SOCIAL POLICY ECOLOGY RESEARCH INSTITUE (SPERI)

PROJECT “H2O-ANTH/2024/02”

WATER RESOURCES ASSESSMENT OF HEPA AREA, LOCATED IN UPPER REGION OF NGANPHO RIVER BASIN, SON KIM 1 AND SON KIM 2 COMMUNES, HUONG SON DISTRICT, HA TINH PROVINCE

REPORT
CALCULATION DESCRIPTION

Hanoi, April 2024

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Independent Evaluation	Host unit SOCIAL POLICY ECOLOGY RESEARCH INSTITUE (SPERI)
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Independent Monitoring and Supervisor

Signed

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Hanoi, April 2024

Contents

I. Introduction of the study area

The HEPA study area is located in Son Kim 1 and Son Kim 2 communes, Huong Son district, Ha Tinh province. The entire area is located in the Ngan Pho river basin, which belongs to the Ca river basin.

The HEPA study area has a total area of 310.7 ha (see Figure 1), of which

- Area of rich evergreen broadleaf natural forest: 217 ha
- Area of medium evergreen broadleaf natural forest: 76 ha
- Area of poor evergreen broadleaf natural forest: 8 ha
- Area of bare land and land outside forestry planning: 9.7 ha

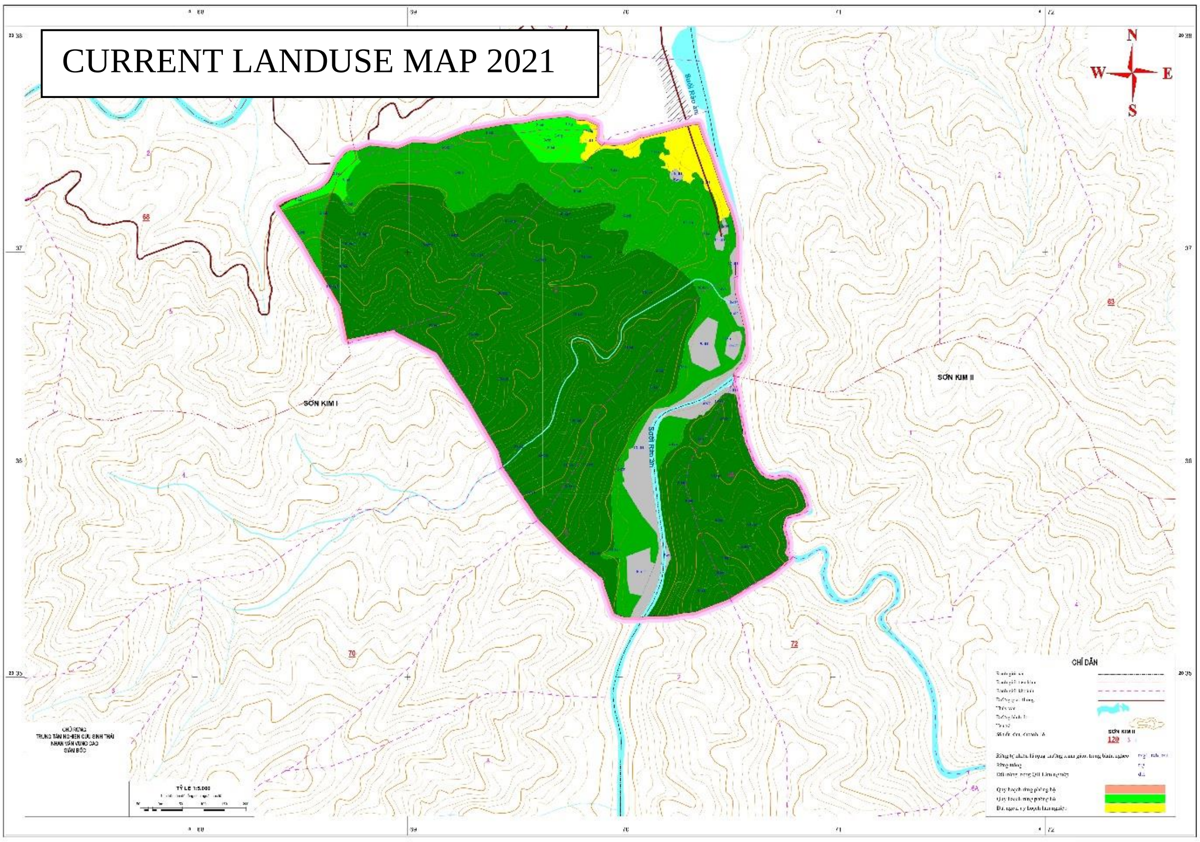

Figure 1. Current landuse map in 2021

	Land planned for protective forest
	Land planned for protective forest
	Land outside forest planning

II. Collection of meteorological and hydrological data

The collected data include:

- Meteorological data: rainfall, temperature, humidity, wind speed, sunshine hours, evaporation of Huong Son station, measurement period from 1987 to 2023.

- Hydrological data: average daily flow of Son Diem station, measurement period from 1997 to 2022.

The locations of meteorological and hydrological stations are shown in Figure 2.

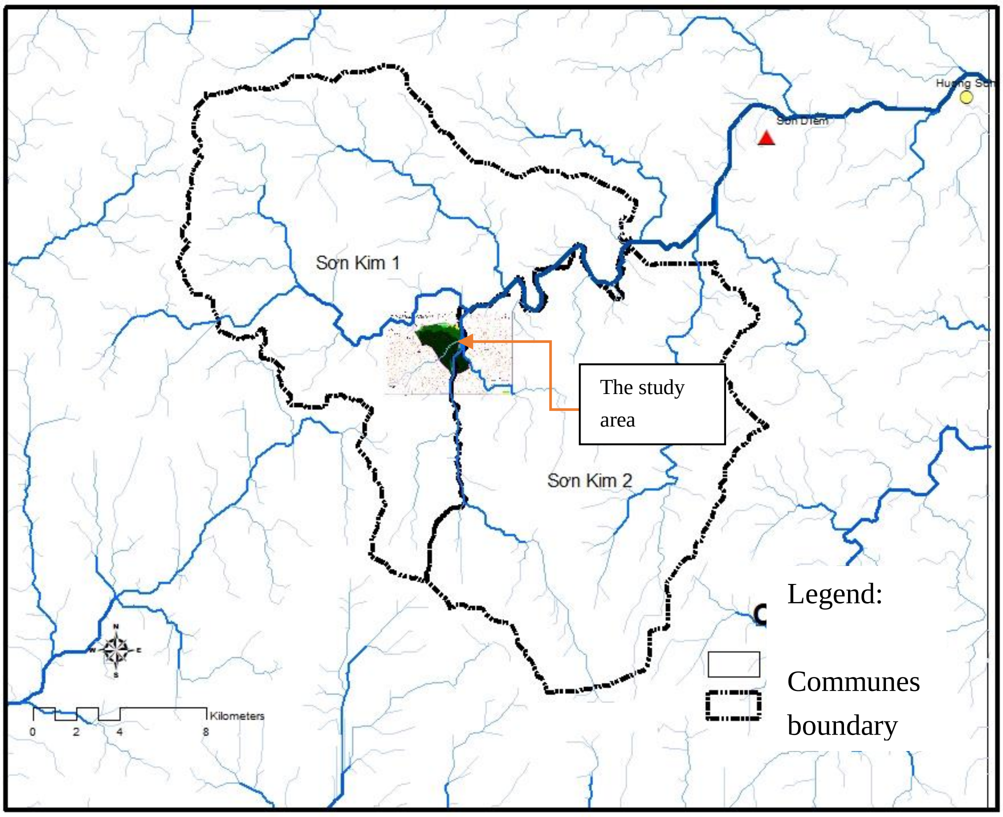

Figure 2. Meteorological and hydrological station network and location of study area

II. Selection of water balance calculation method

The fundamental water balance equation:

$$X - Q - E - T - G = \Delta S \quad (1)$$

where:

