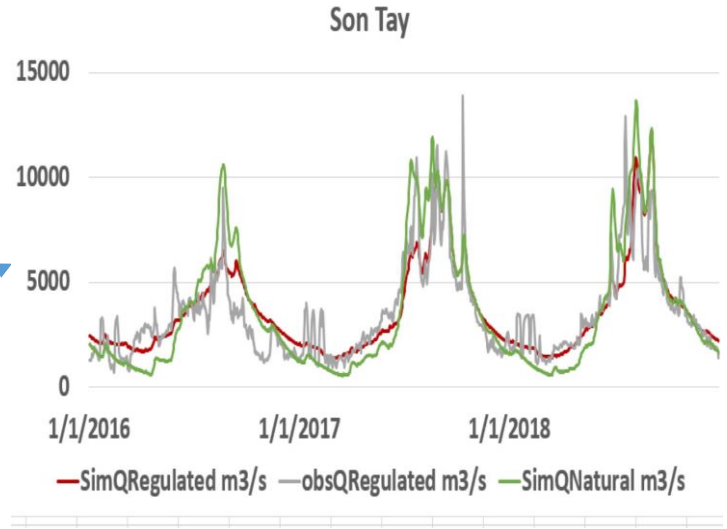


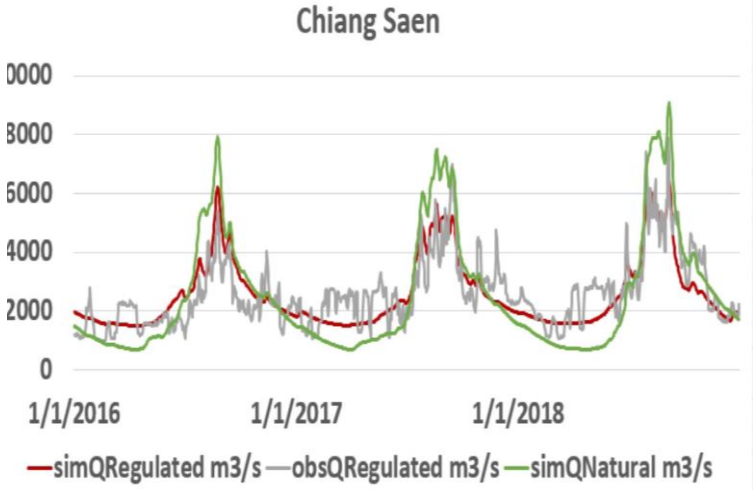
Information Classification: General

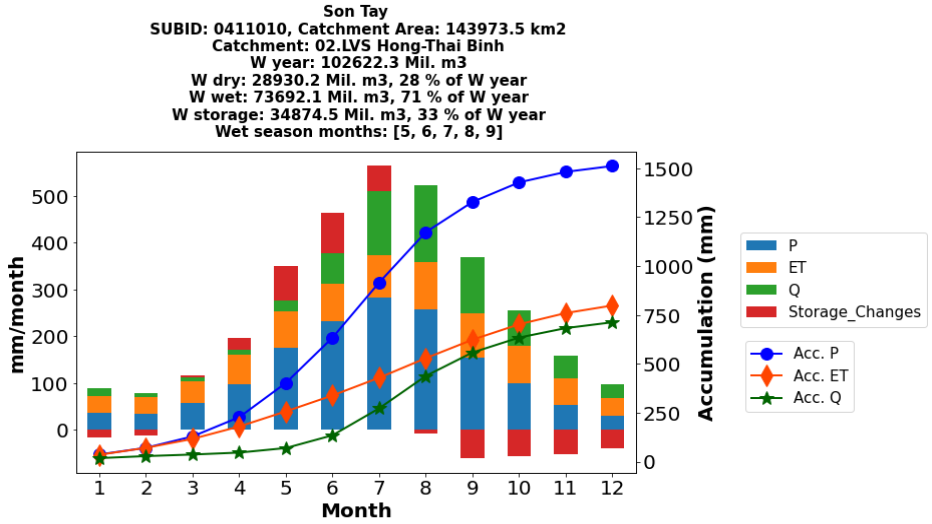
Modeling the Impacts of interconnected cascade dams to downstream flow?

