ASSESSING THE IMPACTS OF CLIMATE CHANGE ON DEPENDABLE FLOW AND POTENTIAL IRRIGABLE AREA USING THE SWAT MODEL: THE CASE OF MAASIN RIVER WATERSHED IN LAGUNA, PHILIPPINES

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THE PROBLEM

- Climate change affects both dependable water supply and irrigation water requirements
- Climate change affects irrigable areas, cropping intensities and land productivity
- Need for quantitative impact assessment of climate change on irrigation parameters
- SWAT modeling is key

SOURCE: http://pnoys.com/wp-content/uploads/2015/06/Rice-drought-tolerance.jpg

SOURCE::
https://www.google.com/search?safe=active&biw=1366&bih=613&tbm=isch&sa=1&ei=czBpVV9bQE4_dhwO5l6SwDw&q=rice+during+floods+in+the+philippines&oq=rice+during&gs_l=img.1.0.35i39k1l2.5768.6998.0.9157.11.9.0.0.0.0.224.1011.0j4j2.6.0....0...1c.1.64.img..5.6.1011...0j0i67k1.0.Pj35dNU70e8#

OBJECTIVES

To assess the quantitative impacts of climate change on dependable flow and irrigable area under a typical irrigation system in the Philippines using the SWAT model

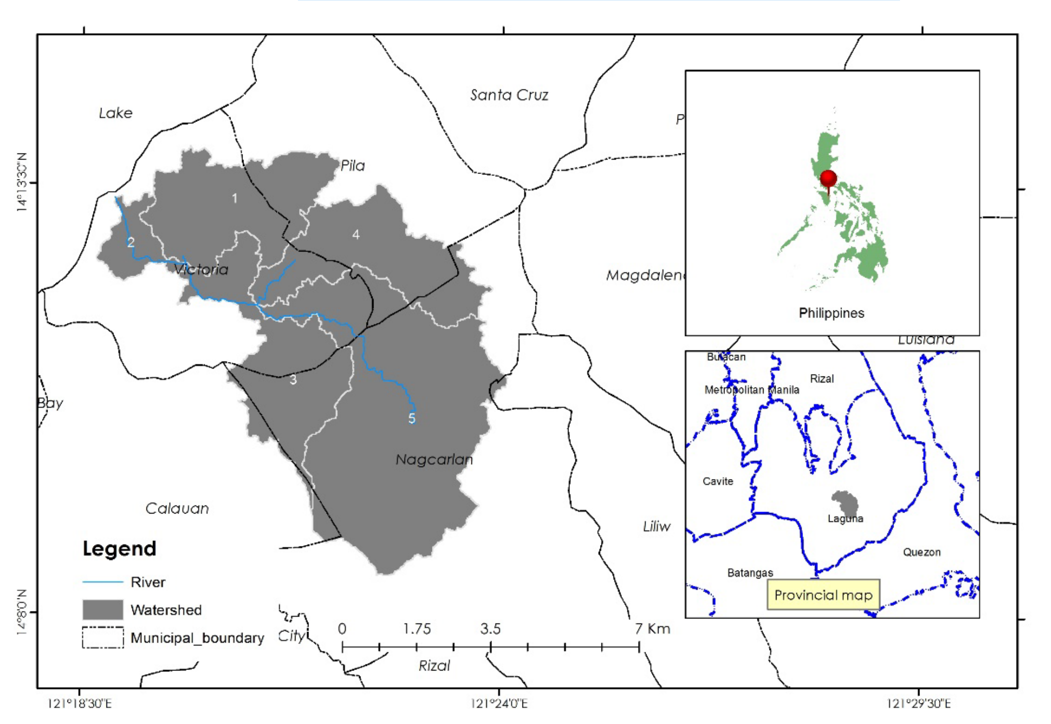
Specifically, it aims to:

1. Calibrate and validate SWAT model for Maasin River watershed
2. Estimate the dependable flow of the river under climate change scenarios
3. Estimate the irrigation water requirements under climate change scenarios
4. Estimate the potential irrigable area under climate change scenarios
5. Assess the overall impact of climate change on irrigation water supply and demand

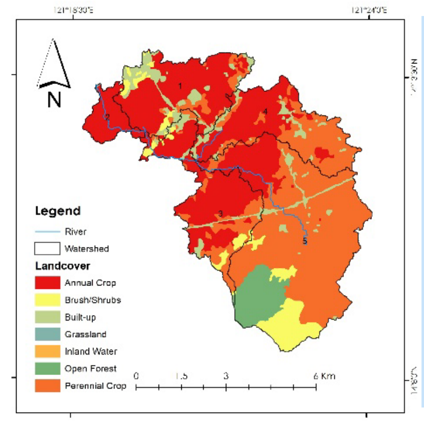
THE MAASIN RIVER WATERSHED

	Area (ha)	%Watershed Area
Landuse		
Annual Crop	2008	39.63
Brush/Shrubs	340	6.71
Built-up	359	7.09
Grassland	2	0.03
Open Forest	262	5.16
Perennial Crop	2097	41.38
SOILS:		
Clay	1632	32.2
Clay loam	865	17.06
Loam	2531	49.95
Water	40	0.79
SLOPE:		
0-3	1229	24.26
3-8	2132	42.08
8-18	992	19.58
>18	714	14.08

