HYDROLOGICAL MODELLING TO DETERMINE SEDIMENT PRODUCTION AND EROSION ZONES IN THE MANTARO RIVER BASIN

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2024 Lima, Peru SWAT Conference

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- OBJECTIVES
- METHODOLOGY
- RESULTS
- DISCUSSIONS
- CONCLUSSIONS AND RECOMMENDATIONS

INTRODUCTION

Fig.1 Sedimentation and desander cleaning works in the reservoir of Tablachaca dam
situated some hundred kilometers upstream of Cerro del Águila dam
From (Arbolí Nevot et al, 2018)

Annual average rate of sediment quantity of

58.2 Tn/ha/year

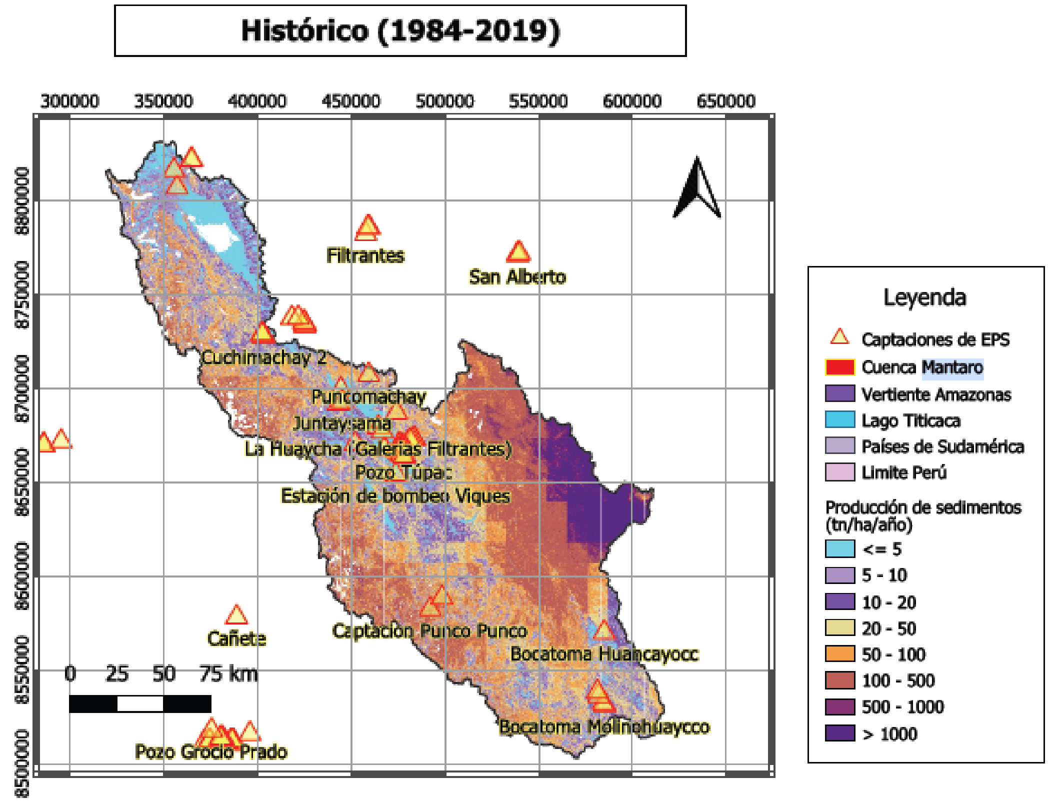
High Erosion Degree (according to FAO)

Fig 2. Contaminated River and Agricultural Problems (lamula.pe ,2017)

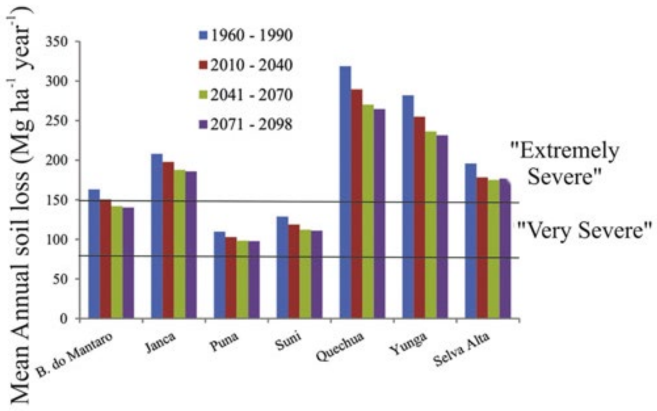
Fig 3. Hydroelectric Power Plant Mantaro(From Google Photos)

INTRODUCTION

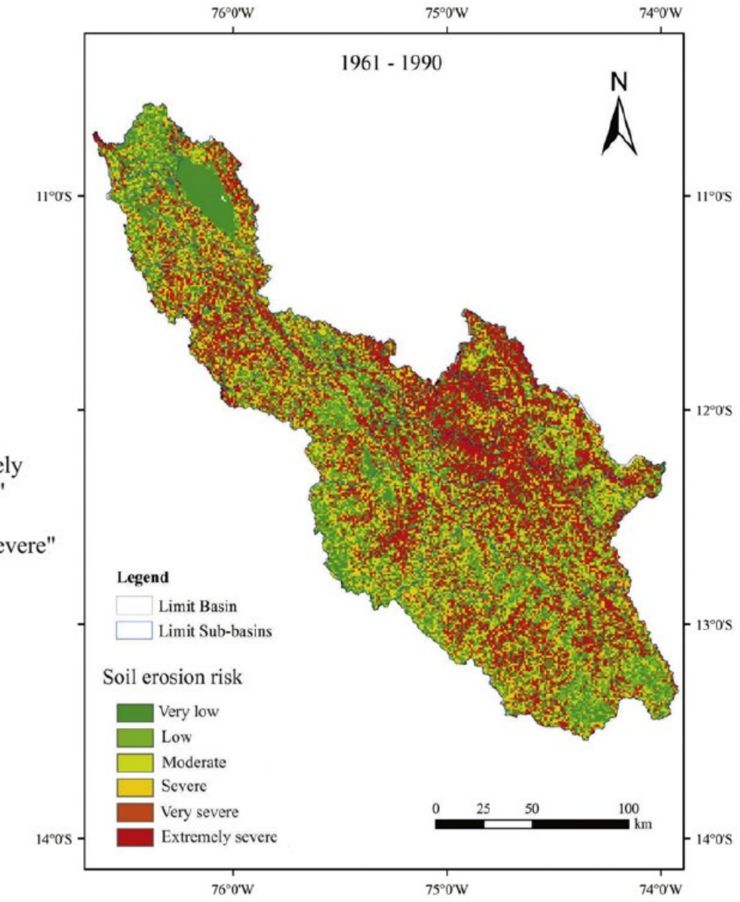
The Mantaro River is one of the most important rivers in the Andes in central Peru for the use of water for agriculture and electricity generation.



ATLAS SENAMHI,2021



Correa et al ,2016



Correa et al ,2016

OBJECTIVES

Estimate **sediment production** in the Mantaro river basin using the MUSLE equation incorporated into the **SWAT model.**

Fig 5. Mantaro River(Google photos)

Fig 6.Location of Mantaro River(Google photos)

Mantaro Basin->34546.51 km2
Amazonas River
Atlantic Ocean

METHODOLOGY

Climate data

25 real stations
1 virtual station

(1995-2020 period)

