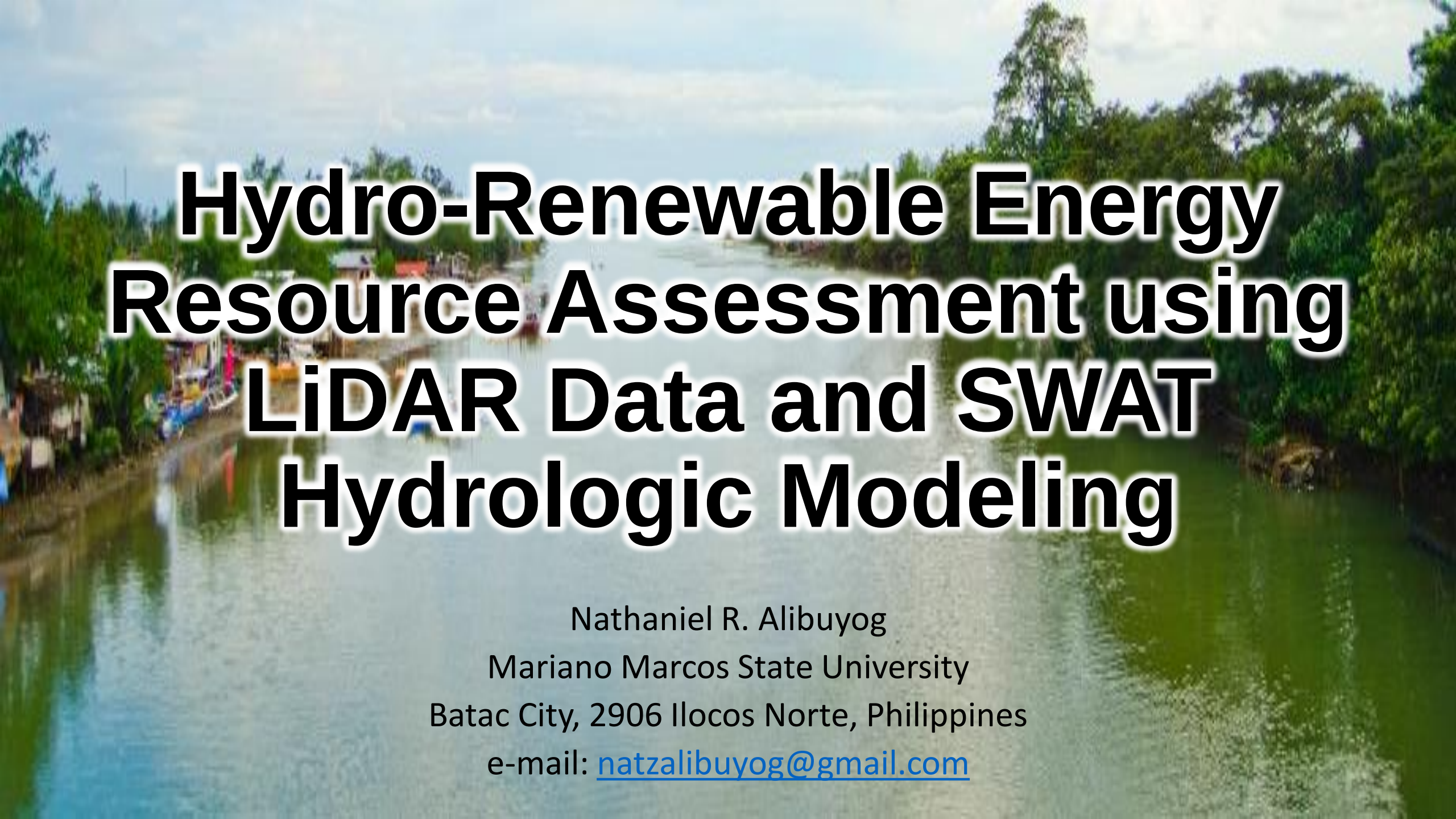

Hydro-Renewable Energy Resource Assessment using LiDAR Data and SWAT Hydrologic Modeling

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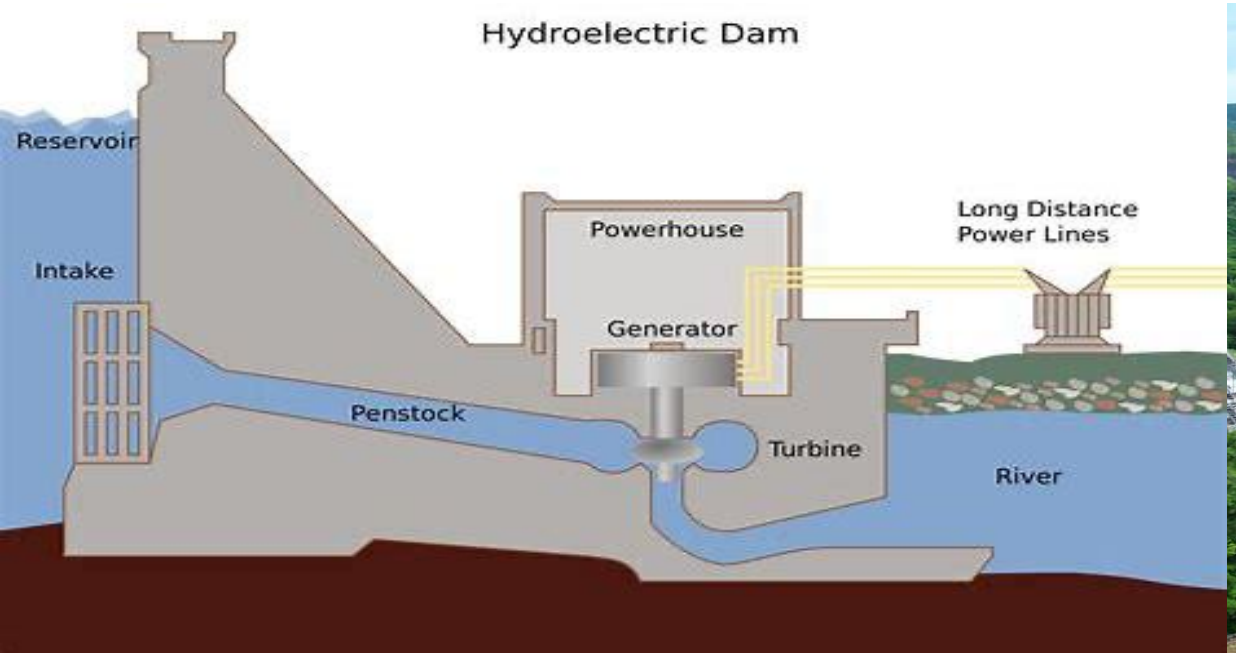
State of Hydropower development in the Philippines

- Hydropower is the dominant renewable energy source.
- It contributes 13.31% of the country's energy needs .
- By the year 2030, the country's energy sector targets to triple the country's RE capacity and in particular, to increase hydropower installed capacity by an additional of approximately 5,394 MW
- With its estimated hydropower potential of 15,615MW, approximately 77% still remains unharnessed.



