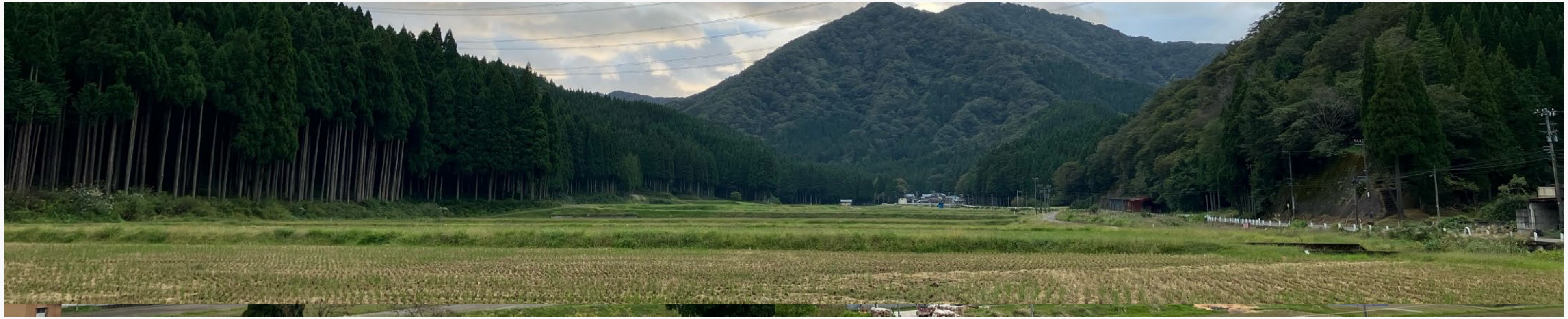

Assessment of Ecosystem Services by applying SWAT model for forest and paddy fields watershed in snowy area

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Ecosystem services

Ecosystem services (ESs)are “The benefits people obtain from ecosystems” (MA, 2005)

Provisioning
- Food
- **Fresh water**
- Wood and Fiber
- Fuel

Regulating
- Climate regulation
- **Flood regulation**
- Disease regulation
- **Water purification**

Cultural
- Aesthetic
- Spiritual
- Educational
- Recreational

Supporting
- Nutrient cycling
- **Soil formation**
- Primary production

Ecosystem services in Japanese rural area

- **Concern: Impact of agricultural management change caused by depopulation, and climate change on ESs.**
- **Policy: Government subsidy is paied for the activities that aim to maintain the paddy field.**
- **Needs for assess impact of environmental conservation agriculture**

This study focus on ESs in Japanese rural area in current situation to make standard to assess ESs by analyzing water balance.

Assessing hydrological ecosystem services in Asuwa river basin, Japan

- **Assessing snow melt affect on agricultural management (water regulation services)**
- **Quantifying water balance of the forest and paddy fields watershed in snowy area**
- **Analyzing Observed water quality to compare with the model results**
- **Hydrological process was evaluated by using SWAT model.**