Sources

Senamhi → **Pp, tmax and tmin**

ANA Autoridad Nacional del Agua → **Flow out**

NASA POWER | DAV → **Wet, wind, solar**

Data processing

R

1. Clustering script

2. Climatol package

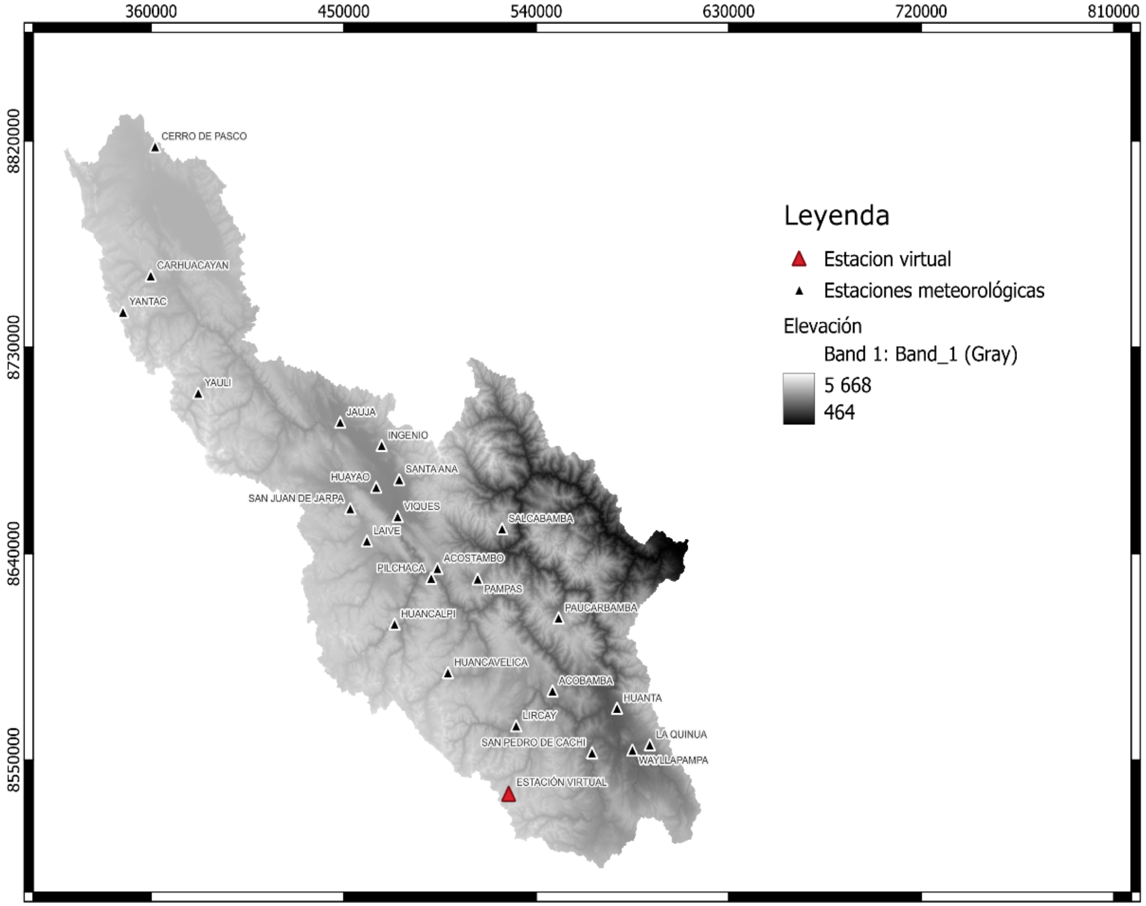


Fig 7. Meteorological Stations in Mantaro basin

METHODOLOGY

->Cluster for pp, tmax and tmin

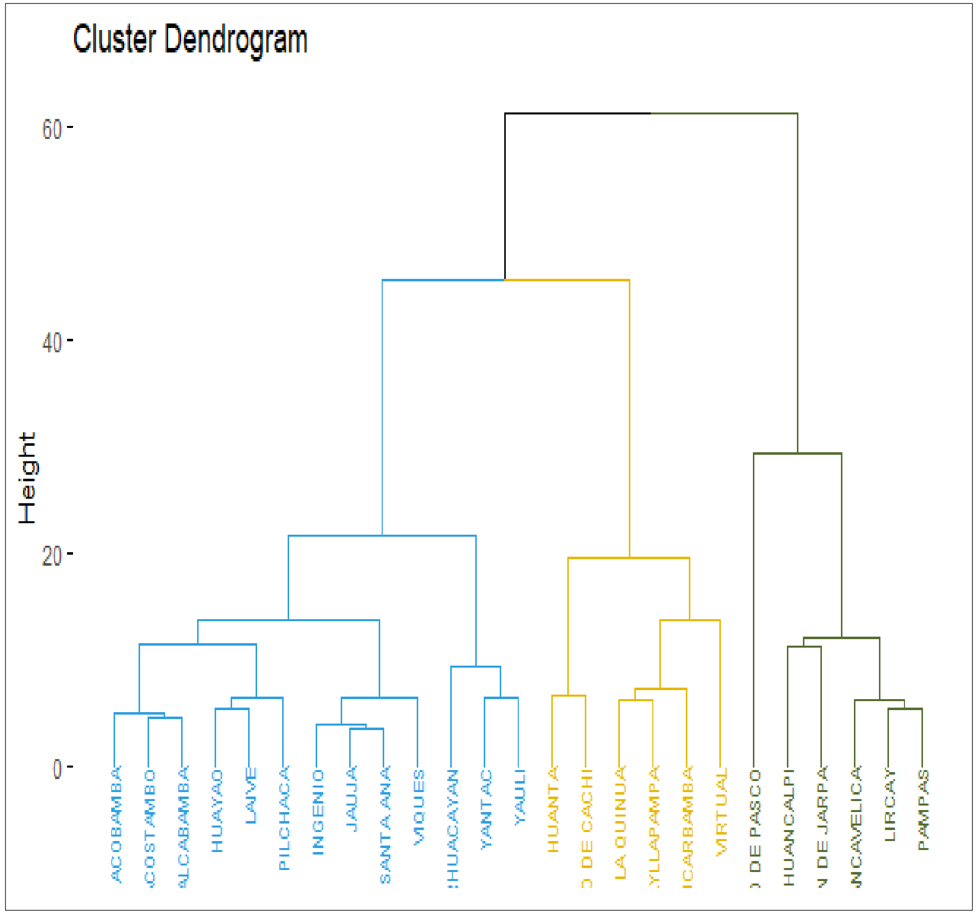


Fig 8. Dendogram of real and virtual stations

->Results of climatol process(Group 1 of pp)

