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



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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 Eflows

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 km², 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



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	\leftrightarrow 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 R² = 0.69, NSE = 0.71, and RSR = 0.56.
- Validation (2014–2018) also performed well with R² = 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

= 3.1544x + 960.23

Nov

Oct

Dec

How Do These Land Cover Changes Affect Flow and Sediment?



Annual Average Discharge Q

- 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



Annual Sediment Yield

v = 0.0892x + 37.282

- 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.

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2010s

Defining Environmental Flow Thresholds in Aklan River

Flow Duration Curve with Environmental Flow Indicators



Environmental Flow Indicators

Q10 = 2586.6 m³/s: Represents high flow conditions exceeded only 10% of the time — important for sediment flushing and habitat resetting.

Q50 = 638.03 m³/s: The median flow, showing typical daily or monthly conditions — often used for habitat suitability assessments.

 $Q95 = 26.1 \text{ m}^3/\text{s}$: 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

- Annual Crop
 Barren Land
 Forests
 Grassland
 Permanent Crop
 Paddy Rice
 Shrubland
 Urban High Density
 Urban Low Density
 Water
 Aquaculture
 Masaganary
 - Mangroves

- Subbasin 8 in the northeastern delta exhibits the highest Q10 (157.17 m³/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 m³/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 temperat