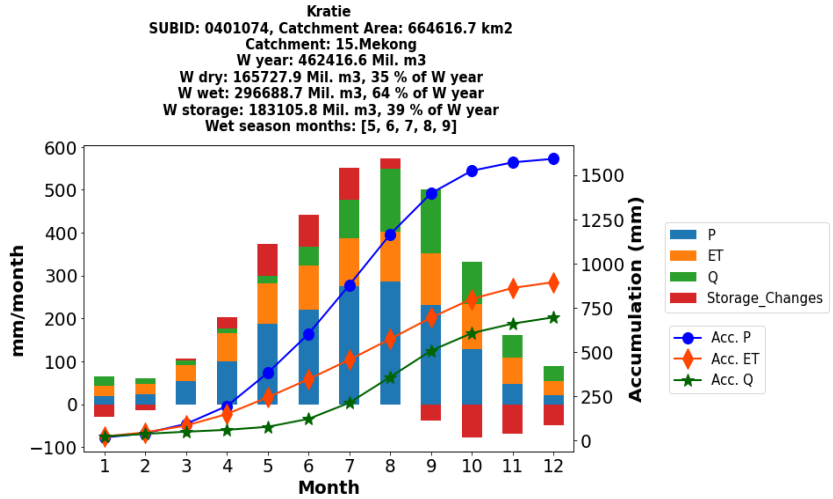
At Sontay Station, Red River Delta





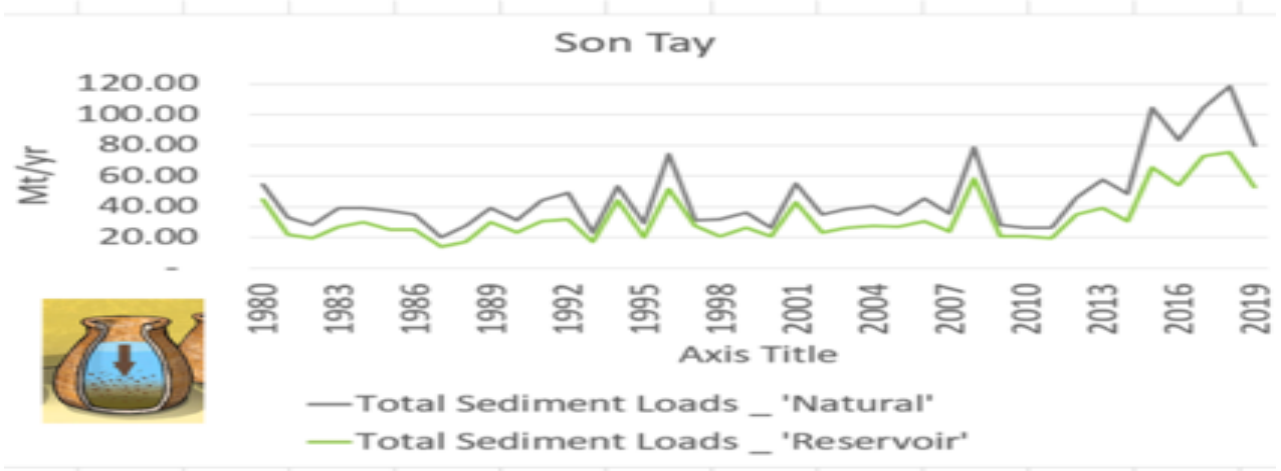


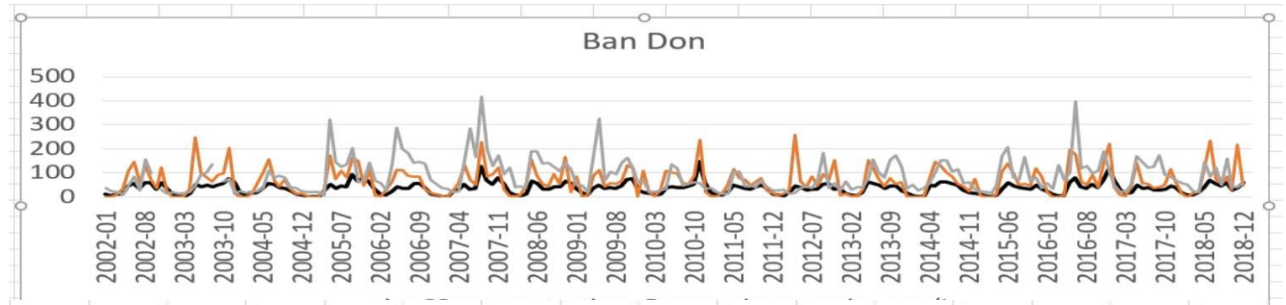


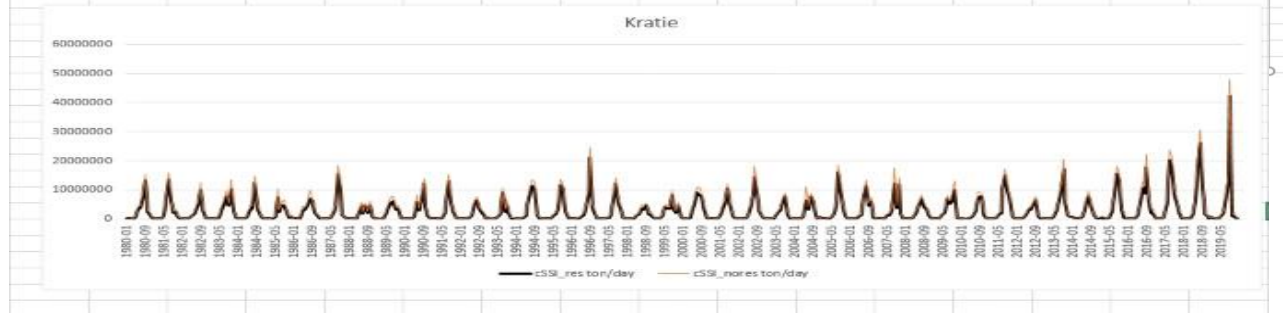


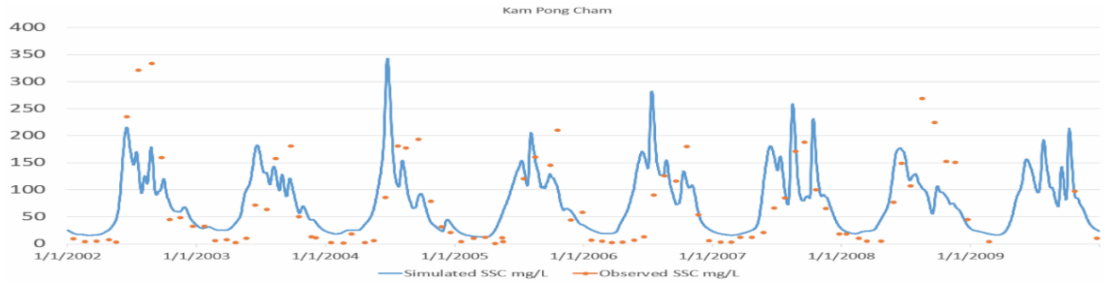
Information Classification: General

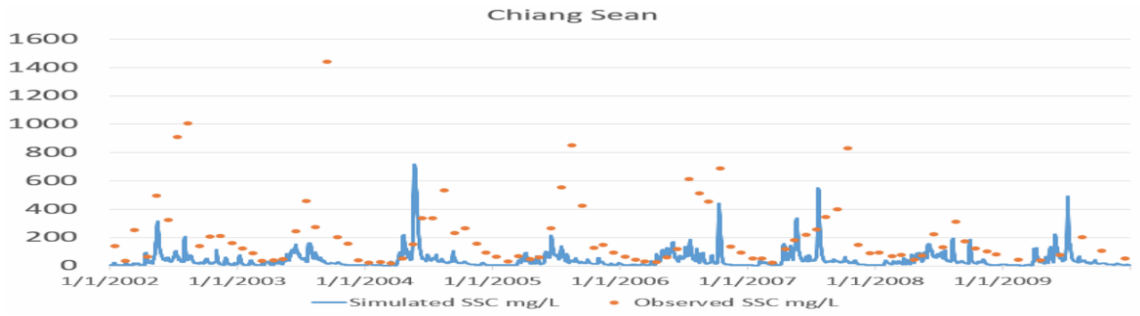
Simulation of Erosion/Sediment yield (SSC)