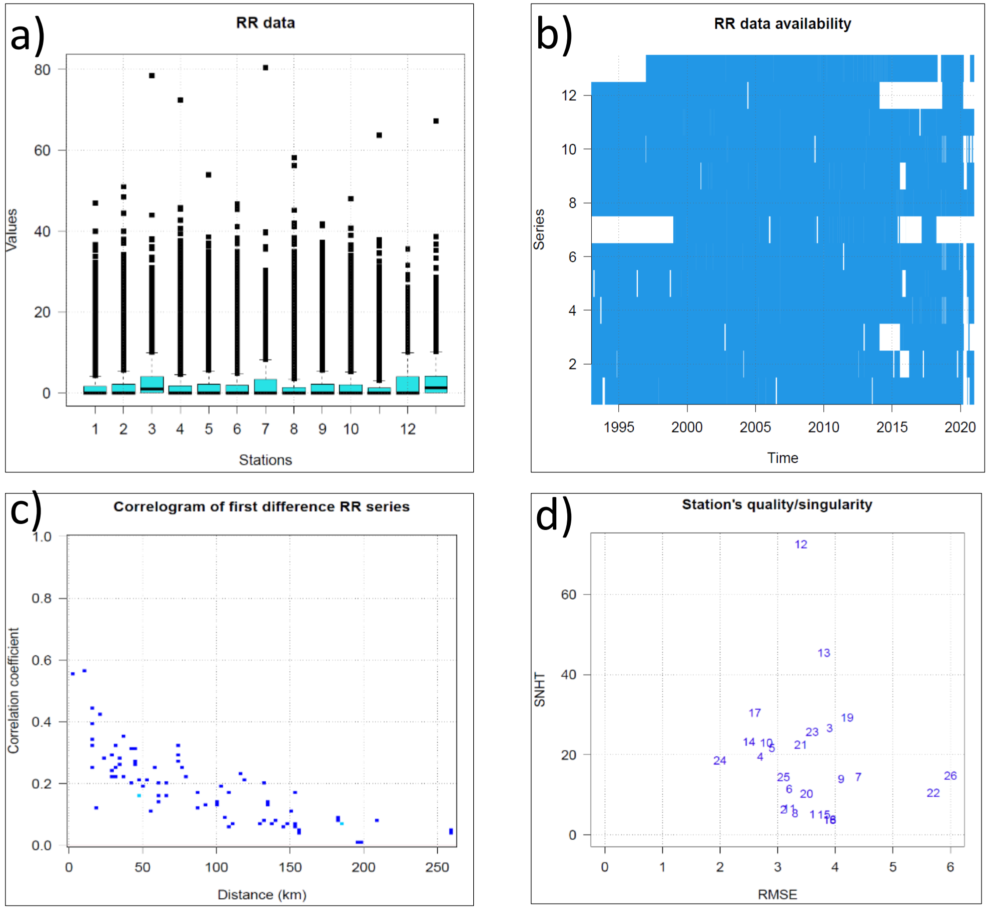
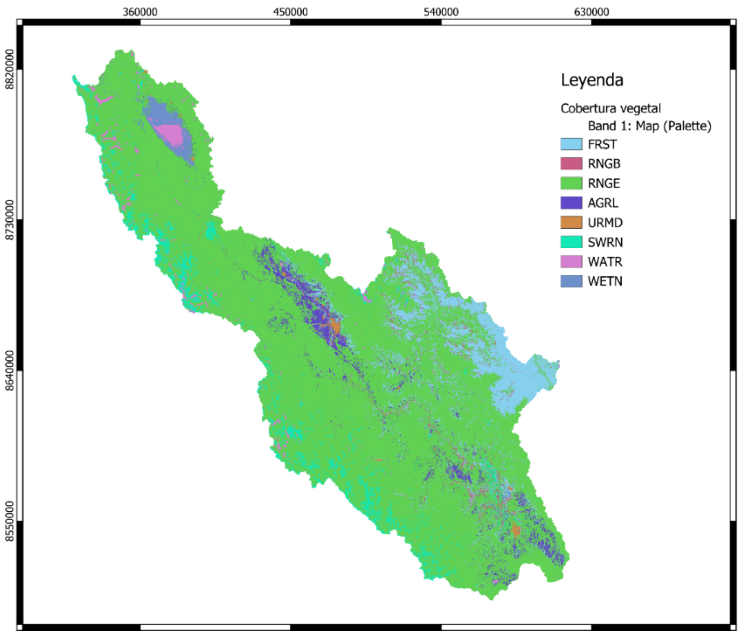
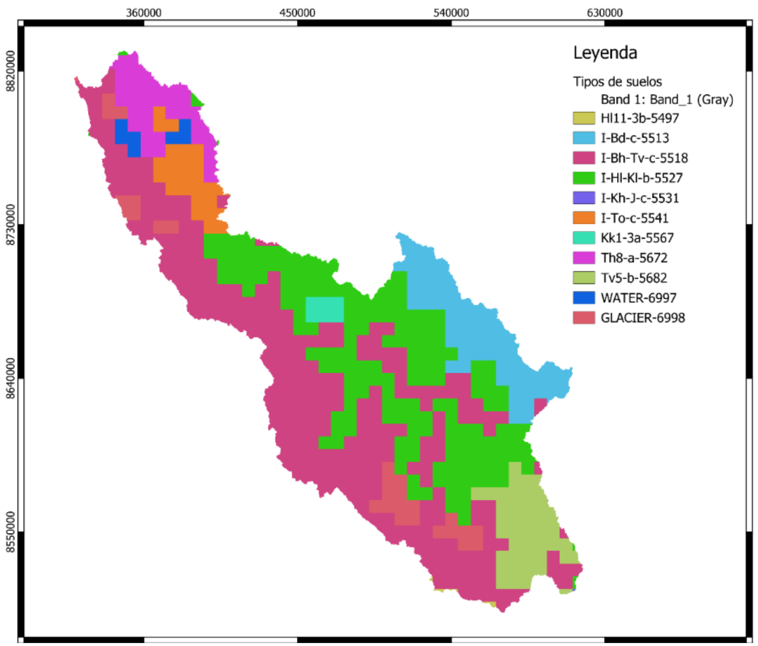


Fig 9. a)Box plot of the data. b) Data availability over the period studied. c) Correlogram of the first differences of the series. d) Singularity and quality of the stations.

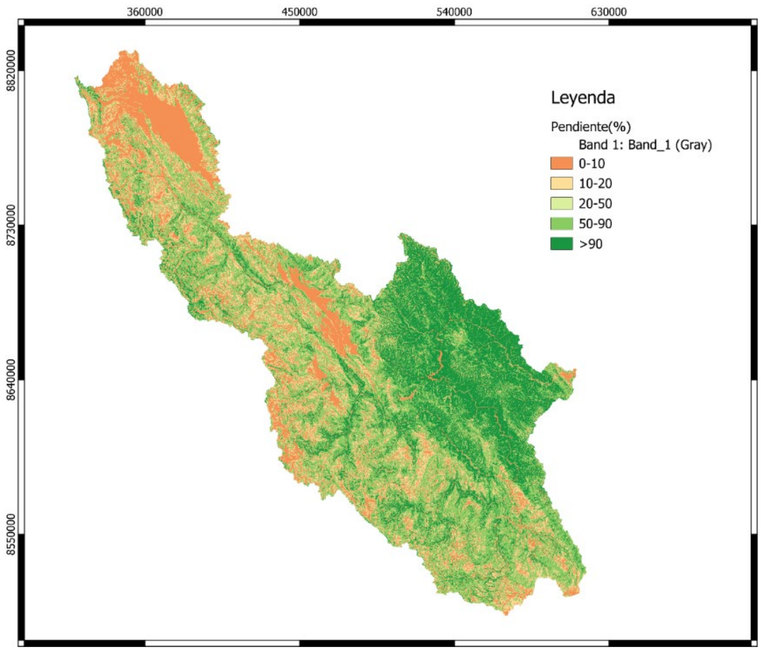
METHODOLOGY



LandUse Map



Soil Map



Slope Map

Source: MINAM(2015)
Satelital Data: ESA 2021 from GEE

Abundance of **high Andean grasslands** and **scrublands** as well as **humid forests**.

After the **agricultural activity**

Source: FAO(Soil Map of de World)

(I-Bh-Tv-c) Quaternary ashes and **lava flows**, **glacial deposits**; Mesozoic elastic and calcareous rocks);

(I-HI-KI-bc) Acid igneous rocks, **Mesozoic and Early Mesozoic calcareous** and calcareous rocks, **colluvial layers**)

Source: OpenTopography 2021 from QGIS complement

Andean Cordillera and Amazonian Plain determines all the topography, altitudes: until m to 5730 masl.