Month	(°C)	Range*	2021-2050	2031-2060	2041-2070	2051-2080	2061-2090	2071-2100
		Upper Bound	27.3 (1.8 °C)	27.7 (1.4 'C)	27.9 (1.6 °C)	28.2 (1.9 °C)	28.7 (2.4.10)	29.1 (2.8 10)
January	26.3		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 *0)
	2010	Lour David	27.0 (0.7 °C)	27.2 (0.9 °C)	27.3 (1.0 %)	27.4 (1.1 'C)	27.5 (1.2 %)	27.6 (1.2 'C)
		Upper Bound	27.7 (1.1 °C)	28.0 (1.4 °C)	28.3 (1.7 'C)	20.6 (2.8 'C)	28.9 (2.3 %)	29.3 (2.7 'C)
February	26.6	them	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)	28.5 (2.0 °C)
		Low Band	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)
		Upper Black	28.6 (1.1 °C)	28.8 (1.3 °C)	29.2 (1.7 °C)	29.5 (2.0 °C)	30.0 (2.6 °C)	30.4 (2.9 10)
March	27.5	Median .	28.4 (0.9 °C)	28.8 (1.1 °C)	28.8 (1.3 'C)	29.1 (1.8 °C)	28.3 (1.8 °C)	29.5 (2.0 *C)
		Lower Baund	28.1 (D.8 "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)
		Very-Brand	29.7 (1.1 °C)	30.1 (1.5 °C)	30.4 (1.8 °C)	30.8 (2.2.*0)	31.3 (2.7 *C)	31.7 (3.1 *0)
April	28.6	Medan	29.5 (0.9 °C)	29.8 (1.2 °C)	30.0 (1.4 °C)	30.3 (1.7 °C)	38.6 (2.0 °C)	30.8 (2.2 °C)
		Low-Board	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)
		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 %)	32.0 (3.2 °C)
May	28.8	Median	29.7 (0.9 °C)	39.8 (1.2 °C)	30.3 (1.5 °C)	30.6 (1.7 °C)	30.8 (2.0 °C)	31.0 (2.2 °C)
		Less Band	29.6 (0.8 °C)	29.8 (1.0 °C)	29.9 (1.1 °C)	30.0 (1.2 *C)	30.1 (1.2 °C)	30.1 (1.3 *C)
		Upper Round	29.2 (1.0 °C)	29.5 (1.4 °C)	30.0 (1.8 °C)	30.3 (2.1 *0)	38.8 (2.6 *C)	31.2 (3.0 °C)
June	28.2	Made:	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)	28.4 (1.2 °C)	25.4 (1.2 °C)
		Upper Brand	28.6 (1.0 °C)	29.0 (1.4 °C)	29.4 (1.8 °C)	29.7 (2.1 *0)	30.1 (2.5 °C)	30.6 (3.0 °C)
July	27.6	Bedan	28.4 (0.8 °C)	28.7 (1.1 °C)	29.0 (1.4 °C)	29.2 (1.6 °C)	28.4 (1.8 °C)	29.7 (2.1 °C)
		Low-Beard	28.3 (0.7 °C)	28.5 (9.9 °C)	28.6 (1.0 °C)	26.7 (1.1 °C)	28.8 (1.2 °C)	28.8 (1.2 °C)
		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)
August	27.6	Bedan	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 * 0)
		Lower Broad	28.4 (0.8 °C)	28.6 (1.0 °C)	28.7 (1.1 "C)	28.8 (1.2 °C)	28.9 (1.2 °C)	28.9 (1.3 °C)
		Upper Bound	28.7 (1.1 °C)	29.9 (1.4 °C)	29.4 (1.8 °C)	29.8 (2.2 *0)	30.3 (2.7 °C)	30.7 (3.1 °C)
leptember	27.6	Mindan	28.5 (0.9 °C)	28.7 (1.1 °C)	29.0 (1.4 °C)	29.2 (1.6 °C)	28.4 (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)
		Vepr: Band	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)	30.8 (2.9 °C)
October	27.6	Hele	28.4 (0.8 °C)	28.6 (1.0 °C)	28.9 (1.3 °C)	29.1 (1.5 °C)	28.4 (1.8 °C)	29.6 (2.6 °C)
		Lown 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)
		Upper Banad	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 (2.5 *C)
lovember	27.5	Biller	28.4 (0.9 °C)	28.6 (1.1 °C)	28.8 (1.3 °C)	29.1 (1.6 °C)	28.4 (1.9 °C)	29.6 (2.1 °C)
		Lour Band	28.2 (0.7 °C)	28.4 (0.9 °C)	28.6 (1.1 °C)	28.6 (1.1 °C)	28.7 (1.2 %)	28.7 (1.2 °C)
		Upper Brand	27.9 (1.0 °C)	28.1 (1.3 °C)	28.5 (1.7 °C)	28.9 (2.0 *C)	29.2 (2.4 °C)	29.6 (2.8 °C)
December	26.8	Nedan	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)
er 710 januarile		Lower Broad	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)
	CLIRA	M of the	projected cha	nges in month		dan		mperature