X: precipitation

Q: surface runoff

E: evaporation

T: transpiration

G: groundwater flow

ΔS: change in storage

1. Precipitation

In the area of Son Kim 1 and Son Kim 2 communes, there are two automatic rain gauges recently installed, Son Kim and Cau Treo stations. The data of these stations are not stable and have only been measured for a short duration, so they are not used for calculations in this report. In the downstream of the Ngan Pho river basin, there is a level -1 meteorological station named Huong Son station that measures all meteorological factors, including rain. Therefore, in this report, the observed rainfall data at Huong Son station was used to represent the study area. Due to the influence of terrain and forest, it is possible that the rainfall in the study area (in the mountainous area) will be higher than the rainfall in Huong Son (in the midland area). However, because there is lack of previous relevant research, in this report, the rainfall data measured at Huong Son station is used to represent for the study area. The annual monthly rainfall at Huong Son station is shown in Table 1.

Table 1. Annual monthly rainfall at Huong Son station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
X (mm)	47.4	45.1	69.3	88.6	205.5	111.5	173.1	233.1	425.9	471.1	148.7	66.6	**2086**

2. Runoff

The Son Diem hydrological station (basin area 790km^2) located in Ngan Pho main river, measured daily discharge in 2 periods, from 1961 to 1982 and from 1997 to present. In this report, the data series from 1997 to present is used to calculate the mean value of discharge.

Table 2. Annual monthly discharge at Sơn Diem station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Q (m^3/s)	24.2	19.8	17.6	17.1	21.8	19.1	24.5	35.5	95.7	129.5	60.8	33.3	**41.6**

From the observed data, it is also determined that the flood season in the area lasts from September to November, and the dry season from December to August of the following year.

The river flow is generated from surface runoff and groundwater flow. To separate surface runoff (direct runoff) and groundwater flow (baseflow), there are a number of methods such as: straight line method, fixed bottom length method and variable slope method. (Ven Te Chow et al., 1988).

Groundwater flow can be determined based on surveying, measuring groundwater levels, and assessing the water transport capacity in aquifers. However, this is a time-consuming and labor-intensive task, and is costly. Actual groundwater flow data are sparse and lacking.

3. Hydrological abstractions

Hydrological abstractions are including: interception, detention storage, depression storage, evaporation, transpiration, infiltration.

To calculate the hydrological abstrations, each component can be individually estimated or the sum of all abstractions can be estimated using the runoff coefficient. In which, the runoff coefficient is the ratio between the direct runoff and the rainfall depth.

a) Interception

The amount of water stored on leaves (canopy) or dry carpet (litter), especially for forests can be estimated through conducting experiments. Some studies of this type are done by the authors Truong Tat Do et al. (2014), Tran Thi Nhai et al. (2017). The method gives detailed results with high reliability, however, the disadvantage lies in the limited ability to conduct experiments. The types of forests studied include rubber forests or pine forests. In reality, the natural forests have many different types of trees, so it will be very difficult to follow this method. For example, in the study of Bryant et al. (2005), the amount of storage in tropical or subtropical forests can range from 6 to 42% of rainfall.

FOREST TYPE	ANNUAL INTERCEPTION (%)
Upland conifers	30–35
Broadleaves	15–25
Tropical forests	10–15
Eucalyptus	5–15
Savannas	5–10

Table 3.2: Typical values of annual interception loss (% precipitation) for different forest types (Calder, 1990; Hall et al., 1992; IH, 1998, Pereira et al, 2009b)

(source: Hydrology: Principles and processes – M.Robinson and R.C. Ward)

Take the average value of 12.5% for Tropical forests:

I = 12.5% * 2086mm = 260.8 mm

b) Evaporation

Evaporation includes two types: water surface evaporation and ground evaporation.