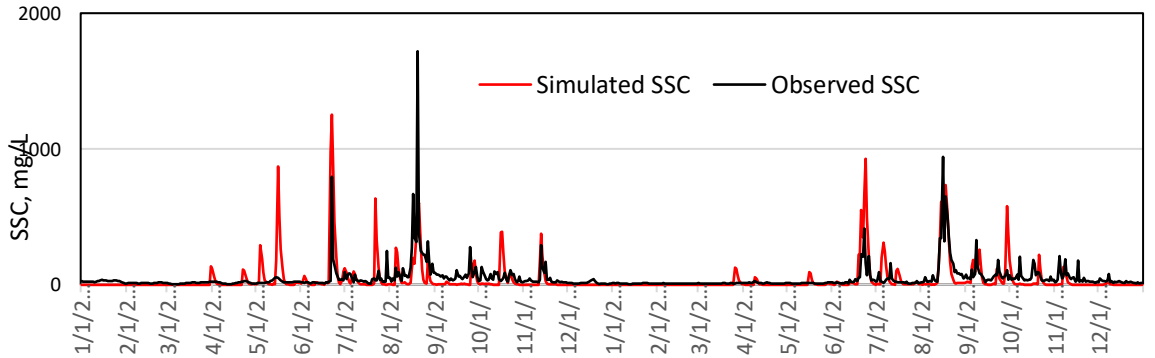


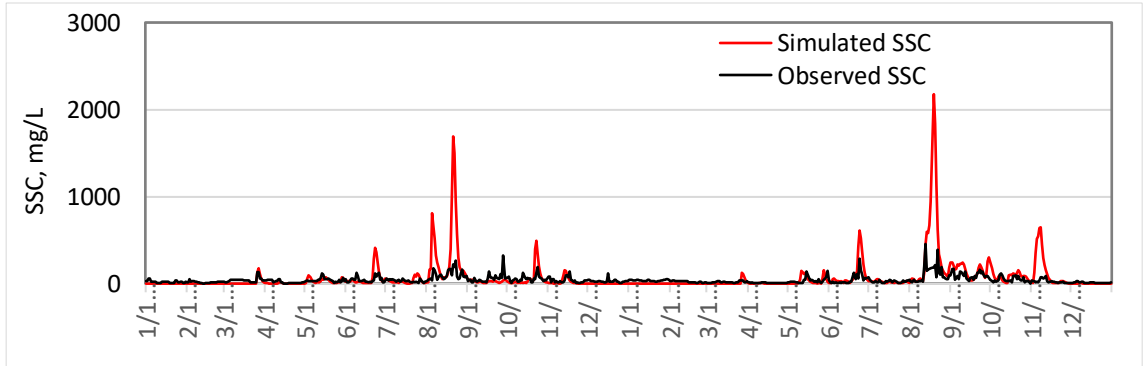






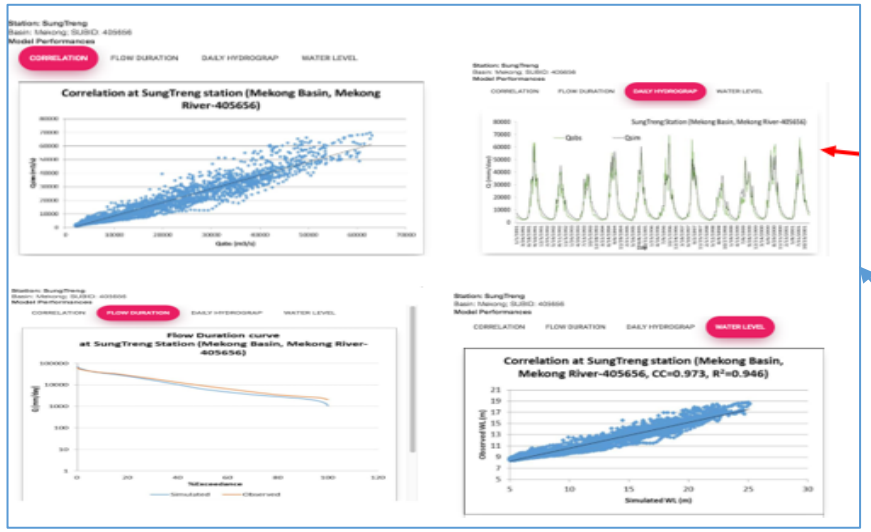


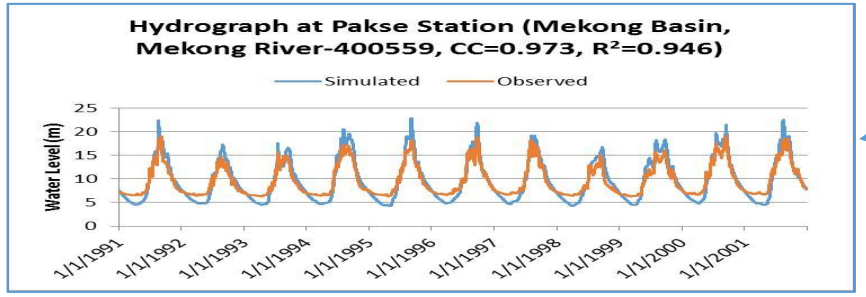


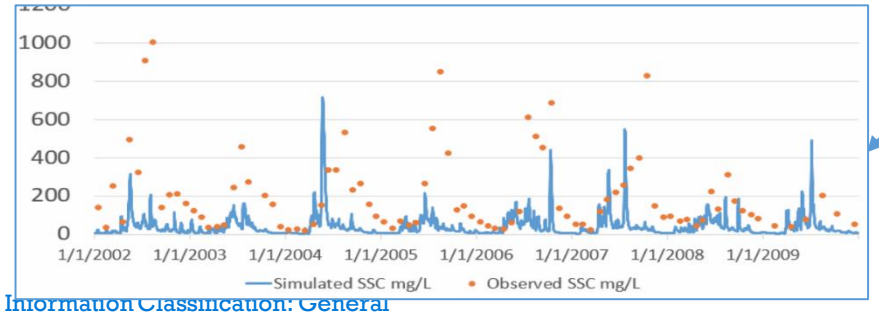


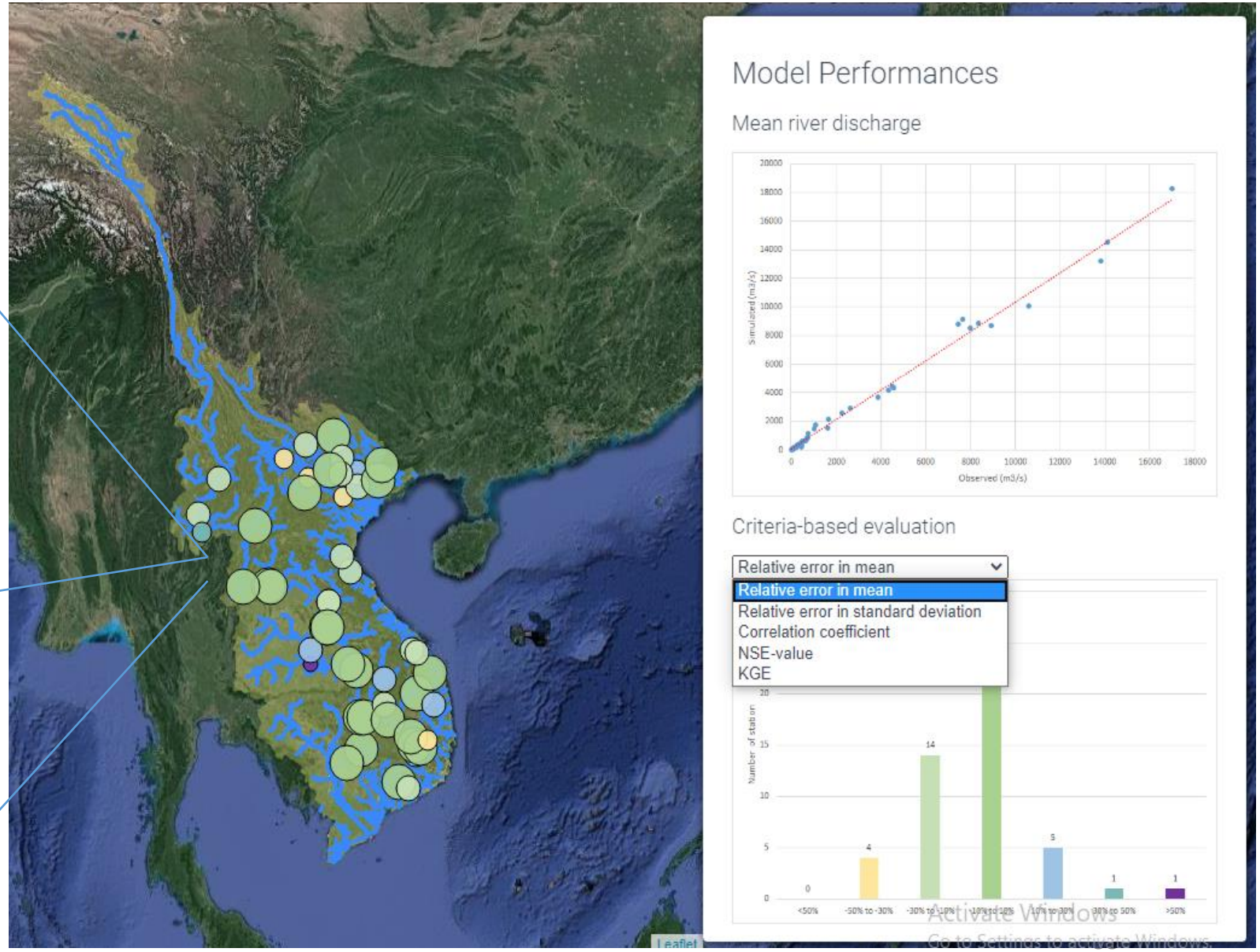