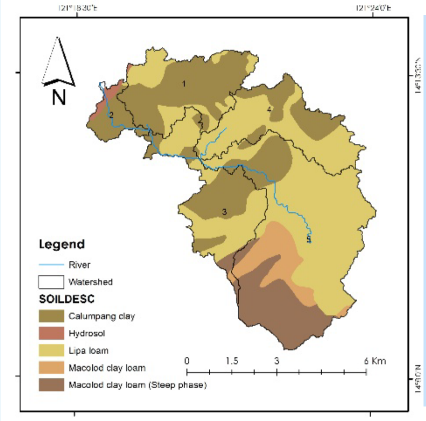
LOCATION MAP



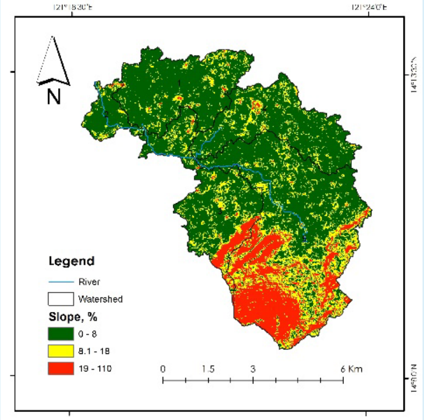
LANDCOVER



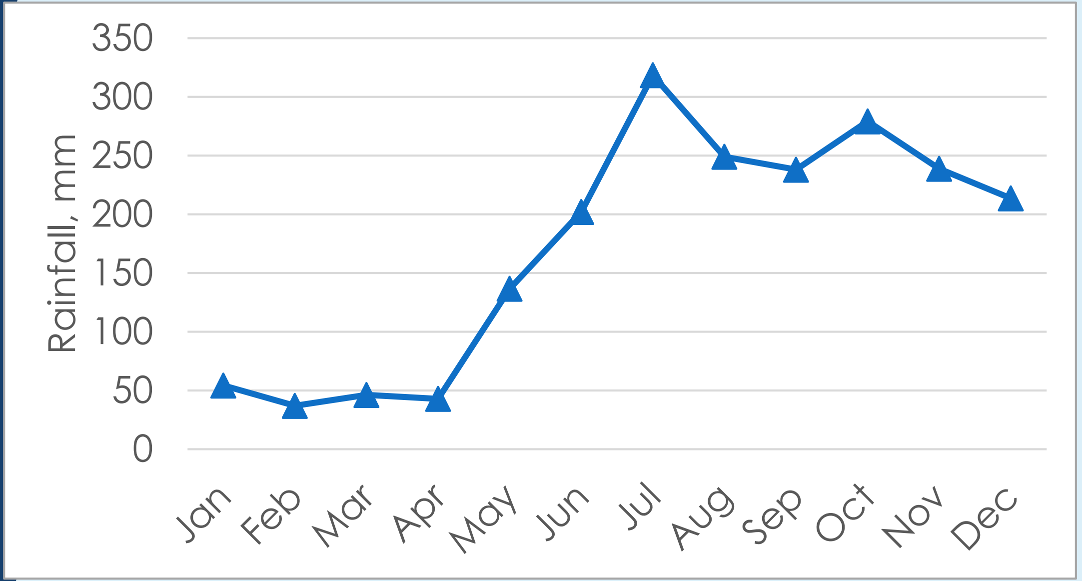
SOIL MAP

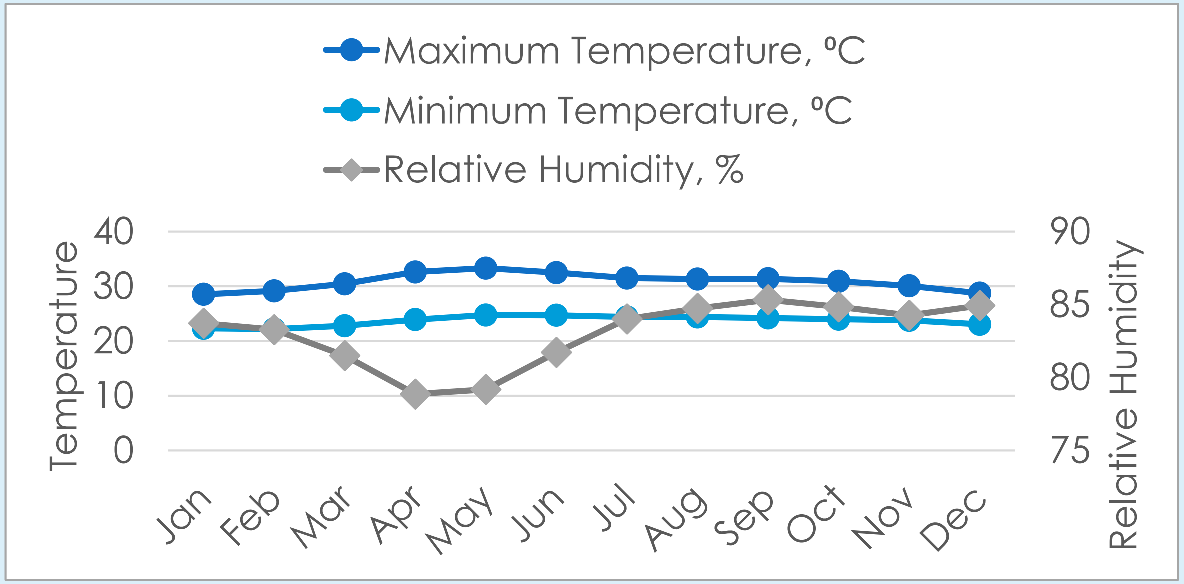


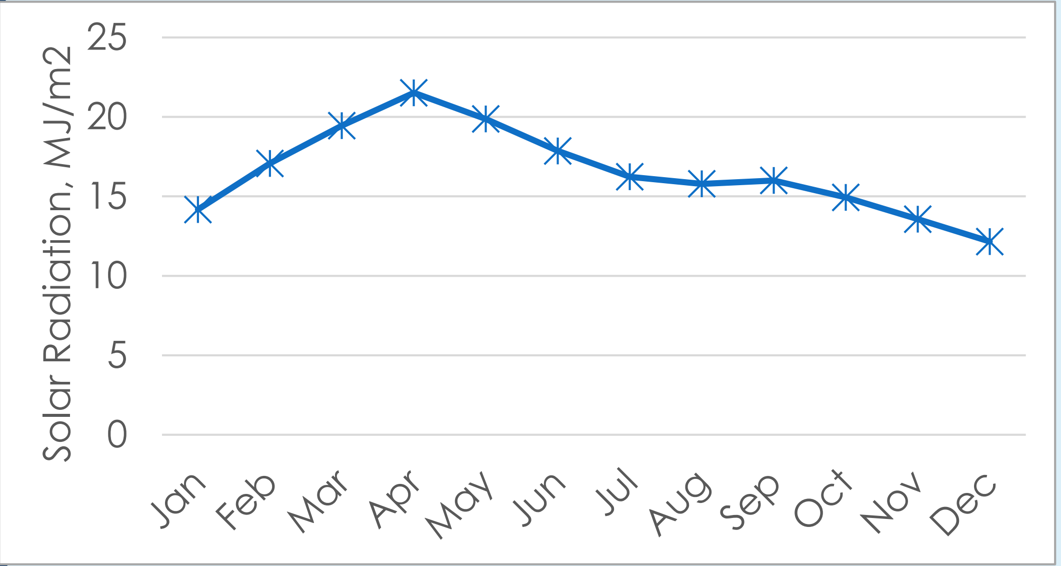
SLOPE MAP

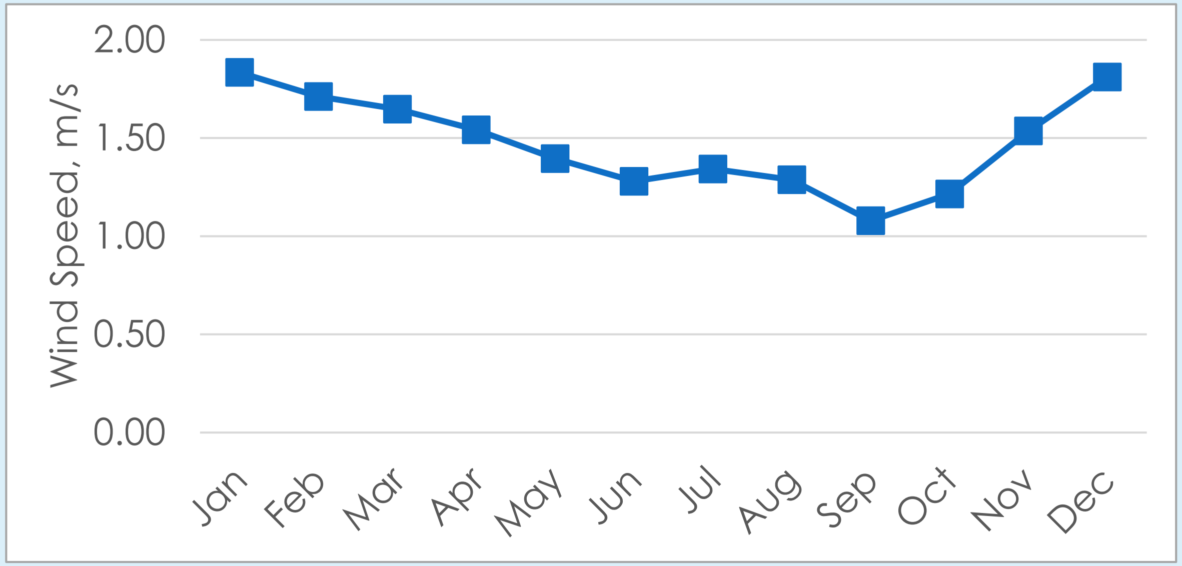


