Modeling Environmental Flow Regimes in a Changing Landscape

Decadal Land Cover and Climate Change Impacts on the Aklan River Basin in Central Philippines

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E1: Ecological Flow

Soil and Water Assessment Tool (SWAT) Model
Conference in Jeju Island, South Korea

Remote Presentation on Thursday, 26 June, 12:00 - 12:20

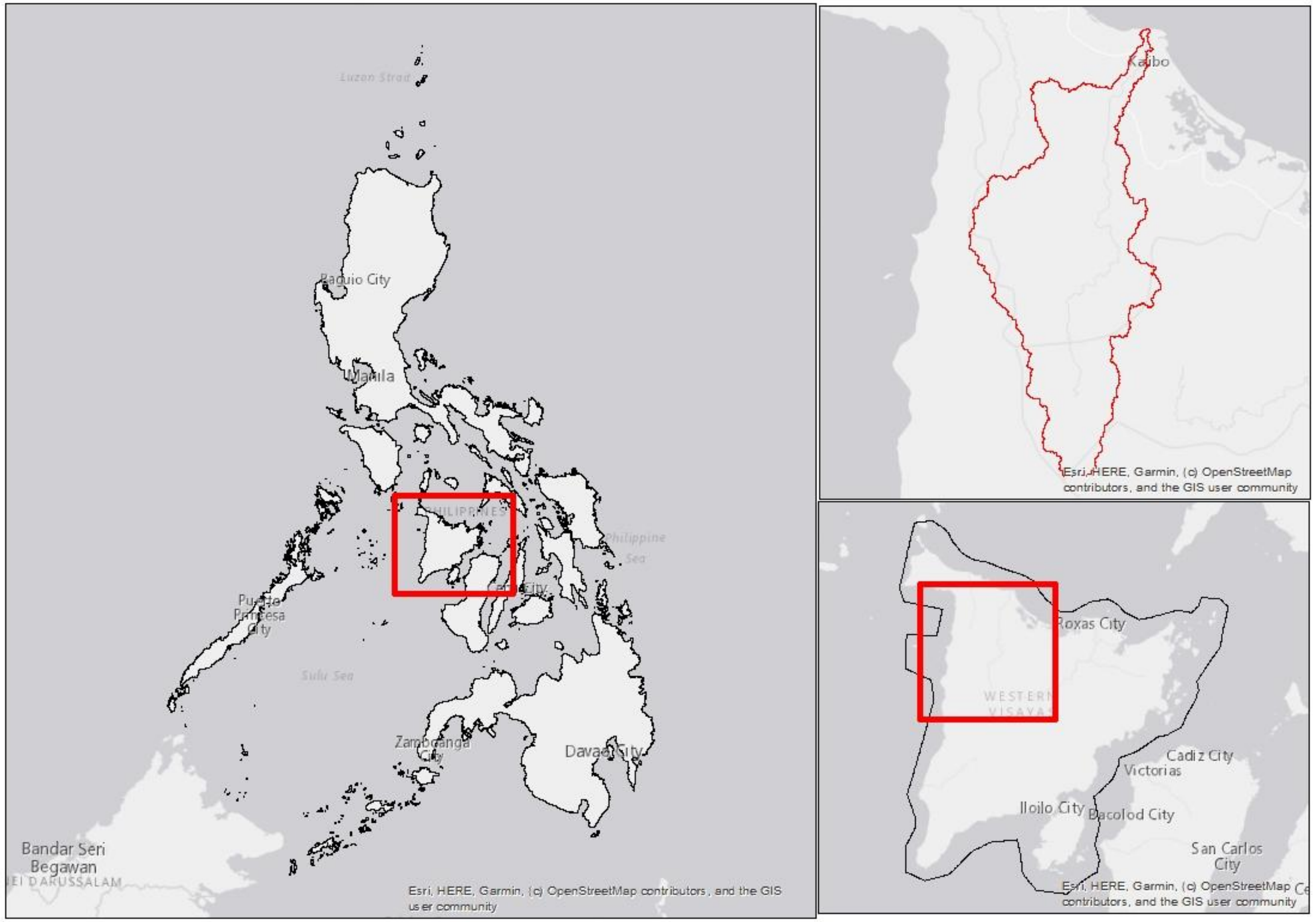
Study Rationale

- Environmental flows support ecological health from uplands to coastal zones
- Aklan River Basin is experiencing land cover shifts: forest gain, urban growth
- Changing land use and climate alter flow regimes and sediment transport
- Downstream mangroves and flood-prone areas rely on stable hydrologic inputs
- Limited local studies on how land cover + climate change affect E-flows

Research Objectives

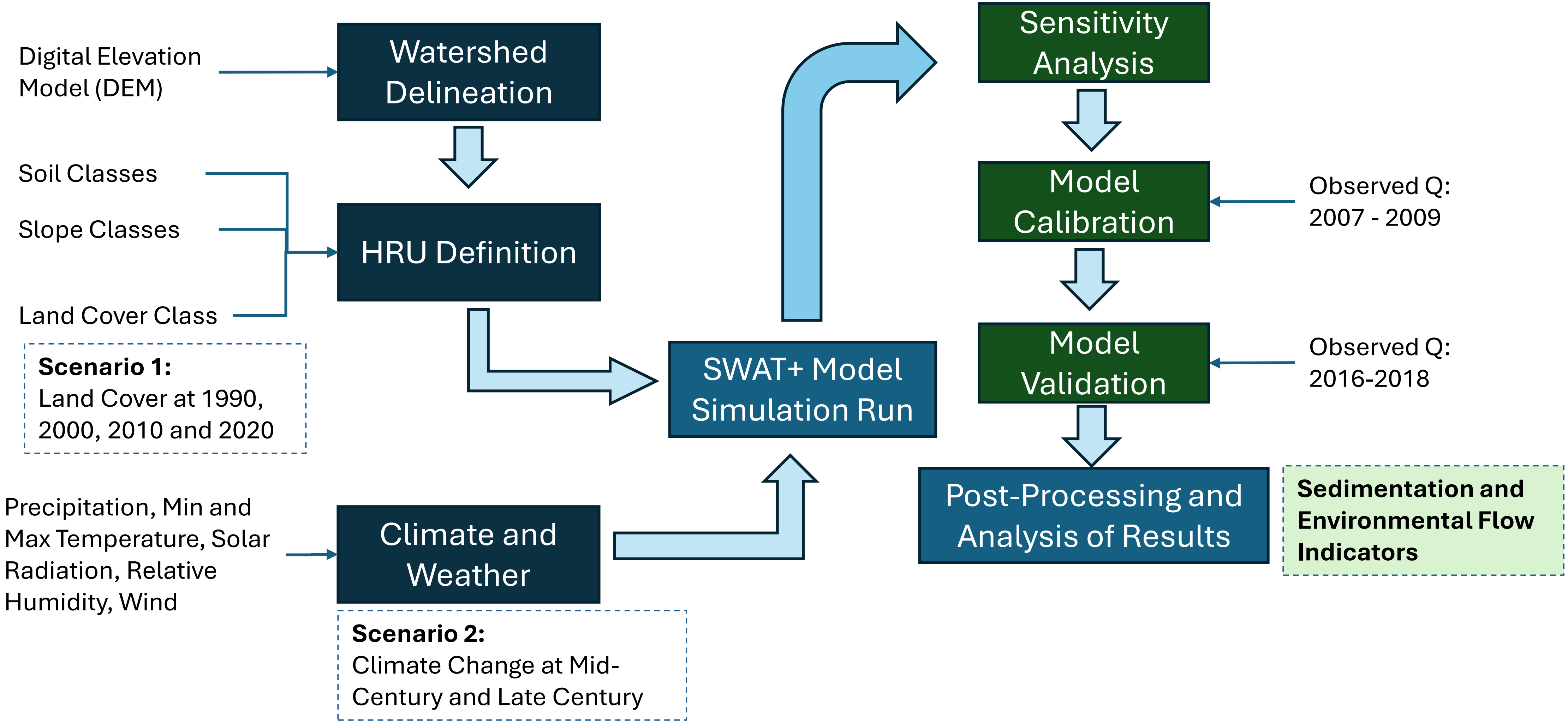
1. To analyze decadal land cover transitions (1990, 2000, 2010, 2020) in the Aklan River Basin using Landsat-derived classifications.
2. To simulate river flow and sediment yield under changing land cover scenarios using the SWAT+ hydrologic model.
3. To evaluate key environmental flow indicators (Q95, Q50, Q10) under historical and projected conditions.
4. To assess climate change impacts on flow regimes using downscaled CMIP6 climate scenarios (SSP5-8.5).
5. To identify critical spatial and temporal patterns of hydrologic alteration that influence downstream ecosystems, including floodplain and mangrove zones.To provide actionable insights for integrating environmental flows into future river basin planning and policy.

Study Area Overview

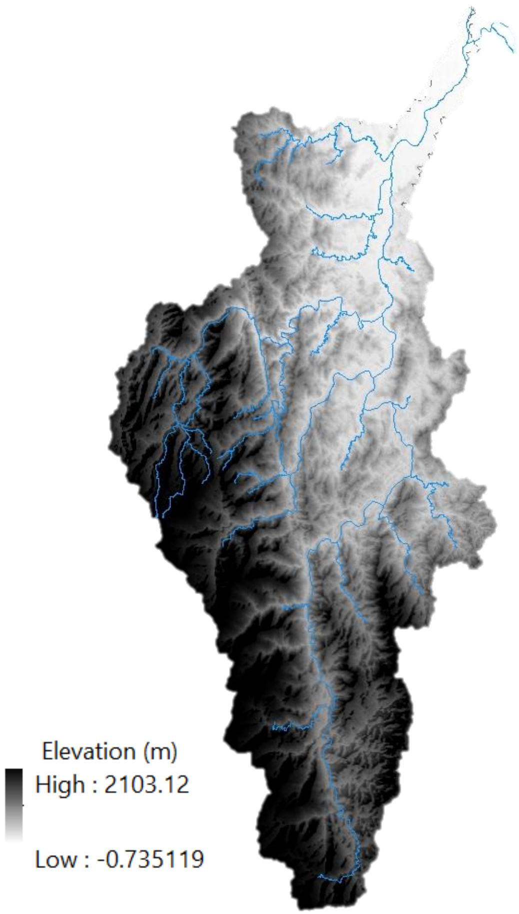


- The study focuses on the Aklan River Basin, located in the northwestern part of Panay Island, Western Visayas, Philippines.
- The basin drains into the coastal municipalities of Kalibo and Numancia, flowing out to the Sibuyan Sea.
- The river catchment covers approximately 892 km^2, with elevations ranging from sea level to over 2,100 meters.
- The basin plays a vital role in providing water supply, irrigation, flood control, and ecosystem services, including support to downstream mangrove systems.
- It has been identified as vulnerable to land use change, climate variability, and downstream flooding, making it a priority for integrated river basin management.