Information Classification: General

Overall Model performance: Spatial distribution of multi-metrics for different hydrological variables across scales





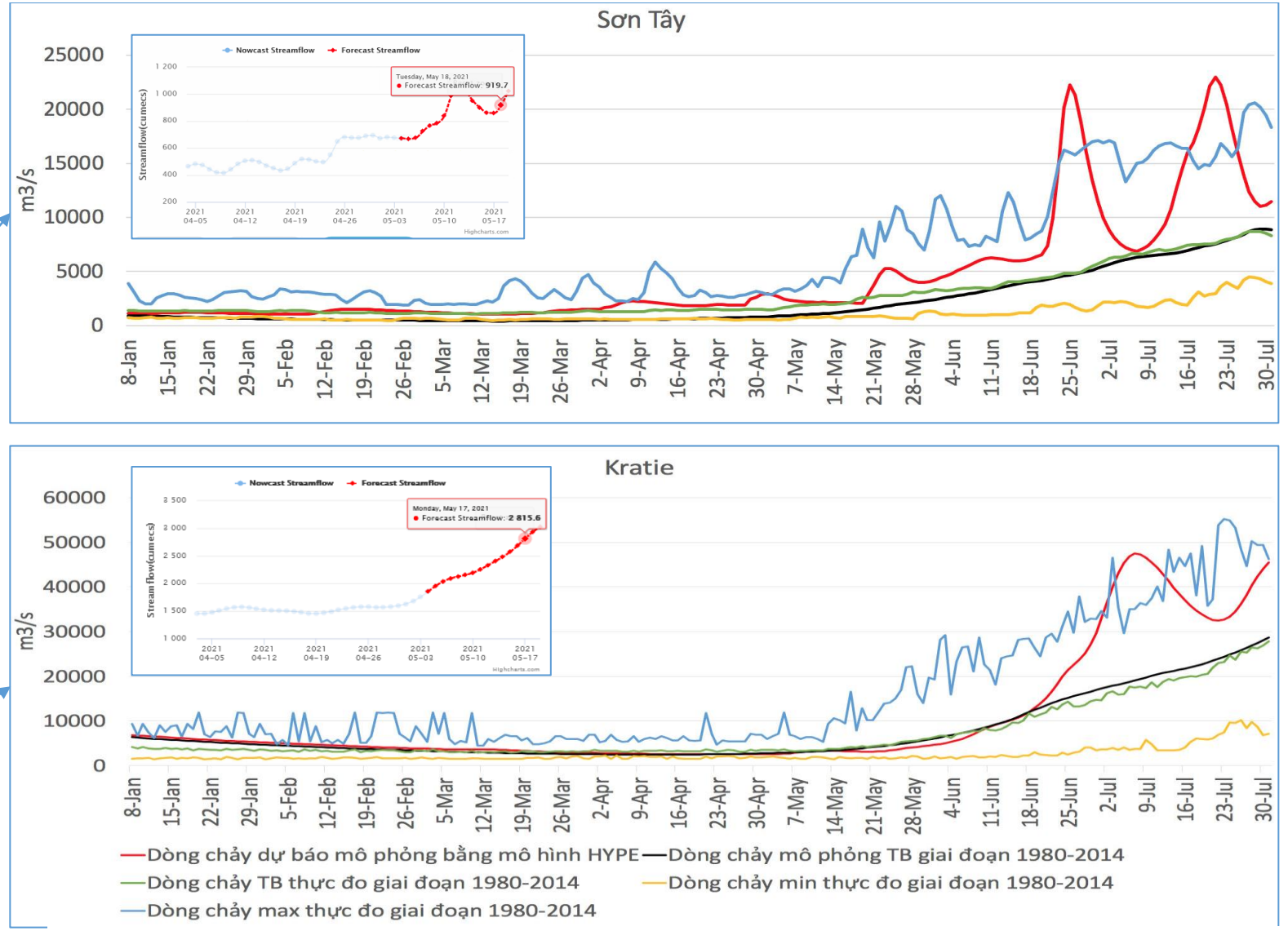




Activate Windows
Go to Settings to activate Windows.