Philippine Dream - LiDAR

Project Components

- Agricultural Resources Assessment (PARMap)
- Aquatic Resources Assessment (CoastMap)
- Forest Resources Assessment using LIDAR (FRExLS)
- Development of the Philippine Hydrologic Dataset (PHD) for Watersheds
- Renewable Energy Resources Mapping (REMaps)

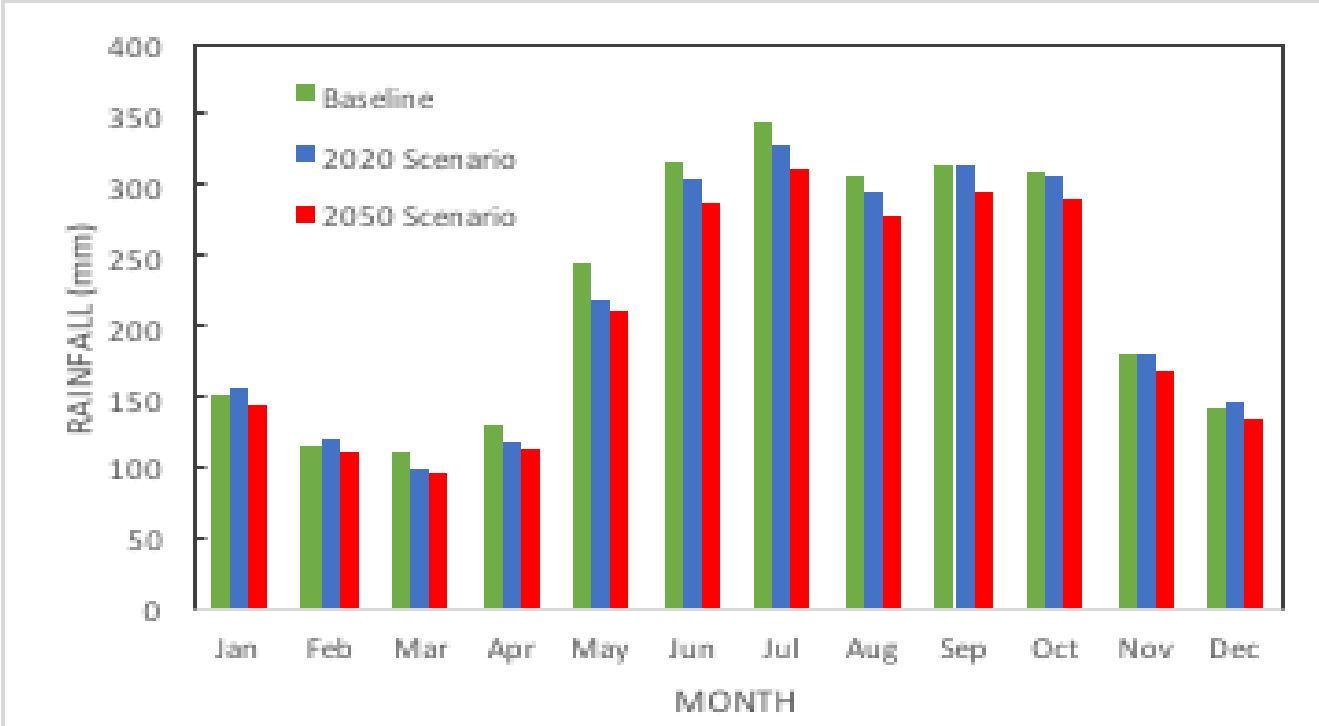
Objectives

Assess the hydropower potential of the Davao River basin

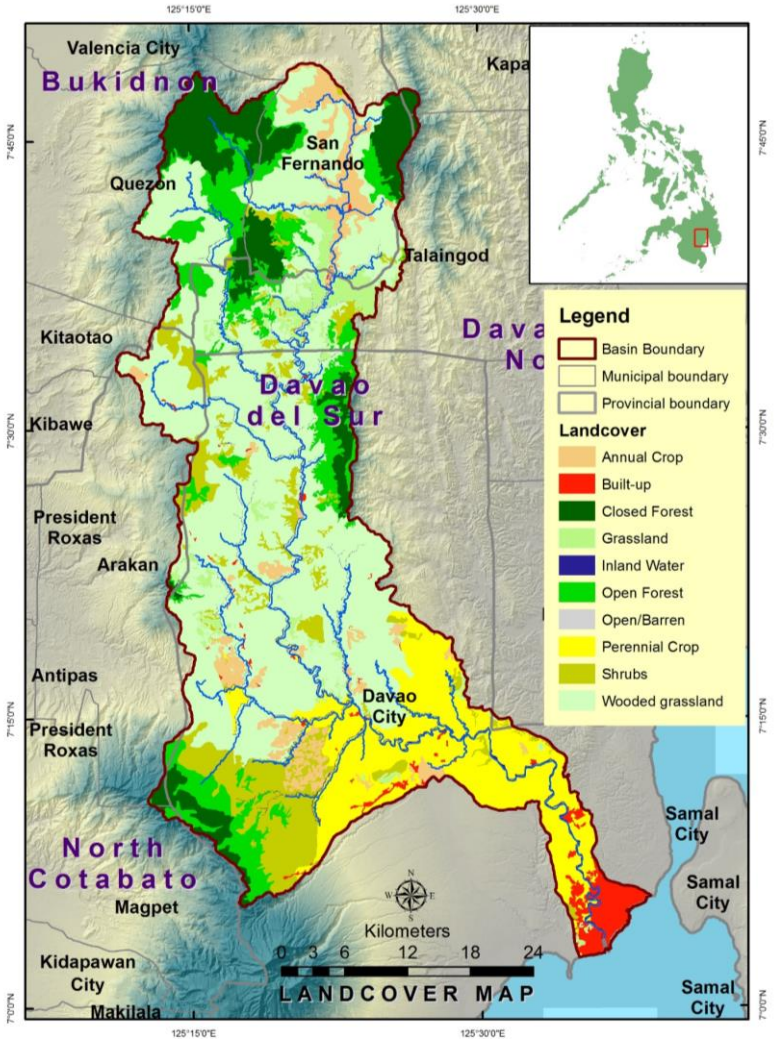
- Assess the streamflow pattern of the Davao River Basin
- Develop the flow duration curve of the river as basis for hydropower development
- Determine potential sites for hydropower development based on head and flow
- Quantify the hydropower potential of the river basin