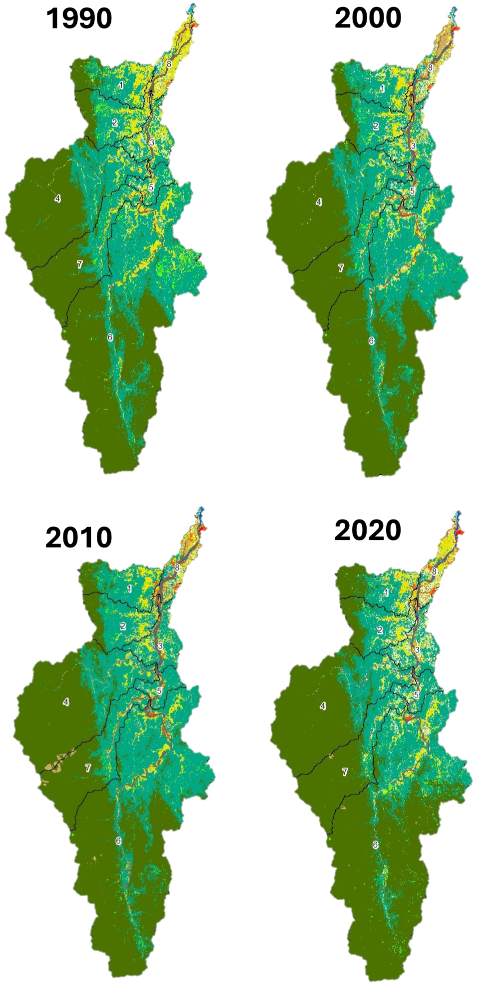
Methodology



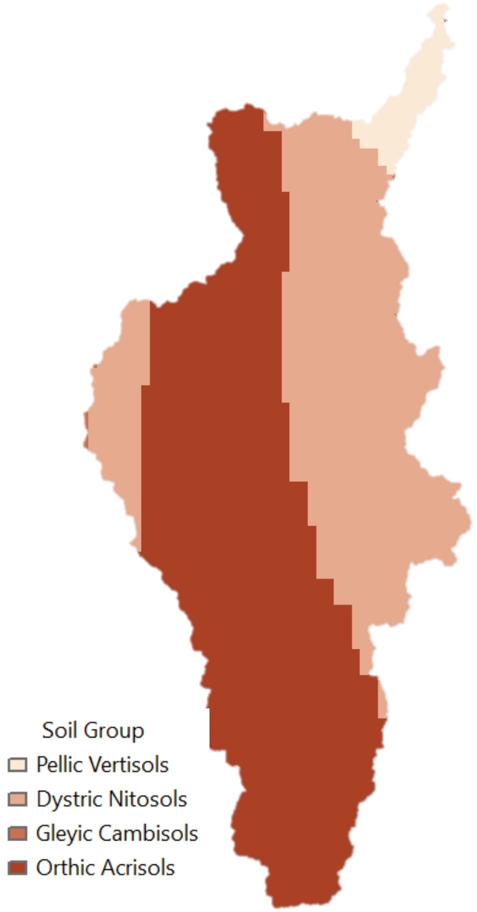
Model Input Datasets



Elevation



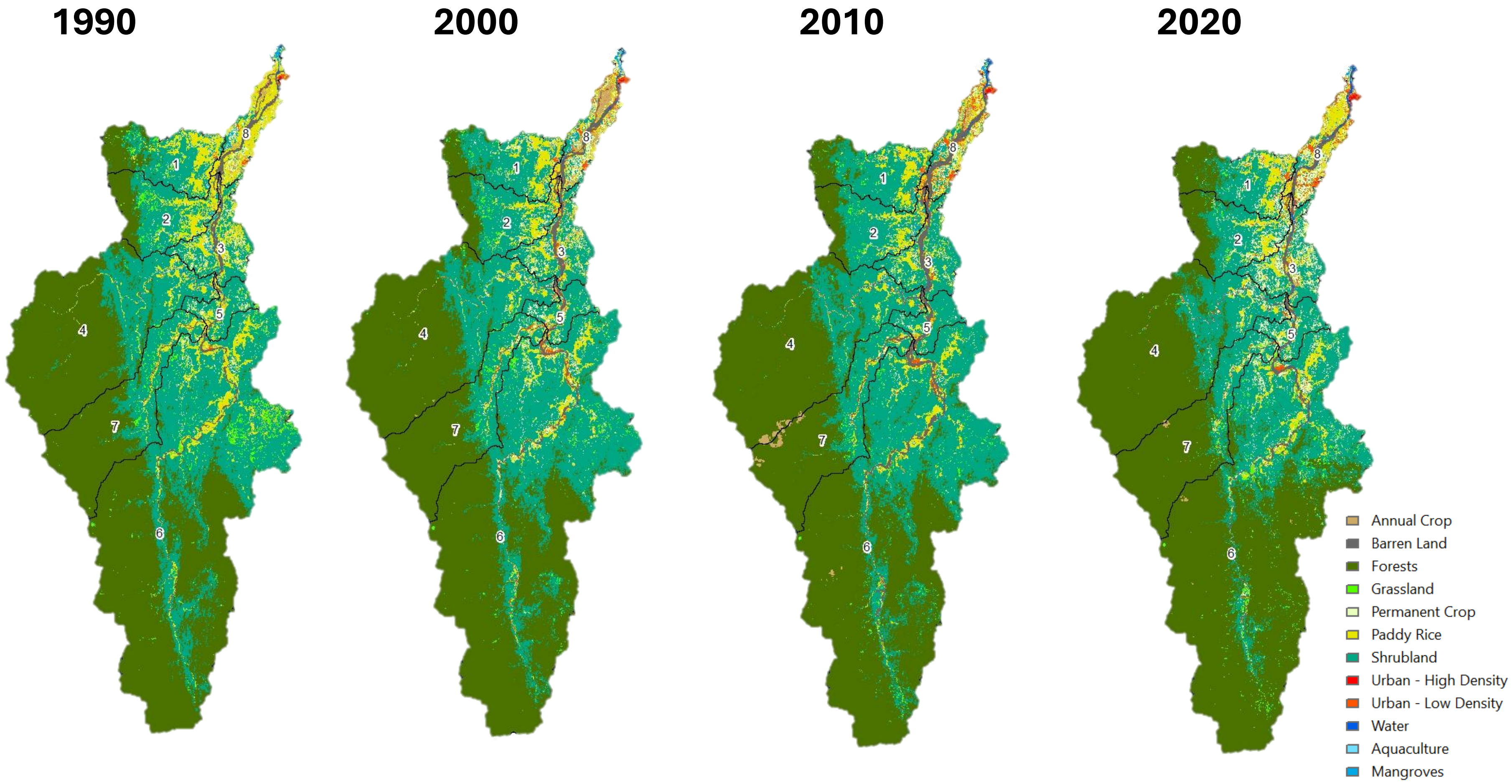
Land Cover



Soils

Data	Source	Period
Elevation: IFSAR (5m)	NAMRIA (PH Mapping Agency	2013
Land Cover	Landsat-derived	1990 (1990-1997) 2000 (2003-2007) 2010 (2008-2012) 2020 (2019-2021)
Soils	FAO Soils of the World	2012
Climate and Weather (rainfall, min and max temp, relative humidity, solar radiation, wind)	CHIRPS NASA IMERG PAGASA (Roxas Station)	1983-2020 2021-2023 1983-2023 (for bias-correction
Discharges	DPWH (PH Public Works Agency)	2007-2018

Land Cover Change at Basin Level



- Four-panel map shows spatial dynamics across subbasins 1–8
- Visible expansion of forest cover in uplands (esp. Subbasins 4, 6, 7)
- Shrubland and agricultural areas transition to forest
- Urbanization concentrated near Subbasins 2, 3, and 5 (downstream and midstream zones)

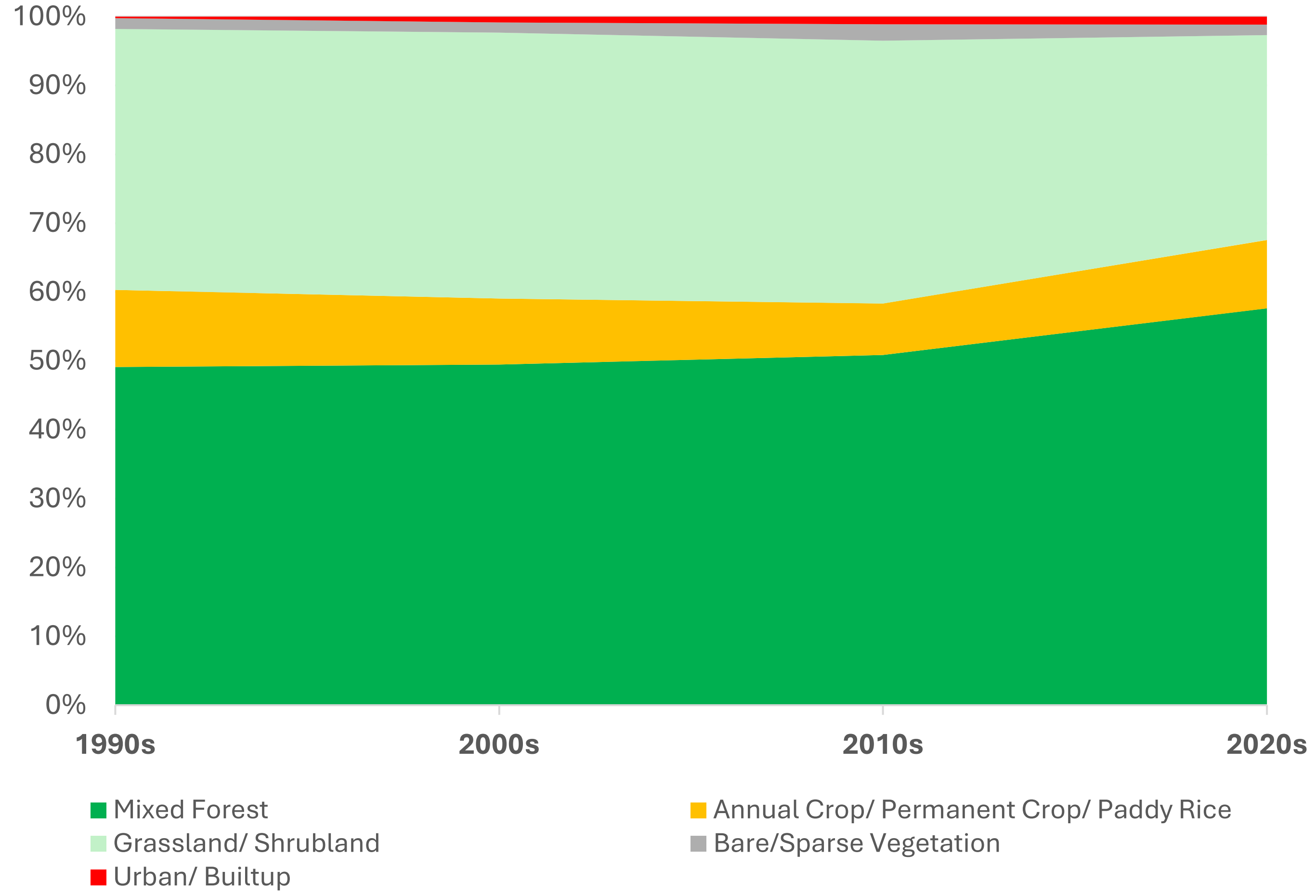
Land Cover Change at Basin Level

Land Cover Group (in has)	1990s	2000s	2010s	2020s	Trend
Mixed Forest	43,573.42	43,910.74	45,115.21	51,147.65	▲ steady
Annual Crop/ Permanent Crop/ Paddy Rice	9,936.32	8,543.54	6,601.99	8,796.73	▼ then ▲
Grassland/ Shrubland	33,634.09	34,262.57	33,848.19	26,400.76	⬌ then ▼
Bare/Sparse Vegetation	1,392.71	1,321.05	2,127.80	1,357.52	▲ steady
Urban/ Builtup	173.78	744.72	969.91	1,025.74	▲ sharp