Information Classification: General

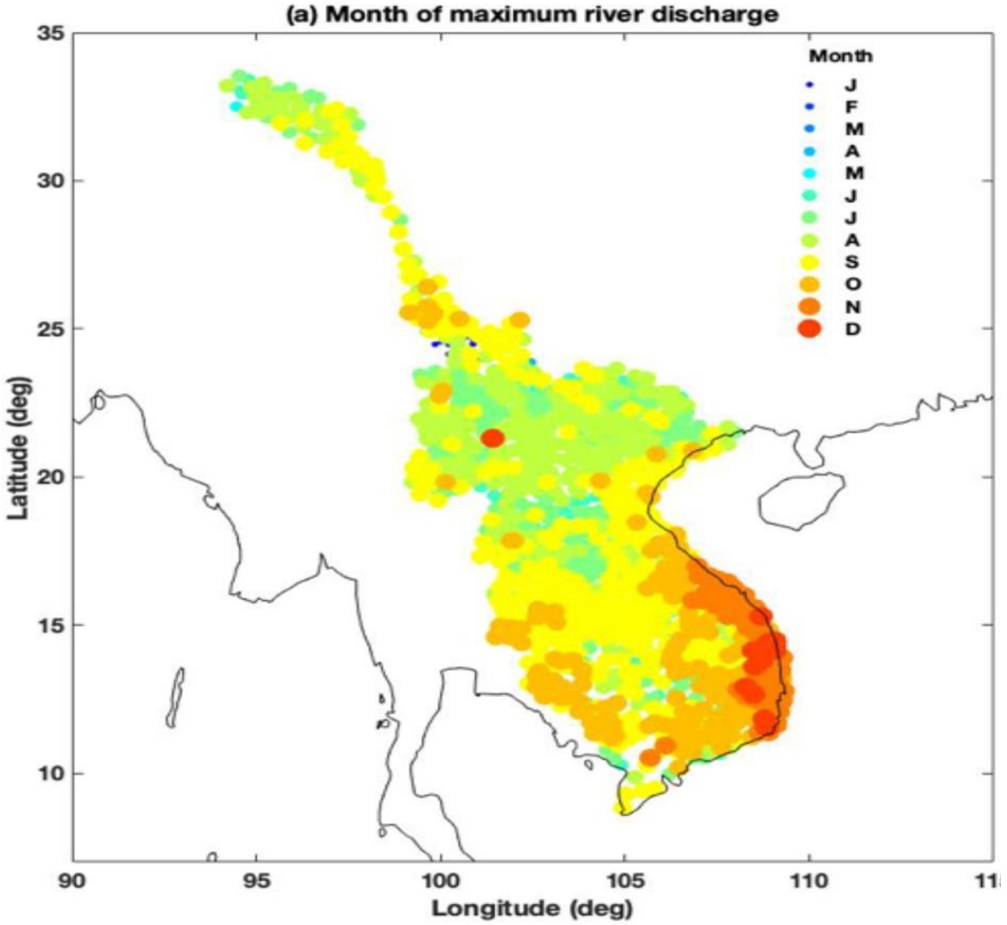
Provision of 16-day to 6-month (seasonal) water forecasts at 1200 sub-basins over the region

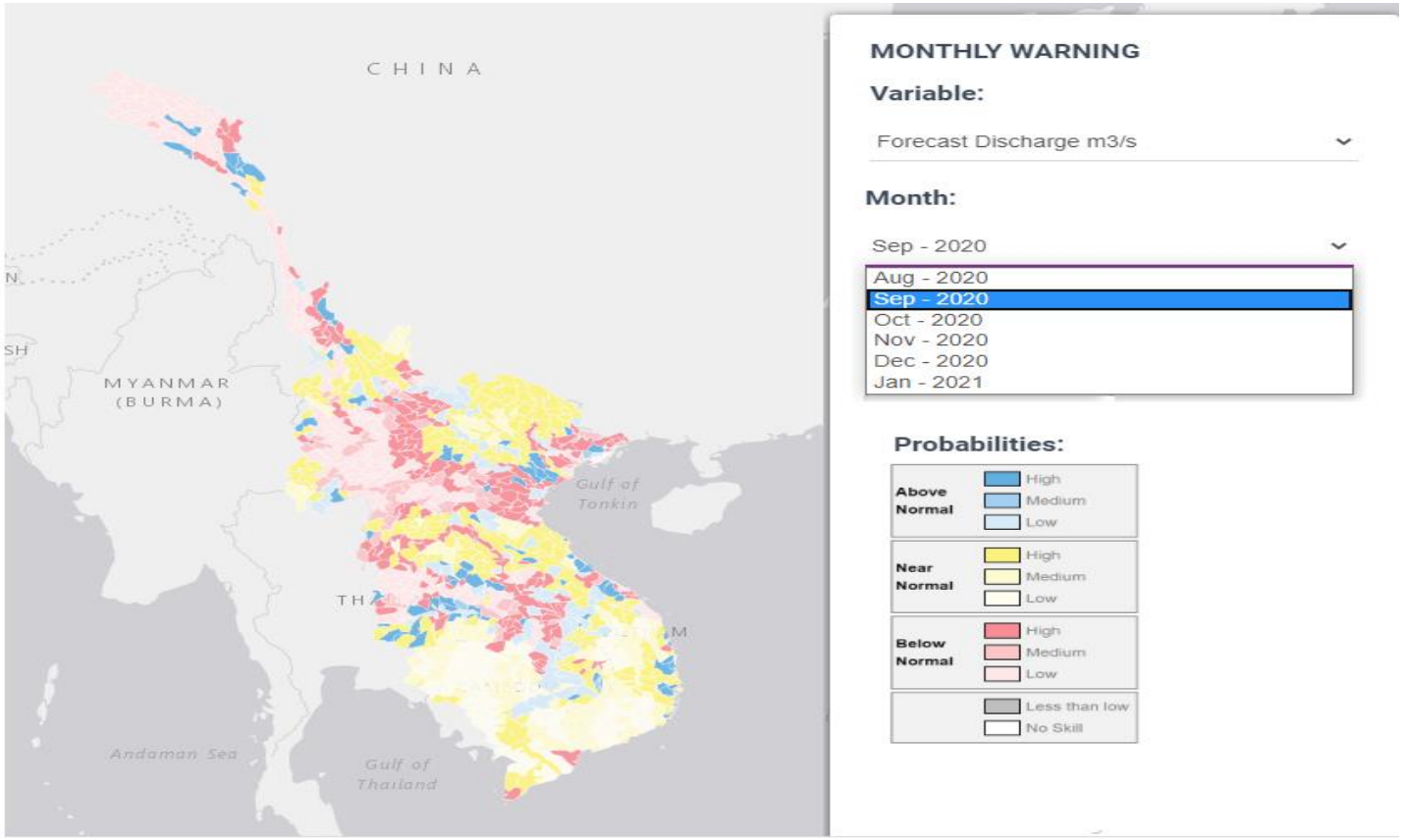


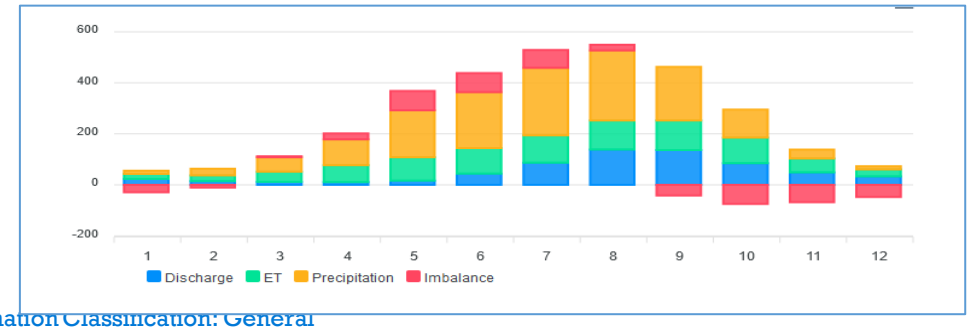
Examples of 16-day to seasonal forecasts of streamflow at Sontay (Red river) and Kratie (Mekong river)