CLIMATE IN THE STUDY AREA









SWAT MODELING

1. Weather
   - ✓ Rainfall
   - ✓ Temperature
   - ✓ RH
   - ✓ Solar Rad
   - ✓ Wind speed
2. Soil
   - ✓ Bulk density
   - ✓ % sand, silt & clay
   - ✓ Ksat
3. Landcover

Soil & Water Assessment Tool | SWAT

SWAT Simulated Streamflow

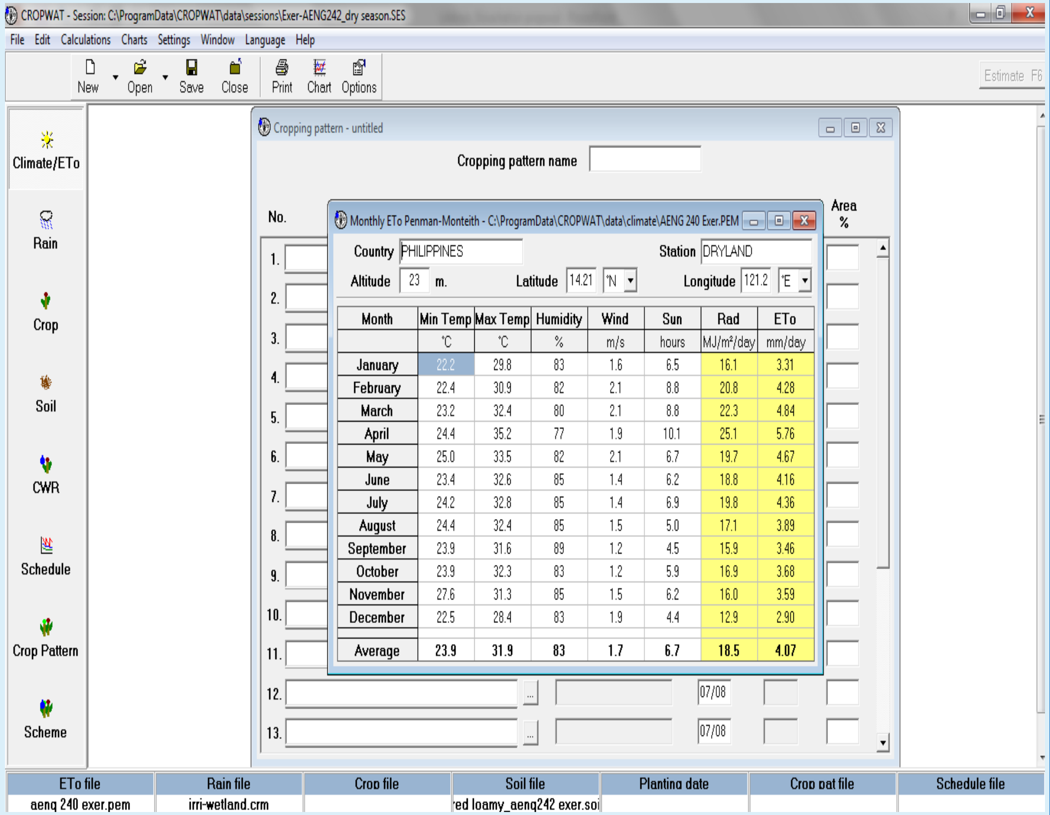
Actual Streamflow

- ✓ CN2.mgt
- ✓ ALPHA_BF.gw
- ✓ GW_DELAY.gw
- ✓ GWQMN.gw
- ✓ GW_REVAP.gw
- ✓ ESCO.hru
- ✓ CH_N2.rte
- ✓ CH_K2.rte
- ✓ ALPHA_BNK.rte
- ✓ SOL_AWC(1).sol
- ✓ SOL_K(1).sol
- ✓ SOL_BD(1).sol
- ✓ OV_N.hru