Urban Expansion in the Downstream

- Permanent cropland and paddy rice declined until the 2010s and then slightly rebounded.
- Urban land consistently increased. Mangroves saw a decline early on but partially recovered.
- These trends align with observed spatial transitions and provide both clarity and numerical depth.

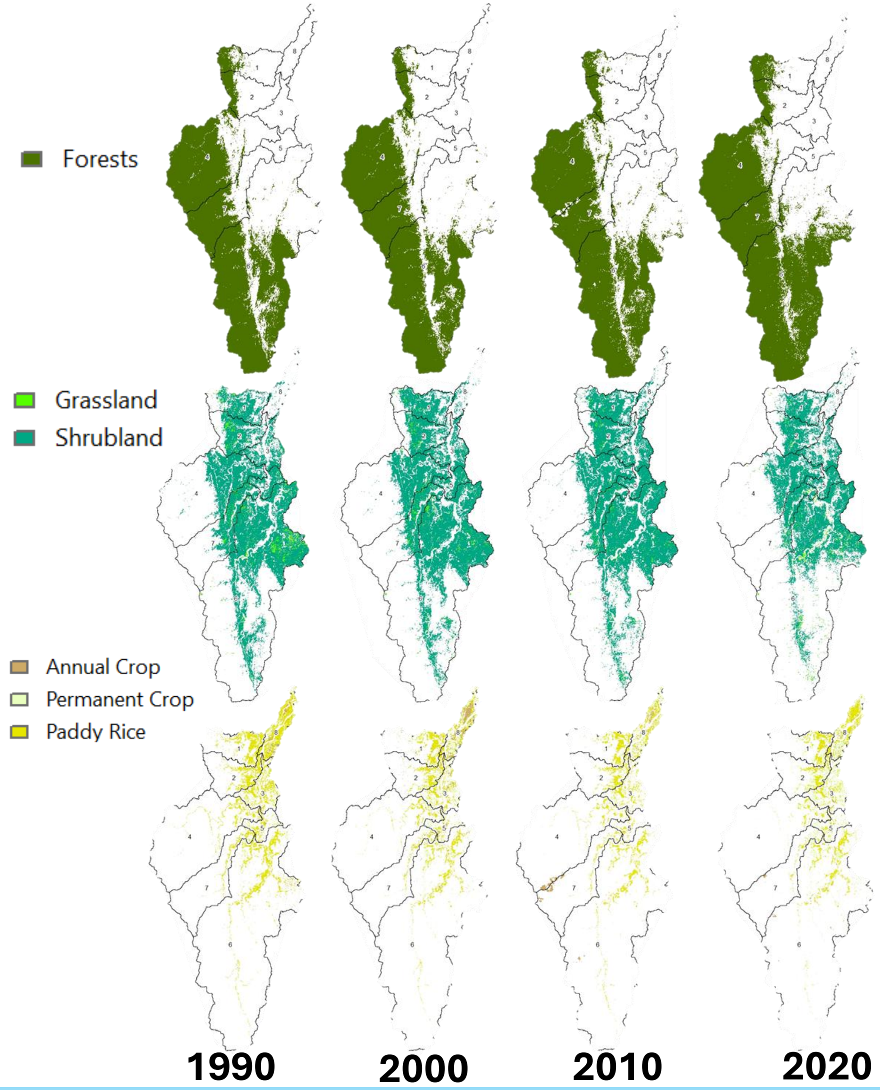
Land Cover Transitions at Basin Level



From Agricultural Dominance to Urban Expansion

- Mixed forest steadily increased its share of the total basin
- Urban/built-up area grew but still occupies a small total percentage
- Agricultural land declined then slightly rebounded by 2020
- Grassland/shrubland steadily declined
- Bare/sparse vegetation remained stable with minor fluctuations

Land Cover Transitions in Aklan River Basin (1990–2020)

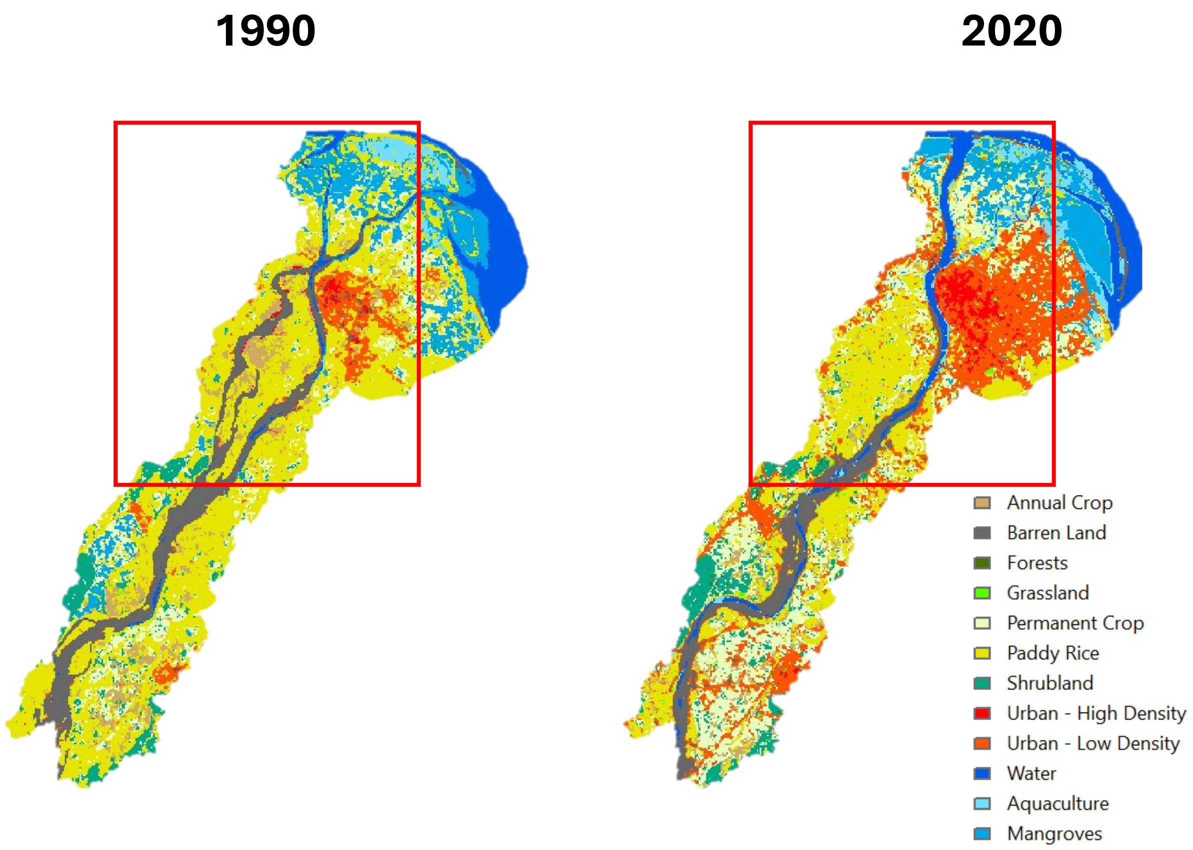


From Agricultural Dominance to Reforestation and Urban Expansion

- From 1990 to 2020, forest cover increased in upland subbasins (especially 4, 6, and 7), often replacing shrubland and grassland.
- Agricultural land declined from the 1990s to 2010, then rebounded slightly by 2020.
- Urban expansion concentrated in midstream and downstream zones (subbasins 2, 3, 5, and 8), increasing impermeability and runoff risk.
- Land cover transitions reflect a shift from agricultural dominance to reforestation and urbanization.