Information Classification: General

Flood/Drought outlooks and Warnings

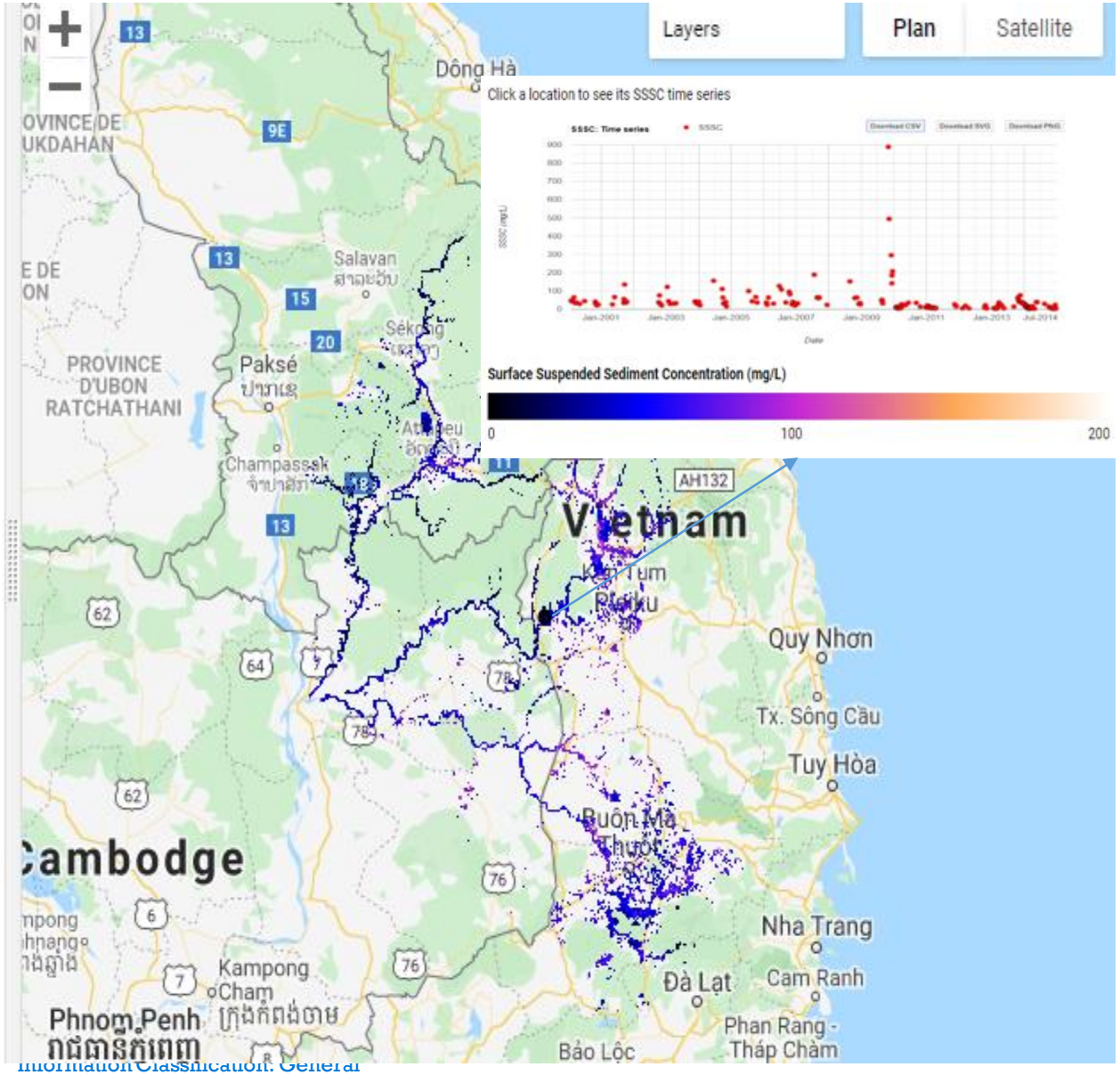


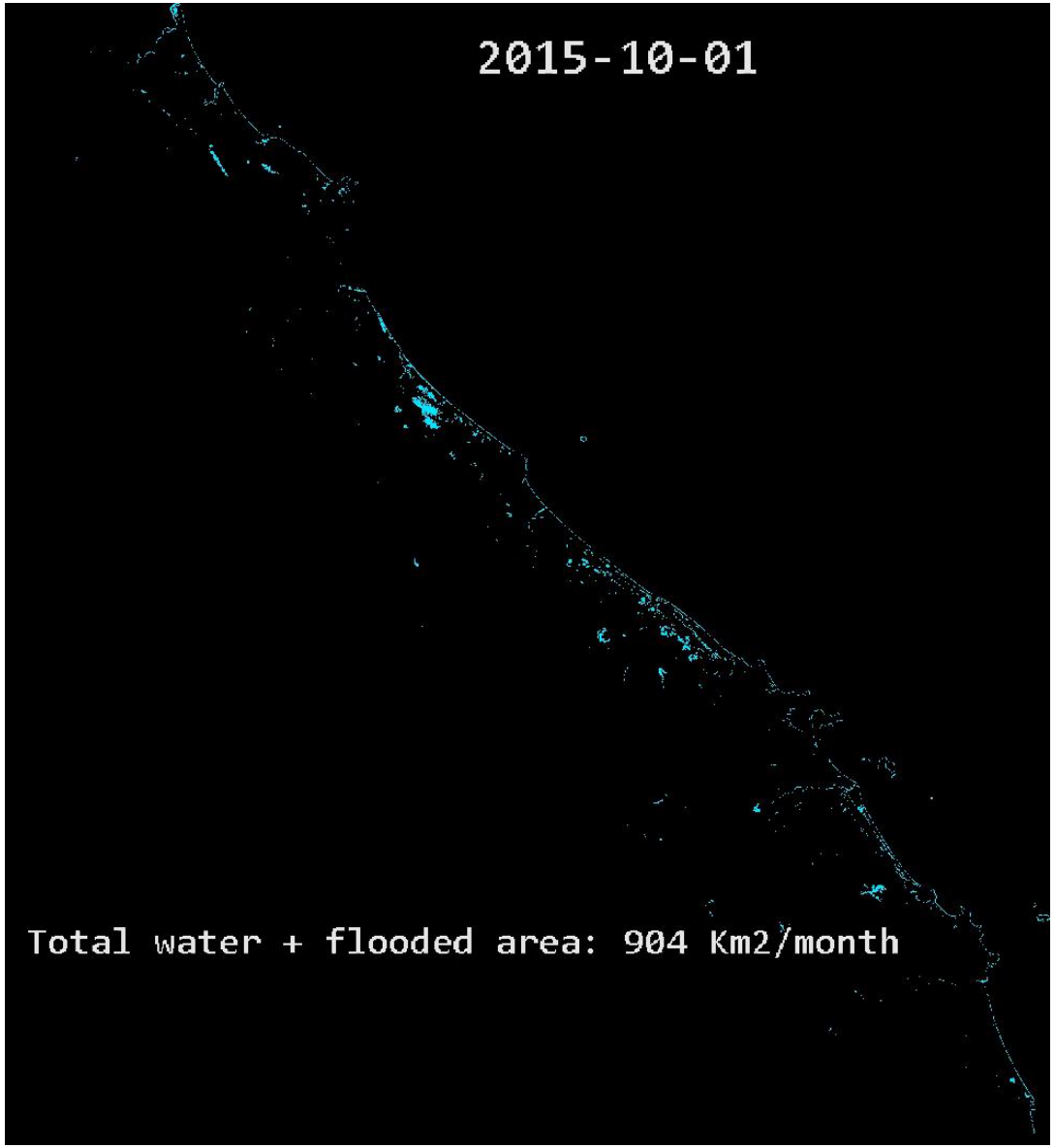




Information Classification: General

Other applications: Near-Realtime monitoring of Sediment