	CLIRA			nges in monthl	ojected Monthly	dan Mean Rainfall (m	(m)	
le A - 4.2	CLIRA	M of the Range*	2021-2050	nges in monthl Pro 2031-2060	ojected Monthly 2041-2070	dan Mean Rainfall (m 2051-2080	m) 2061-2080	2071-2100
le A - 4.2	Coserved baseline (mm)		2021-2050 125.0 (+23.6 %)	nges in month Pro 2031-2060 127.9 (+26.5%)	ojected Monthly 2041-2070 133.1 (+31.7 %)	tlan Mean Rainfall (m 2051-2050 134.3 (+32.8 %)	m) 2061-2090 134.6 (+32.1 %)	2071-2100 133.6 (+32.8 %)
le A - 4.2	CLIRA	Range*	2021-2050 125.0 (+23.6 %) 107.5 (+6.3 %)	nges in month Pro 2031-2060 127.9 (+28.5%) 112.0 (+11.8%)	2041-2070 133.1 (+31.7 %) 119.9 (+8.7 %)	clan Mean Rainfall (m 2051-2080 124.3 (+22.8 %) 108.9 (+7.7 %)	m) 2061-2090 134.6 (+32.1 %) 112.0 (+11.8 %)	2071-2100 133.6 (+22.8 %) 108.6 (+7.4 %)
le A - 4.2	Coserved baseline (mm)	Range* Igen Baard Binder Lane Baard	20215050 125.0 (+23.6 %) 107.5 (+6.3 %) 94.0 (-7.0 %)	nges in month Pro 2001-2060 127.9 (+28.5 %) 112.0 (+11.8 %) 95.9 (-8.0 %)	2041-2070 133,1 (+31,7 %) 118,9 (+8,7 %) 94,3 (-8,7 %)	clan Mean Rainfall (m 2051-2080 134.3 (+32.8 %) 108.9 (+7.7 %) 92.3 (+8.7 %)	m) 2061-2010 134.6 (+33.1 %) 113.0 (+11.8 %) 92.4 (-8.4 %)	2071-2100 133.6 (+22.8 %) 108.6 (+7.4 %) 29.1 (-11.8 %)
ile A - 4.2 Monta January	Observed Localiza (rem)	Rango* Hore Road Hore Laser Road	2021-2050 128.0 (+23.6 %) 107.5 (+6.3 %) 94.0 (-7.0 %) 87.0 (+16.6 %)	nges in month Pr 2031-2000 127.9 (+26.5 %) 113.0 (+11.8 %) 35.9 (+6.9 %) 09.6 (+0.0 %)	ojected Monthly 2041-2070 133,1 (+31,7 %) 110,9 (+8,7 %) 94,3 (-8,7 %) 91,4 (+22,8 %)	clan Mean Rainfall (m 2051-2080 134.3 (+22.8 %) 109.8 (+7.7 %) 92.3 (+3.7 %) 87.6 (+17.6 %)	m) 2051-2010 134.5 (+32.1 %) 112.0 (+11.8 %) 32.4 (-8.4 %) 83.7 (+20.2 %)	2071-2100 133.5 (+22.0 %) 108.6 (+7.4 %) 89.1 (+11.9 %) 89.5 (+20.0 %)
ile A - 4.2 Monta January	Coserved baseline (mm)	Range* Here Road Here Road Here Road Here Road	2021-2050 128.0 (+22.6 %) 107.5 (+6.3 %) 94.0 (-7.0 %) 87.0 (+16.6 %) 76.5 (+2.6 %)	nges in month Pro 2039-2000 127-9 (+26.5 %) 113.0 (+11.8 %) 95.9 (+0.0 %) 76.9 (+0.0 %) 76.9 (+0.1 %)	ojected Monthly 2041-2070 133.1 (+31.7 %) 110.8 (+9.7 %) 94.3 (-42.8 %) 78.1 (+6.9 %)	dan Mean Rainfall (m 2051-2080 134.3 (+22.8 %) 100.8 (+7.7 %) 92.3 (+8.7 %) 87.8 (+2.7 %) 76.6 (+2.7 %)	m) 2051-2090 1026 (+033 1%) 113.0 (+11.8 %) 92.4 (+8.4 %) 92.4 (+8.4 %) 93.7 (+20.2 %) 76.1 (+20.3 %)	2074-2100 133.5 (+22.0 %) 108.6 (+7.4 %) 89.5 (+20.0 %) 74.8 (+0.3 %)
ile A - 4.2 Monta January	Coscented Localities (rect)	Range* Here Asset Here Asset Here Asset Here Asset	20212000 128.0 (+22.6 %) 107.6 (+6.3 %) 96.0 (+7.0 %) 87.0 (+16.6 %) 76.6 (+2.6 %) 67.2 (-6.8 %)	2031-2060 2231-2060 2231-2060 2231-2060 2231-2060 2351-2060 2351-2000 2351-2000 2000 2000000000000000000000000000	ojected Monthly 2041-2070 123.1 (+31.7 %) 110.0 (+8.7 %) 94.3 (+82.8 %) 78.1 (+6.9 %) 70.3 (-6.8 %)	clan Mean Rainfall (m 2051-2080 134.3 (+32.8 %) 100.8 (+7.7 %) 92.3 (+47.%) 87.6 (+17.8 %) 76.6 (+27.5 %) 66.7 (-11.9 %)	m) 2001-2000 134.6 (+33.1 %) 132.0 (+11.8 %) 32.4 (+3.4 %) 35.7 (+20.2 %) 76.1 (+20.5 %) 64.7 (+13.3 %)	2074-2100 133.5 (+22.0 %) 108.6 (+7.4 %) 89.5 (+22.0 %) 74.8 (+20.0 %) 74.8 (+0.3 %) 62.0 (-16.9 %)