Davao River Basin

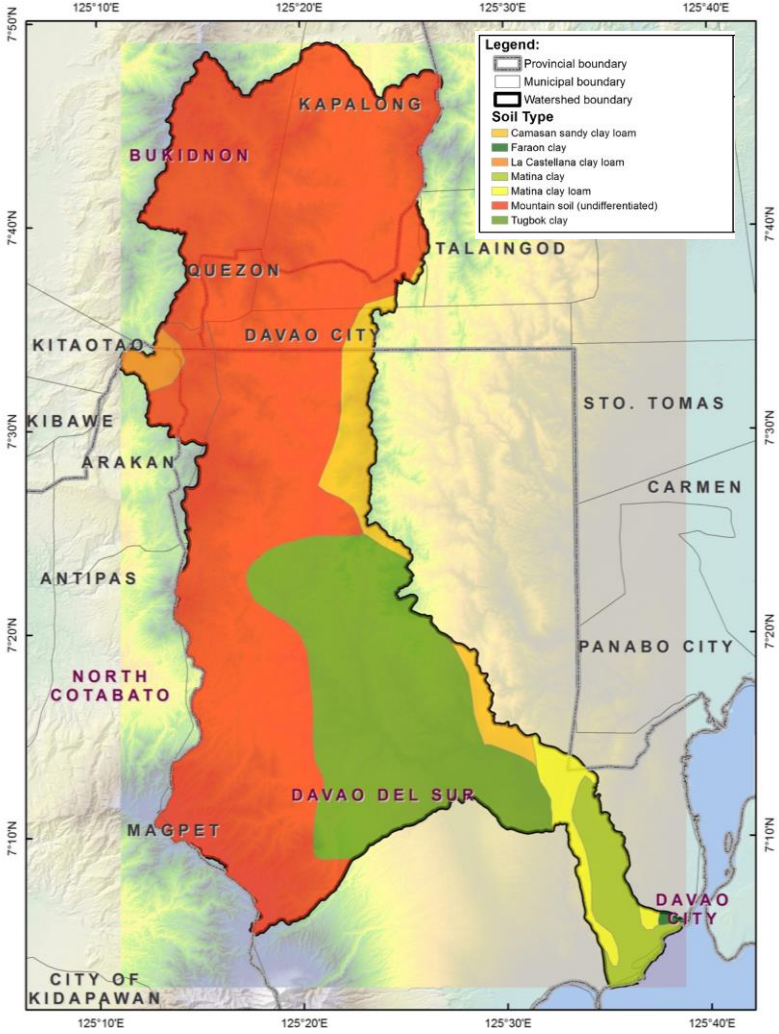
- Watershed Area = 1732 km^2
- Natural forest (77%) and alienable and disposable (23%)
- Average rainfall = 2665 mm