Downstream Coastal Land Cover

Geomorphologic Changes



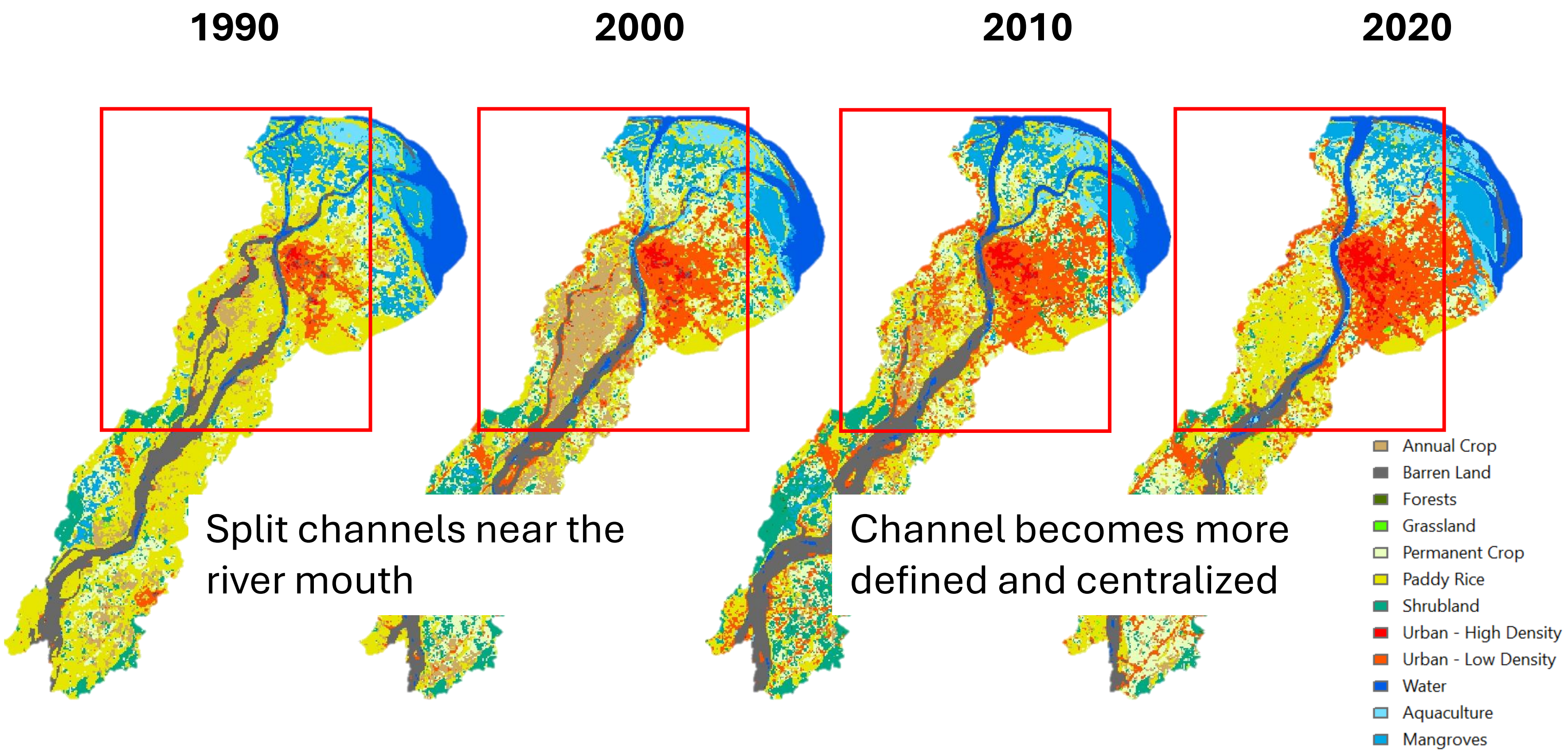
In 1990s, downstream river exhibited anastomosing form with wide floodplain, multiple channels, wetland buffers.

By 2020s, this pattern shifts toward a more singular, confined channel, bank hardening, urban edges.

Indicative of changing sediment dynamics, land use pressures, and possible river engineering.

Downstream Coastal Land Cover

Decadal Transitions



- Shows progressive simplification of river channel from 1990 to 2020
- Lateral channels in 1990s and 2000s become less visible in 2010 and 2020
- Urban development and aquaculture expansion evident in the red and purple areas
- Mangrove area shifts—some sections lost, others stabilized by afforestation
- Confirms a systemic trend toward flow path centralization and land cover pressure

Land Cover Transitions in the Downstream

Urban Expansion in the Downstream

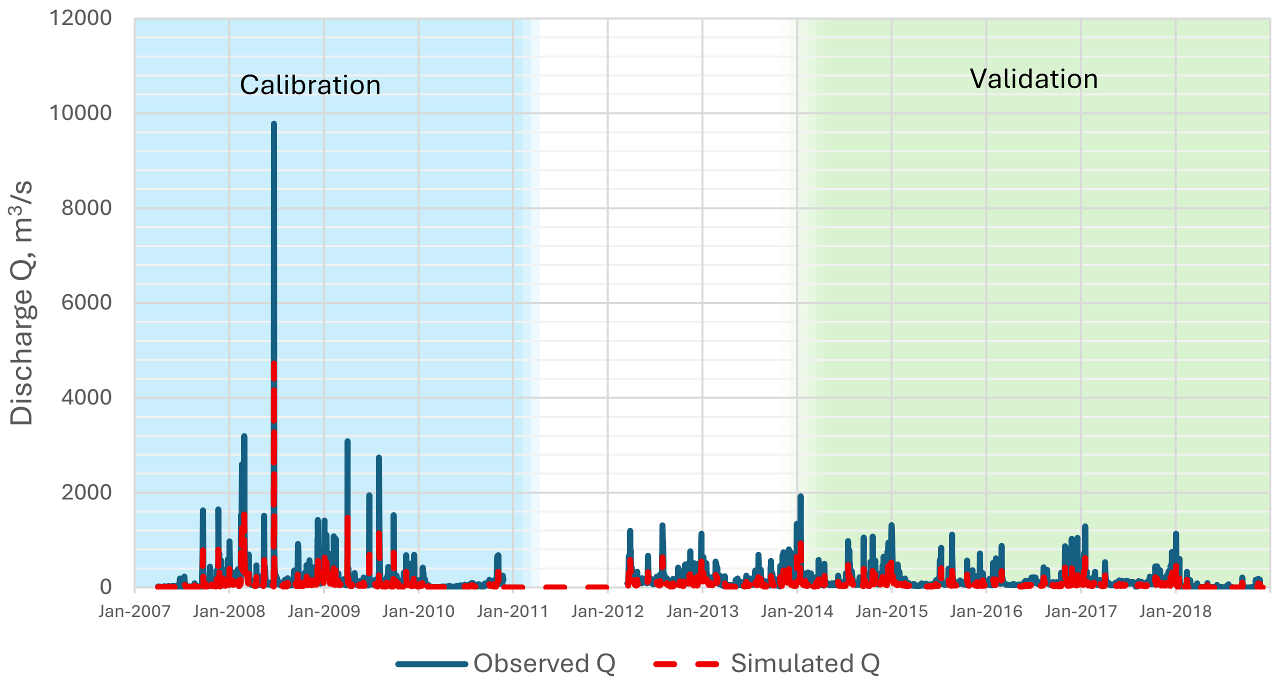
Land Cover Group (in has)	1990s	2000s	2010s	2020s	Trend
Permanent Crop / Paddy Rice	2,828.24	2,438.61	1,876.34	2,146.08	▼ then ▲
Grassland / Shrubland	241.47	434.67	512.29	290.80	▲ then ▼
Bare/Sparse Vegetation	465.03	436.43	545.24	361.59	⬌ then ▼
Urban / Built-up	230.37	603.17	896.06	1,023.67	▲ steady
Woody Wetland / Mangroves	531.66	329.73	378.27	344.50	▼ slight ▲
Aquaculture / Wetland	102.00	179.97	127.18	183.72	⬌ slight ▲

- Permanent cropland and paddy rice declined until the 2010s and then slightly rebounded.
- Urban land consistently increased. Mangroves saw a decline early on but partially recovered.
- These trends align with observed spatial transitions and provide both clarity and numerical depth.

From Land Cover to Hydrologic Response

How Do These Land Cover Changes Affect Flow and Sediment?

Hydrologic Modelling of Aklan River Basin

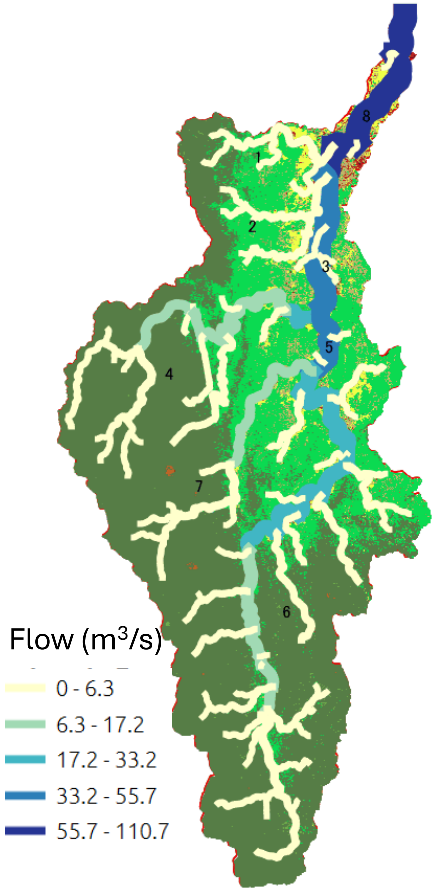


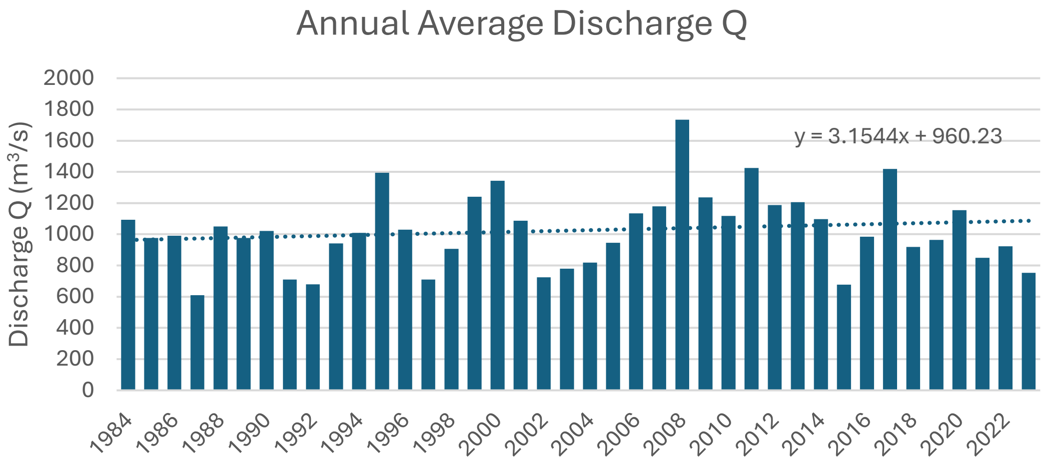
Metric	Calibration (2007-2011)	Validation (2014-2018)	Remarks
R^2	0.69	0.66	Satisfactory
NSE	0.71	0.67	Satisfactory
RSR	0.56	0.66	Good

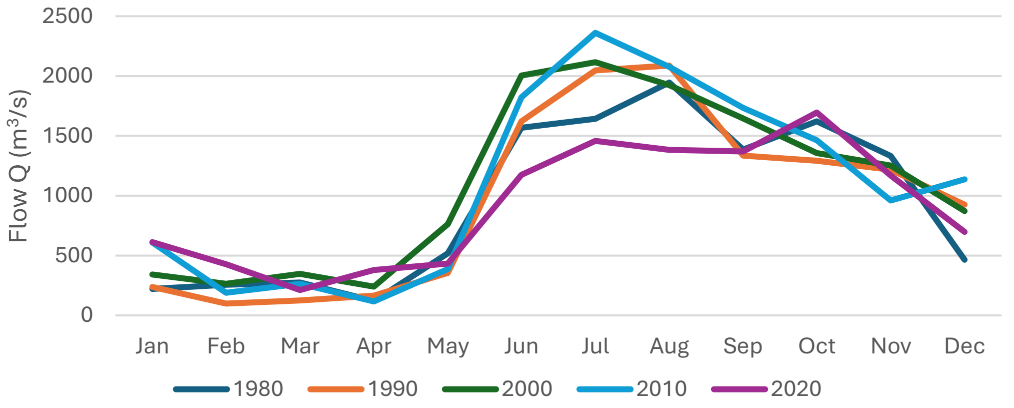
- The model showed satisfactory calibration performance (2007–2011) with R^2 = 0.69, NSE = 0.71, and RSR = 0.56.
- Validation (2014–2018) also performed well with R^2 = 0.66, NSE = 0.67, and RSR = 0.66.
- Results indicate good model reliability and consistent performance across periods.
- The model is suitable for simulating flow dynamics in the basin.