ile A - 4.2 Month January February	101.1	Ranger Here Same Here Law Rand Here Law Rand Law Rand Law Rand	2021+2050 128 0 (+22 6 %) 107.5 (+6.3 %) 94.0 (-7.0 %) 87.0 (+16.8 %) 76.5 (+2.5 %) 67.2 (-6.8 %) 99.1 (+18.0 %)	2031-2060 2031-2060 2078 (+26.5%) 112.0 (+11.8%) 95.0 (4.0%) 06.5 (+20.0%) 76.9 (+20.0%) 76.4 (+20.0%) 95.6 (+17.4%)	ojected Monthly 2041-2070 123.1 (+31.7 %) 110.0 (+8.7 %) 94.3 (+8.7 %) 91.4 (+22.8 %) 76.1 (+6.0 %) 76.3 (+6.8 %) 96.8 (+15.2 %)	Clan Mean Rainfall (m 2051-2050 134-2 (+22.8 %) 100.8 (+7.7 %) 92.3 (+7.7 %) 97.6 (+7.6 %) 76.6 (+2.7 %) 98.5 (+17.3 %)	m) 2061-2010 134.6 (+33.3 %) 133.0 (+11.8 %) 22.4 (+3.5 %) 25.7 (+20.2 %) 26.8 % (+20.5 %) 26.4 (+14.8 %)	2071-2100 133.5 (+22.6 %) 108.6 (+24.6 %) 89.5 (+26.0 %) 74.8 (+0.3 %) 62.0 (+36.9 %) 95.8 (+14.0 %)
ile A - 4.2 Monta January	Coscented Localities (rect)	Rango ^a New Road New Road New Road New Road New Road New Road	2021-2050 128.0 (+28.6 %) 107.8 (+6.3 %) 54.0 (-7.0 %) 87.0 (+18.8 %) 76.8 (+2.8 %) 67.2 (-4.8 %) 39.1 (+18.0 %) 34.3 (+6.4 %)	nges in monthl Pro 2031-2060 127.9 (-26.5%) 112.0 (-11.8%) 95.9 (-20.5%) 95.8 (-20.5%) 76.9 (-2.1%) 76.9 (-2.1%) 95.8 (-17.4%) 95.8 (+7.4%) 95.8 (+7.4%) 95.8 (+7.4%)	ojected Monthly 2041-2070 1323 (+35.7 %) 110.8 (+8.7 %) 94.3 (+8.7 %) 95.8 (+8.7 %) 78.1 (+6.0 %) 78.3 (+8.8 %) 96.8 (+5.2 %) 85.8 (+5.2 %)	dan Mean Rainfall (m 2051-2010 134.3 (+32.6 %) 100.8 (+7.7 %) 92.3 (+37.6 %) 77.6 (+2.7 %) 93.5 (+17.3 %) 93.5 (+17.3 %) 93.5 (+17.3 %)	m) 2051-2010 194.5 (434.1 %) 193.6 (413.5 %) 294.4 (48.5 %) 88.7 (420.%) 78.1 (420.%) 88.4 (416.3 %) 88.3 (48.5 %) 83.3 (48.5 %)	2074-2160 133.6 (+22.0 %) 108.6 (+7.4 %) 293.5 (+13.9 %) 295.6 (+20.0 %) 74.8 (+0.3 %) 205.6 (+14.0 %) 21.5 (-3.0 %) 21.5 (-3.0 %)
ile A - 4.2 Month January February	101.1	Ranger Hore Band Hore Land Band Hype Band Hore Land Band Hore Hore Hore Land Band Hore Land Band	2021-2050 128.0 (+25.6 %) 107.8 (+25.6 %) 84.0 (+2.5 %) 87.0 (+18.6 %) 75.8 (+2.8 %) 95.1 (+18.6 %) 84.3 (+4.6 %) 75.8 (+8.8 %)	nges in month Pr 2031-2060 1272 (+225-53) 1122 (+113-53) 955 (+20,53) 955 (+20,53) 955 (+20,53) 955 (+20,53) 955 (+20,53) 955 (+72,453) 955 (+72,453) 955 (+72,453)	ojected Monthly 2041-2070 122.1 (+23.7 %) 910.8 (+27.%) 94.2 (+27.%) 94.2 (+27.%) 95.8 (+22.8 %) 95.8 (+52.5 %) 72.4 (+32.6 %)	dan Mean Rainfall (m 2051-2060 104.3 (+22.5 %) 92.3 (+27.5 %) 92.3 (+27.5 %) 92.3 (+27.5 %) 92.5 (+27.5 %) 93.5 (+17.5 %) 93.5 (+17.5 %) 93.6 (+2.5 %) 93.6 (+2.5 %)	m) 2061-2010 1346 (+03.3 %) 13.0 (+14.8 %) 32.4 (+8.6 %) 83.7 (+20.%) 64.7 (+13.3 %) 84.4 (+14.8 %) 84.3 (+14.8 %) 84.3 (+14.8 %) 7.18 (+16.5 %)	2071-2100 113.6 (+72.6 %) 190.6 (+72.4 %) 89.5 (+73.9 %) 89.6 (+72.9 %) 42.0 (+72.9 %) 85.6 (+12.0 %) 81.6 (+3.0 %) 81.6 (+3.0 %) 81.6 (+3.0 %)
le A - 4.2 Montes January February March	00100000 10111 10111 74.6 86.0	Range Sant Sene Sant	2024-2050 1220 (+228 %) 107.6 (+2.3 %) 94.6 (+7.0 %) 87.6 (+2.6 %) 76.5 (+2.6 %) 96.1 (+18.0 %) 84.3 (+18.0 %) 84.3 (+12.5 %)	nges in month Pro 2031-2060 1977 (+28.5%) 113.0 (+11.8%) 555 (+0.5%) 555 (+0.5	2041-2070 2041-2070 123.6 (+21.7 %) 110.9 (+21.7 %) 110.8 (+21.8 %) 110.4 (+22.8 %) 110.8 (+22.8 %) 1	clan Mean Rainfall (m 2051-2060 1243 (1928.5%) 100.8 (1927.5%) 92.3 (427.5%) 92.3 (427.5%) 92.5 (497.5%) 93.5 (497.5%) 94.2 (49.2.5%) 94.2 (49.2.5%) 94.2 (49.2.5%)	m) 2051-2060 154.6 (+23.5 %) 152.6 (+23.5 %) 152.6 (+23.5 %) 152.6 (+24.8 %) 152.6 (+24.8 %) 153.6 (+24.8 %) 153.6 (+34.8 %) 171.8 (+15.8 %) 171.8 (+	2074-2100 123.5 (+22.6 %) 100.6 (+7.4 %) 29.5 (+22.6 %) 74.8 (+0.3 %) 20.5 (+22.6 %) 74.8 (+0.3 %) 20.5 (+22.6 %) 21.5 (+0.5 %) 41.5 (+0.0 %) 49.6 (+7.1 %) 79.7 (+4.8 %)