Asuwa river basin in Fukui prefecture, Japan

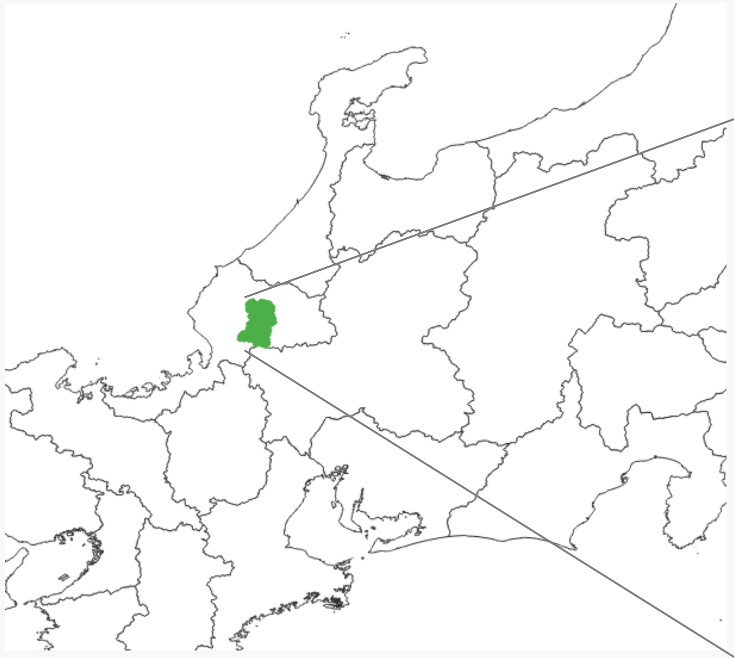


Fig1. Location of the study area

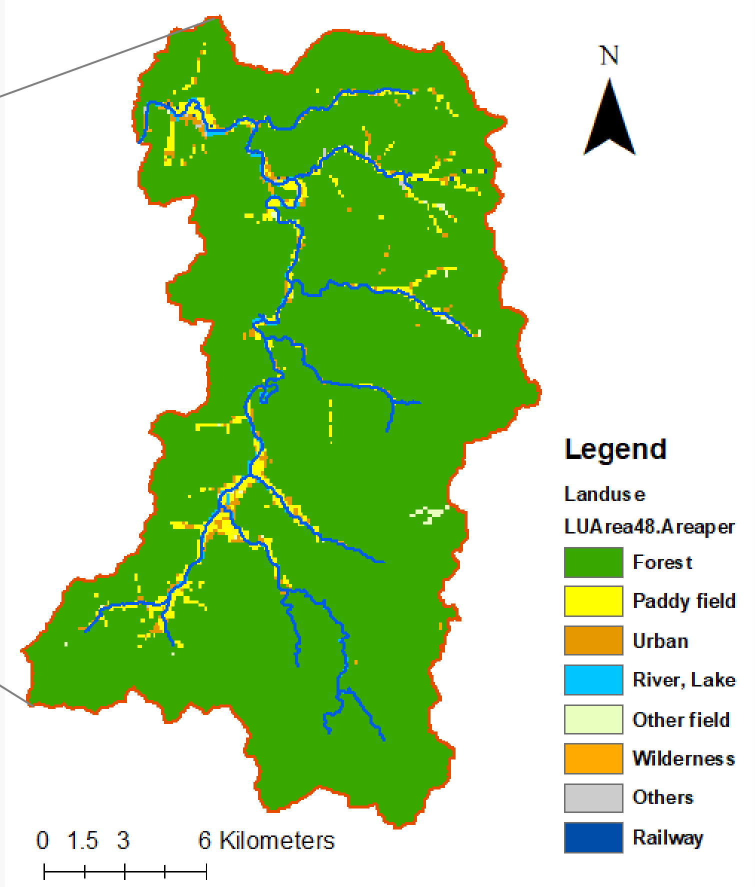


Fig2. Land use

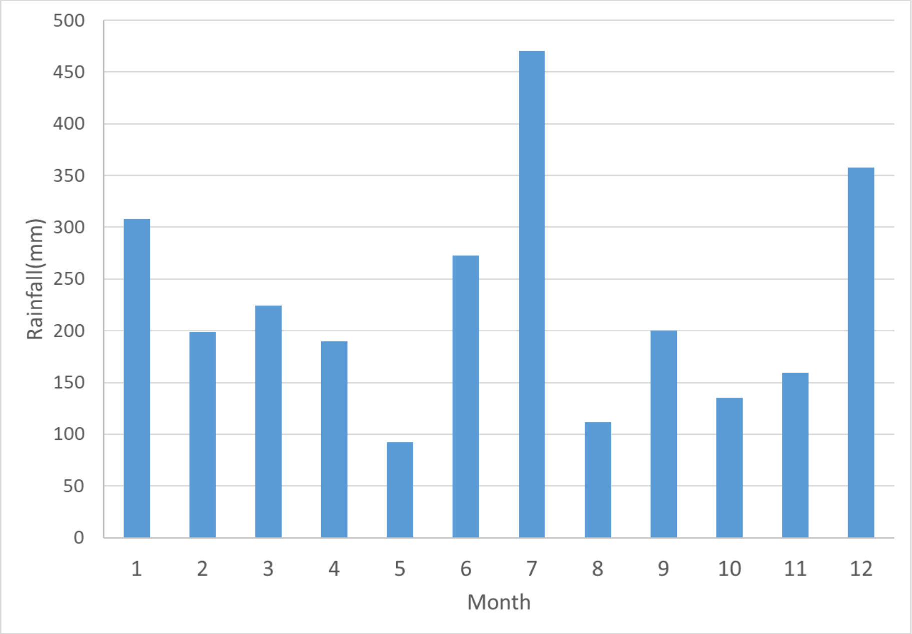


Fig3. Monthly rainfall (Miyama, 2020)

Downstream area village
Population: 2327
Age of aging(over 65 years old): 45.51%

Area: 19,465 ha

Annual rainfall: 2500mm
Snow fall: Dec.-Mar.

SWAT model

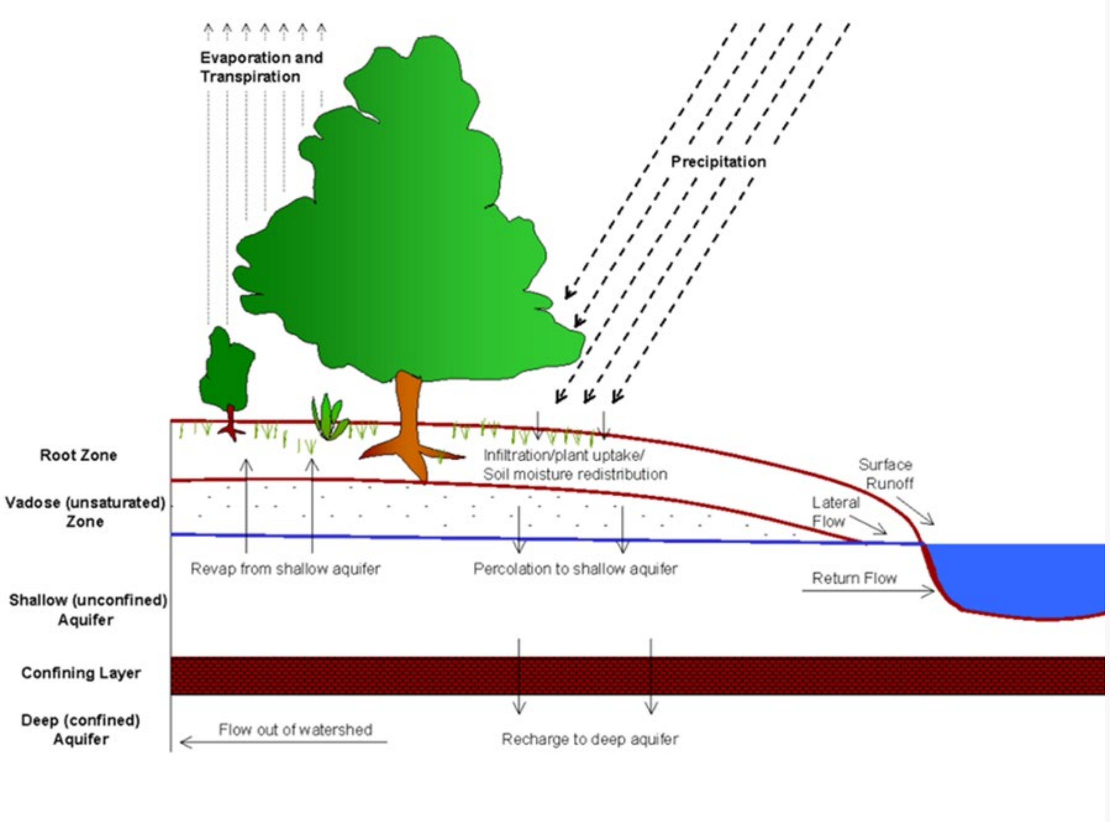


Fig4. SWAT model
(Source: SWAT 2009 Theoretical documentation)

- **A physically based hydrological model**
- **Designed to predict the effects of land management practices on water, sediment, and agricultural chemical yields in basins**
- **Based on water balance equation**

$$SW_t = SW_0 + \sum_{i=1}^{t} R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw}$$

SW_t : final soil water content; SW_o : initial soil water content
R_{day} : precipitation ; Q_{surf} : surface runoff ;
E_a : evapo-transpiration; W_{seep} : water entering unsaturated zone;
Q_{gw} : amount of return flow