"What if" scenarios

DETERMINATION OF POTENTIAL IRRIGABLE AREA

- Determination of dependable flow
  - ✓ Flow duration analysis
- Determination of diversion water requirement
  - ✓ CropWAT
- Determination of potential irrigable area



$$Irrigable\ area = \frac{Dependable\ flow}{Diversion\ water\ requirement}$$

PROJECTED CHANGES IN RAINFALL AND TEMPERATURE AT THE STUDY AREA

		2020			2050		
Scenarios	**Quarter**	**%Change in Rainfall, mm**	**Tmax, ⁰C**	**Tmin, ⁰C**	**%Change in Rainfall, mm**	**Tmax, ⁰C**	**Tmin, ⁰C**
HIGH-RANGE EMISSION	DJF	-31.6	0.4	0.6	-31	1.3	1.5
	MAM	-9.8	0.8	0.8	-21.3	1.8	1.9
	JJA	10.7	0.5	0.8	0.3	1.7	1.9
	SON	0	0.6	0.7	2.1	1.6	1.7
MEDIUM-RANGE EMISSION	DJF	-20.2	1	0.9	0.1	2	1.8
	MAM	-31.5	1.3	1.1	-34.8	2.4	2.1
	JJA	2.9	0.9	1.2	6.8	1.7	2.3
	SON	2	1	1	0.4	2	1.9

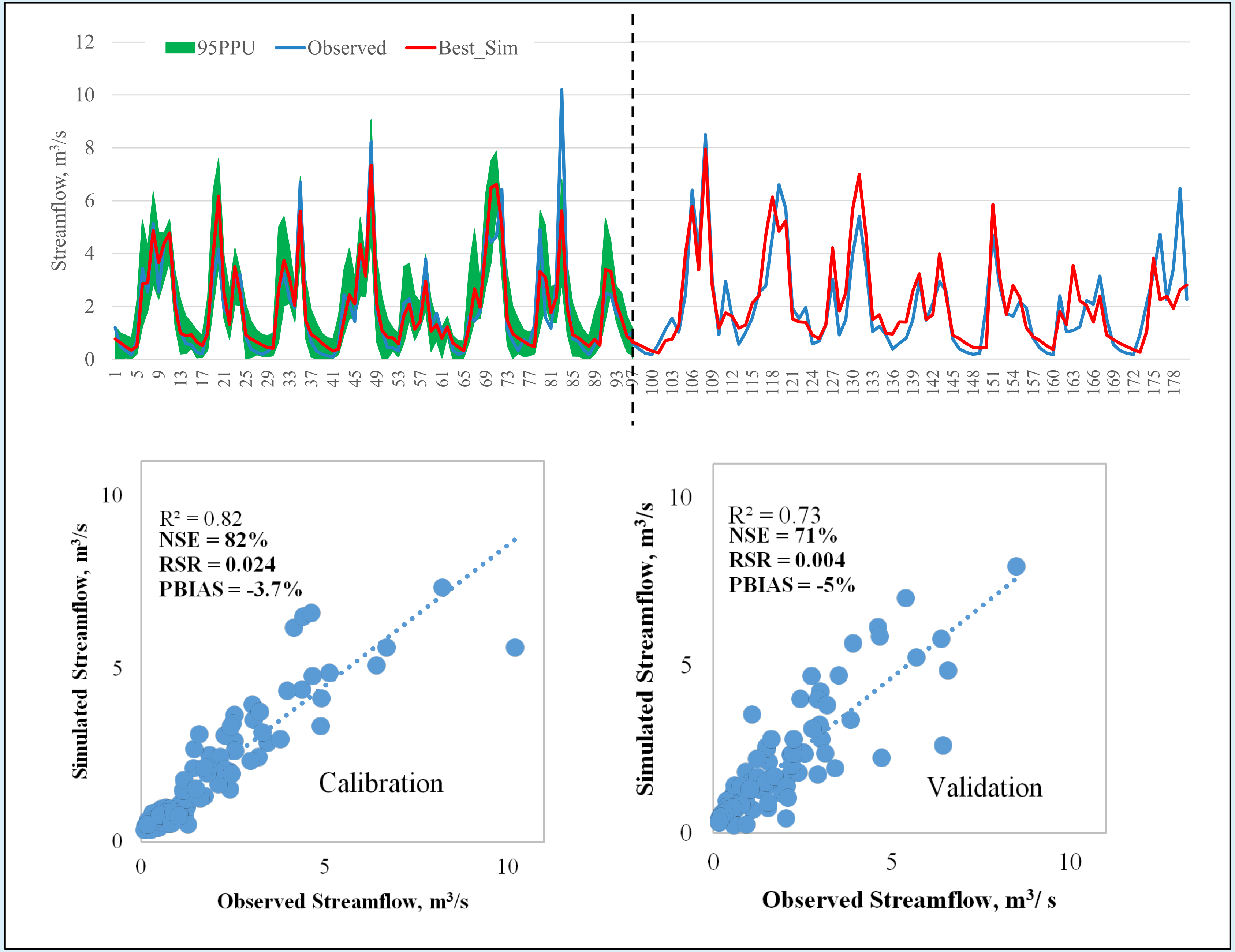
Source: PAGASA (2017)