From Land Cover to Hydrologic Response

How Do These Land Cover Changes Affect Flow and Sediment?



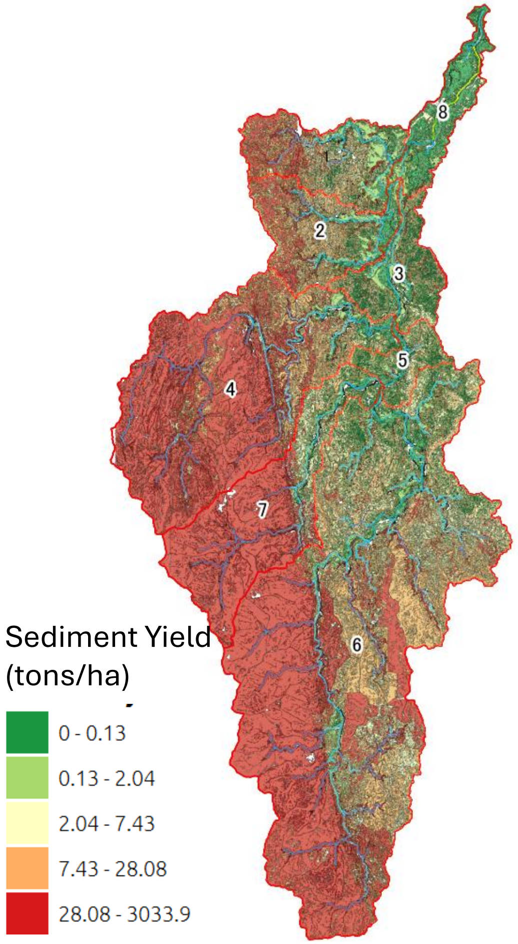


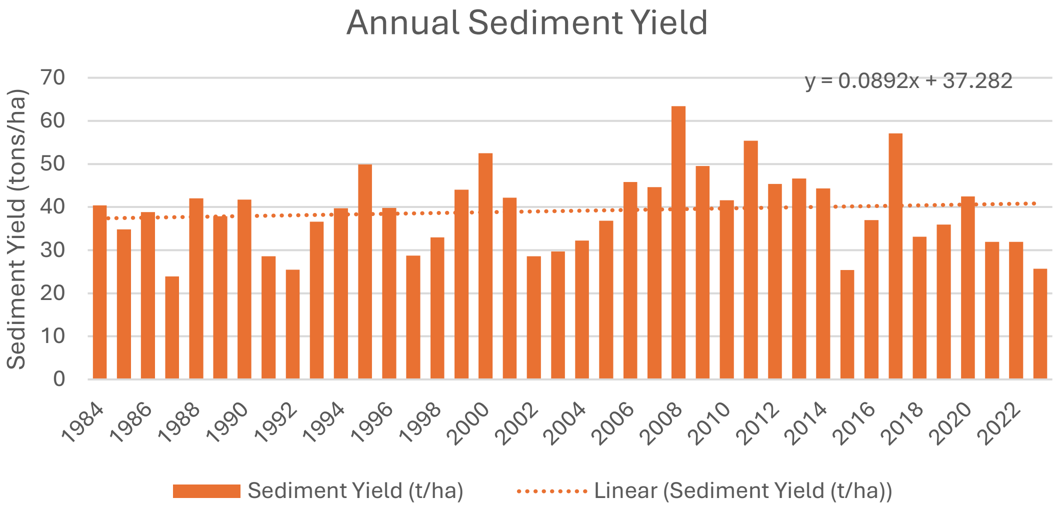


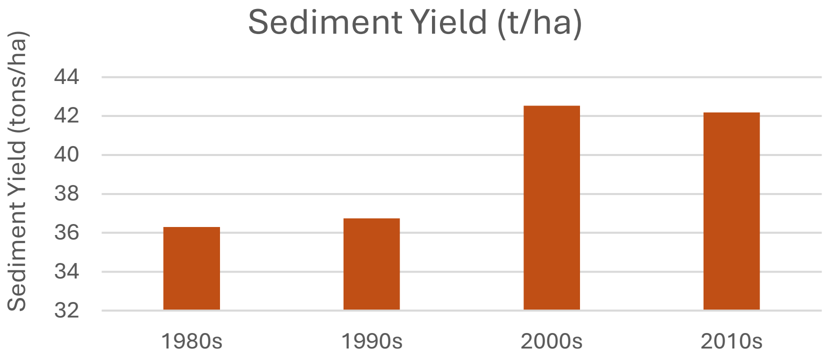
- Peak flows occur from June to September, with July as the wettest month (~2,200 m^3/s).
- Low flows are observed in the dry season from January to April.
- The 2000s and 2010s show higher wet season peaks; 1980s–1990s had lower overall flow.
- The 2020s show flatter peaks and elevated baseflow in Sept–Nov, likely from land or climate changes.
- All decades follow the same seasonal pattern, driven by the monsoon cycle.

Sediment Yield Patterns and Trends

Upland Erosion Hotspots and Decadal Trends in Sediment



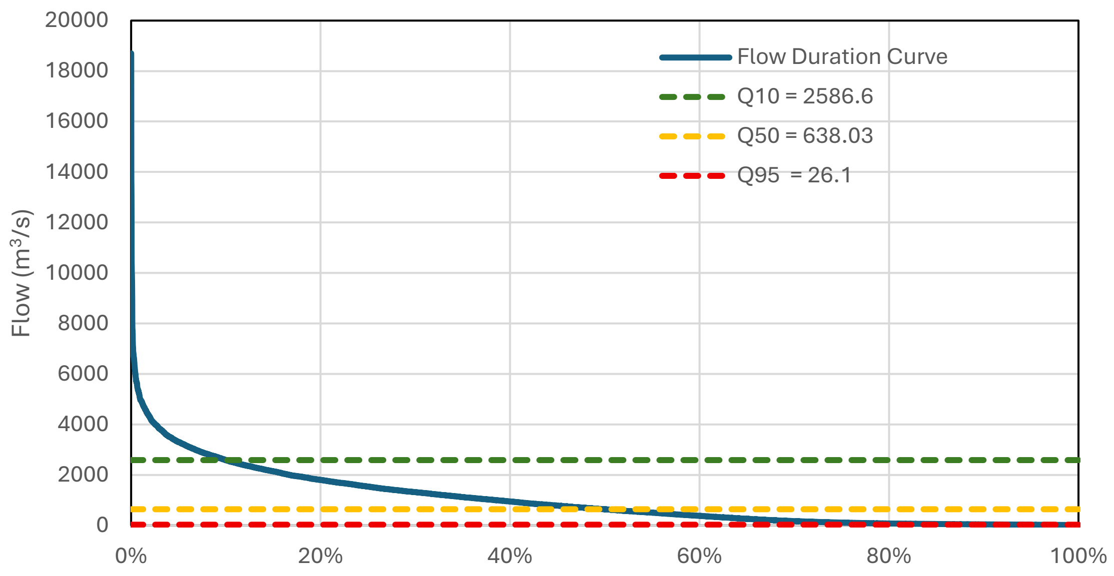




- High sediment yields are concentrated in subbasins with steep slopes and annual crops (Subbasins 4, 6, and 7).
- Annual sediment yield shows peaks linked to major events (e.g., Typhoon Frank in 2008).
- Decadal trends show increasing sediment pressure from the 1980s to 2000s, then a plateau in the 2010s.
- Land use, especially deforestation and intensive agriculture, is the main driver of sediment yield variability.

Defining Environmental Flow Thresholds in Aklan River

Flow Duration Curve with Environmental Flow Indicators

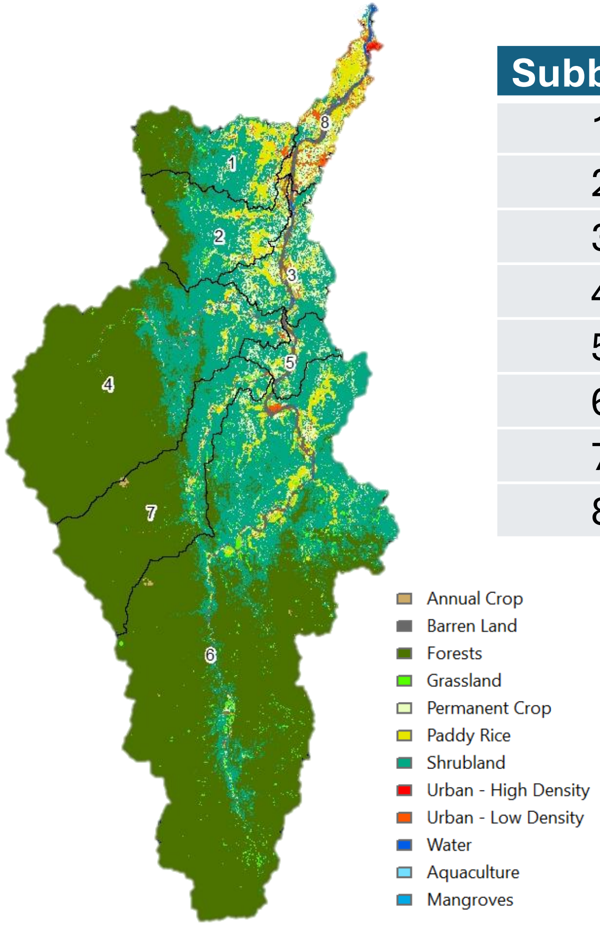


Environmental Flow Indicators
Q10 = 2586.6 m^3/s: Represents high flow conditions exceeded only 10% of the time — important for sediment flushing and habitat resetting.
Q50 = 638.03 m^3/s: The median flow, showing typical daily or monthly conditions — often used for habitat suitability assessments.
Q95 = 26.1 m^3/s: Indicates low flow conditions exceeded 95% of the time — crucial for dry-season ecosystem support and water allocation.