Input data

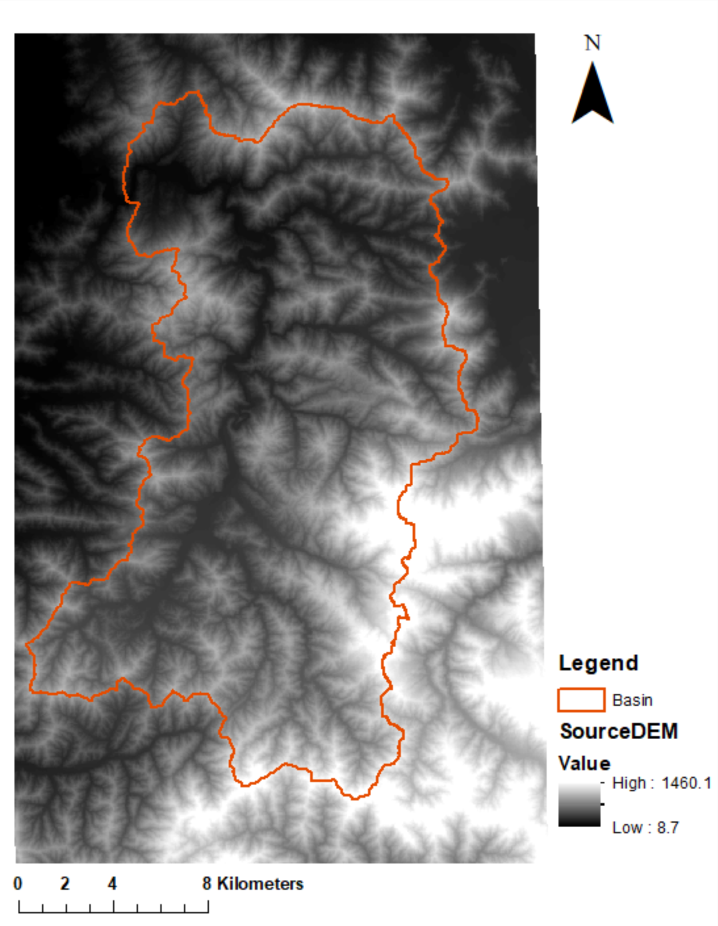


Fig5. DEM (2016, GSI)

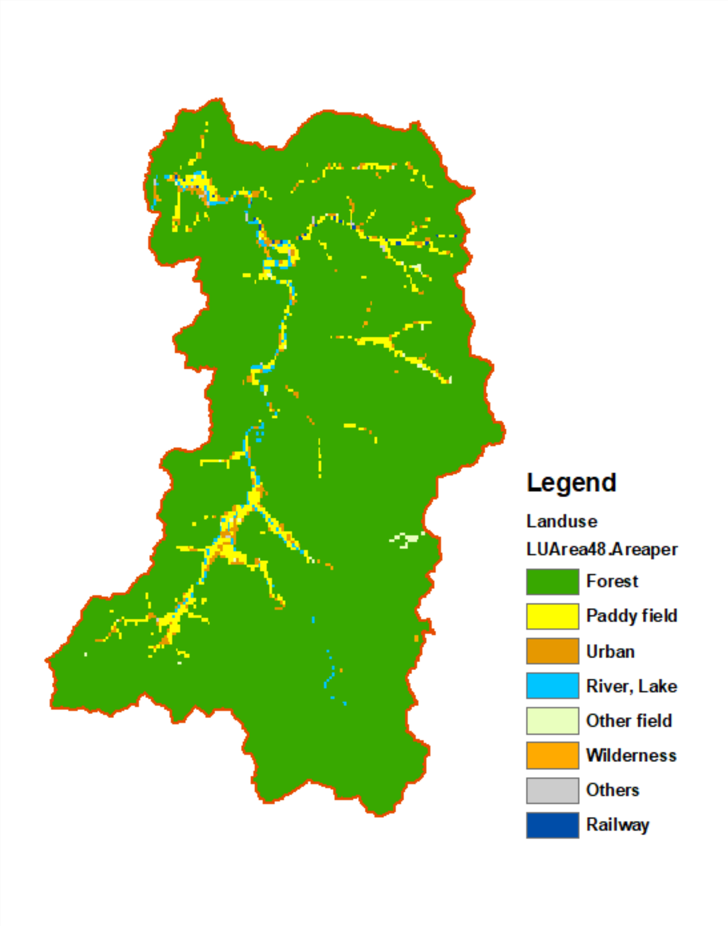


Fig6. Landuse (2016, MLIT)

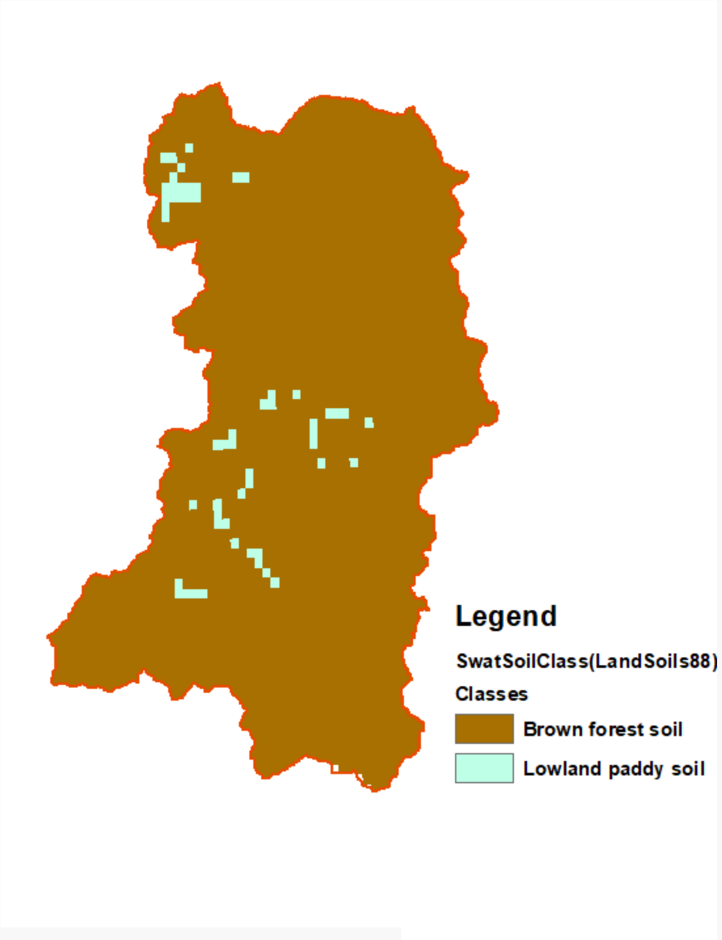


Fig7. Soil (2017, NARO)