ile A - 4.2 Month January February	101.1 74.6	Ranger Hore Band Hore Land Band Hype Band Hore Land Band Hore Hore Hore Land Band Hore Hore Land Hore	2021-2050 125.0 (+23.6 %) 107.6 (+6.3 %) 94.0 (+7.0 %) 76.5 (+2.6 %) 76.5 (+2.6 %) 76.5 (+2.6 %) 76.5 (+2.6 %) 76.6 (+2.6 %) 76.6 (+2.6 %) 76.6 (+2.5 %) 76.6 (+2.5 %)	nges in monthl Pro 2031-2063 127.9 (126.5%) 112.0 (11.8%) 95.0 (40.%) 95.0 (40.%) 95.0 (40.%) 95.0 (40.%) 95.0 (40.%) 95.0 (40.%) 95.0 (40.%) 75.2 (40.%) 75.2 (40.%)	ojected Monthly 2041-2070 123.1 (+31.7 %) 110.2 (+37.%) 94.2 (+37.%) 94.3 (+37.%) 78.1 (+60.%) 78.1 (+60.%) 78.1 (+60.%) 85.8 (+23.%) 85.8 (+23.%) 72.8 (+38.4 %) 85.8 (+2.3 %) 72.8 (+38.4 %) 85.8 (+2.3 %) 74.6 (+2.6 %)	dan Mean Rainfall (m 2051-2010 1243 (+22.5 %) 100.8 (+7.7 %) 92.2 (+2.7 %) 92.3 (+7.7 %) 93.5 (+7.7 %) 95.5 (+7.7 %) 95.5 (+7.7 %) 95.5 (+7.7 %) 95.5 (+7.7 %) 95.5 (+7.5 %) 95.5 (+7.	m) 2051-2050 134.6 (+23.1 %) 132.6 (+12.5 %) 237.6 (+22.5 %) 247.6 (+22.5 %) 258.7 (+12.5 %) 258.6 (+12.6 %) 218.6 (+	2074-2100 133.6 (+7.4 %) 393.5 (+7.4 %) 393.5 (+7.4 %) 393.5 (+7.2 %) 393.5 (+7.3 %) 31.5 (+2.3 %) 31.5 (+2.3 %) 31.5 (+2.3 %) 31.5 (+2.4 %) 31.5 (+2.4 %) 31.5 (+2.4 %) 31.5 (+2.4 %)
le A - 4.2 Montes January February March	00100000 10111 10111 74.6 86.0	Ranger Here have Here have Lever have Here Gyre have Here Here Lever have Uppe have Here Lever have Uppe have Here Lever have	2021-2050 125.0 (+23.6 %) 107.5 (+6.3 %) 84.0 (+2.5 %) 87.2 (+8.5 %) 87.2 (+8.5 %) 85.3 (+0.4 %) 75.8 (+8.5 %) 75.8 (+8.5 %) 75.8 (+8.5 %) 75.6 (+2.5 %) 75.8 (+	nges in monthi Pro 2031-2000 1272 (+026.5%) 1120 (+11.8%) 556 (+02.6%) 556 (+02.6%) 565 (+02.0%) 565 (+02.0%) 566 (+17.4%) 578 (+0.5%) 578	ojected Monthly 2041-2070 133.1 (+33.7 %) 115.8 (+87.%) 94.4 (+87.%) 94.8 (+87.%) 94.8 (+52.%) 75.1 (+60.%) 75.3 (+60.%) 75.3 (+60.%) 75.4 (+52.%) 72.6 (+12.6 %) 85.8 (+22.5 %) 72.6 (+12.6 %) 82.3 (+17.6 %)	Clan Mean Reinfold (m 2051-2010 142 g 1922 50 1908 (+7.7 %) 923 (+7.7 %) 923 (+7.7 %) 925 (+7.7 %) 935 (+7.7 %) 945 (+7.7 %) 945 (+7.7 %) 945 (+7.7 %) 945 (+7.7 %) 945 (+7.5 %) 954 (+2.7 %) 730 (+3.5 %) 954 (+2.3 %)	m) 2051-2010 134.6 (+0.33.5%) 132.6 (+0.33.5%) 132.6 (+0.12.5%) 232.4 (+0.45.5%) 233.4 (+0.45.5%	2074-2160 132.6 (+22.6 %) 198.6 (+22.6 %) 293.1 (+13.6 %) 293.1 (+13.6 %) 203.6 (+13.6 %) 203.
lle A - 4.2 Mento January February March April	Coscored Loocenee (energy) 101.1 74.6 84.0 75.5	Range Sant Sene Sant	2021-2050 128.0 (+23.6 %) 107.6 (+2.5 %) 25.0 (+2.5 %) 25.0 (+2.5 %) 27.2 (+2.5 %) 27.2 (+2.5 %) 27.2 (+2.5 %) 25.1 (+2.5 %) 25.0 (+2.5 %) 25.0 (+2.5 %)	nges in month Pro 2003-2060 127.9 (+26.5 %) 113.0 (+11.8 %) 156.9 (+20.5 %) 156.9 (+20.5 %) 156.9 (+20.5 %) 156.9 (+20.5 %) 156.9 (+15.2 %) 156.9 (+5.2 %) 156.9 (+	ojected Monthly 2041-2020 1223 (+23.7%) 1158 (+27%) 453 (+27%) 453 (+27%) 453 (+27%) 783 (+25%) 784 (+22%) 858 (+22%) 858 (+22%) 784 (+26%) 784 (+26%) 784 (+26%) 784 (+26%) 784 (+26%)	Lan Maan Rainfall (m 2651-2016) 124.3 (+27.5) 92.3 (+27.5) 92.3 (+27.5) 92.3 (+27.5) 64.7 (+17.6 %) 64.7 (+17.6 %) 64.7 (+17.6 %) 94.5 (+27.5 %) 94.2 (+27.5 %) 95.2 (+27.5 %) 95.2 (+26.5 %) 95.4 (+21.5 %) 95.4 (+21.5 %) 95.4 (+21.5 %) 95.4 (+21.5 %)	m) 2061-2010 134.6 (+03.1 %) 433.0 (+113.%) 433.0 (+113.%) 437.(+20.%) 437.(+	2071-2100 112.6 +1-20.5% 108.6 +1-7.4 % 199.1 (-11.9 %) 45.6 (-12.6 %) 45.8 (-12