- The FDC illustrates the percentage of time specific flows are equaled or exceeded, providing a clear view of flow variability.
- The curve shows a steep decline at low exceedance probabilities indicating the occurrence of extreme high-flow events.
- Toward the right, the curve flattens, representing sustained baseflow or low-flow conditions.
- The FDC is a powerful tool for identifying thresholds relevant to hydropower, flood control, and ecological flow management.

Defining Environmental Flow Thresholds in Aklan River

Environmental Flow Indicators Per Subbasin



Subbasin	Q10	Q50	Q95
1	11.80	1.10	0.13
2	11.70	1.40	0.05
3	136.00	36.10	2.01
4	48.56	9.46	0.55
5	84.18	22.67	1.34
6	63.30	16.48	0.94
7	21.63	4.63	0.31
8	157.17	42.43	2.28

- Subbasin 8 in the northeastern delta exhibits the highest Q10 (157.17 m^3/s) and Q50 values, suggesting large high-flow and median flow conditions, likely due to downstream accumulation and floodplain characteristics.
- Subbasins 3 and 5 also show relatively high Q10 and Q50 values, reflecting urban expansion and agricultural land cover, which increase runoff and peak flows.
- Subbasins 1 and 2 in the upper watershed display very low Q50 and Q95 values, indicating limited baseflow and quick runoff response, possibly linked to steeper terrain and less developed drainage.
- Subbasins 4, 6, and 7 show moderate flow regimes, with Q50 values between 4 and 22 m^3/s — possibly reflecting a mix of forests, permanent crops, and upland farming systems.
- Q95 values are universally low, reinforcing that dry-season flows are limited and may be vulnerable to climate variability or upstream water extraction.

Climate Change Projections for Aklan River Basin

CMIP6-Based Downscaled Scenarios

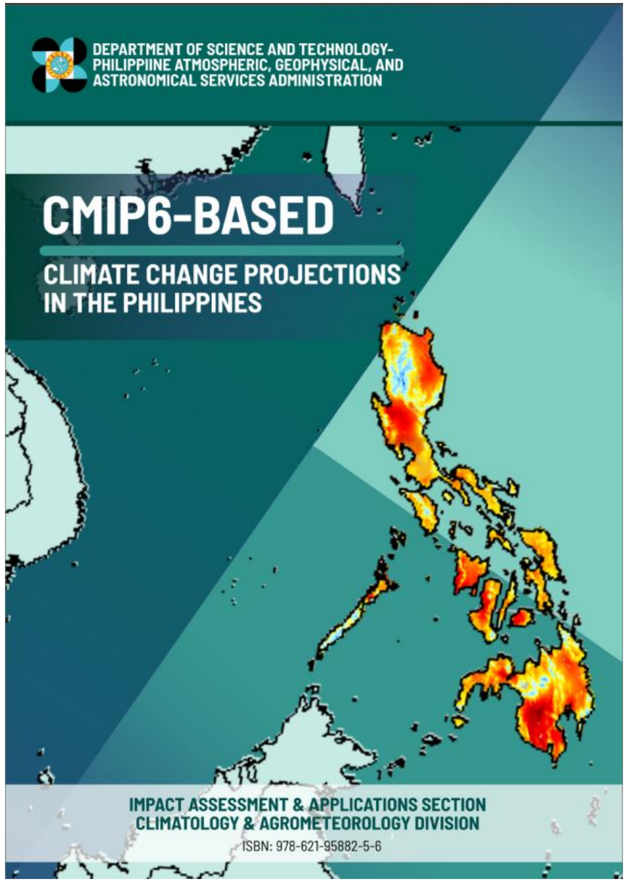


Table A - 4.1. CLIRAM of the projected changes in monthly temperature of **Aklan**

Month	Observed baseline (°C)	Range*	Projected Monthly Mean Temperature (°C) 2021-2050	2031-2060	2041-2070	2051-2080	2061-2090	2071-2100
January	26.3	Upper Bound	27.3 (1.0 °C)	27.7 (1.4 °C)	27.9 (1.6 °C)	28.2 (1.9 °C)	28.7 (2.4 °C)	29.1 (2.8 °C)
		Median	27.1 (0.8 °C)	27.4 (1.1 °C)	27.6 (1.3 °C)	27.9 (1.6 °C)	28.1 (1.8 °C)	28.4 (2.1 °C)
		Lower Bound	27.0 (0.7 °C)	27.2 (0.9 °C)	27.3 (1.0 °C)	27.4 (1.1 °C)	27.5 (1.2 °C)	27.5 (1.2 °C)
February	26.6	Upper Bound	27.7 (1.1 °C)	28.0 (1.4 °C)	28.3 (1.7 °C)	28.6 (2.0 °C)	28.9 (2.3 °C)	29.3 (2.7 °C)
		Median	27.5 (0.9 °C)	27.7 (1.1 °C)	28.0 (1.4 °C)	28.2 (1.6 °C)	28.4 (1.8 °C)	28.6 (2.0 °C)
		Lower Bound	27.3 (0.7 °C)	27.6 (1.0 °C)	27.6 (1.0 °C)	27.8 (1.2 °C)	27.8 (1.2 °C)	27.9 (1.3 °C)
March	27.5	Upper Bound	28.6 (1.1 °C)	28.8 (1.3 °C)	29.2 (1.7 °C)	29.5 (2.0 °C)	30.0 (2.5 °C)	30.4 (2.9 °C)
		Median	28.4 (0.9 °C)	28.6 (1.1 °C)	28.8 (1.3 °C)	29.1 (1.6 °C)	29.3 (1.8 °C)	29.5 (2.0 °C)
		Lower Bound	28.1 (0.6 °C)	28.3 (0.8 °C)	28.5 (1.0 °C)	28.6 (1.1 °C)	28.7 (1.2 °C)	28.8 (1.3 °C)
April	28.6	Upper Bound	29.7 (1.1 °C)	30.1 (1.5 °C)	30.4 (1.8 °C)	30.8 (2.2 °C)	31.3 (2.7 °C)	31.7 (3.1 °C)
		Median	29.5 (0.9 °C)	29.8 (1.2 °C)	30.0 (1.4 °C)	30.3 (1.7 °C)	30.6 (2.0 °C)	30.8 (2.2 °C)
		Lower Bound	29.3 (0.7 °C)	29.5 (0.9 °C)	29.6 (1.0 °C)	29.7 (1.1 °C)	29.9 (1.3 °C)	30.0 (1.4 °C)
May	28.8	Upper Bound	30.0 (1.2 °C)	30.3 (1.5 °C)	30.7 (1.9 °C)	31.1 (2.3 °C)	31.6 (2.8 °C)	32.0 (3.2 °C)
		Median	29.7 (0.9 °C)	30.0 (1.2 °C)	30.3 (1.5 °C)	30.5 (1.7 °C)	30.8 (2.0 °C)	31.0 (2.2 °C)
		Lower Bound	29.6 (0.8 °C)	29.8 (1.0 °C)	29.9 (1.1 °C)	30.0 (1.2 °C)	30.1 (1.3 °C)	30.1 (1.3 °C)
June	28.2	Upper Bound	29.2 (1.0 °C)	29.6 (1.4 °C)	30.0 (1.8 °C)	30.3 (2.1 °C)	30.8 (2.6 °C)	31.2 (3.0 °C)
		Median	29.0 (0.8 °C)	29.3 (1.1 °C)	29.5 (1.3 °C)	29.8 (1.6 °C)	30.1 (1.9 °C)	30.3 (2.1 °C)
		Lower Bound	28.9 (0.7 °C)	29.1 (0.9 °C)	29.2 (1.0 °C)	29.3 (1.1 °C)	29.4 (1.2 °C)	29.4 (1.2 °C)
July	27.6	Upper Bound	28.6 (1.0 °C)	29.0 (1.4 °C)	29.4 (1.8 °C)	29.7 (2.1 °C)	30.1 (2.5 °C)	30.6 (3.0 °C)
		Median	28.4 (0.8 °C)	28.7 (1.1 °C)	29.0 (1.4 °C)	29.2 (1.6 °C)	29.4 (1.8 °C)	29.7 (2.1 °C)
		Lower Bound	28.3 (0.7 °C)	28.5 (0.9 °C)	28.6 (1.0 °C)	28.7 (1.1 °C)	28.8 (1.2 °C)	28.8 (1.2 °C)
August	27.6	Upper Bound	28.7 (1.1 °C)	29.1 (1.5 °C)	29.4 (1.8 °C)	29.9 (2.3 °C)	30.3 (2.7 °C)	30.7 (3.1 °C)
		Median	28.5 (0.9 °C)	28.8 (1.2 °C)	29.0 (1.4 °C)	29.2 (1.6 °C)	29.5 (1.9 °C)	29.7 (2.1 °C)
		Lower Bound	28.4 (0.8 °C)	28.6 (1.0 °C)	28.7 (1.1 °C)	28.8 (1.2 °C)	28.9 (1.3 °C)	28.9 (1.3 °C)
September	27.6	Upper Bound	28.7 (1.1 °C)	29.0 (1.4 °C)	29.4 (1.8 °C)	29.8 (2.2 °C)	30.3 (2.7 °C)	30.7 (3.1 °C)
		Median	28.5 (0.9 °C)	28.7 (1.1 °C)	29.0 (1.4 °C)	29.2 (1.6 °C)	29.4 (1.8 °C)	29.7 (2.1 °C)
		Lower Bound	28.3 (0.7 °C)	28.5 (0.9 °C)	28.6 (1.0 °C)	28.7 (1.1 °C)	28.8 (1.2 °C)	28.9 (1.3 °C)
October	27.6	Upper Bound	28.6 (1.0 °C)	28.9 (1.3 °C)	29.3 (1.7 °C)	29.6 (2.0 °C)	30.2 (2.6 °C)	30.5 (2.9 °C)
		Median	28.4 (0.8 °C)	28.6 (1.0 °C)	28.9 (1.3 °C)	29.1 (1.5 °C)	29.4 (1.8 °C)	29.6 (2.0 °C)
		Lower Bound	28.2 (0.6 °C)	28.4 (0.8 °C)	28.6 (1.0 °C)	28.7 (1.1 °C)	28.8 (1.2 °C)	28.8 (1.2 °C)
November	27.5	Upper Bound	28.5 (1.0 °C)	28.9 (1.4 °C)	29.2 (1.7 °C)	29.6 (2.1 °C)	30.0 (2.5 °C)	30.4 (2.9 °C)
		Median	28.4 (0.9 °C)	28.6 (1.1 °C)	28.8 (1.3 °C)	29.1 (1.6 °C)	29.4 (1.9 °C)	29.6 (2.1 °C)
		Lower Bound	28.2 (0.7 °C)	28.4 (0.9 °C)	28.6 (1.1 °C)	28.6 (1.1 °C)	28.7 (1.2 °C)	28.7 (1.2 °C)
December	26.8	Upper Bound	27.8 (1.0 °C)	28.1 (1.3 °C)	28.5 (1.7 °C)	28.8 (2.0 °C)	29.2 (2.4 °C)	29.6 (2.8 °C)
		Median	27.6 (0.8 °C)	27.9 (1.1 °C)	28.1 (1.3 °C)	28.4 (1.6 °C)	28.6 (1.8 °C)	28.8 (2.0 °C)
		Lower Bound	27.4 (0.6 °C)	27.7 (0.9 °C)	27.8 (1.0 °C)	27.9 (1.1 °C)	28.0 (1.2 °C)	28.0 (1.2 °C)