Climate data

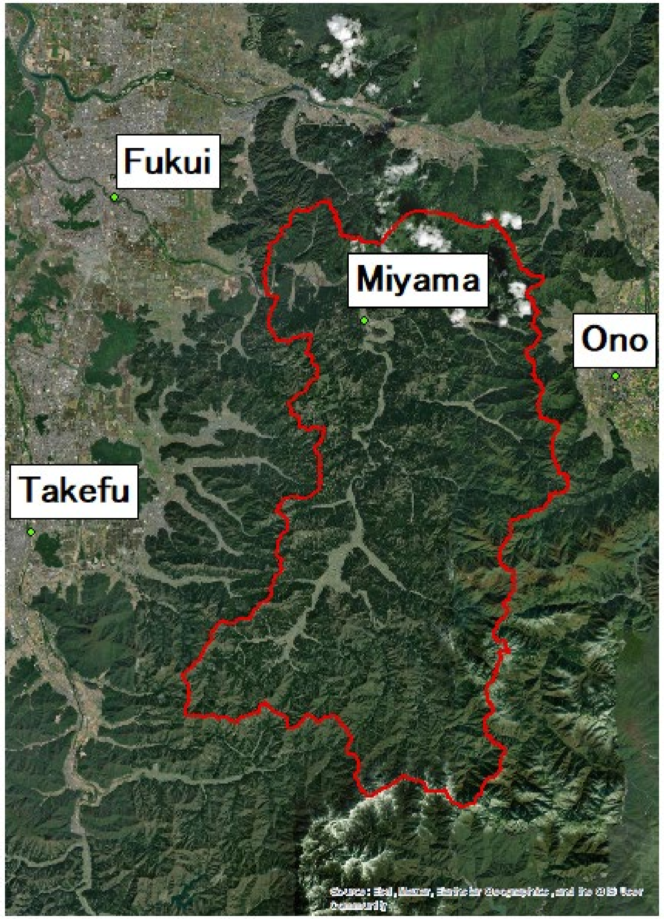


Fig8. Location of weather stations

Table1. *Weather data and weather station*

Climate	Station
Rainfall	Miyama, Takefu, Fukui
Temperature	Fukui, Ono
Wind speed, Humid, Radiation	Fukui

Table2. *Weather data*

Climate	Average	Min.	Max.
Rainfall (mm/day)	7.14	0	185
Temperature_Fukui (℃)	15.2	-5.2,	37.7
Temperature_Ono (℃)	13.7	-12.5	36.9

Year: 2009-2020

Sources: Japan Meteorological Agency

Flow chart

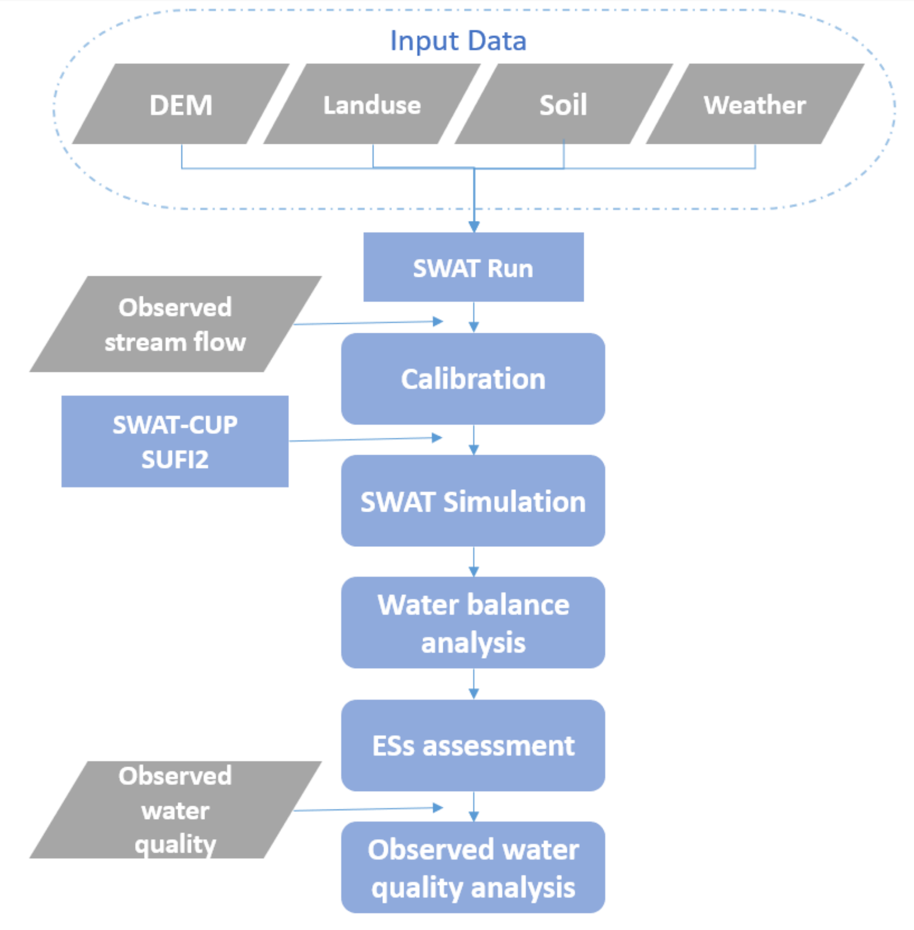


Fig9. Flow chart

- **ESs was assessed by separating water discharge to surface runoff, lateral flow and ground water discharge.**
- **At discussion part, observed water quality was analyzed to compare with the model result.**

Calibration

Table3. *Parameter*

Parameter	Default	Fitted	Rank	Description
CN2	74	51.383335	1	SCS runoff curve number
CH_K2	0	7.831329	2	Effective hydraulic conductivity in main channel alluvium (mm/hr).
CH_N2	0.014	0.035177	3	Manning's "n" value for the main channel
GW_DELAY	31	5	4	Groundwater delay
ALPHA_BF	0.048	0.3	5	Base flow alpha factor
GW_REVAP	0.02	0.0395	6	Groundwater “revap” coefficient
SMFMX	1	1.5	7	Maximum melt rate for snow during year (summer solstice)
SMTMP	0.5	1	8	Snowmelt base temperature
SFTMP	3	5	9	Snowfall temperature
GWQMN	1000	1142.5	10	Threshold in the shallow aquifer for return flow to occur
ESCO	0.95	0.5	11	Soil evaporation compensation factor

