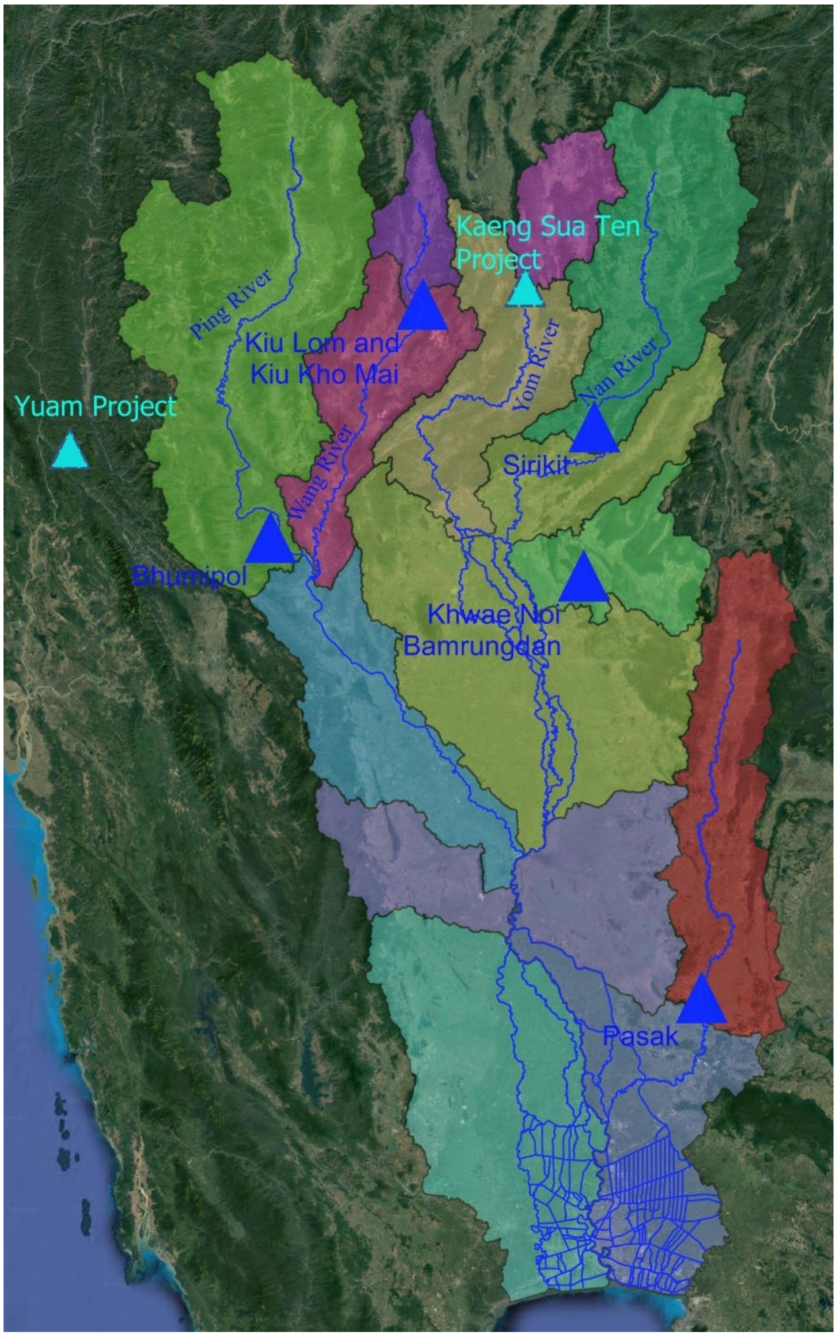
Course 12345 – Chao-Phraya Basin hydroeconomic modeling and investment analysis – Spring 2023

In the second part of the course 12345, we will focus on water resources optimization, hydroeconomic modeling and investment analysis in the Chao Phraya (CPY) River Basin in Thailand. We suggest that you work with the following subcatchment division for the CPY River basin (shapefile Subcatchments_CPY.shp on Learn):



Subcatchment characteristics are summarized in the following table (file Subcatchments_CPY_input.xlsx on Learn):

ID	Name	Area (km2)	Number of people	Area equipped for irrigation (ha)
10	Upper Yom	3639	79547	12664
7	Lower Wang	8020	625912	109640
15	Lower Nan	26834	2654192	510206
14	Lower Ping	10262	1012461	168451
20	Phitsanulo	5572	252406	33456
24	Upper Chao	12980	1092080	259233
28	Tha Chin	17998	7419434	764696
33	Lower Chao	11931	11915321	576382
1	Upper Ping	26188	1950780	386984
12	Upper Nan	13112	455665	148703
5	Upper Wang	2781	104398	23988
25	Pasak	12785	1032686	159925
9	Lower Yom	9582	631371	127777