The two main factors affecting water surface evaporation are the heat source (solar radiation) and the ability to transport water vapor away from the water surface (depending on wind speed and air humidity). Determining water surface evaporation can be based on the energy balance method, the aerodynamic method or a combination method (Ven Te Chow et al., 1988). The Huong Son meteorological station has measured water surface evaporation with the annual monthly values as follows:

Table 3. Annual monthly evaporation at Huong Son station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
E(mm)	36.1	35.5	43.9	62.5	99.9	154.8	150.3	111.6	63.3	48.4	44.0	38.2	888.4

Evaporation from the ground includes direct soil evaporation and evaporation through the leaves, in which water is taken up by the roots, transported up through the stem and transferred to the atmosphere through the tiny stomata on the leaves. Evaporation from the ground and evaporation from the plant are collectively called transpiration. The actual amount of transpiration depends on the type of crop, climate and soil conditions. The FAO CROPWAT software supports the calculation of evaporation for specific cultivated crops, thereby determining irrigation water requirements.

c) Infiltration

Infiltration is the downward movement of water through the soil surface. There are many factors that influence the rate of infiltration including ground conditions and vegetation cover, soil properties such as porosity, hydraulic conductivity and existing moisture content in the soil.

Some common methods of calculating infiltration are Horton, Phillip and Green-Ampt methods.

It should be noted that the types of hydrological abstractions including intercepion, depression storage, and detention storage play an important role when calculating floods caused by a heavy rain. When considering over a long period, the amount of water intercepted on the leaves will either flow down the tree stem to the ground, or will evaporate back into the air. Similarly, the amount of water that penetrates into the ground after a period of time can evaporate back into the air or infiltrate deeper into the underground aquifer, ultimately running into rivers and streams.

Therefore, in the water balance equation (1) written for a period, for example a certain year, we do not see the components of interception, depression storage, and detention storage.

When applying water balance equation for a period of many years, there are wet years and dry years. Therefore, if we calculate the average over a period of many years, the change in the storage can be neglected ΔS ≅ 0. Then, the water balance equation will have a simplified form:

$$X - (Q+G) - (E+T) = 0 \qquad (2)$$

To meet the requirements for detailed assessment of the components in the water balance equation, we propose to use the mathematical modeling method. The NAM model is a rainfall-runoff simulation model, a product of the DHI Denmark, which has been widely applied in the world and in Vietnam. The structure of the model is described in the figure below.