Hydrograph

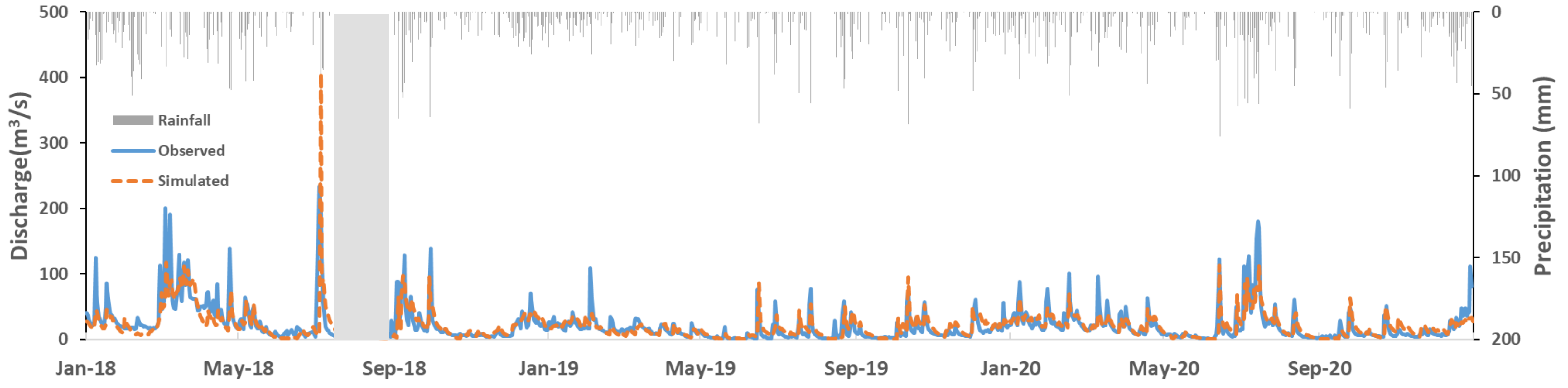


Fig10. Hydrograph (2018-2020)

Calibration and Validation: 2014 - 2020

Indications (2014-2020)
R2: 0.64
NSE: 0.62
PBAIS: 17.0

Hydrograph

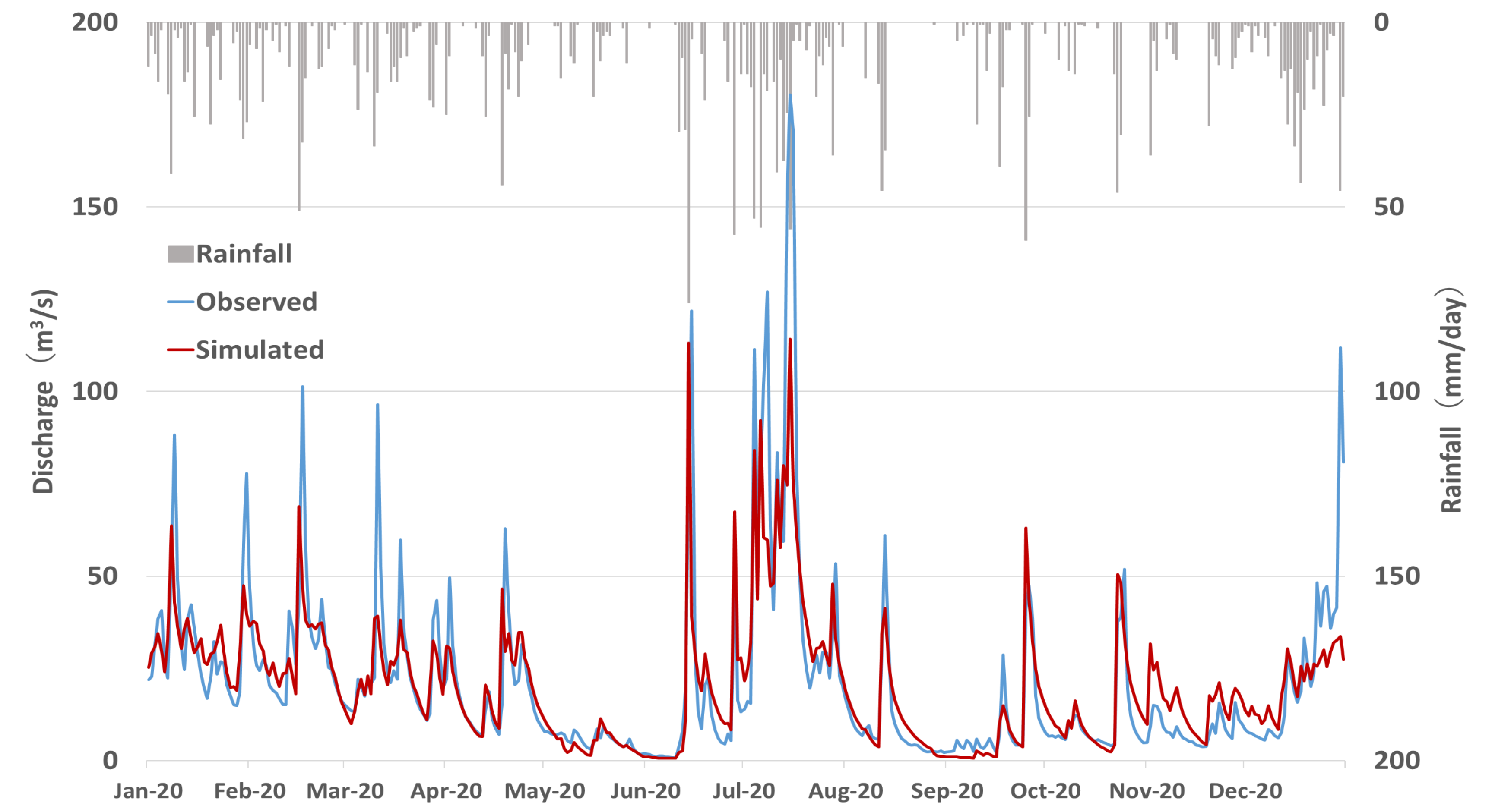


Fig11. Hydrograph (2020)