le A - 4.2 Montes January February March	00100000 10111 10111 74.6 86.0	Ranger Here have Here have Lever have Here Gyre have Here Here Lever have Uppe have Here Lever have Uppe have Here Lever have	2021-2050 125.0 (+23.6 %) 107.5 (+6.3 %) 84.0 (+2.5 %) 87.2 (+8.5 %) 87.2 (+8.5 %) 85.3 (+0.4 %) 75.8 (+8.5 %) 75.8 (+8.5 %) 75.8 (+8.5 %) 75.6 (+2.5 %) 75.8 (+	nges in monthl Pro 2031-2000 1272 (+026.5%) 1132 (+11.8%) 555 (+02.5%) 555 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%) 758 (+02.5%)	ojected Monthly 2041-2070 133.1 (+33.7 %) 115.8 (+87.%) 94.4 (+87.%) 94.8 (+87.%) 94.8 (+52.%) 75.1 (+60.%) 75.3 (+60.%) 75.3 (+60.%) 75.4 (+52.%) 72.6 (+12.6 %) 85.8 (+22.5 %) 72.6 (+12.6 %) 82.3 (+17.6 %)	Clan Masar Reinfold (m 2051-2010 143 2 (+22,8 %) 1908 (+7,7 %) 923 (+2,7 %) 923 (+2,7 %) 935 (+17,3 %) 945 (+12,3 %) 946 (+12,3 %) 946 (+12,3 %)	m) 2051-2010 134.6 (+0.33.5%) 132.6 (+0.33.5%) 132.6 (+0.12.5%) 232.4 (+0.45.5%) 233.4 (+0.45.5%	2071-2100 1136 6 (+2.2.5%) 1906 6 (+2.4%) 2931 (+13.9%) 293 (+12.9%) 293 (+2.4%) 293 (+2.4%) 293 (+2.4%) 293 (+2.4%) 293 (+2.5%) 293 (+2.5
lle A - 4.2 Mento January February March April	Coscored Loocenee (energy) 101.1 74.6 84.0 75.5	Rango Japa Baad Japa Baad Laar Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad	$\begin{array}{c} 2021 \pm 000\\ 120 & 0 \left(\pm 23.6 \ hg)\\ 107.6 \left(\pm 23.6 \ hg)\\ 34.6 \left(\pm 27.6 \ hg)\\ 37.6 \left(\pm 25.6 \ hg)\\ 76.6 \left(\pm 25.6 \ hg)\\ 39.1 \left(\pm 18.6 \ hg)\\ 76.8 \left(\pm 25.6 \ hg)\\ 76.8 \left(\pm 25.6 \ hg)\\ 76.8 \left(\pm 25.6 \ hg)\\ 56.0 \left(\pm 7.6 \ hg)\\ 46.7 \left(\pm 25.6 \ hg)\\ 46.7 \left(\pm 25.6 \ hg)\\ 46.7 \left(\pm 25.6 \ hg)\\ 51.6 \left(\pm 25.6 \ hg)\\ 515.6 \left(\pm 55.6 \ hg)\\ 515.6 \left(\pm 55.6$	nges in monthil Pro 2031-2060 11279 (+28.5%) 1138 (+11.8%) 959 (48.0%) 959 (48.0%) 958 (+00.0%) 758 (+6.6%) 958 (+07.4%) 758 (+6.4%) 758 (+6.4%) 758 (+6.4%) 268 (+5.4%) 268 (+5.4\%) 268	ojected Monthly 2041-2070 122.6 (+21.7 %) 119.8 (+27.%) 94.8 (+27.%) 94.8 (+22.8 %) 78.1 (+60.%) 12.6 (+52.%) 72.6 (+32.6 %) 72.6 (+32.6 %) 72.6 (+32.6 %) 72.6 (+32.6 %) 20.8 (+3	Lan Maan Rainfall (m 2051-2010 1143-21228,5-33 1008 (+7.7-5), 923 (+8.7-5), 923 (+8.7-5), 923 (+7.5-5), 924 (+9.2-7-5), 935 (+7.3-5), 935 (+7.3-5), 935 (+7.3-5), 935 (+7.3-5), 935 (+7.3-5), 936 (+7.	m) 2051-2010 154.6 (+3.8.5) 153.6 (+3.8.5) 25.4 (+3.8.5) 25.4 (+3.8.5) 25.4 (+3.8.5) 25.4 (+3.8.5) 25.4 (+3.8.5) 25.4 (+3.8.5) 25.5	2071-2100 133 6+22.5 %) 198.6 (+7.4 %) 29.1 (+1.9 %) 39.6 (+2.6 %) 42.6 (+2.6 %) 42.6 (+2.6 %) 45.6 (+2.6 %) 45.6 (+2.6 %) 45.6 (+2.6 %) 45.7