* upper: 75th percentile; median: 50th percentile; lower: 25th percentile

Cooler · Warmer · Temperature Change (°C)

Table A - 4.2. CLIRAM of the projected changes in monthly rainfall of **Aklan**

Month	Observed baseline (mm)	Range*	Projected Monthly Mean Rainfall (mm) 2021-2050	2031-2060	2041-2070	2051-2080	2061-2090	2071-2100
January	101.1	Upper Bound	125.0 (+23.6 %)	127.9 (+26.5 %)	133.1 (+31.7 %)	134.3 (+32.8 %)	134.6 (+33.1 %)	133.5 (+32.0 %)
		Median	107.5 (+6.3 %)	113.0 (+11.8 %)	110.9 (+9.7 %)	108.9 (+7.7 %)	113.0 (+11.8 %)	108.6 (+7.4 %)
		Lower Bound	94.0 (-7.0 %)	95.0 (-6.0 %)	94.3 (-6.7 %)	92.3 (-8.7 %)	92.4 (-8.6 %)	89.1 (-11.9 %)
February	74.6	Upper Bound	87.0 (+16.6 %)	89.5 (+20.0 %)	91.6 (+22.8 %)	87.9 (+17.8 %)	89.7 (+20.2 %)	89.5 (+20.0 %)
		Median	76.5 (+2.6 %)	76.9 (+3.1 %)	79.1 (+6.0 %)	76.6 (+2.7 %)	76.1 (+2.0 %)	74.8 (+0.3 %)
		Lower Bound	67.2 (-9.9 %)	70.4 (-5.6 %)	70.3 (-5.8 %)	65.7 (-11.9 %)	64.7 (-13.3 %)	62.0 (-16.9 %)
March	84.0	Upper Bound	99.1 (+18.0 %)	98.6 (+17.4 %)	96.8 (+15.2 %)	98.5 (+17.3 %)	96.4 (+14.8 %)	95.8 (+14.0 %)
		Median	84.3 (+0.4 %)	87.3 (+3.9 %)	85.9 (+2.3 %)	84.2 (+0.2 %)	83.3 (-0.8 %)	81.5 (-3.0 %)
		Lower Bound	75.8 (-9.8 %)	74.3 (-11.5 %)	72.6 (-13.6 %)	69.9 (-16.8 %)	71.0 (-15.5 %)	69.6 (-17.1 %)
April	75.5	Upper Bound	84.9 (+12.5 %)	82.2 (+8.9 %)	81.2 (+7.5 %)	81.2 (+7.5 %)	78.3 (+3.7 %)	79.1 (+4.8 %)
		Median	75.0 (-0.7 %)	75.2 (-0.4 %)	74.0 (-2.0 %)	73.0 (-3.3 %)	69.3 (-8.2 %)	68.7 (-9.0 %)
		Lower Bound	64.7 (-14.3 %)	64.0 (-15.2 %)	62.3 (-17.5 %)	59.4 (-21.3 %)	58.6 (-22.4 %)	52.5 (-30.5 %)
May	196.1	Upper Bound	210.4 (+7.3 %)	206.7 (+5.4 %)	204.0 (+4.0 %)	206.8 (+5.5 %)	203.6 (+3.8 %)	208.4 (+6.3 %)
		Median	191.5 (-2.3 %)	190.6 (-2.8 %)	189.1 (-3.6 %)	186.6 (-4.8 %)	181.8 (-7.3 %)	178.8 (-8.8 %)
		Lower Bound	174.3 (-11.1 %)	168.1 (-14.3 %)	165.7 (-15.5 %)	161.1 (-17.8 %)	157.1 (-19.9 %)	150.3 (-23.4 %)
June	351.5	Upper Bound	385.2 (+9.6 %)	386.1 (+9.8 %)	384.2 (+9.3 %)	388.9 (+10.6 %)	385.1 (+9.6 %)	388.2 (+10.4 %)
		Median	358.2 (+1.9 %)	359.6 (+2.3 %)	358.6 (+2.0 %)	360.9 (+2.7 %)	357.4 (+1.7 %)	362.8 (+3.2 %)
		Lower Bound	335.4 (-4.6 %)	339.0 (-3.6 %)	336.4 (-4.3 %)	339.5 (-3.4 %)	337.8 (-3.9 %)	335.7 (-4.5 %)
July	394.6	Upper Bound	420.1 (+6.5 %)	426.1 (+8.0 %)	431.3 (+9.3 %)	440.8 (+11.7 %)	442.4 (+12.1 %)	445.1 (+12.8 %)
		Median	396.2 (+0.4 %)	404.2 (+2.4 %)	401.5 (+1.7 %)	407.3 (+3.2 %)	405.7 (+2.8 %)	413.1 (+4.7 %)
		Lower Bound	374.6 (-5.1 %)	373.4 (-5.4 %)	379.3 (-3.9 %)	378.5 (-4.1 %)	380.4 (-3.6 %)	373.5 (-5.3 %)
August	296.7	Upper Bound	308.4 (+3.9 %)	309.5 (+4.3 %)	311.2 (+4.9 %)	312.2 (+5.2 %)	314.4 (+6.0 %)	312.3 (+5.3 %)
		Median	292.6 (-1.4 %)	293.1 (-1.2 %)	296.7 (0.0 %)	297.6 (+0.3 %)	296.0 (-0.2 %)	297.5 (+0.3 %)
		Lower Bound	279.8 (-5.7 %)	278.0 (-6.3 %)	281.7 (-5.1 %)	281.2 (-5.2 %)	284.3 (-4.2 %)	284.0 (-4.3 %)
September	318.8	Upper Bound	339.0 (+6.3 %)	338.6 (+6.2 %)	340.1 (+6.7 %)	343.0 (+7.6 %)	341.5 (+7.1 %)	348.6 (+9.3 %)
		Median	320.3 (+0.5 %)	321.3 (+0.8 %)	319.5 (+0.2 %)	316.9 (-0.6 %)	319.0 (+0.1 %)	317.9 (-0.3 %)
		Lower Bound	306.6 (-3.8 %)	301.8 (-5.3 %)	306.1 (-4.0 %)	303.6 (-4.8 %)	303.0 (-5.0 %)	300.7 (-5.7 %)
October	330.7	Upper Bound	368.3 (+11.4 %)	372.5 (+12.6 %)	368.9 (+11.6 %)	373.2 (+12.9 %)	371.5 (+12.3 %)	370.9 (+12.2 %)
		Median	341.8 (+3.4 %)	339.7 (+2.7 %)	344.3 (+4.1 %)	345.5 (+4.5 %)	342.1 (+3.4 %)	342.8 (+3.7 %)
		Lower Bound	313.0 (-5.4 %)	318.1 (-3.8 %)	314.2 (-5.0 %)	316.1 (-4.4 %)	313.3 (-5.3 %)	309.7 (-6.4 %)
November	241.6	Upper Bound	267.3 (+10.6 %)	270.4 (+11.9 %)	272.8 (+12.9 %)	271.6 (+12.4 %)	273.2 (+13.1 %)	277.6 (+14.9 %)
		Median	244.0 (+1.0 %)	252.2 (+4.4 %)	245.5 (+1.6 %)	244.9 (+1.4 %)	244.4 (+1.2 %)	245.8 (+1.7 %)
		Lower Bound	225.9 (-6.5 %)	227.5 (-5.8 %)	226.4 (-6.3 %)	229.8 (-4.9 %)	230.6 (-4.6 %)	223.2 (-7.6 %)
December	229.3	Upper Bound	260.3 (+13.5 %)	267.5 (+16.7 %)	264.6 (+15.4 %)	266.2 (+16.1 %)	269.4 (+17.5 %)	264.6 (+15.4 %)
		Median	236.0 (+2.9 %)	231.7 (+1.0 %)	232.0 (+1.2 %)	237.9 (+3.8 %)	239.1 (+4.3 %)	243.7 (+6.3 %)
		Lower Bound	211.5 (-7.8 %)	210.3 (-8.3 %)	213.3 (-7.0 %)	216.1 (-5.8 %)	218.7 (-4.6 %)	216.4 (-5.6 %)

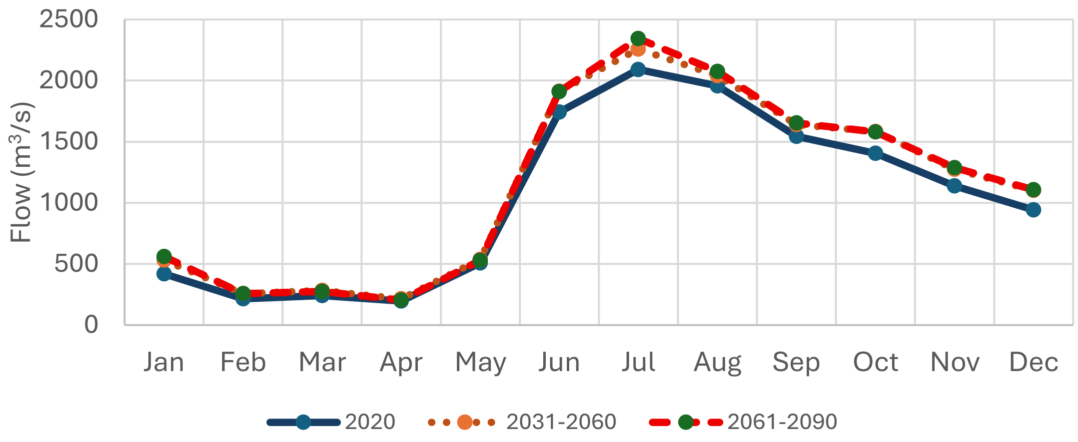
* upper: 75th percentile; median: 50th percentile; lower: 25th percentile