concentration and inundation extents





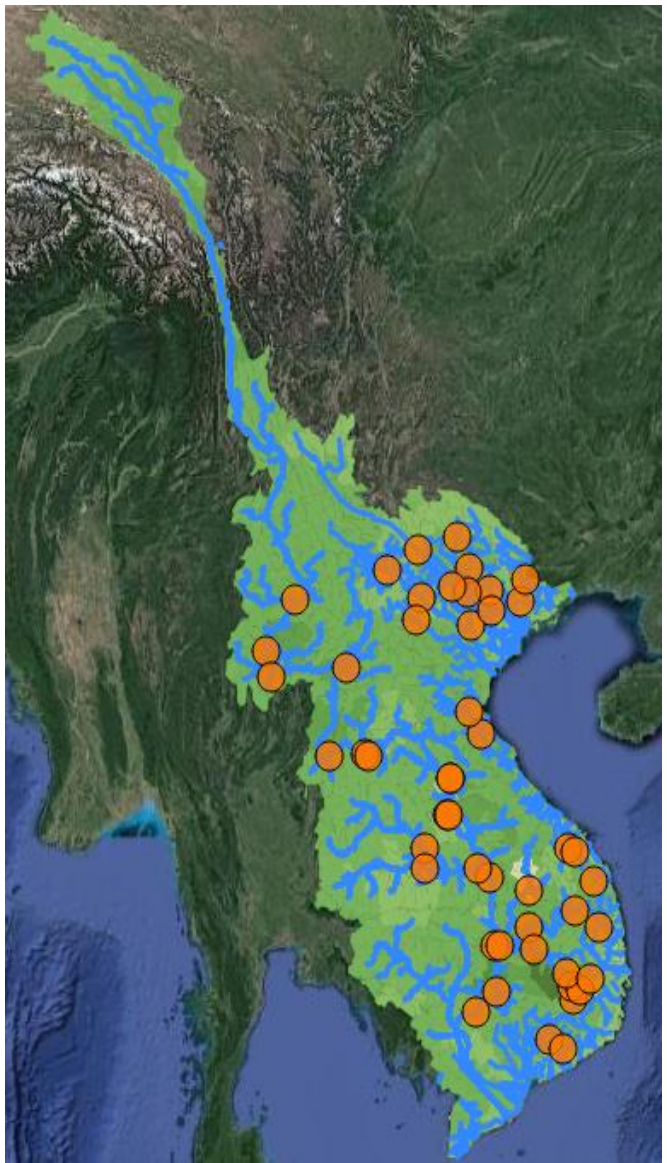
Information Classification: General

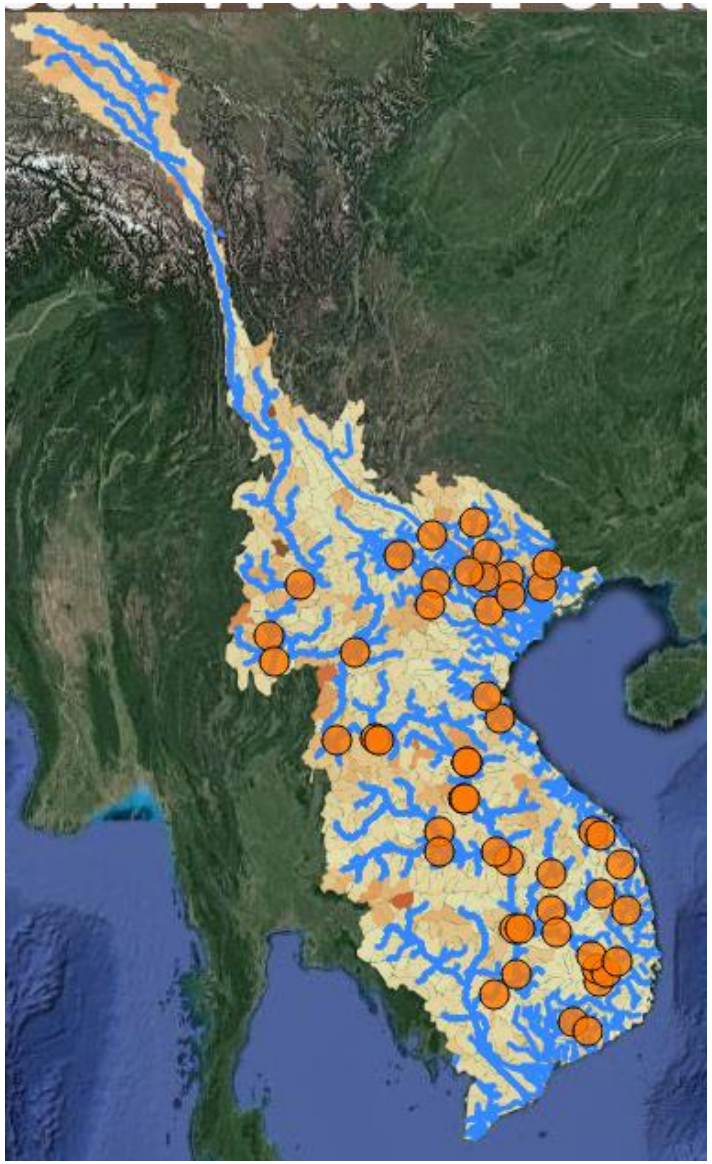
Impacts of climate change on essential water variables (Runoff, ET, soil moisture, water quality..)