lle A - 4.2 Mento January February March April	Coscored Loocenee (energy) 101.1 74.6 84.0 75.5	Rango Japa Baad Japa Baad Laar Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad Japa Baad	2021-2040 1250 (+236 %) 1076 (+436 %) 940 (70 %) 870 (+56 %) 950 (70 %) 951 (+186 %) 953 (+186 %) 953 (+186 %) 953 (+186 %) 953 (+25 %) 756 (+73 %) 950 (+73 %) 1916 (+23 %	nges in monthil Pro 2031-2065 1727 9 (-2645 %) 1122 (-114 %) 956 (-405 %) 956 (-405 %) 956 (-405 %) 956 (-405 %) 956 (-405 %) 956 (-114	0(ected Monthly) 2041-2070 133.1 (437.7%) 1108 (457.7%) 81.8 (427.%) 81.8 (427.%) 81.8 (427.%) 81.8 (427.%) 81.8 (427.%) 81.8 (427.%) 81.9 (427.%) 204.0 (448.%) 204.0 (448.%) 1987 (428.%)	dan Maan Rainfall (m 2651-2010 1243 (+22.8 %) 1243 (+22.8 %) 1243 (+22.8 %) 1243 (+22.8 %) 1243 (+22.8 %) 1242 (+22.8 %) 1242 (+22.8 %) 1242 (+22.8 %) 1242 (+22.8 %) 1242 (+22.8 %) 1243 (+22.8 %) 1243 (+22.8 %)	11) 2051-2010 134.6 (-23.5 %) 134.6 (-23.5 %) 132.6 (-43.5 %) 132.6 (-43.5 %) 135.1 (-20.5 %) 135.2 (2071-2100 1136 6 (+2.2.5%) 1906 6 (+2.4%) 2931 (+13.9%) 293 (+12.9%) 293 (+2.4%) 293 (+2.4%) 293 (+2.4%) 293 (+2.4%) 293 (+2.5%) 293 (+2.5
lle A - 4.2 Month January February March April May	Coserved baseline (enn) 101.1 74.8 84.0 75.5 195.1	Ranger Spen South Hone South Learn South Spen South Spen South Spen South Spen South Spen South Spen South South South South South South South South South South South South South South South Spen South Spen South Spen South	$\begin{array}{c} 2021+2050\\ 1220(+228+56)\\ 107.5(+22.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 84.0(+2.5(+2))\\ 75.0(+2.5(+2))\\ 75.0(+2.5(+2))\\ 101.5(+2.2(+2))$	Bits Bits 2031-2060 127.9 127.9 143.6 127.9 143.6 127.9 143.6 127.9 143.6 127.9 143.6 127.9 143.6 128.2 143.6 128.4 143.5 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.6 128.2 143.7 128.2 143.7 128.2 143.7 128.2 143.7	ojected Monthly 2041-2070 122.0 (23.7 %) 118.8 (28.7 %) 94.3 (42.7 %) 94.5 (42.7 %) 95.8 (42.7 %) 128.6 (42.8 %) 128.6 (42.8 %) 128.6 (42.8 %) 128.6 (42.8 %) 128.6 (42.8 %) 129.6 (43.6 %) 129.6	Clan Mean Rainfall (m 2051-2010 1143 (1228.00) 1143	2011-2010 1046 (+23.5.%) 1130 (+11.8.%) 824 (+48.5) 827 (+20.5.%) 827 (+20.5.%) 827 (+20.5.%) 823 (+20.5.%) 824 (+20.5.%) 824 (+20.5.%) 824 (+20.5.%) 825 (+20.5	2074-2100 133.6 (+22.6 %) 136.6 (+2.4 %) 139.5 (+24.5 %) 139.5 (+24.6 %) 148.6 (+24.6 %) 148.6 (+24.6 %) 148.6 (+24.6 %) 149.6 (+7.1 %) 149.6 (+7.1 %) 149.6 (+2.6 %) 149.8 (+2.4 %) 149.8 (+2.4 %)
lle A - 4.2 Month January February March April May	Coserved baseline (enn) 101.1 74.8 84.0 75.5 195.1	Ranger Herr Bank Herr Lans Bank Herr Herr Herr Herr Herr Herr Herr Her	2021-2050 1250 (+22.6 %) 107.6 (+2.6 %) 84.0 (-7.0 %) 87.0 (+2.6 %) 87.2 (+2.6 %) 84.3 (+2.6 %) 84.3 (+2.6 %) 84.3 (+2.6 %) 84.3 (+2.5 %) 75.6 (+2.5 %) 210.4 (+7.3 %) 107.6 (+2.3 %) 107.6 (+2.3 %) 107.6 (+2.3 %) 107.6 (+2.5 %) 208.2 (+3.5	2015/000 1278 (-06.6 %) 1278 (-06.6 %) 1278 (-06.6 %) 1280 (-01.5 %) 1290 (-01.5	0(ected Monthly) 2041-2070 133.1 (+33.7%) 1108 (+67.7%) 51.6 (+65.7%) 51.6 (+57.7%) 51.6 (+57.7%) 51.6 (+57.7%) 51.6 (+57.7%) 51.6 (+25.7%) 51.6 (+25.7%) 51.6 (+25.7%) 20.6 (+26.7%) 20.6 (dan Ana Rainfall (m 2055 2006 194 (2023 Ba) 198	m) 2045-2040 154.6 (-25.1 %) 152.6 (-45.3 %) 887.7 (402.7 %) 887.7 (402.7 %) 98.4 (-154.8 %) 98.4 (-154.8 %) 98.4 (-154.8 %) 98.4 (-154.8 %) 28.4 (-1	2074-2100 1135 £1422.0 %) 1136 £147.4 %) 2015 £147.4 %) 2015 £147.4 %) 2015 £147.4 % 2015 £147.4 % 2015 £147.4 %) 2016 £147.4 %) 2017 £147.4