METHODOLOGY

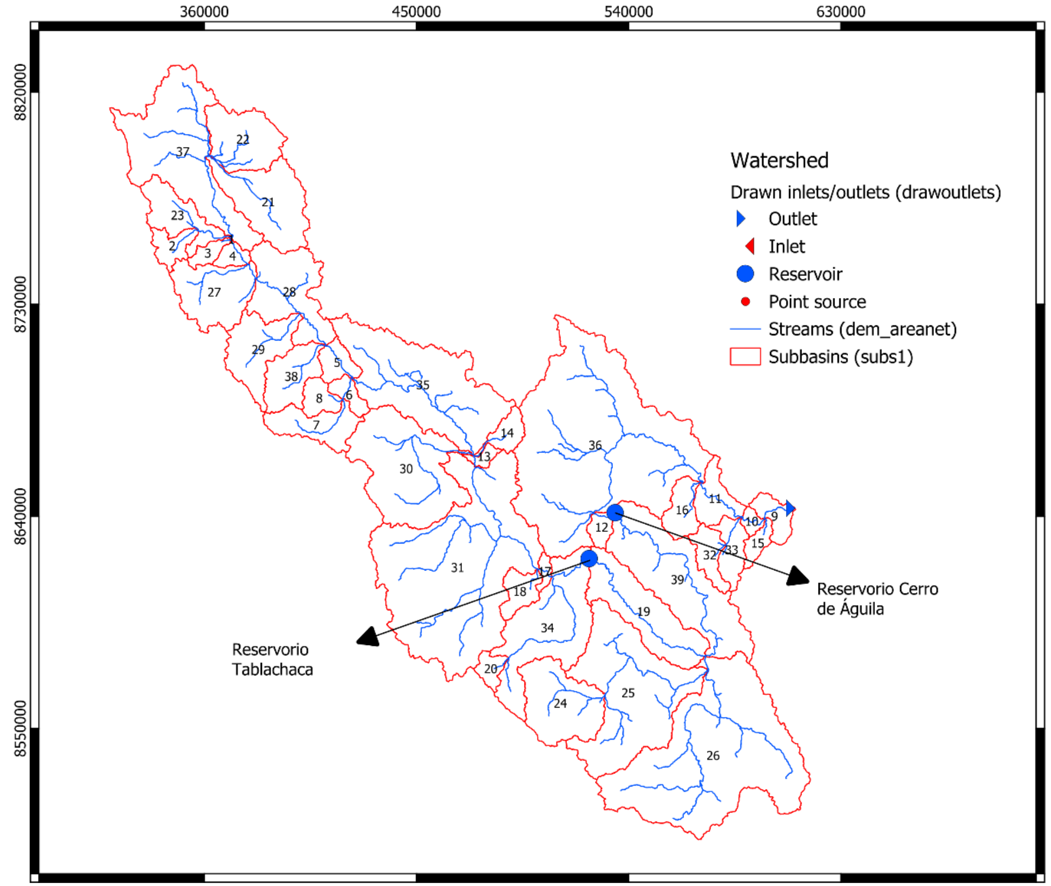


Fig 10. SWAT model

2 Reservoirs(+IMPORTANT)

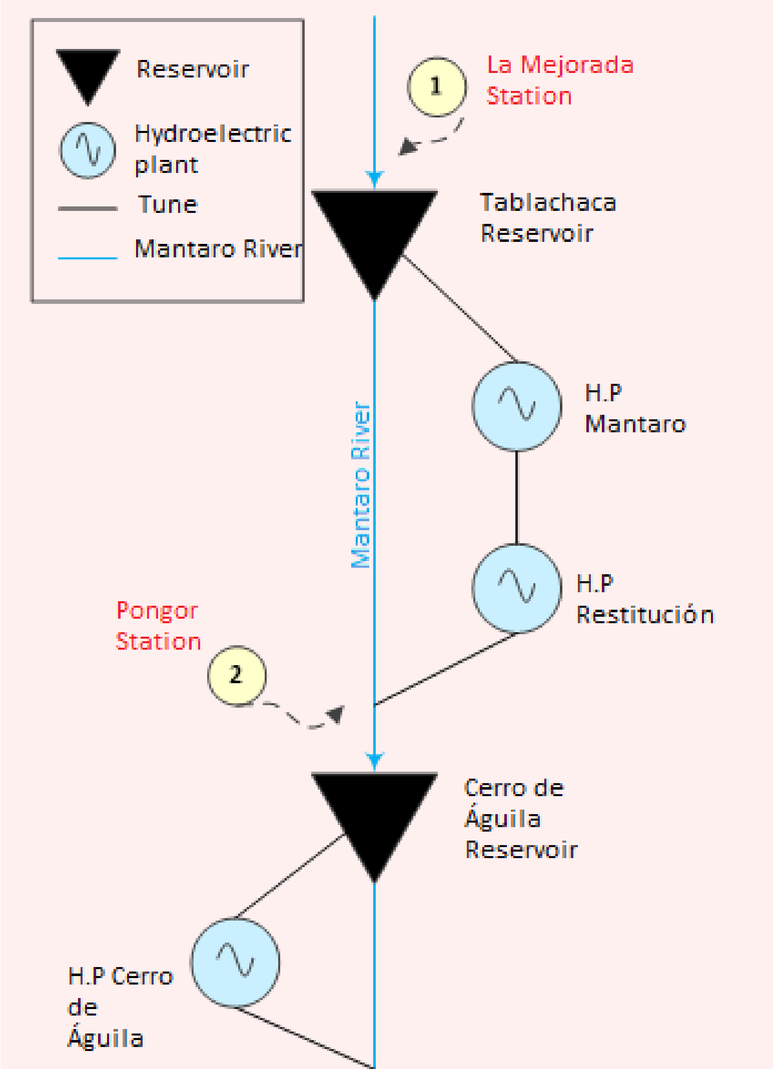


Fig 11. Topology diagram of the reservorios in Mantaro River

RESULTS

Calibration Parametres and Sensitive Parameters

Paremeters	t-stat	p-value	Default value	Best fit
v__ESCO.hru	10.6275551	2.54E-20	0.901	0.83
v__SOL_AWC().sol	5.183868	0.00001	0.03	0.13
v__rchr_dp.mgt	4.04406535	0.00008	0.05	0.15
v__GW_DELAY.gw	-3.05235117	0.00266	149	125
v__HRU_SLP.hru	2.81751279	0.00545	0.309	0.6
r__CN2.mgt	2.09567703	0.03768	79.2	0.76989*
v__SLSUBBSN.hru	-2.09228343	0.03798	61.79	80
v__ALPHA_BF.gw	1.90809157	0.05816	0.22	0.13
v__CANMX.hru	-1.65555195	0.09976	4.75	5
v__SOL_ALB().sol	-1.53840658	0.12591	0.14	0.19
v__REVAPMN.gw	1.32918878	0.18567	465	1200
v__SURLAG.hru	-1.17611335	0.24129	2	2
v__GW_REVAP.gw	0.89820226	0.37042	0.038	0.025
v__GWQMN.gw	-0.52134374	0.42018	310	100
v__OV_N.hru	0.73839769	0.46135	0.15	0.01
v__USLE_P.mgt	0.49412581	0.62189	0.74	0.9
v__TLAPS.sub	0.46966218	0.63923	5.4	6
v__BIOMIX.mgt	-0.19001546	0.84954	0.2	0.51
v__EPCO.hru	-0.17786757	0.85905	0.329	0.1

Modifies Flow out

Parametres	t-stat	p-value	Default value	Best fit
v_NDTARGR	1.227016 78	0.2216075 29	1	50
v_EVRSV	0.369922 89	0.7119261	0.6	0.8
v_STAR_FPS	0.211891 38	0.8324597 76	1	0.42