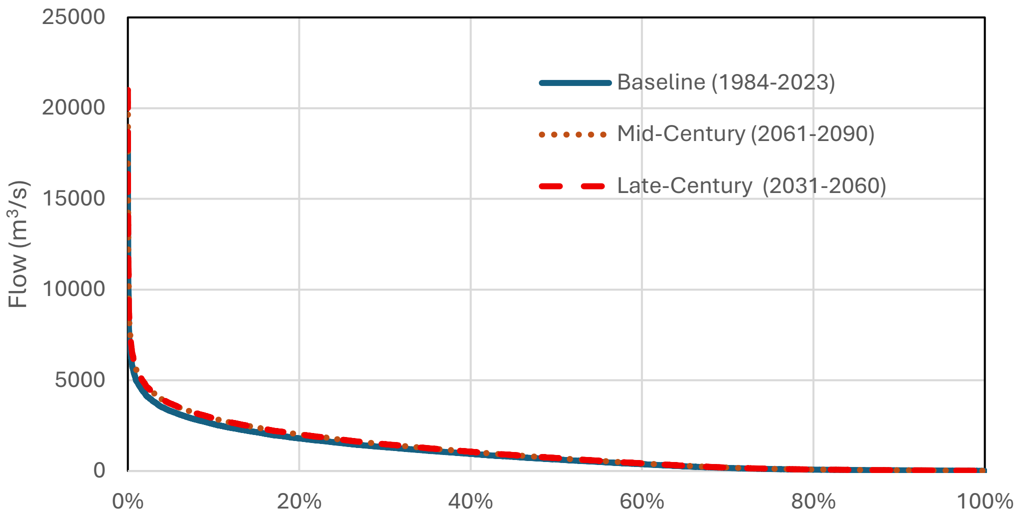
Drier · Wetter · Rainfall Change (%): -40, -30, -20, -10, 0, 10, 20, 30, 40

- Source: DOST-PAGASA (2024), using CMIP6-based projections and the CLIRAM tool
- Scope: Provincial-scale projections for Aklan, downscaled at 1 km^2 resolution
- Variables updated: Monthly Rainfall and Temperature
- Time slices: Mid-century (2031–2060), Late-century (2061–2090)
- Scenarios: SSP5-8.5 (high emissions)
- Projected changes:
  - Temperature (Upper Bound): +1.4°C to +2.8°C by 2061–2090 (SSP5-8.5)
  - Rainfall (Upper Bound): Increased rainfall is projected in most months, especially during peak monsoon months (July–September)

Climate Change Projections and Hydrologic Impacts (SSP5–8.5)

Warming, Wetter Monsoons, and Intensified Flow Regimes in the Future



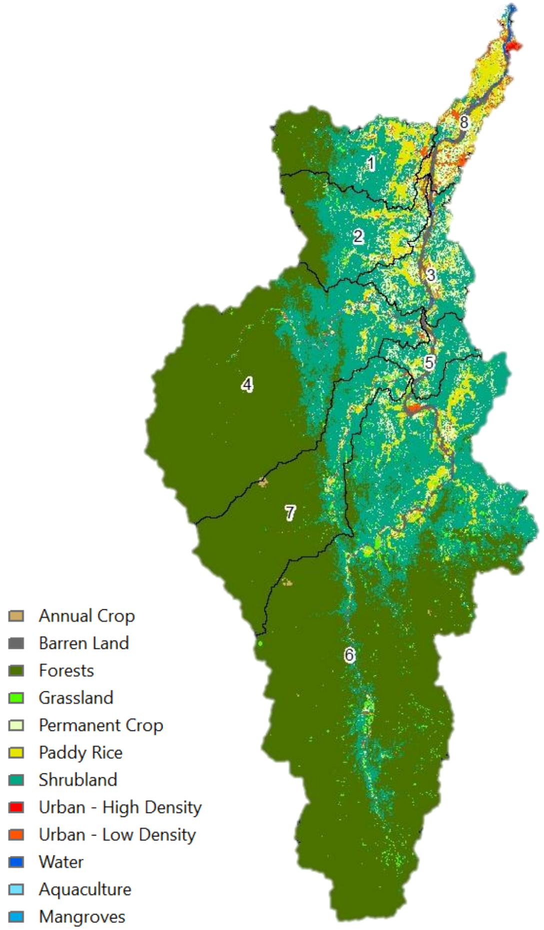


- Climate projections under SSP5–8.5 show +1.4 to +2.8°C warming and wetter monsoon months by late century.
- July to September are expected to receive 20–30% more rainfall, increasing flood and flow volumes.
- SWAT simulations project increases in Q10, Q50, and Q95 across future scenarios.
- Flow Duration Curves shift rightward, reflecting more frequent high flows and elevated baseflow conditions.

Flow Duration Curve	Q95	Q50	Q10
Baseline (1984-2023)	26.10	638.03	2,586.10
Mid-Century (2061-2090)	29.31	716.50	2,904.72
Late-Century (2031-2060)	29.44	719.69	2,917.66

Integrated Insights and Policy Relevance

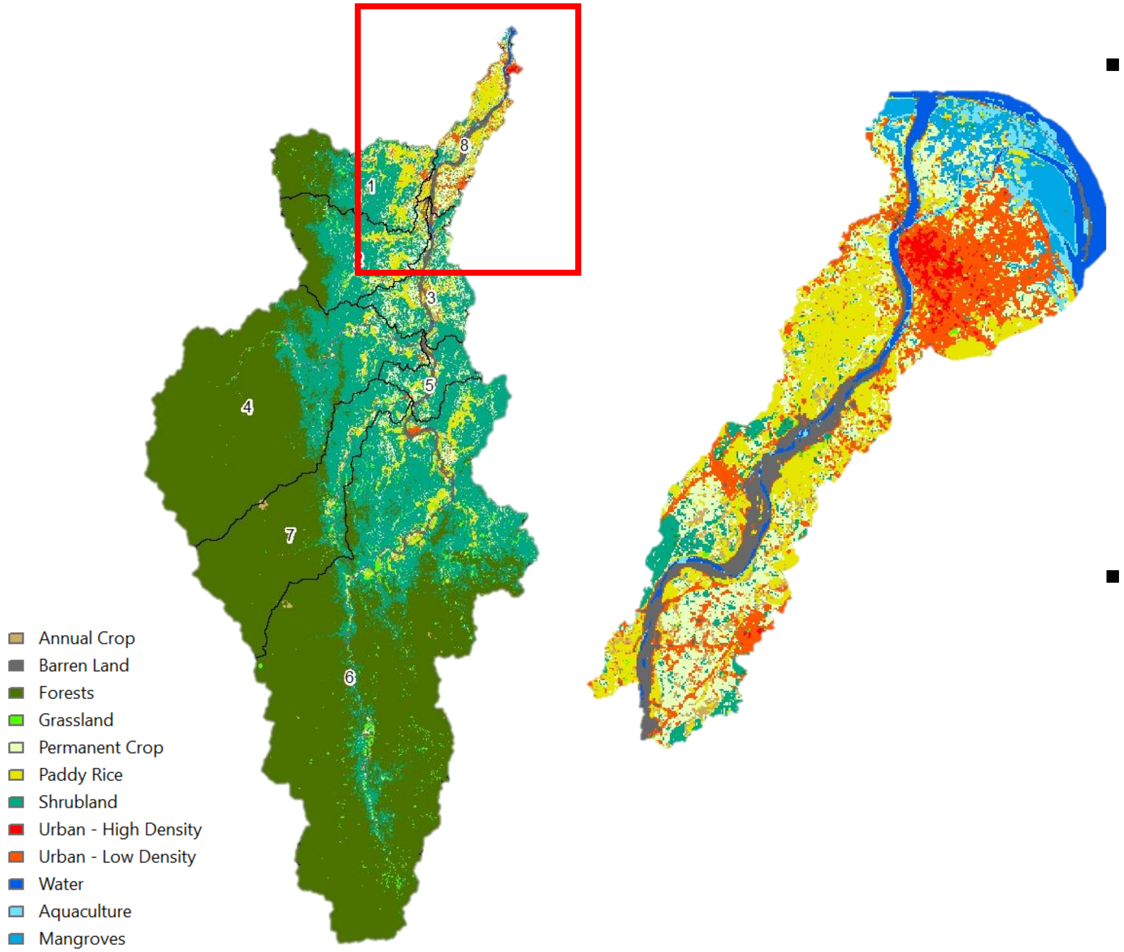
Integrating Land and Climate Impacts for Environmental Flow Management



- Upstream (Subbasins 4, 6, 7 – Forest-dominated zones):
  - Characterized by dense forest and shrubland cover, which promotes baseflow stability and reduced sediment yield.
  - These headwater areas act as natural flow regulators, contributing to sustained dry-season flows and buffering high runoff.
  - Maintaining forest cover is essential to preserve hydrological integrity under future climate conditions.
- Midstream (Subbasins 3 and 5 – Mixed land use):
  - Transition zones with grasslands, permanent crops, and expanding agriculture.
  - Increased land conversion in these areas can lead to higher peak flows and sediment loads, affecting flow variability.
  - These subbasins are key leverage points for implementing land management interventions to reduce downstream impacts.

Integrated Insights and Policy Relevance

Integrating Land and Climate Impacts for Environmental Flow Management



- Downstream (Subbasins 1, 2, and 8 – Urban–Agro–Coastal Interface):
  - Highly fragmented land cover including paddy rice, aquaculture, and high-density urban areas, as shown in the zoom-in map.
  - These areas experience intense flow convergence and are most vulnerable to flooding, erosion, and sediment accumulation.
  - The presence of mature mangrove forests in the coastal fringe underscores the need for sustained freshwater flows to support estuarine ecosystems.
  - These are priority zones for environmental flow regulation, flood protection infrastructure, and integrated land–water policies.
- Policy Relevance:
  - A spatially explicit analysis from headwaters to coast links land use, hydrology, and ecosystem services.
  - Supports evidence-based planning for watershed management, climate resilience, and the long-term sustainability of downstream communities and ecosystems.

Summary and Key FIndings

- The SWAT+ model was successfully calibrated and validated for the Aklan River Basin, showing strong model performance for simulating flow and sediment.
- Land cover changes from 1990 to 2020 reveal a significant reduction in forest cover and expansion of agriculture and urban areas, especially in midstream and downstream zones.
- Sediment yield hotspots were observed in deforested and cultivated subbasins, highlighting land degradation risks.
- Environmental flow indicators (Q10, Q50, Q95) vary across subbasins, with downstream areas showing more variable flow regimes due to land use intensity.
- Climate change projections under SSP5-8.5 show increasing flows, especially during wet months, with potential flood risks in lowland areas and altered dry-season flows.

Conclusion and Policy Implications

- Forest protection in upstream subbasins is essential for regulating baseflows and reducing sediment load.
- Midstream and downstream areas need targeted land use management and sediment control to stabilize hydrologic regimes.
- Sustaining freshwater inflows to mangrove-rich coastal zones is crucial for ecological health and flood buffering.
- Climate-smart water management should incorporate future flow scenarios to inform infrastructure and land planning.
- Environmental flow assessments can guide decision-making for basin-scale policy, water allocation, and ecological conservation.

Thank you for listening!

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