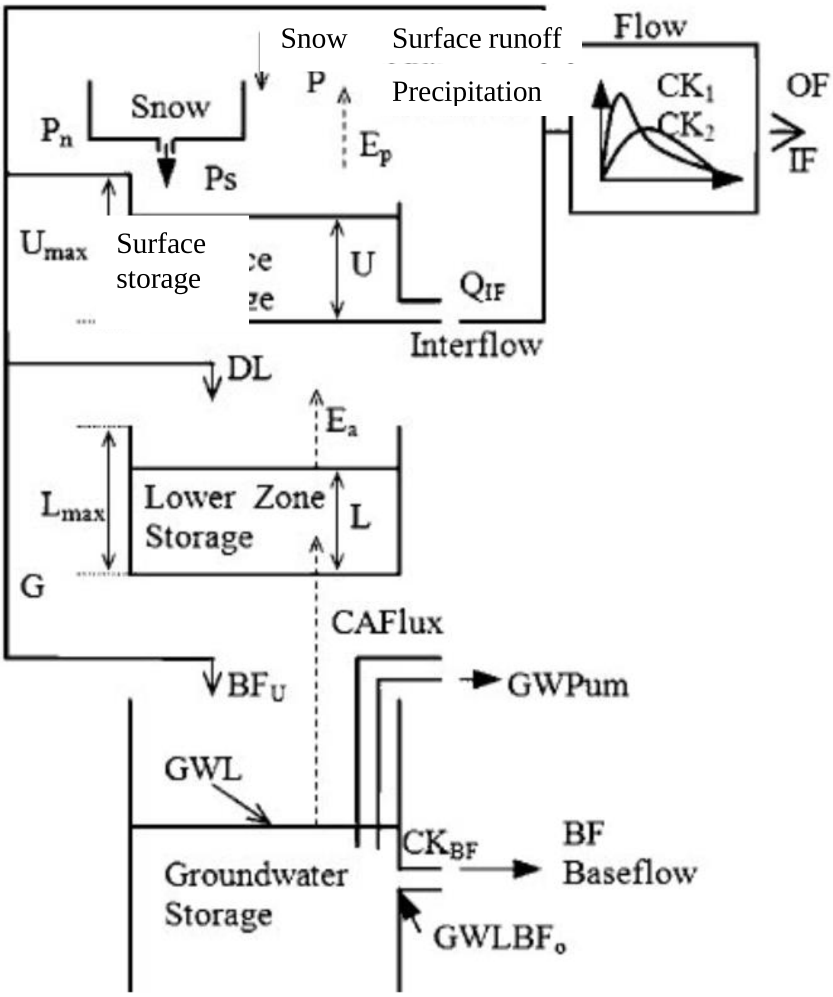

Figure 3. Structure of NAM model (DHI, 2021)

The input data of the NAM model include rainfall, potential evaporation, and temperature (applicable to snowy areas), through the structure of four vertical storages, which interact with each other to describe the physical properties of the basin, the NAM model allows simulating the entire continuous flow process or single events (floods) in the river basin. Along with that, the groundwater level and other information in the hydrological cycle such as temporary changes in soil moisture and groundwater recharge capacity are also simulated in the model.

We used the collected hydrometeorological data to calibrate and verify the model parameter set. The results show that the NASH index is at a fairly average level (0.6).

III. Assessment of water resources in the study area

From the results of simulating the rainfall-flow process using the NAM model, it is determined that the surface flow component accounts for 53%; the groundwater flow accounts for 47%.

Components in the water balance equation: X= 2086mm; Q = 879.6mm; G=780.0mm; E+T=426.4mm.

According to Schlesinger and Jasechko, 2014: the amount of transpiration (T) in tropical forests accounts for a proportion of about 70 ± 14% compared to the total amount of evapotranspiration (ET).

T = 70% * 426.4 = 298.5 mm

E = 30% * 426.4 = 127.9 mm

The water balance calculation was performed for 2 scenarios:

- KBHT: current scenario with forests cover above 70%.
- KBST: recession scenario considering the possibility of forest cover below 30%.

In the study of the impact of forests on streamflow in the Beijing area, China, the authors (Ding et al., 2022) concluded that the highest percentage of baseflow was in broadleaf forests (61.1%) and the lowest in shrubland (43.1%).

In another study by Schlesinger and Jasechko, 2014, the ratio between evaporation and precipitation increased by 1.07 times for shrubland compared to tropical forests.

It can be seen that forests have an impact on reducing evapotranspiration and increasing groundflow. With some such data, we calculate the water balance results as shown in the following table:

Table 4. Calculation of water storage components in the study area

Unit: m^3/ha/year

Storage components	Current scenario (forest cover >70%)	Recession scenario (forest cover <30%)
Water quantity discharged into rivers and streams	8796	10057
Water quantity that penetrate deeper into the underground	5192	5122
Moisture retention in the cultivated surface layer	2608	1117
Evaporation and transpiration	4264	4562
Sum	20860	20860

Conclusion

There are many methods that can be used for assessment of water resources for an area, however, no method is considered omnipotent. Each method has its own advantages and disadvantages. The HEPA study area is a small area, with relatively primitive conditions, not much affected by humans. Data and documents related to this area are very limited, while time and human resources are limited. Therefore, the report used hydrological methods to calculate the water balance for the area. Hydrological methods are considered one of the simple, but quite effective methods. The method makes good use of existing hydrometeorological data, and at the same time evaluates the components in the water balance equation quite thoroughly. The calculation results were performed for two scenarios, the current situtation and when considering the level of forest degradation. Although the total amount of water did not change in the two scenarios, each component changed, showing the contribution of forests to the redistribution of water resources. This research is only considering the vertical water balance equation. In fact, the role of forests also affects spatial and temporal changes, especially the ability of forests to regulate flow in reducing high flow and increasing low flow. To evaluate the effectiveness of forests on water resources, further in-depth research is needed./.

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