Annual water balance change

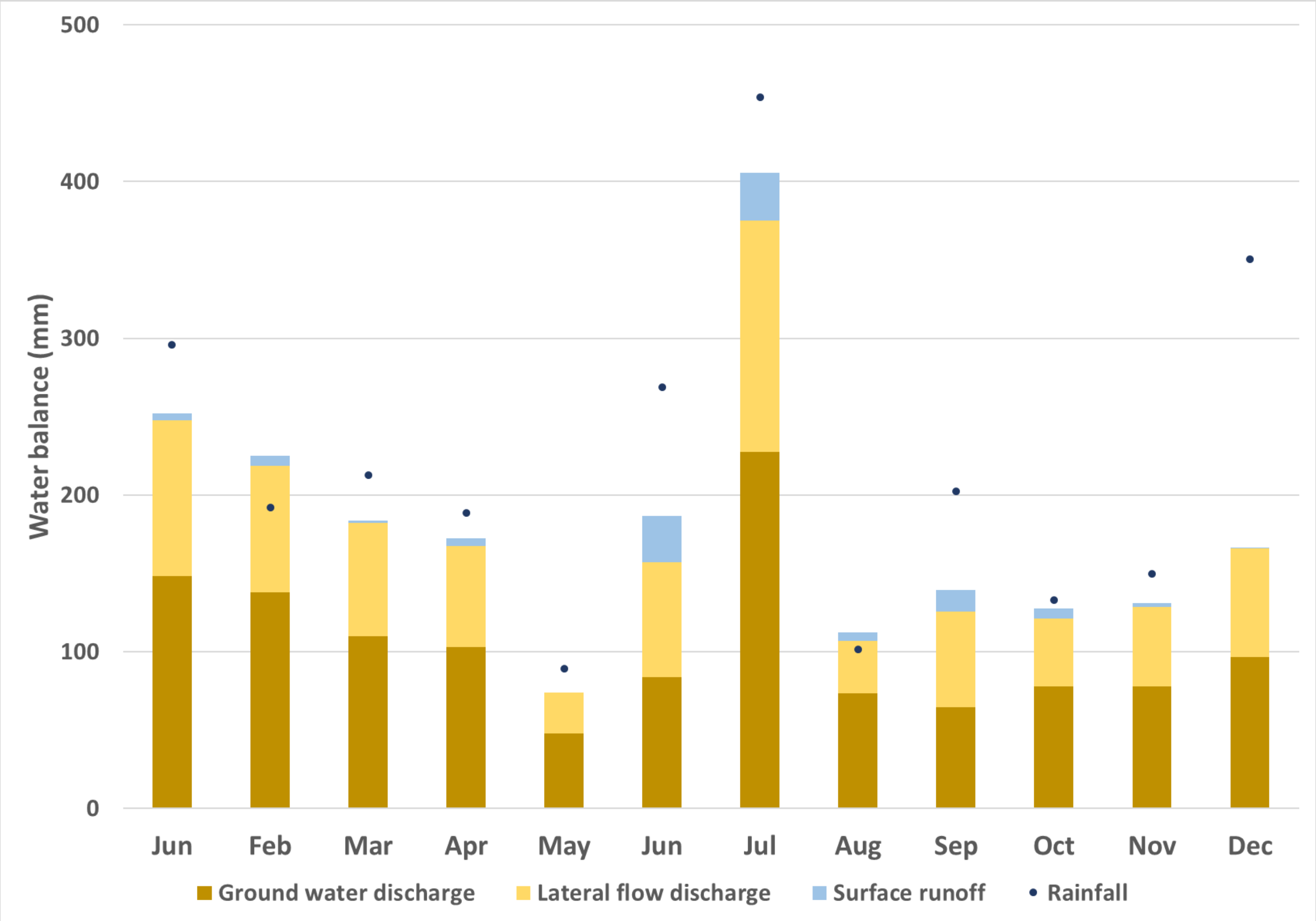


Fig12. Monthly water balance (2020)

- **High discharge ratio at snow melt season.**
- **High ground water discharge ratio especially snow melt season and autumn.**

Paddy management schedule

April -May: Paddling
May-Mid Jun: Inundation
Mid Jun-July: midseason drainage
July-August: Inundation

Water balance

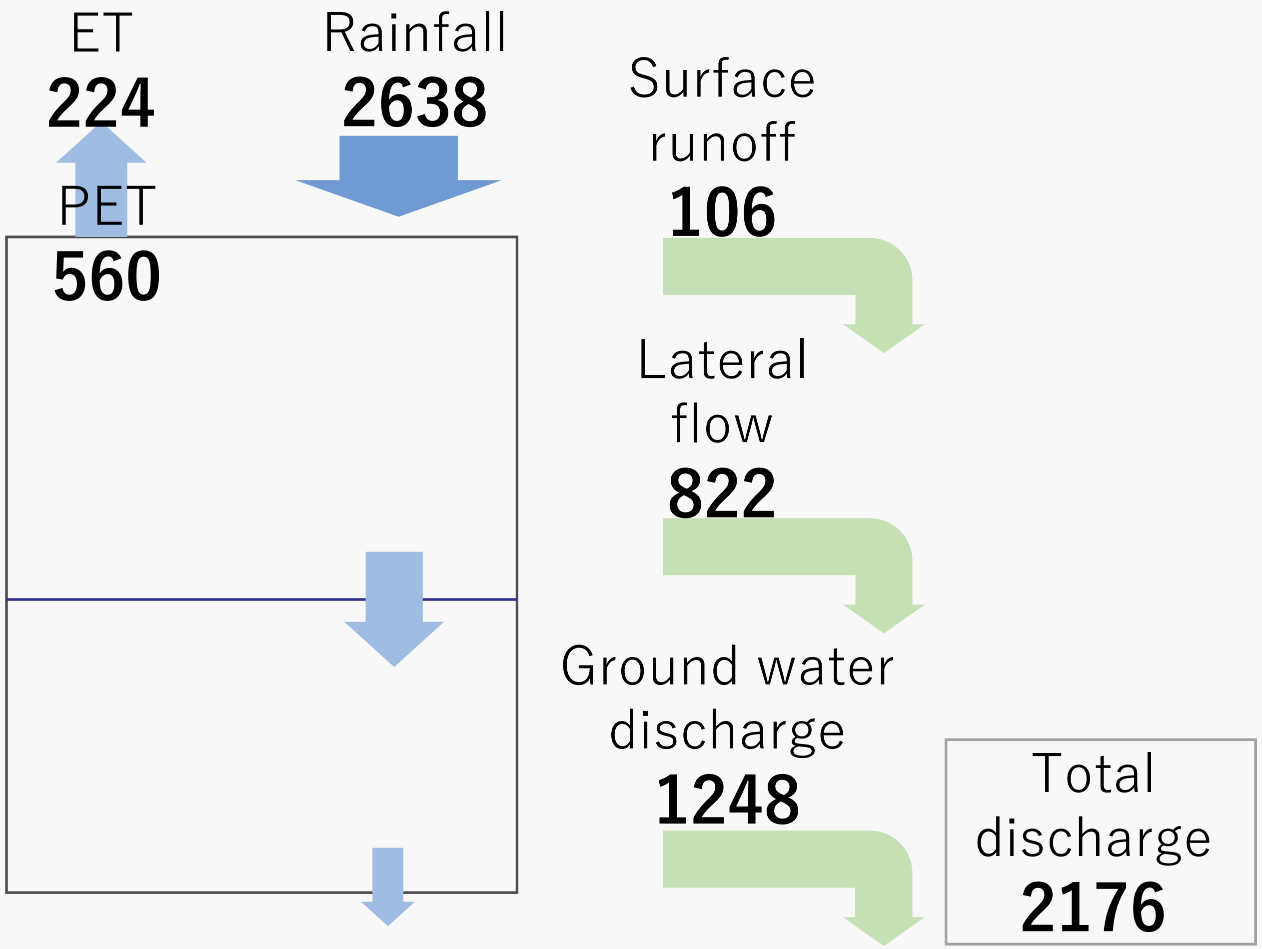


Fig13. Annual Water balance (2020)