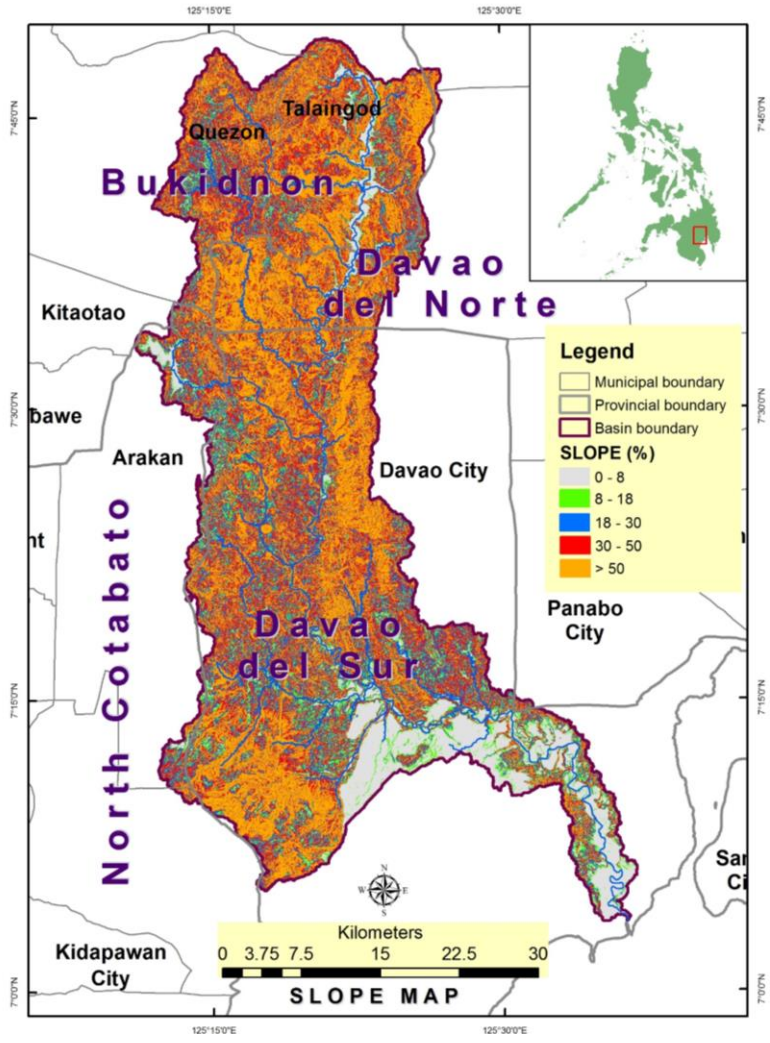
SWAT DATA INPUTS



LANDCOVER



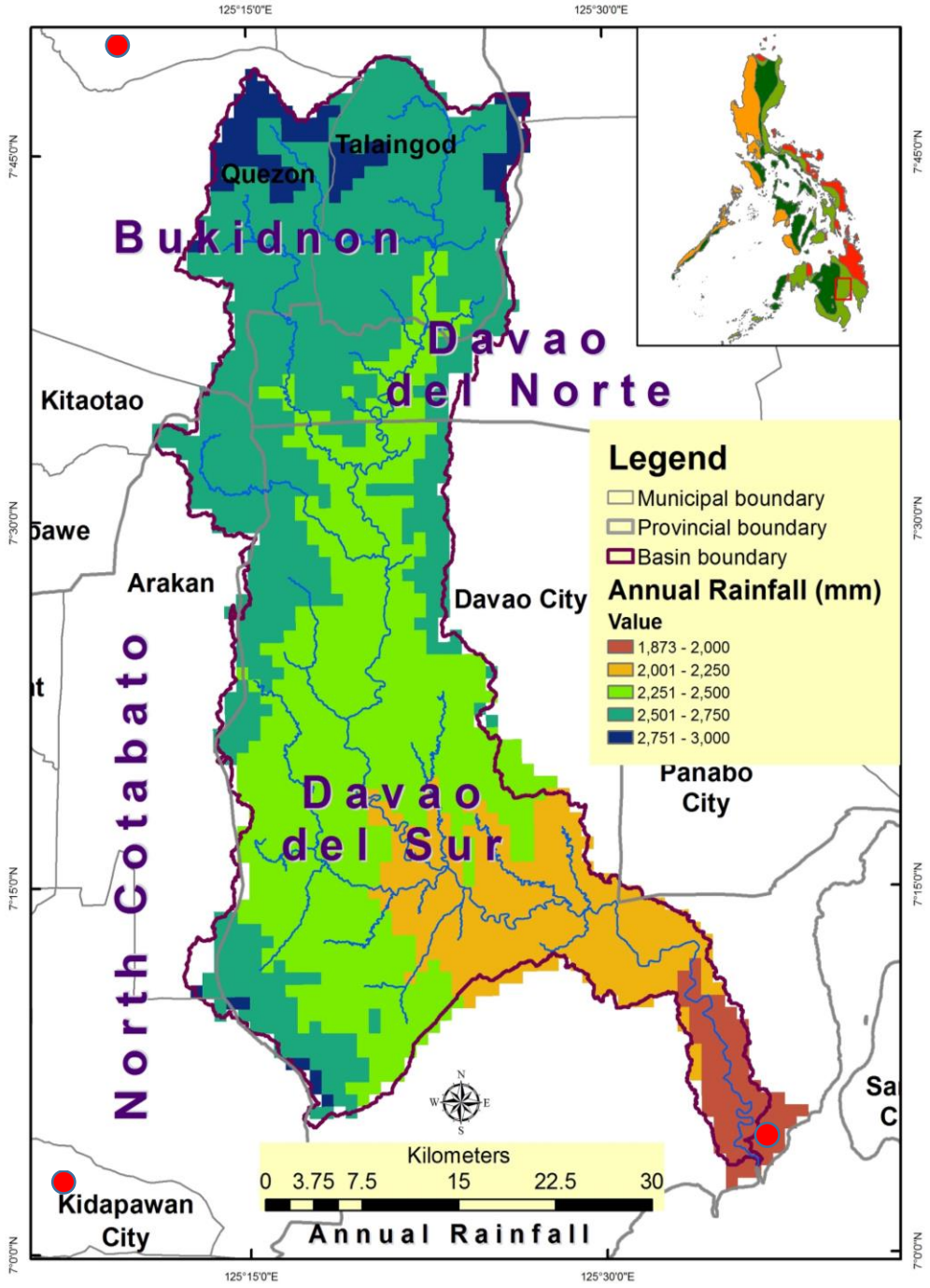
SOILS

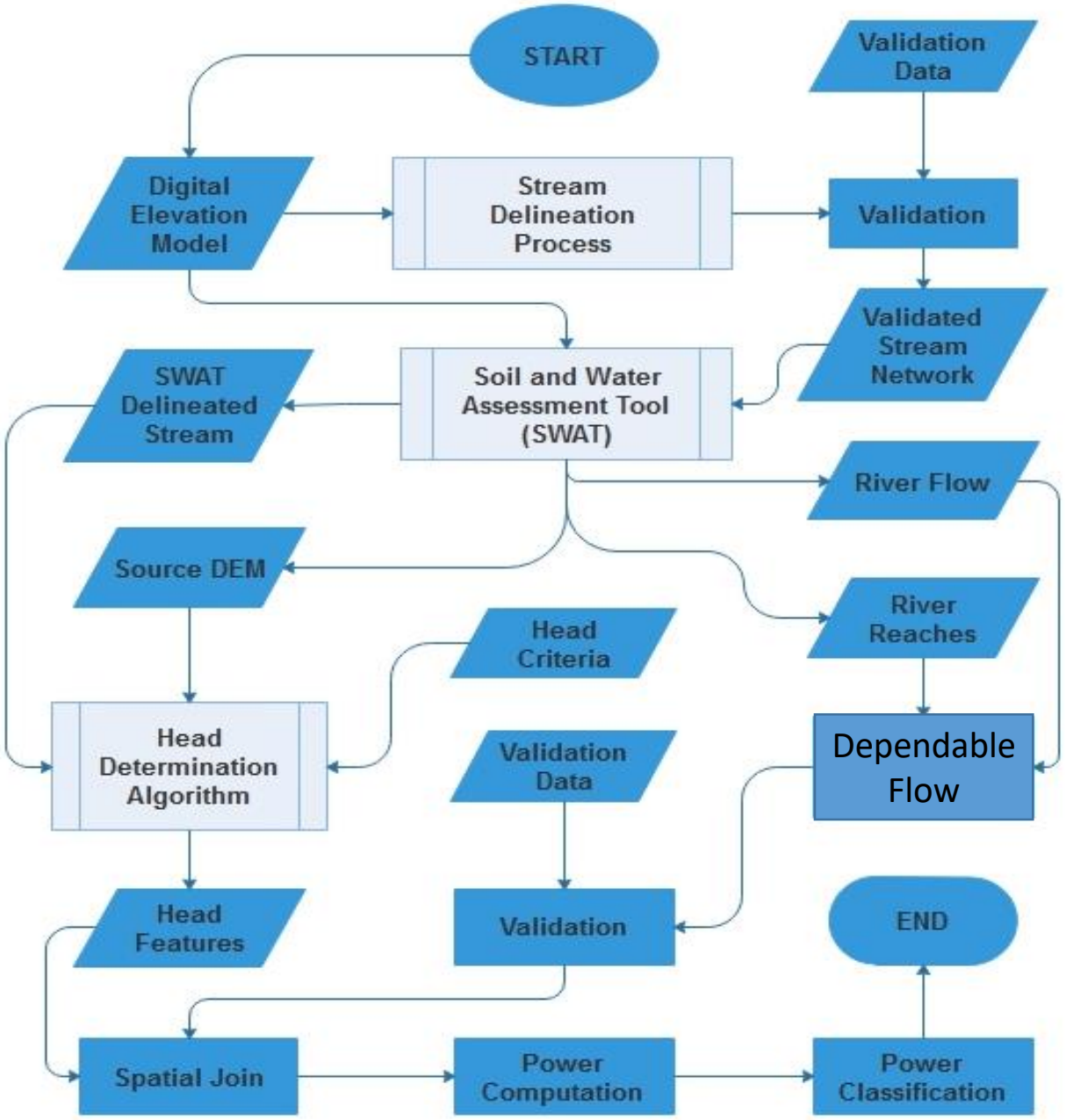


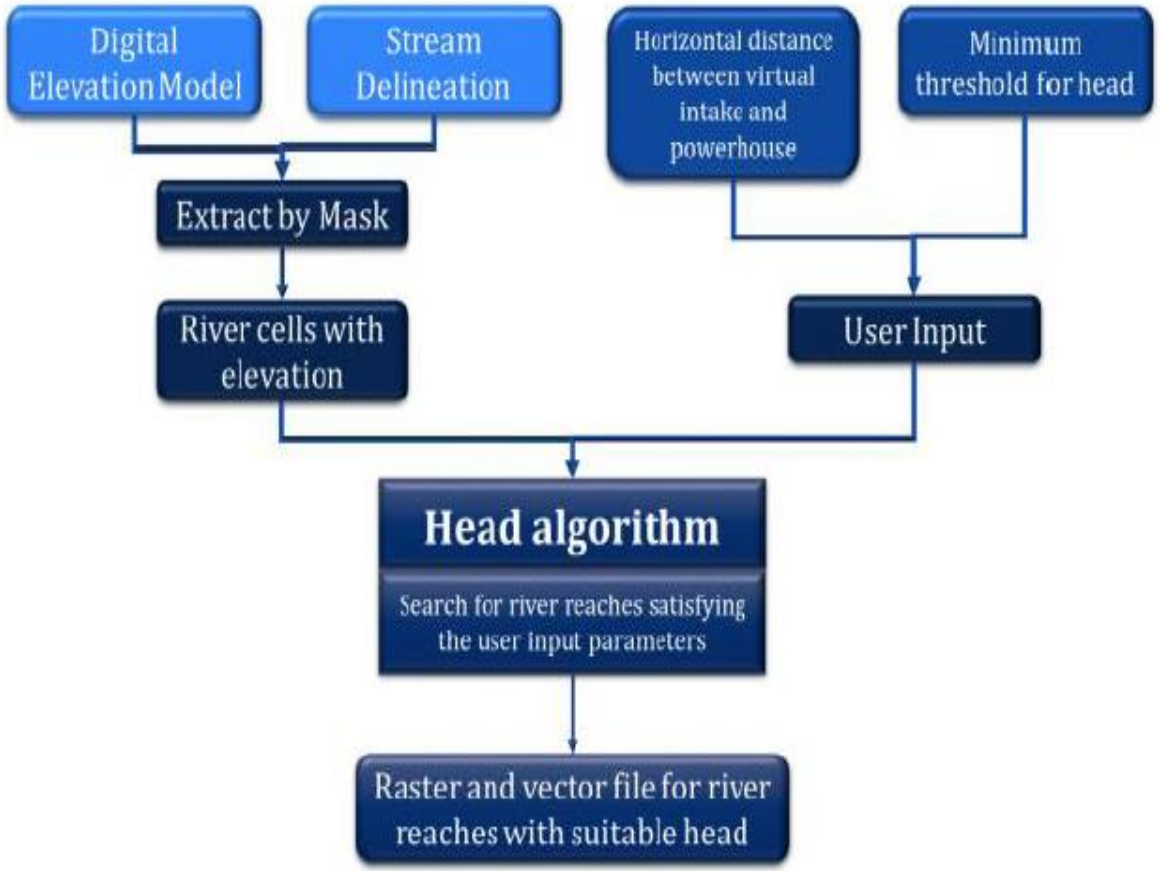
SLOPE (DEM)