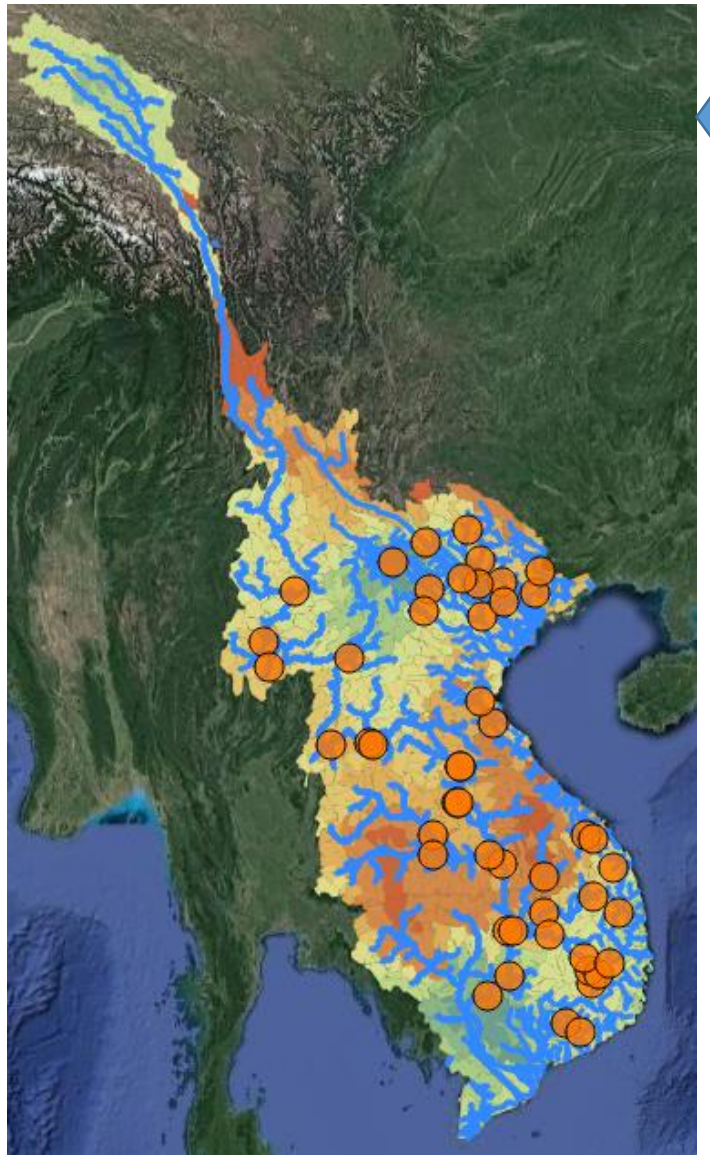
2018-2040

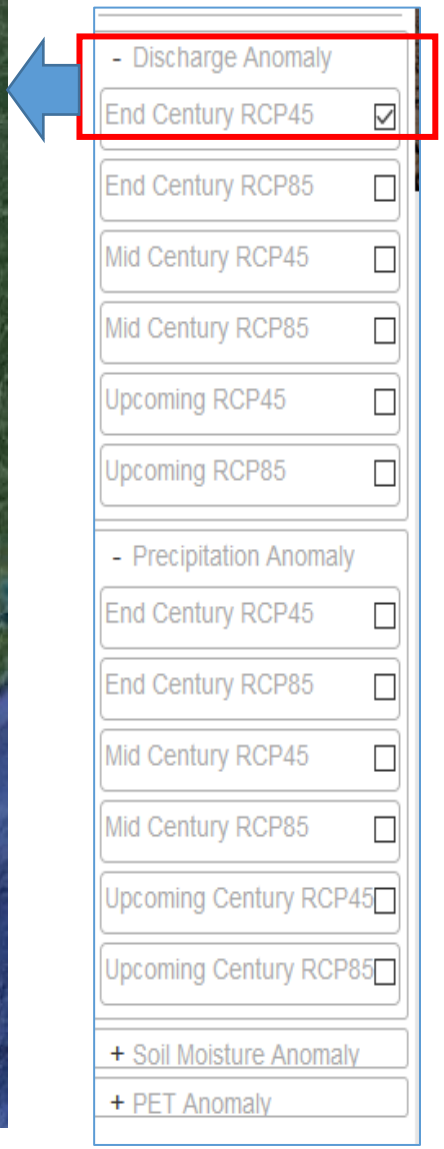
2040-2070

2070-2100









Summary: Greater Mekong model, data and tools in short

-**GM-Force:** A gridded near-real time daily forcing dataset (0.25 deg, 1980-now) for entire Vietnam and Mekong Region by merging multi-sources (GPM, GSMAP, CHIRPS, ERA-5, MSWEP v2) and most dense in-situ precipitation (nearly 600 in-situ stations)

-**GM-ResDam**: A satellite-based, well-calibrated (i.e. against in-situ data of 40 reservoirs) reservoir monitoring tool coupled with hydrological model for generating essential variables (i.e. water extent, bathymetry, operation rules, in-outflow, sediment..) of reservoirs of different areas and operation schemes.

GM_HYPE Model: A well-calibrated (i.e. at nearly 100 streamflow stations) multi-basin model for entire Vietnam and Mekong Region which can be used for different scenario simulation and hydrological analysis (i.e. flood, drought, erosion, sedimentation, ET, Soil moisture, deep aquifer, water quality, floodplain/Wetland, Irrigation, urban, climate change impacts etc.)

Information Classification: General

These works are the accumulated results of multiple works and collaborations at NAWAPI/Ministry of MONRE, Vietnam with a number of partners worldwide since 2013. Please find list of publications, projects and its operational portals/apps bellow for more details:

National water data services: http://waterdata.dawapi.gov.vn; National water prediction and warning http://nwm.cewafo.gov.vn/; ASEAN waterdata: waterportal.vaci.org.vn/; ASEAN Reservoir monitor Apps https://vacisgu.users.earthengine.app/view/ceresv; ASEAN Sediment monitor: scised.vaci.org.vn Vietnam International Water Week: viww.vaci.org.vn

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Thank you & See you again at

VIETWATER HO CHI MINH

10-12 November, 2021 @ SECC, Vietnam