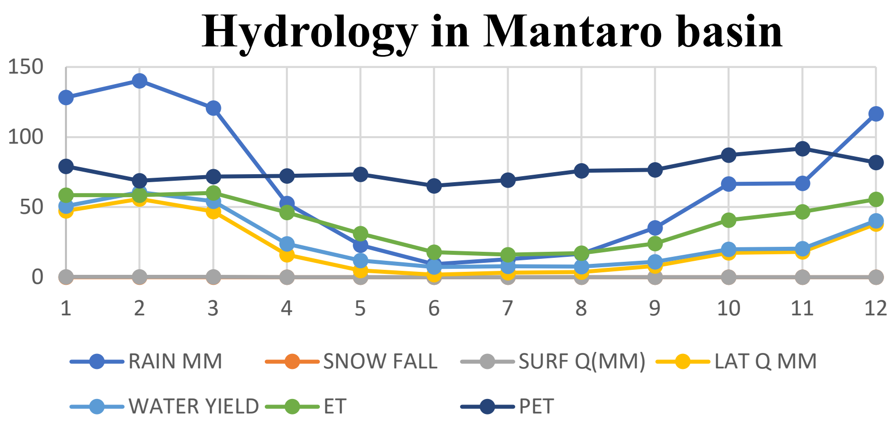
Modifies reservoris

v__: replace

R_: relative

-> SWAT CUP

RESULTS



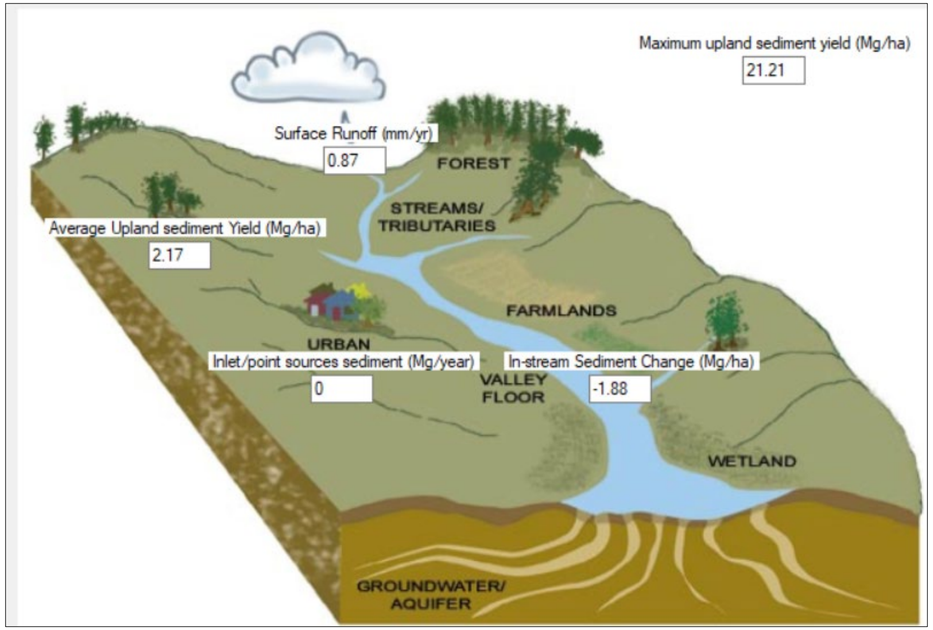


Fig 11. Sediment results

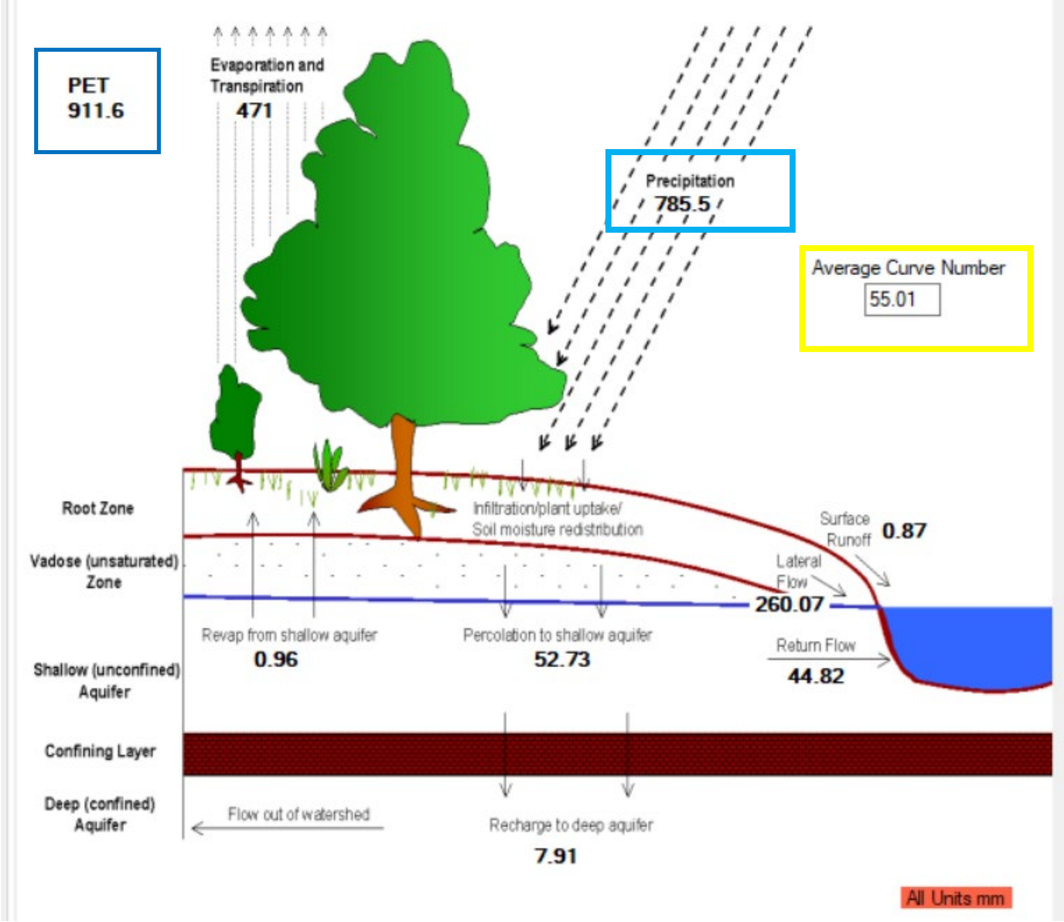
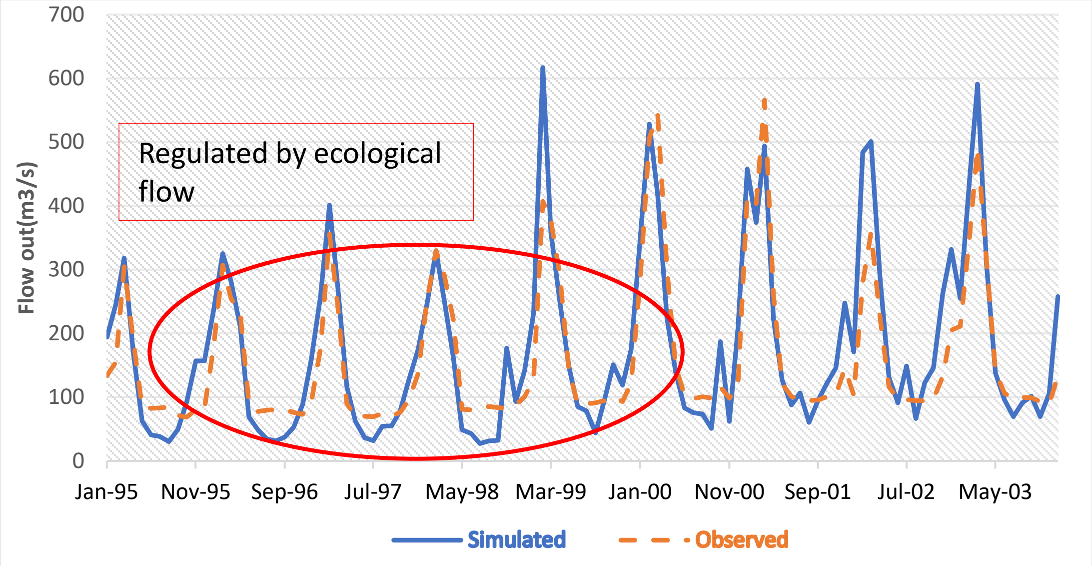