Annual Rainfall Statistics

PARAMETERS	DAVAO CITY	MALAYBALAY CITY	COTABATO CITY
Elevation (amsl)	17.29	627.00	50.14
Mean	1808.0	2633.5	2525.1
Std. Deviation	296.5	427.0	666.3
Maximum	2357.5	3746.3	3893.1
Minimum	1176.3	1864.8	1493.8
Median	1794.3	2589.3	2437.1
Coefficient of Variation	0.16	0.16	0.26







Flowchart of model development and implementation

Hydropower Potential

$$P = E_t E_g \gamma Q H$$

P = Power (kW)

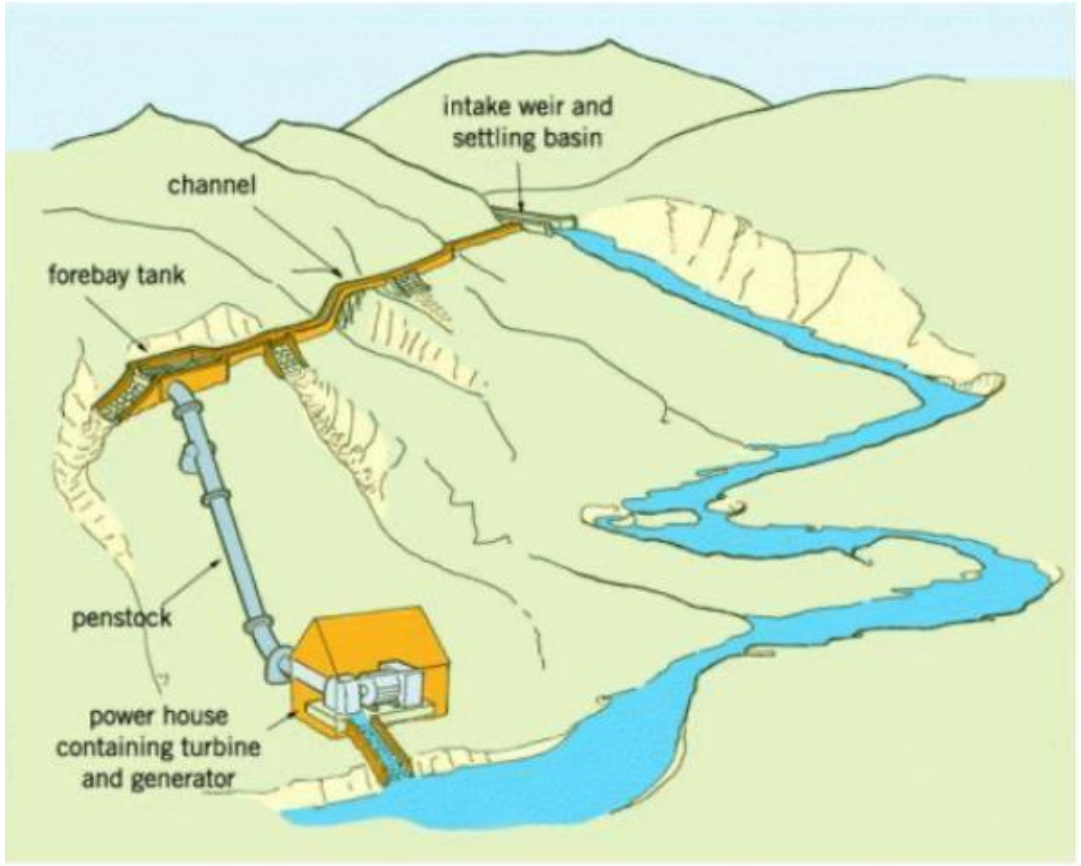
E_t = turbine efficiency (=0.85)

E_g = Generator efficiency (=0.93)

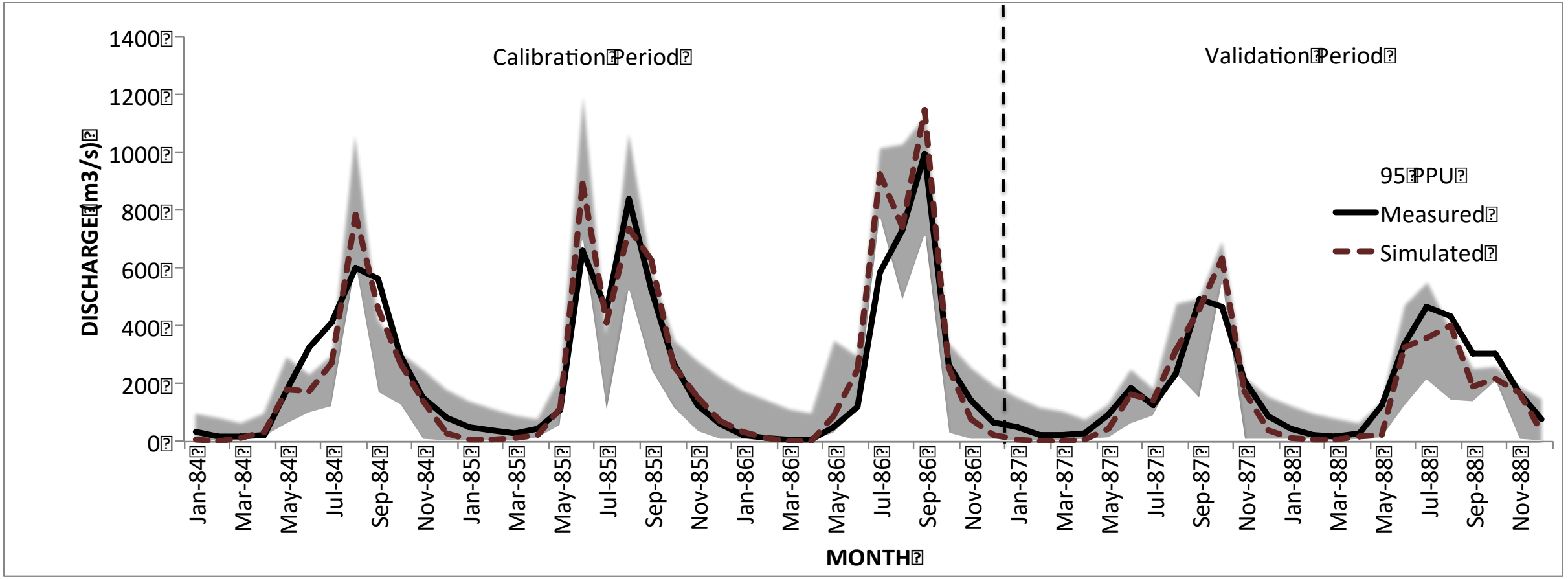
γ = Specific weight of water (kN/m^3)