- **Discharge ratio: 0.82**
  →Water storage
- **ET/ Rainfall: 0.08**
- **Surface runoff/ Total discharge: 0.05**
- **Ground water discharge/ Total discharge: 0.57**

Observed data – Water quality

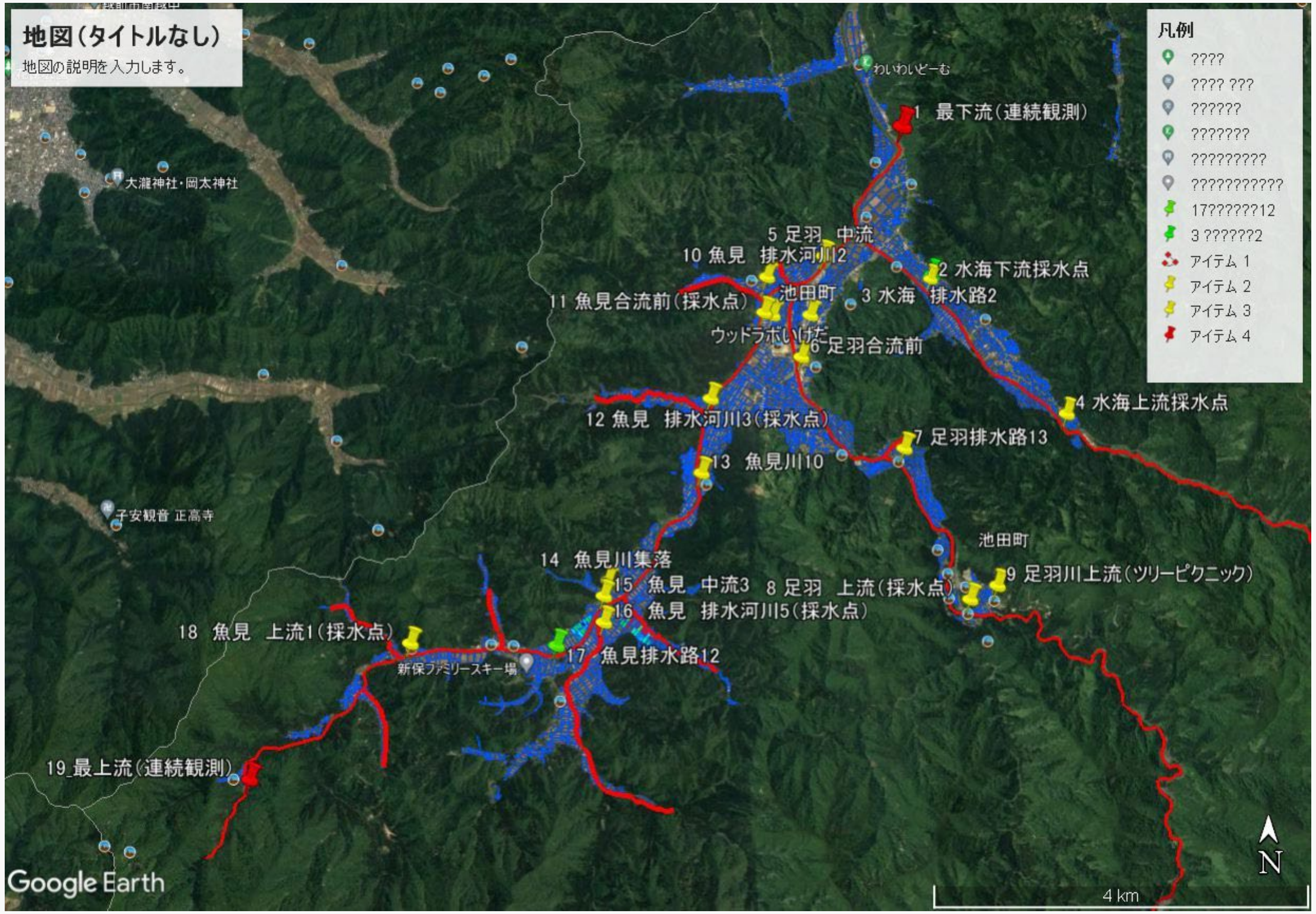


Fig14 Location of water sampling points

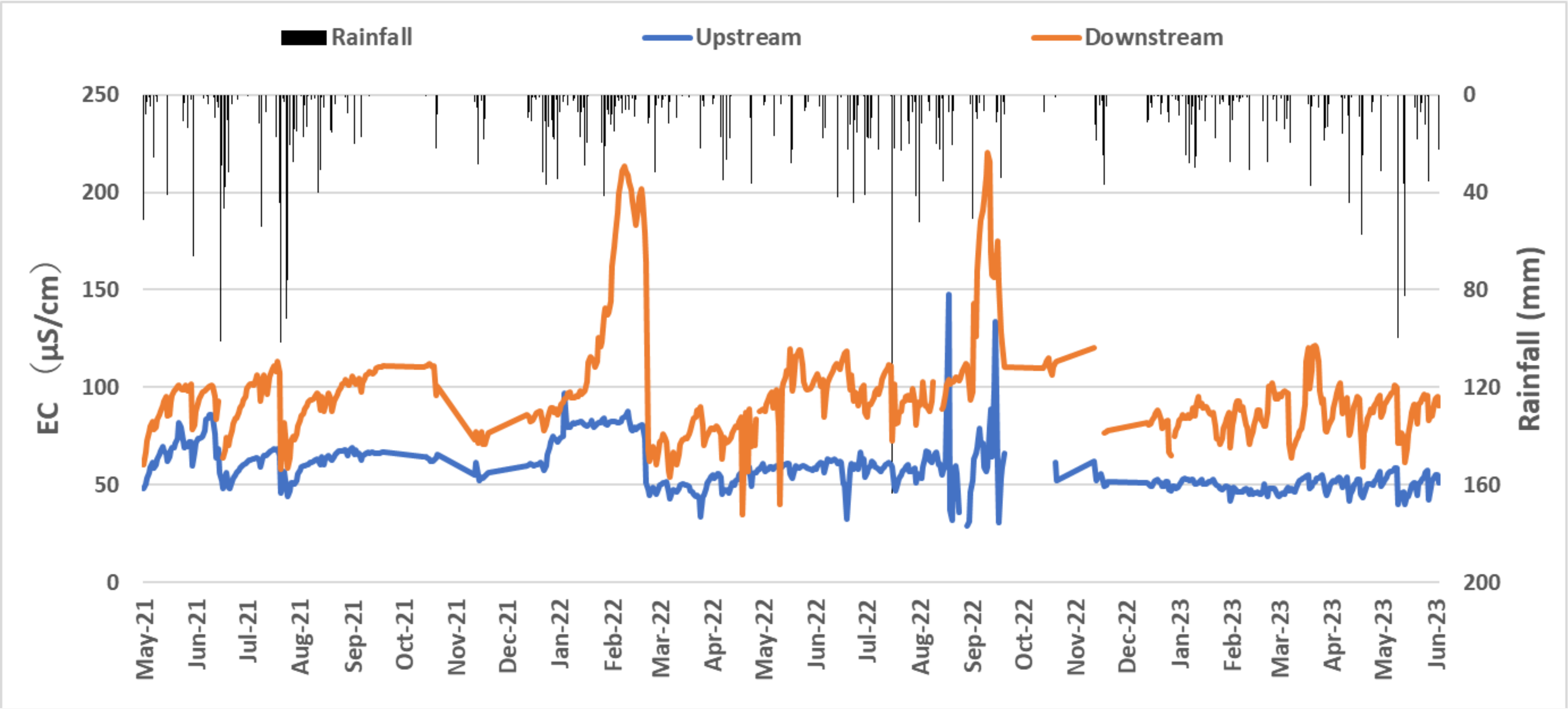
Most of the land use is forest.