In the CPY River basin, there are 5 major reservoirs and 2 big investment projects, that are currently being discussed and evaluated. The following table summarizes the characteristics of these assets (file Assets_CPY_input.xlsx on Learn)

ID	Name	Turbine capacity (MW)	Turbine capacity (million m^3/month)	Estimated water-energy equivalent (kWh/m^3)	Storage Capacity (million m^3)
1	Bhumipol	779.2	1496.6	0.378	13462
2	Pasak	6.7	54.0	0.090	960
3	Sirikit	500	1301.1	0.279	9510
4	Kiu Lom and Kiu Kho Mai	10	42.2	0.172	276
5	Khwae Noi Bamrungdan	30	177.1	0.123	939
6	Kaeng Suea Ten	48	196.9	0.177	1175

The Yuam inter-basin transfer project is dimensioned to transfer 1795.25 million m^3 per year from the Salween basin to the CPY basin. Both the Yuam project and the Kaeng Suea Ten project are controversial and you can find much more information and opinions on the internet.

There are multiple water management objectives in the CPY basin, including irrigation water demand fulfilment, industrial and domestic demand fulfilment, hydropower production, flood risk management and management of seawater intrusion. To counter seawater intrusion, managers try to maintain a minimum outflow from the system of 100 m^3/s at all times.

Data:

- River network (shapefile Rivers_CPY.shp)
- Subcatchments (shapefile Subcatchments_CPY.shp and Subcatchments_CPY_input.xlsx)
- Example subcatchment connectivity matrix (CPY_catch_connectivity.xlsx)
- Existing assets and planned projects (shapefile Assets_CPY.shp and Assets_CPY_input.xlsx)
- Population density (landscan_2016_Thailand.tif, units of people per pixel)
- Monthly runoff per subcatchment (G-RUN_CPY_1990_2019.xlsx, units of mm/day) from https://figshare.com/articles/dataset/GRUN_Global_Runoff_Reconstruction/9228176
- Monthly potential ET per subcatchment (CRU_PET_CPY_1991_2020.xlsx, units of mm/day) from https://catalogue.ceda.ac.uk/uuid/c26a65020a5e4b80b20018f148556681
- Monthly precipitation per subcatchment (CRU_PRE_CPY_1991_2020.xlsx, units of mm/month) from https://catalogue.ceda.ac.uk/uuid/c26a65020a5e4b80b20018f148556681
- Map of irrigated area (gmia_v5_aei_ha_Thailand.tif, units of hectares per pixel) from https://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/

In order to estimate water availability throughout the basin, we suggest that you use the streamflow estimates that you produced in the first part of the course. As a fallback solution and/or consistency check, you can use the monthly runoff estimates from GRUN.

The assignment work will proceed in the following steps. For each of the steps, more information will be given in the course sessions.

1. Build conceptual system model of the CPY River basin, with and without the different projects
2. Get overview of water availability and water demands (including domestic, irrigation, hydropower, ecosystems)
3. Revise a basin-scale optimization model using linear programming (LP) through the pyomo interface; Run an optimization period of 20-30 years at monthly time steps. The basic setup is provided in the file CPY_baseline_model.py.
4. Investment analysis: Perform cost-benefit analyses for selected projects and for project portfolios using mixed-integer linear programming (MLIP). Modify the baseline model for this purpose
5. Quantitatively analyze the trade-offs between different management objectives (demand fulfilment, firm hydropower production, flood safety, countering seawater intrusion) and perform multi-criteria analysis of projects and project portfolios.

Group deliverables:

1. A preliminary ppt presentation summarizing the background and context of the work, the methods to be applied and the expected results
2. Clean and sufficiently documented model codes for steps 3, 4, and 5, preferably as spyder files.
3. A final ppt presentation summarizing background and context, methods, main results and conclusions/perspectives. This presentation should include both the rainfall-runoff modelling work performed in the first part of the course and the hydroeconomic modeling/investment analysis work performed in the second part of the course.

Deliverable 1 has to be uploaded to DTU learn before March 28th, 2023 and will be presented in class on March 28th. Evaluation will be pass/fail only.

Deliverables 2 and 3 have to be uploaded to DTU learn before May 2nd. You will give your final presentation to your teachers and the other students in the class on May 2nd. In the individual oral exam on May 17th, we will ask follow-up questions on deliverables 2 and 3 and on the course content in general.