Q = Discharge (m^3/s)

H = Head (m)

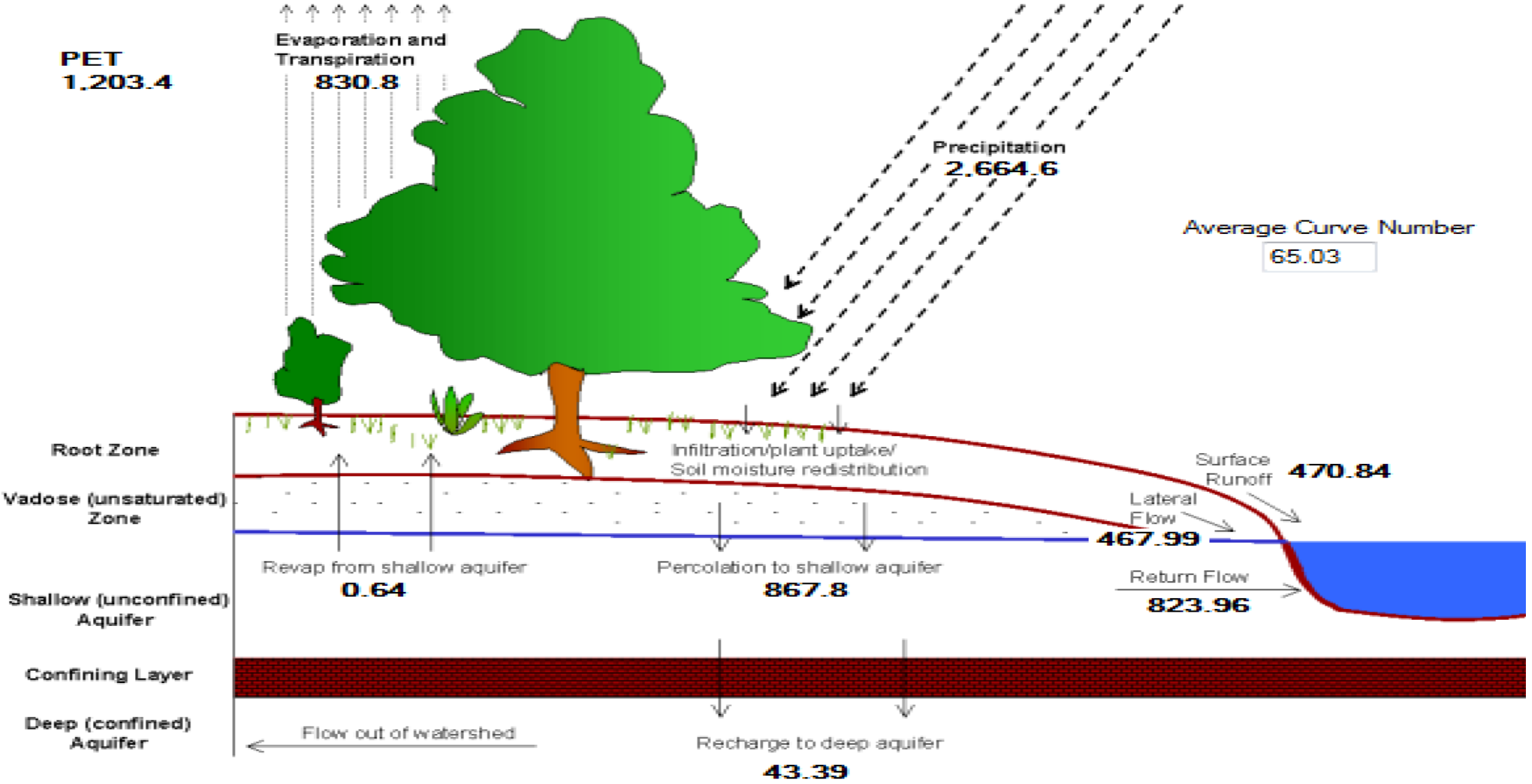


Calibration and Validation Results



$R^2 = 0.81$, NSE = 0.87, RO/RF = 0.18

Mean Annual Water Balance (1984 – 2012)



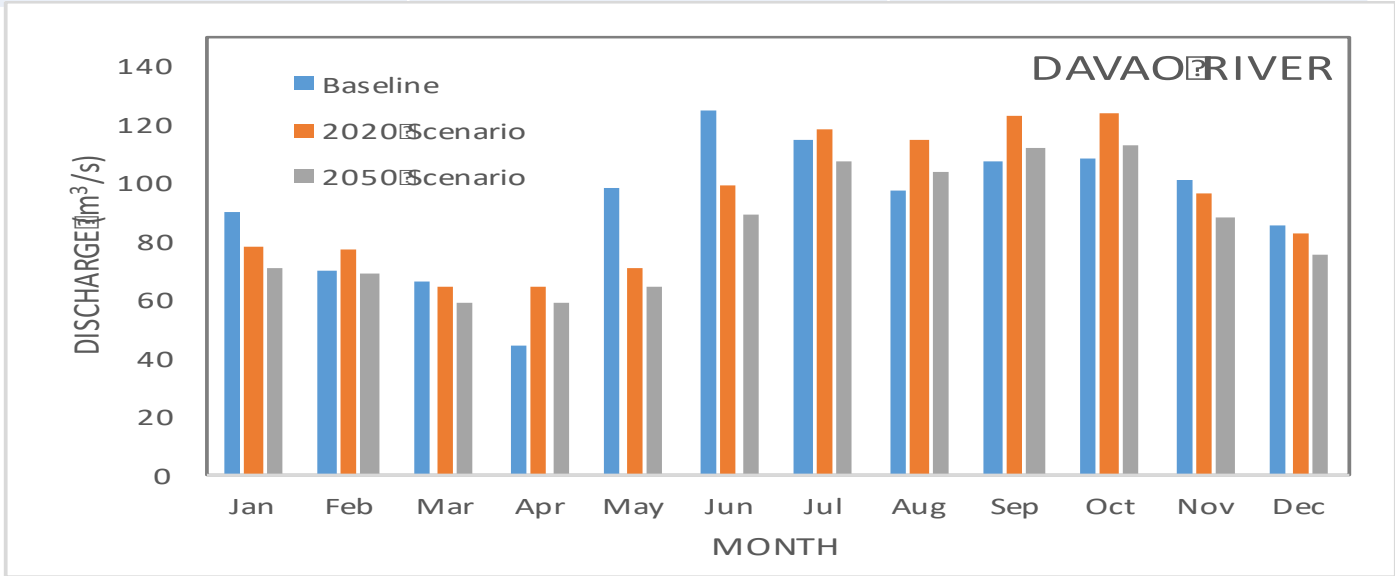
Seasonal temperature increases (ºC) and rainfall change (%) in 2020 and 2050 under the medium-range scenario (A1B)

PROVINCE	Temperature Increase (ºC)				Rainfall Change (%)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
	----------Change in 2020 (2006-2035) ----------							
Davao City	0.9	1.1	1.2	1.1	9.2	-12.5	-3.6	-1.5
Bukidnon	1.0	1.2	1.2	1.0	2.9	-10.3	-4.4	-0.3
	----------Change in 2050 (2036-2065) ----------							
Davao City	1.9	2.3	2.3	2.1	1.1	-22.2	-7.9	-2.2
Bukidnon	1.9	2.3	2.4	2.1	-5.1	-13.0	-9.7	-5.8