Model results of discharge process may not be differed in this basin.

Water quality can be varied because of agricultural and domestic discharge.

Water sampling (EC, N, P)
- **Downstream (1)**
- **Forest (10),**
- **Paddy (5),**
- **Village (4)**

Observed data – Rainfall and EC



Upstream point

Discharge from forest

→EC is stable and raise little during snow melt season and autumn.

Downstream point

Affected by paddy and residence

→EC raise during snow melt season and autumn caused by high ground water discharge ratio

Fig15. Rainfall and EC

Observed data – Nitrogen and Phosphorous

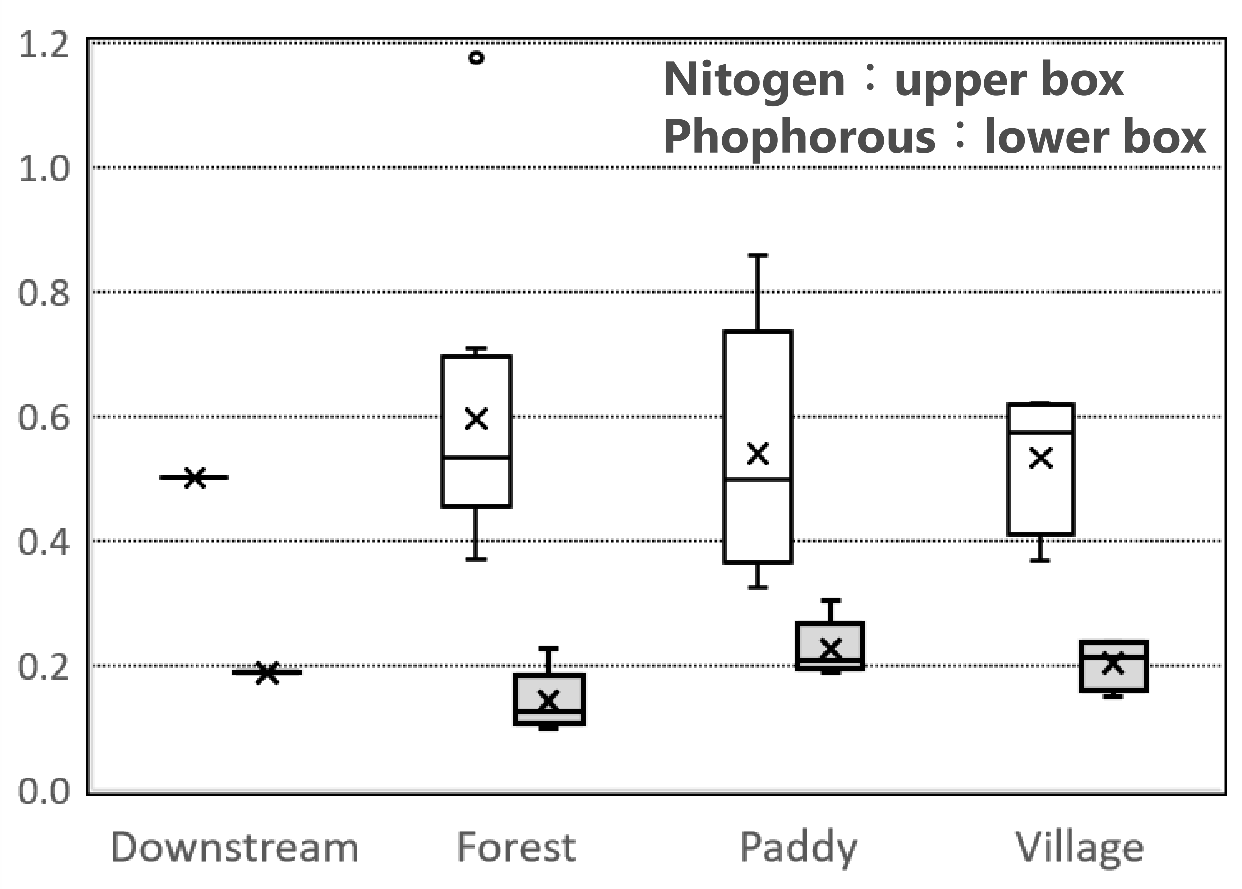


Fig16. Nitrogen and Phosphorous

- **N: Water purification of the river**
- **P: Diluted with discharge from forest**

Water sampling date:
2021/11/17, 2022/4/15, 2022/6/16, 2022/10/17, 2022/12/1

- **Hydrological process was evaluated satisfactory by using SWAT model.**
- **Water balance analysis shows that snow melt water and ground water discharge contribute to spring agricultural management of paddy field in the basin.**
- **Model result shows high ratio of groundwater especially during snow melt season and autumn, and observed water quality analysis shows high EC (high ground water discharge ratio)during this season.**
- **Observed concentration of N and P shows water purification of the river and dilution with discharge from forest.**

Thank you for your attention.