lle A - 4.2 Month January February March April May	Coserved baseline (enn) 101.1 74.8 84.0 75.5 195.1	Ranger Harr bankt Henn Lane Bankt Hyre Bankt Lane Bankt Lane Bankt Henn Harr Henn Lane Bankt Henn Lane Bankt Henn Lane Bankt Henn Lane Bankt	2021-2050 128.0 (+23.6 %) 107.6 (+6.2 %) 94.0 (+2.6 %) 47.8 (+2.6 %) 47.2 (+2.6 %) 47.8 (+2.6 %) 48.3 (+4.8 % %) 48.4 (+2.6 %) 101.6 (+2.5 %) 101.6	Bits Bits <th< td=""><td>0(ected Monthly) 2041-2070 123.7 (43.7 %) 110.9 (45.7 %) 110.1 (45.7 %) 1</td><td>dan Maan Rainfall (m 2051-2036 1942 1942 8 %) 923 1842 753 923 1842 753 926 1942 753 926 1942 753 935 6177 83% 945 (1942 753) 945 (1942 753) 1946 (1942 753) 1</td><td>107) 2065-2000 2046-2021-103 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0 1180-0</td><td>2071-2100 123 (1-22.5 %) 100.6 (1/2.6 %) 100.6 (1/2.6 %) 100.6 (1/2.6 %) 1768 (1-21.5 %) 1988 (1-21.6 %) 1988</td></th<>	0(ected Monthly) 2041-2070 123.7 (43.7 %) 110.9 (45.7 %) 110.1 (45.7 %) 1	dan Maan Rainfall (m 2051-2036 1942 1942 8 %) 923 1842 753 923 1842 753 926 1942 753 926 1942 753 935 6177 83% 945 (1942 753) 945 (1942 753) 1946 (1942 753) 1	107) 2065-2000 2046-2021-103 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0112-0 1180-0 1180-0	2071-2100 123 (1-22.5 %) 100.6 (1/2.6 %) 100.6 (1/2.6 %) 100.6 (1/2.6 %) 1768 (1-21.5 %) 1988 (1-21.6 %) 1988
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le A - 4.2 Mentos January February March April May June	Constant (ma) 101.1 74.6 86.0 75.5 196.1 351.5	Ranger Sand Seger Sand	20215000 1788 (e23 %) 956 (e23 %) 956 (e23 %) 956 (e23 %) 957 (e23 %) 953 (e23 %) 953 (e23 %) 953 (e23 %) 953 (e23 %) 953 (e23 %) 956 (e23	12312-000 12721-0255-500 12721-0255-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1275-50 1	Operated Monthly 2011/2010 1032 (4027 ml) 1038 (4027 ml) <tr< td=""><td>Maan Rainfall (m 2011-2014-2014) 1342-1242-30-30 0000-1977-30-30 923-147-75-30 927-1477-35-30 942-1422-75-30 945-1422-75-30 94</td><td>m) 2013-2016 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1547 (-0.54 h) 1547 (-0.54 h) 1546 (-0.54 h) 1546 (-0.54 h) 1547 (-0.54 h)</td><td>2015-2100 2015 6-220 5 % 2016 6-220 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 201</td></tr<>	Maan Rainfall (m 2011-2014-2014) 1342-1242-30-30 0000-1977-30-30 923-147-75-30 927-1477-35-30 942-1422-75-30 945-1422-75-30 94	m) 2013-2016 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1546 (-0.53 h) 1547 (-0.54 h) 1547 (-0.54 h) 1546 (-0.54 h) 1546 (-0.54 h) 1547 (-0.54 h)	2015-2100 2015 6-220 5 % 2016 6-220 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 2016 6-200 5 % 201
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- Source: DOST-PAGASA (2024), using CMIP6-based projections and the CLIRAM tool
- Scope: Provincial-scale projections for Aklan, downscaled at 1 km² 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



- 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):

Annual Cror

Grassland
 Permanent Cron

Paddy Rice

Aquaculture
 Mangroves

Urban - High Density
 Urban - Low Density

- 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



Mangroves

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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