Monthly Streamflow– Davao River Basin

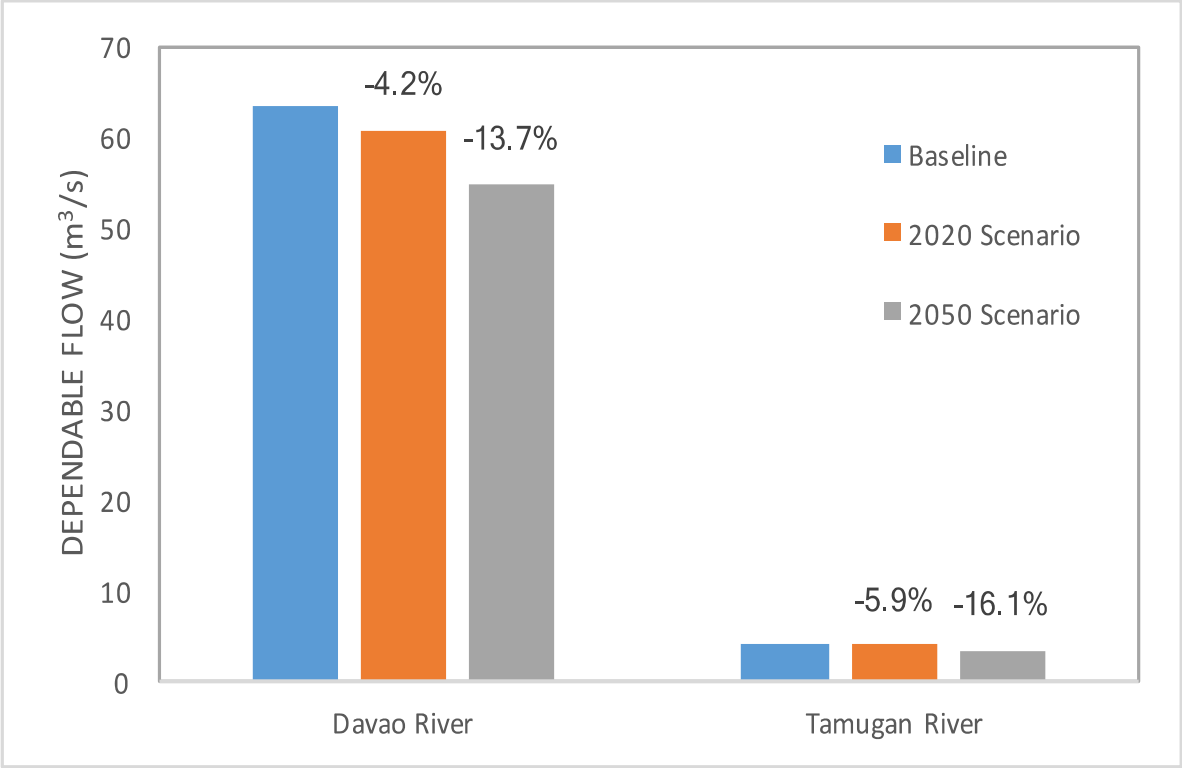
PARAMETERS	DAVAO		
	Baseline (1971-2005)	2006 – 2035 Climate Scenario	2036-2065 Climate Scenario
Mean (m^3/s)	98.09	92.45	83.95
Maximum	264.20	239.60	219.90
Minimum	28.31	26.68	24.22
Standard Deviation	40.63	38.54	35.25
Coefficient of Variation	0.41	0.42	0.42

- Climate Change would likely decrease the mean monthly discharge in Davao by 5.75% in 2020 and 14.41% in 2050



Dependable Flow – Davao River Basin

Percent Exceedance	DAVAO RIVER (Basin)		TAMUGAN RIVER (Subwatershed)	
	2020 Scenario	2050 Scenario	2020 Scenario	2050 Scenario
95	41.920	37.19	2.597	2.379
90	47.460	43.34	3.032	2.76
85	52.460	47.92	3.386	3.078
80	60.770	54.76	3.919	3.493
75	64.140	58.13	4.15	3.808
70	68.260	61.39	4.439	4.017
65	73.090	66.5	4.763	4.351
60	77.030	69.47	5.193	4.663
55	80.710	72.81	5.445	4.916
50	85.830	77.58	5.697	5.153
45	89.810	81.85	6.006	5.471
40	95.090	86.6	6.359	5.791
35	104.600	94.83	7.042	6.403
30	108.700	99.19	7.326	6.688
25	117.800	106.8	7.872	7.154
20	126.200	114.6	8.483	7.728
15	131.200	119.3	8.926	8.146
10	139.200	127.4	9.371	8.586
5	163.900	148.9	10.98	10.06



DAVAO RIVER:

- Decrease of dependable flow by 4.2% in 2020 and 13.7% in 2050

TAMUGAN RIVER:

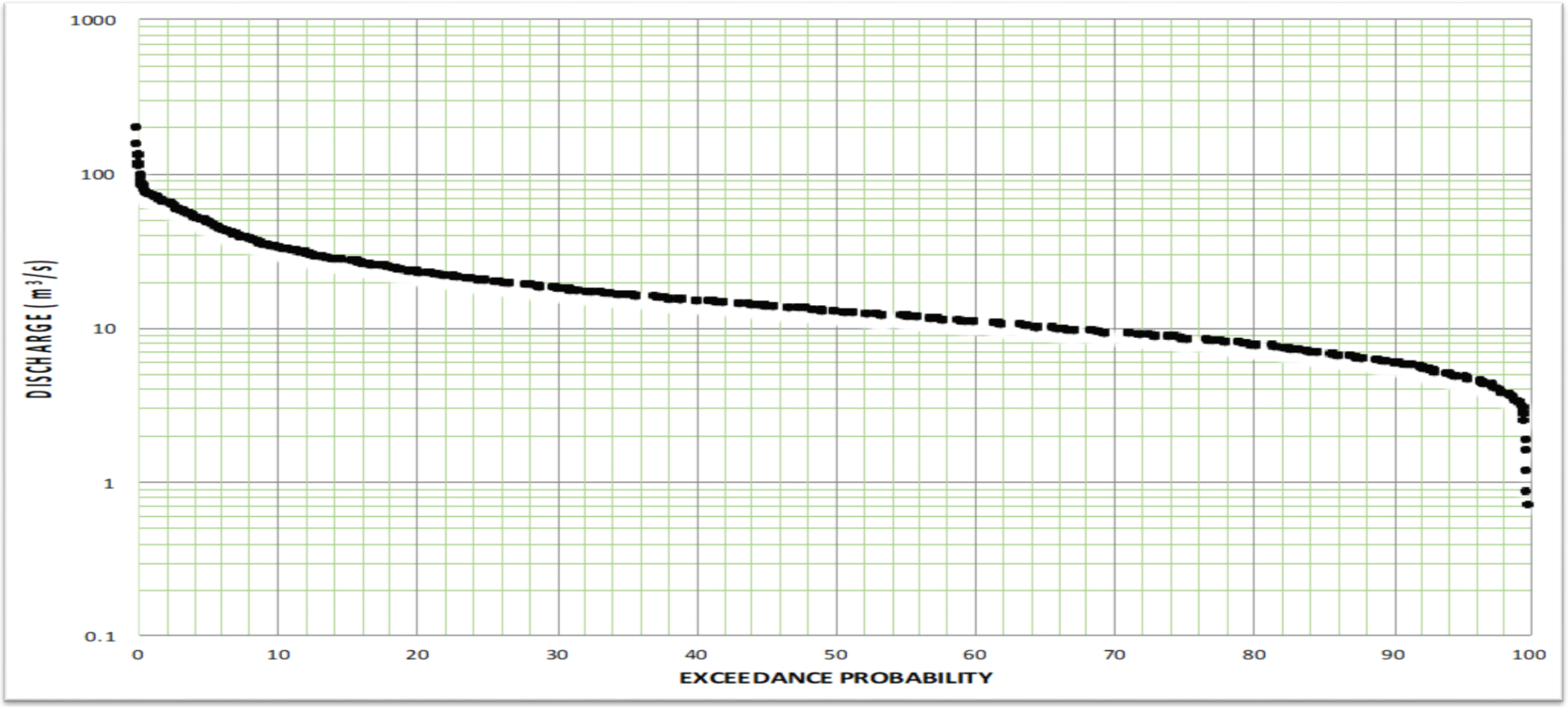
- Decrease of dependable flow by 5.9% in 2020 and 16.1% in 2050