Fig 12.Hydrology results

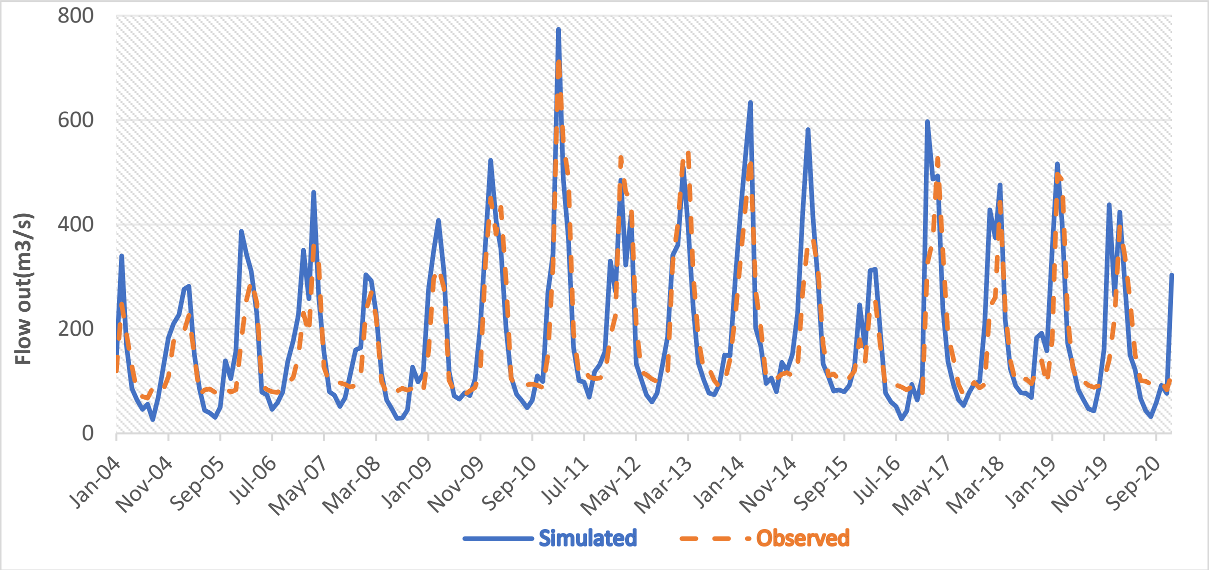
DiSCUSSIONS

Subbasin #34

Calibration

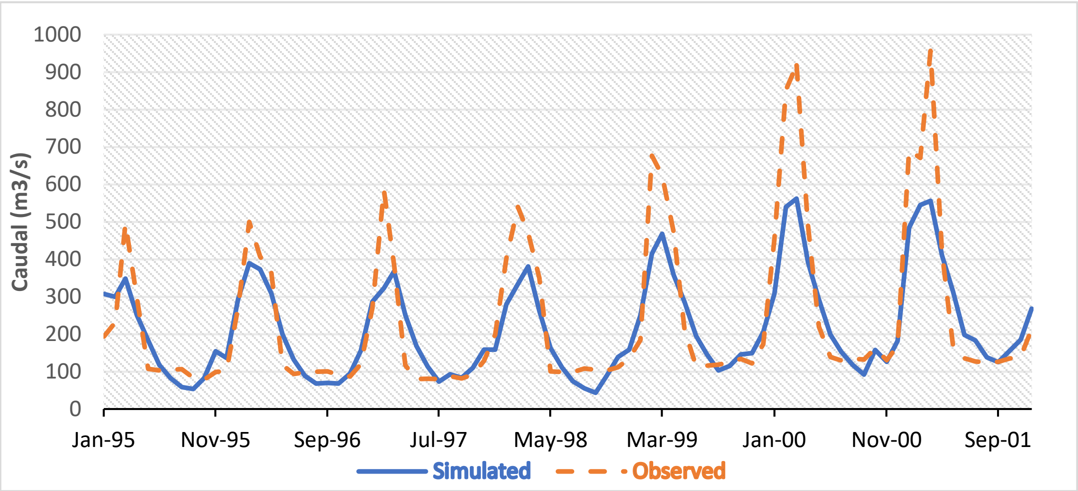


Validation

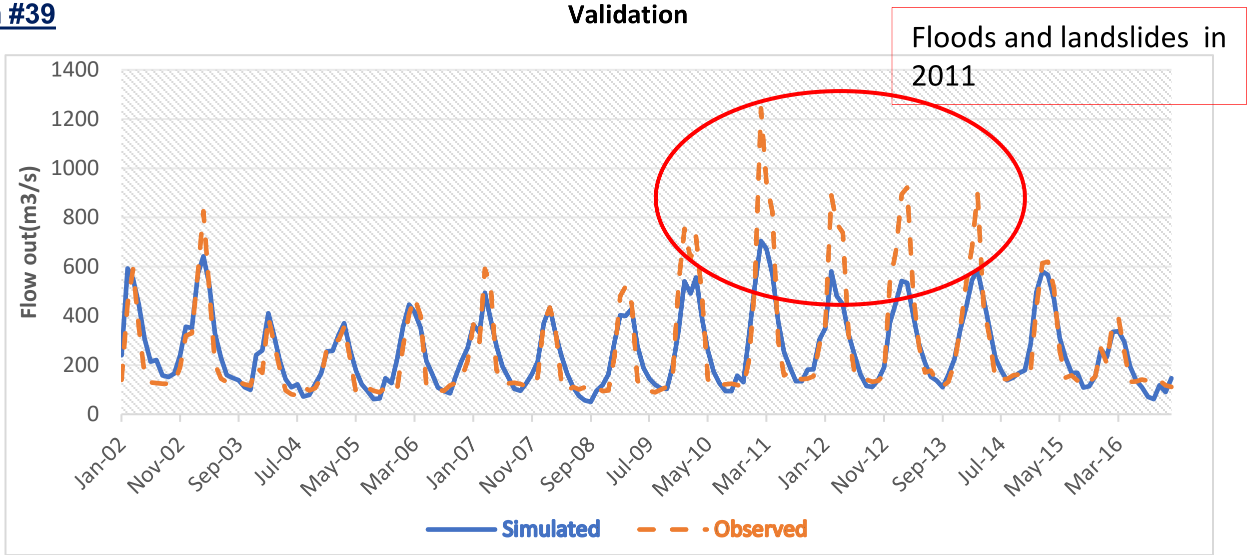


Subbasin #39

Calibration



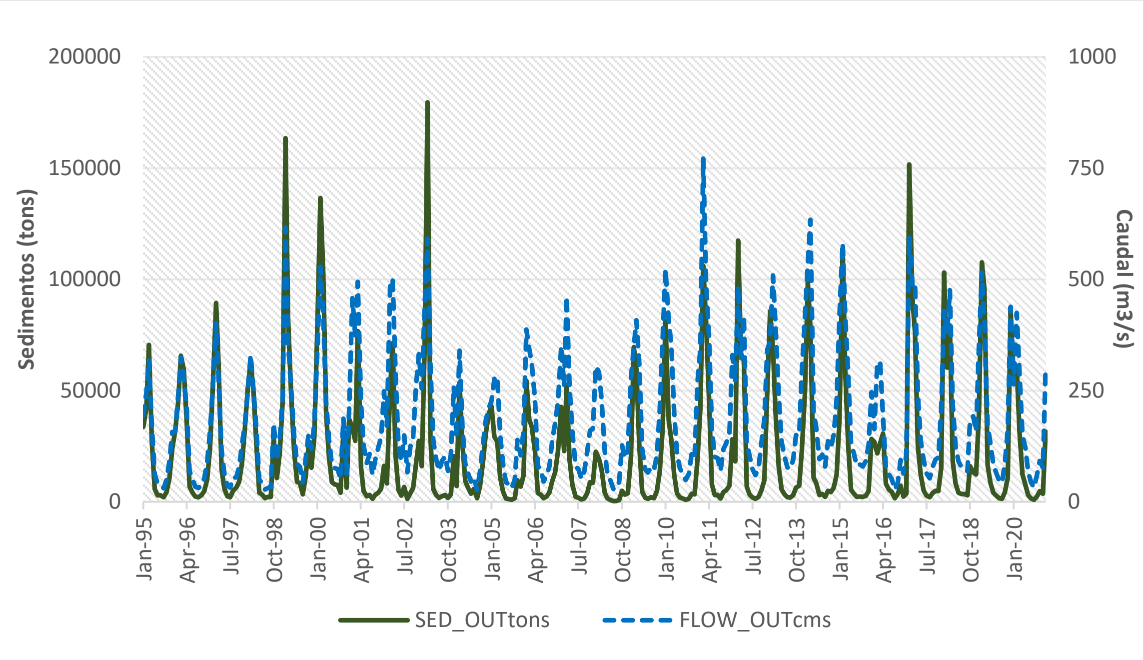
Validation



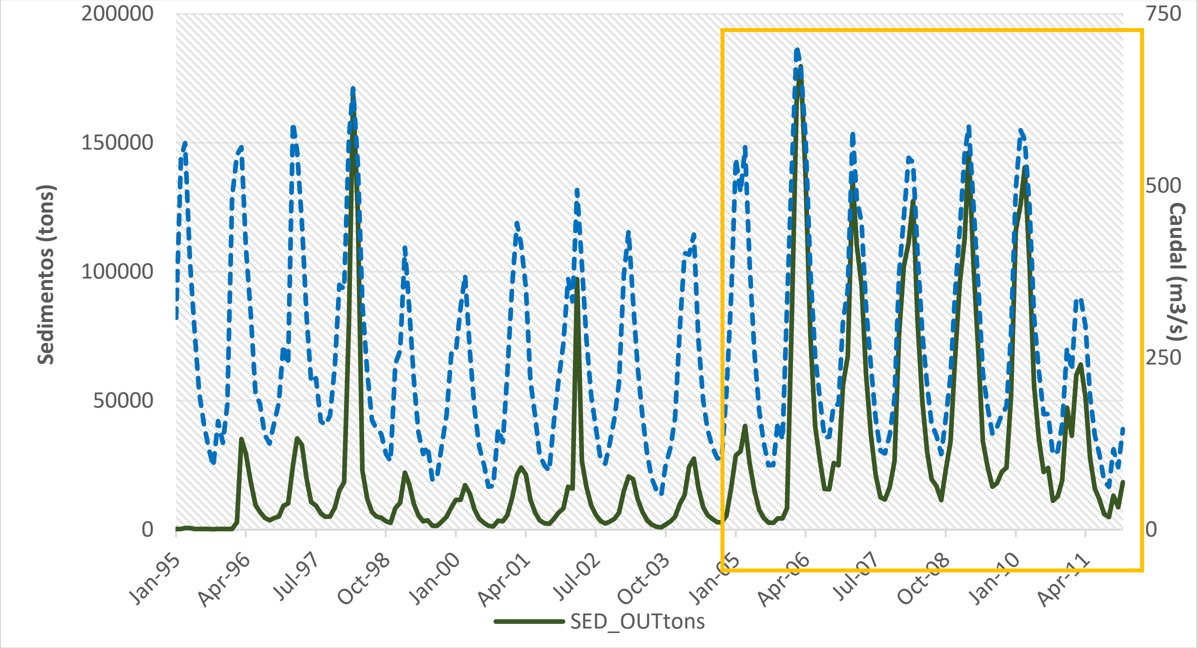
DISCUSSIONS

Sedimontagram

Subbasin #34



Subbasin #39



Increase

DISCUSSIONS

Flow out calibration and validation statistics

Very Good->	*0.75≤**NSE** ≤ 1*	*|**PBIAS**|< 10*	*0.75<R^2<1*
Good ->	*0.65≤**NSE** ≤ 0.75*	*0.65< |**PBIAS** |≤ 15*	*0.5 < | R^2 |< 0.75*