RESULTS

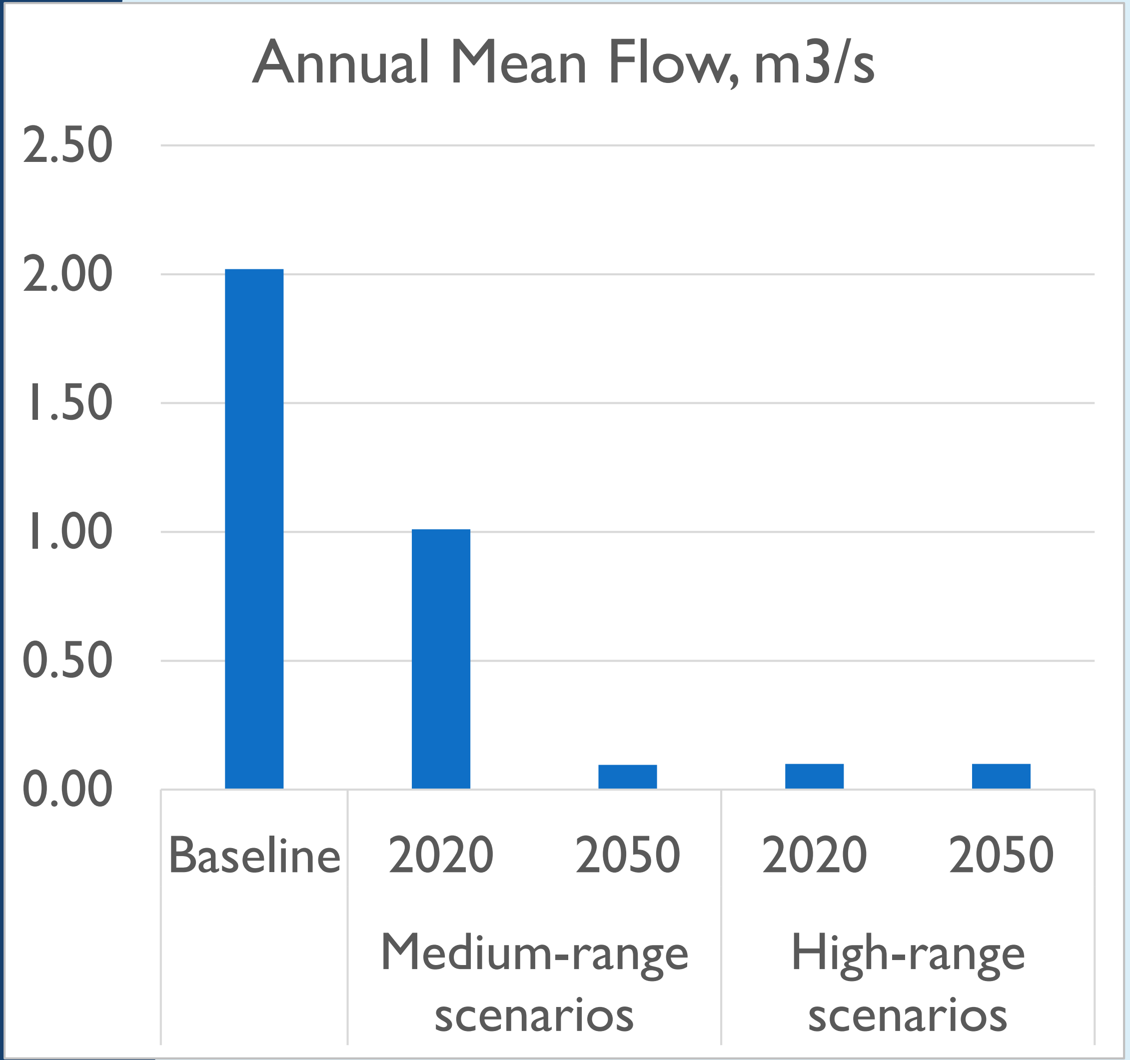
SWAT calibrated parameters

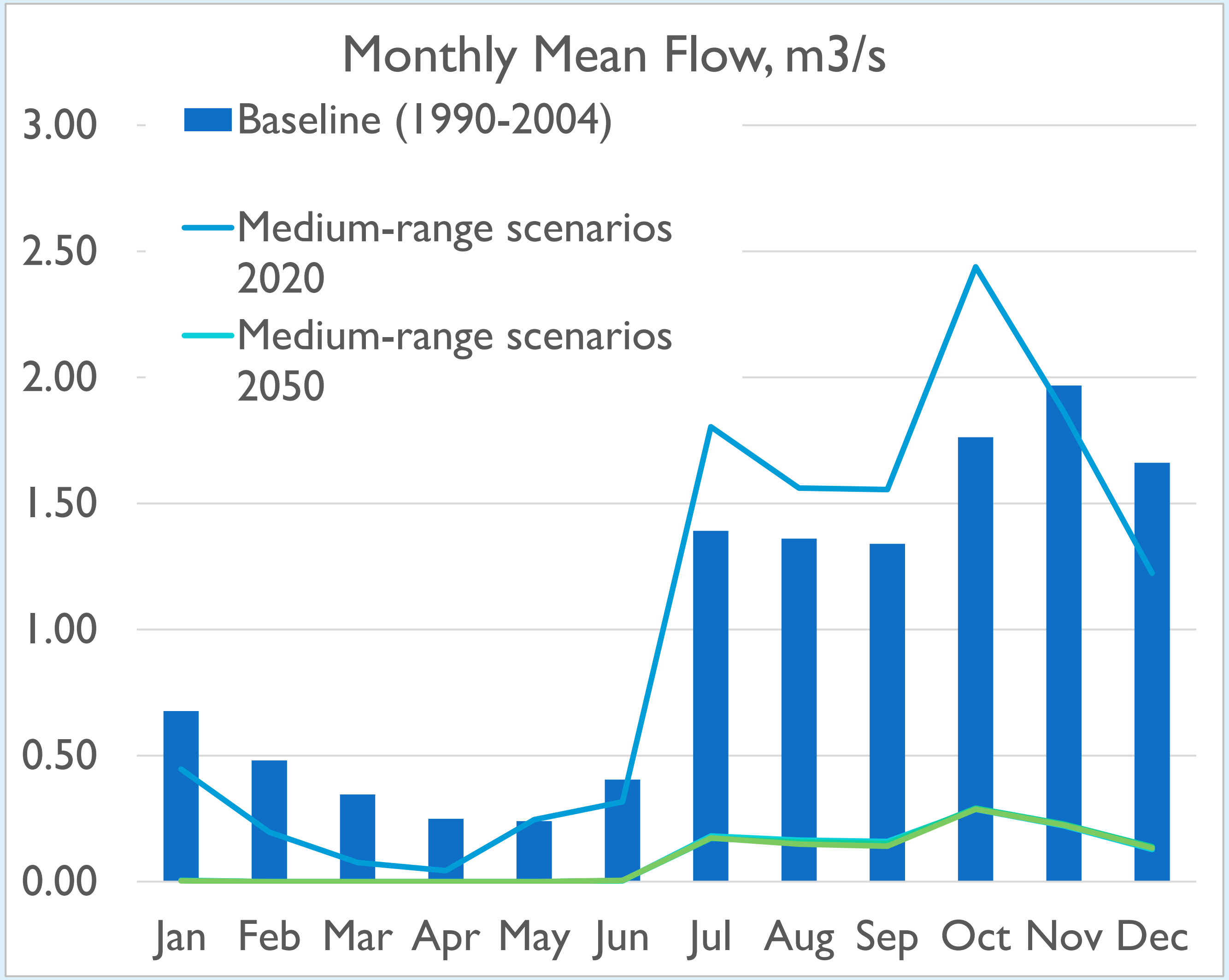
SWAT Parameter	Description	Calibrated value
CN2	Initial SCS CN II value	89.9556
ALPHA_BF	Baseflow alpha factor [days]	0.52575
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur [mm]	0.8775
GW_REVAP	Groundwater "revap" coefficient	0.12955
ESCO	Soil evaporation compensation factor	0.91875
OV_N	Manning's "n" value for overland flow	12.2984
CH_N2	Manning's n value for main channel	0.012225
CH_K2	Effective hydraulic conductivity [mm/hr]	96.78125
ALPHA_BNK	Baseflow alpha factor for bank storage [days]	0.02625