Baseflow – Davao River Basin

RIVER	Q_{95}	Q_{mean}	Q_{95}/Q_{mean}	Remarks
	2020 Climate Scenario			
Davao River Basin	41.920	92.445	0.45	Very high base flow
Tamugan River Subwatershed	2.597	6.139	0.42	Very high base flow
	2050 Climate Scenario			
Davao River Basin	37.190	83.950	0.44	Very high base flow
Tamugan River Subwatershed	2.379	5.584	0.43	Very high base flow

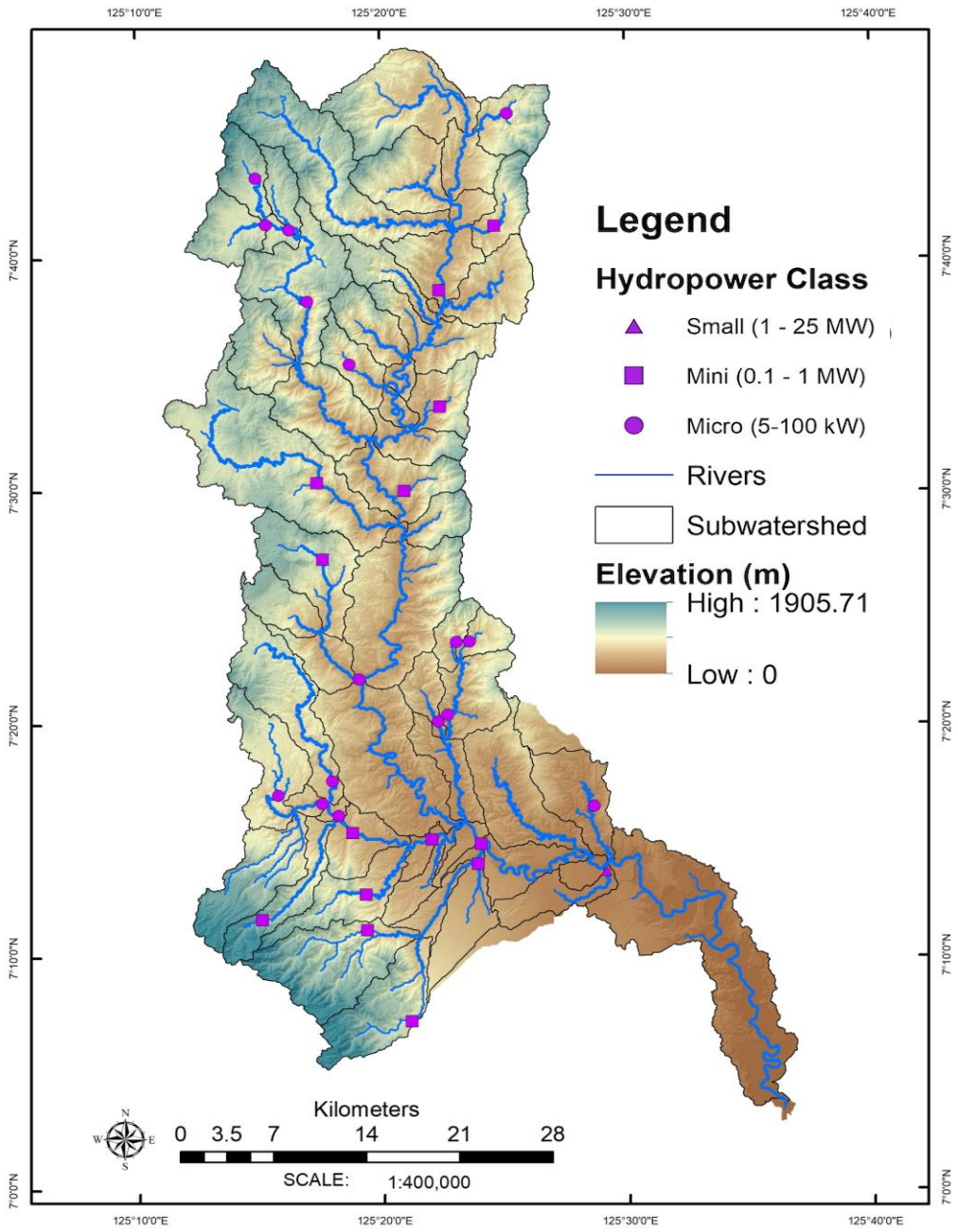
High proportion of the base flow to the total flow of the river indicates a **sustainable source of water**

Flow Duration under the 2050 Scenario



Sample Power Computation

Subbasin	Head (m)	Dependable Flow	Power (kW)	Type
61	24.35	4.48	846.36	Mini (0.1 - 1 MW)
31	24.67	1.42	271.87	Mini (0.1 - 1 MW)
5	16.45	0.59	75.75	Micro (5 - 100 kW)
8	15.77	0.59	72.62	Micro (5 - 100 kW)
12	17.78	0.59	81.9	Micro (5 - 100 kW)
64	20.87	1.81	292.13	Mini (0.1 - 1 MW)
28	20.17	19.90	3112.25	Small (1 - 25 MW)



HYDRO POWER POTENTIAL

TYPE	NUMBER	POTENTIAL POWER (MW)
Micro (5 - 100 kW)	10	0.65
Mini (0.1 - 1 MW)	16	7.25
Small (1 - 25 MW)	5	17.79
Grand Total	31	25.70

Conclusion & Recommendation

- The high resolution LiDAR DTM facilitated the derivation of the stream networks and provided relatively accurate estimates of head for the computation of potential hydropower in the study area.
- SWAT is a useful tool to assess the impact of climate change on the dependable flow of the various tributaries of the river.
- 31 potential sites with a combined potential hydropower of 25.70 MW were identified.
- The information derived from this study is helpful for policy makers and concerned agencies in hydro energy resource management, planning and development.
- This could also provide a current and reliable pre-feasibility study background for possible investors.
- A similar study could be undertaken in other river basins to assess their hydropower potential.

Thank you for Listening

For further information:

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