NSE, Nash-Sutcliffe efficency; PBIAS, Percentage bias

Subbasin	Parameter	Calibration		Validation	
SUB 39	R2	0.85	Very good	0.84	Very good
	NSE	0.75	Very good	0.86	Very good
	PBIAS	-9.75	Very good	3.91	Very good
SUB 34	R2	0.82	Very good	0.79	Very good
	NSE	0.74	Good	0.72	Good
	PBIAS	8.16	Very good	6.1	Very good

DISCUSSIONS

Using of historical data of sediments

Enrouting process: Using GIS toolbox

DEM->Fill sinks->Flow Direction -> Flow Accumulation(**Input weight raster (RUSLE raster)**)

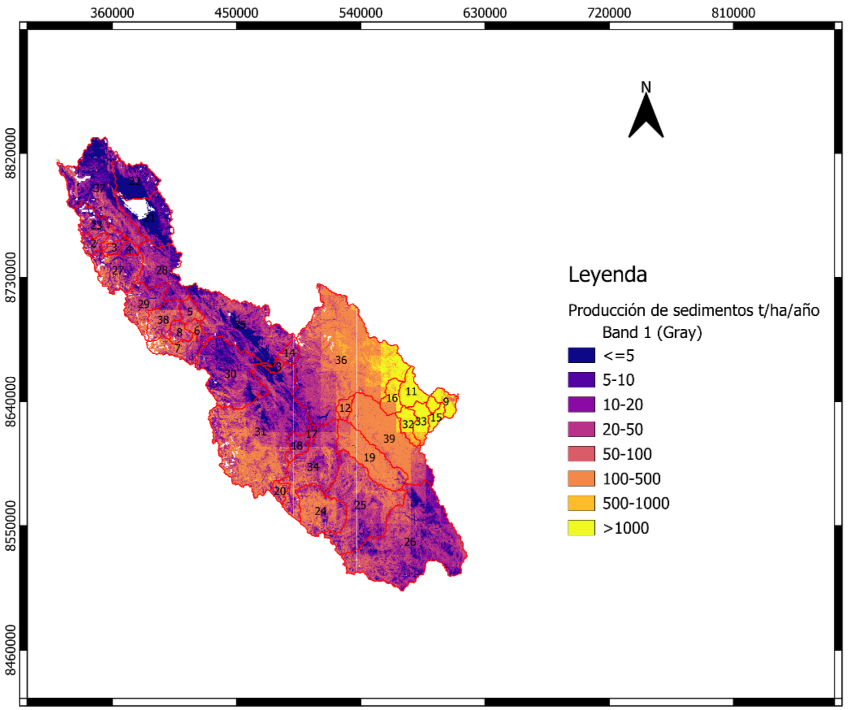


Fig 13. Map of Sediment´s production in Mantaro basin (SENAMHI, 2021)

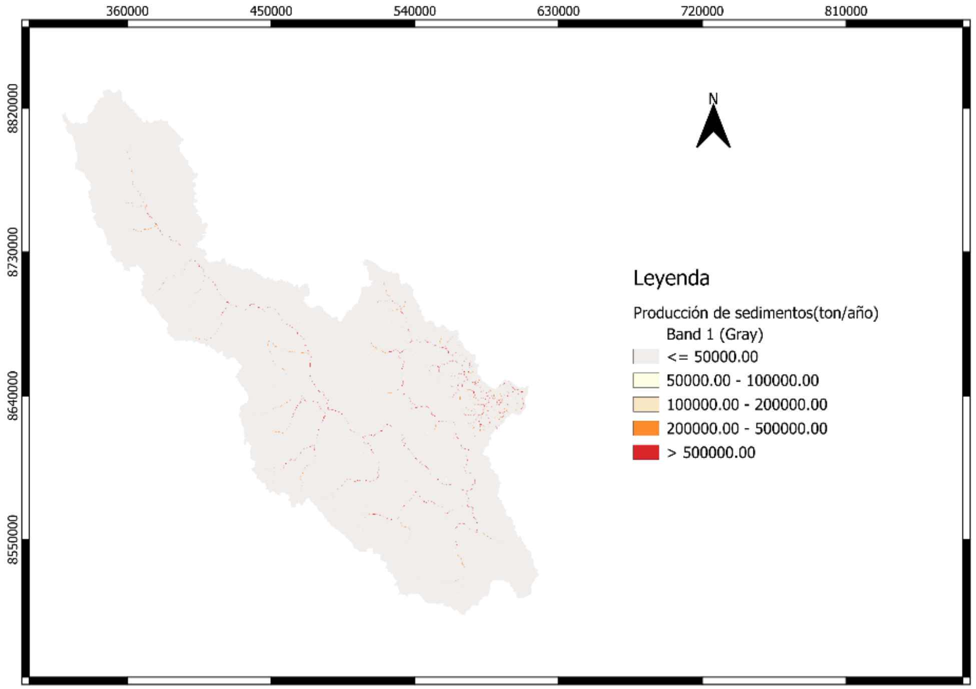


Fig 14.Routing of Sediment´s production in Mantaro basin(ATLAS)