SWAT MODEL CALIBRATION AND VALIDATION RESULTS

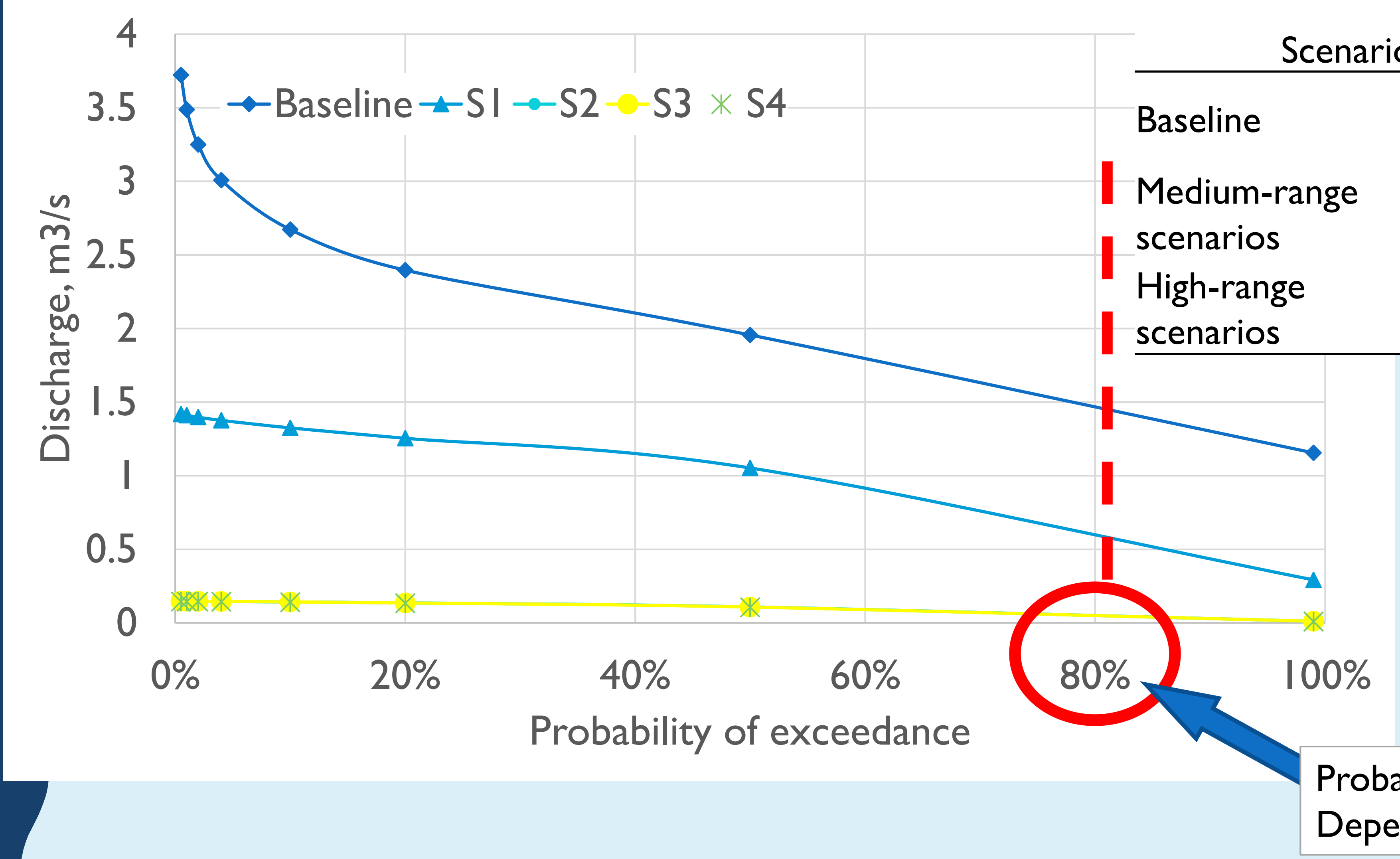


STREAMFLOW PREDICTIONS





DEPENDABLE FLOWS



Scenario		Mean Annual Dependable Flow (m3/s)
Baseline	1990-2004	1.48
Medium-range scenarios	2020 (S1)	0.61
	2050 (S2)	0.05
High-range scenarios	2020 (S3)	0.049
	2050 (S4)	0.048

IRRIGATION WATER REQUIREMENTS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	0	357.7	0	0	0	0	0	0
2. Rice	238.1	78.8	106.1	119	0	0	0	0	0	0	0	172.8
Net irrigation requirement												
in mm/day	7.7	2.8	3.4	4	0	11.9	0	0	0	0	0	5.6
in mm/month	238.1	78.8	106.1	119	0	357.7	0	0	0	0	0	172.8
in l/s/h	0.89	0.33	0.4	0.46	0	1.38	0	0	0	0	0	0.65
Irrigated area (% of total area)	100	100	100	100	0	100	0	0	0	0	0	100
Irrigation requirement for actual area (l/s/h)	0.89	0.33	0.4	0.46	0	1.38	0	0	0	0	0	0.65

FWR (Farm level)

$$DWR = \frac{FWR}{0.8}$$

POTENTIAL IRRIGABLE AREA UNDER VARIOUS CLIMATE CHANGE SCENARIOS

Scenario		Dependable Flow (m3/s)	Water duty (lps/ha)	Potential Irrigable Area (ha)
Baseline		1.48	1.73	855
Medium-range scenarios	2020	0.61	1.73	353
	2050	0.05	1.73	29
High-range scenarios	2020	0.049	1.73	28
	2050	0.048	1.73	28

CONCLUSION

- Climate change leads to substantial reduction in dependable flow in the study area (>50% by 2020 and >90% by 2050) due to reduction in rainfall inputs
- Climate change leads to increase in irrigation water requirements due to increase in temperature
- Climate change leads to decrease in potential irrigable area due to decrease in dependable flow and increase in irrigation water requirements in the study area particularly under high emission scenario based on SWAT simulation results
- SWAT simulation results may be used by water resources and irrigation development planners in the Philippines

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THANK YOU!!!