DISCUSSIONS

Comparison of raster data vs results

Fig. 15 .Map of Sediment´s production in Mantaro basin (SWAT

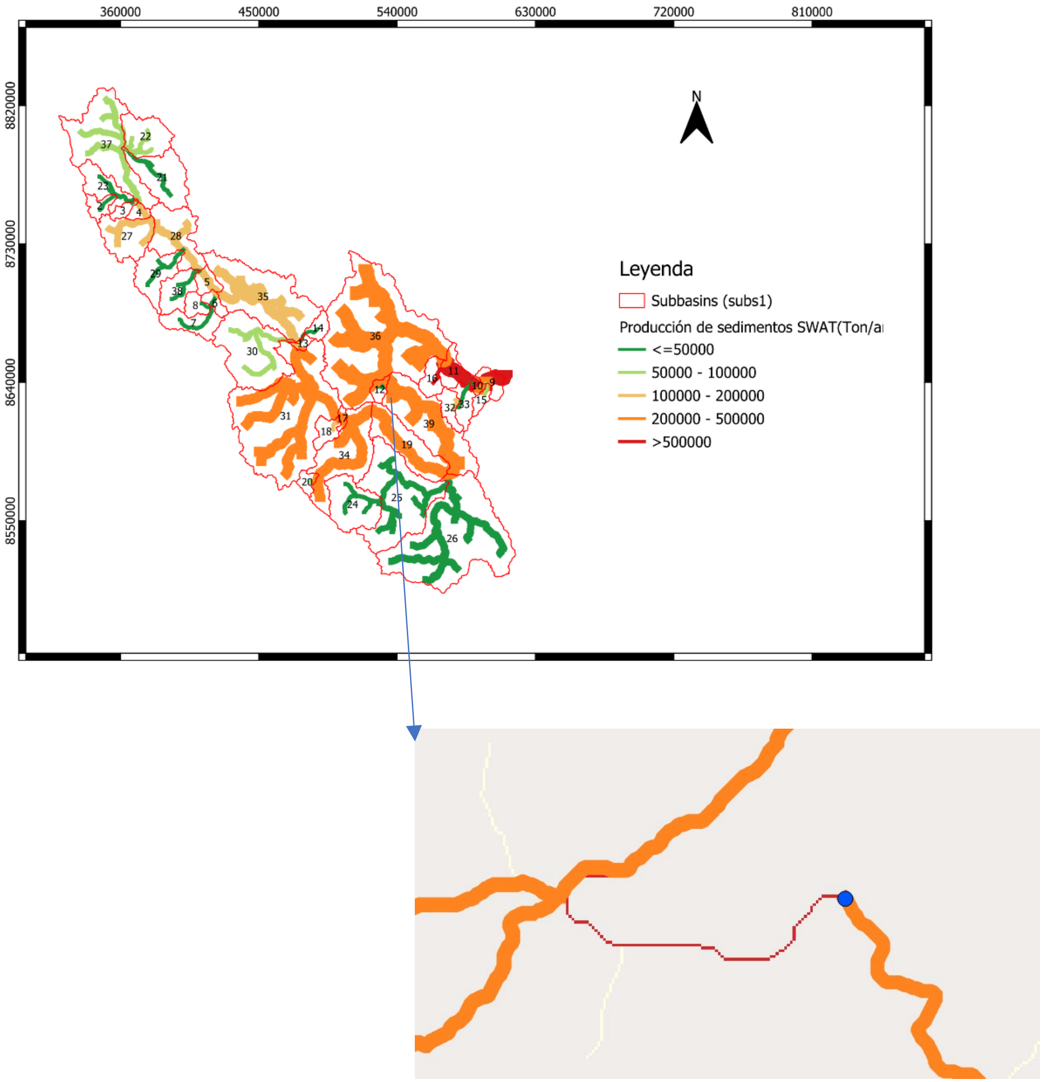
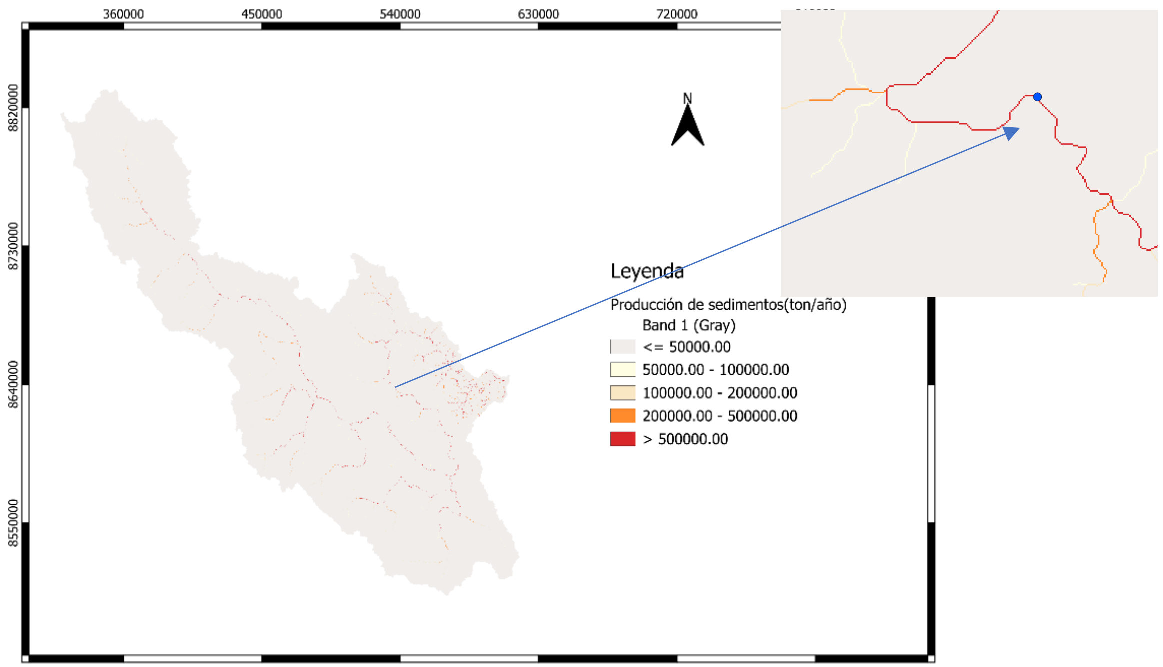


Fig 14. Routing of Sediment´s production in Mantaro basin(ATLAS)



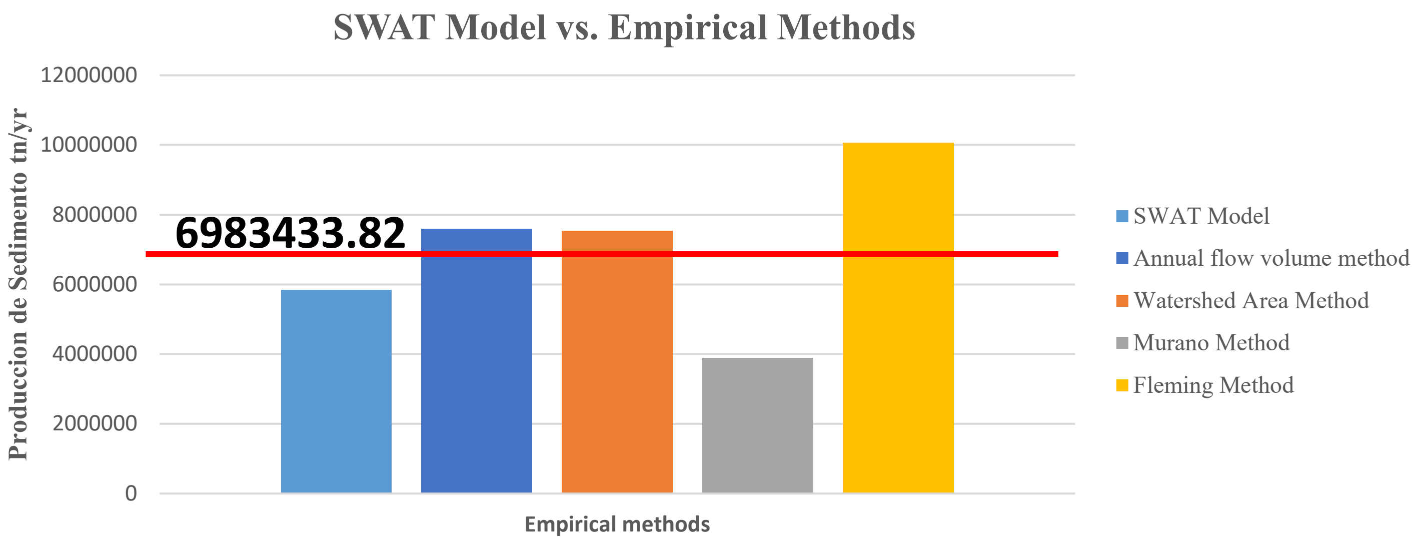
DISCUSSIONS

Comparison between another methods

Principal parameteres of the basin

Parametres	Value	Units
Area(A)	34546.51	km2
Perimeter of the basin	1 527.69	km
Average slope of the channel	0.46	%
Average slope of the land in the catchment area	19.1	%
Compactness index	2.3	-
Shape factor	0.06	-
Average annual Flow(Q)	429.9	m3/s
Average annual precipitation(P)	876.6666667	mm
Average altitude of the catchment(H)	4204.97	msnm
Average catchment slope (I)	0.0327	m/m

1. $Qs = 12.45 \times Q^{1.4}$
2. $Qs = 3.34 \times A^{1.4}$
3. $Qs = 10^{-3.2} A^{-0.21} P^{0.97} H^{1.21} I^{0.68}$
4. $Qs = aQ^{n}$

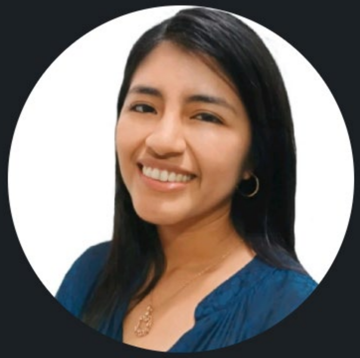


Empirical methods	SWAT Model	1.Annual flow volume method	2.Watershed Area Method	3.Murano Method	4.Fleming Method	Average(tn)
Sediment Production(tn/yr)	5844872.71	7589497.54	7542447.9	3882244.89	10058106.06	6983433.82

CONCLUSSION AND RECOMMENDATIONS

- The Mantaro basin has a sediment production of 5844872.71 tonnes/year
- The calibration of the discharge is considered very good with an NSE greater than 0.75 .
- It is necessary to have historical data of sediments to calibrate the SWAT model and obtain better results.
- It is recommended to create a database of observed suspended sediment data on the river and find a correlation with flow out, then compare with SWAT results (we are working on this).

THANK YOU FOR LISTENING!



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Soil & Water Assessment Tool SWAT