6-5 Analysis of water storage state by the subsurface dam

From the results of the study and the observation described above, an analysis of the water storage mechanism by the subsurface dam was carried out according to the flow chart shown in Fig. 6.7.

This report only shows the results of the analysis, omitting the details of the analysis process.

Because of the constraints of the data available, a very simplified method was used for the analysis. Hereafter, further improvement can be examined in the analysis.

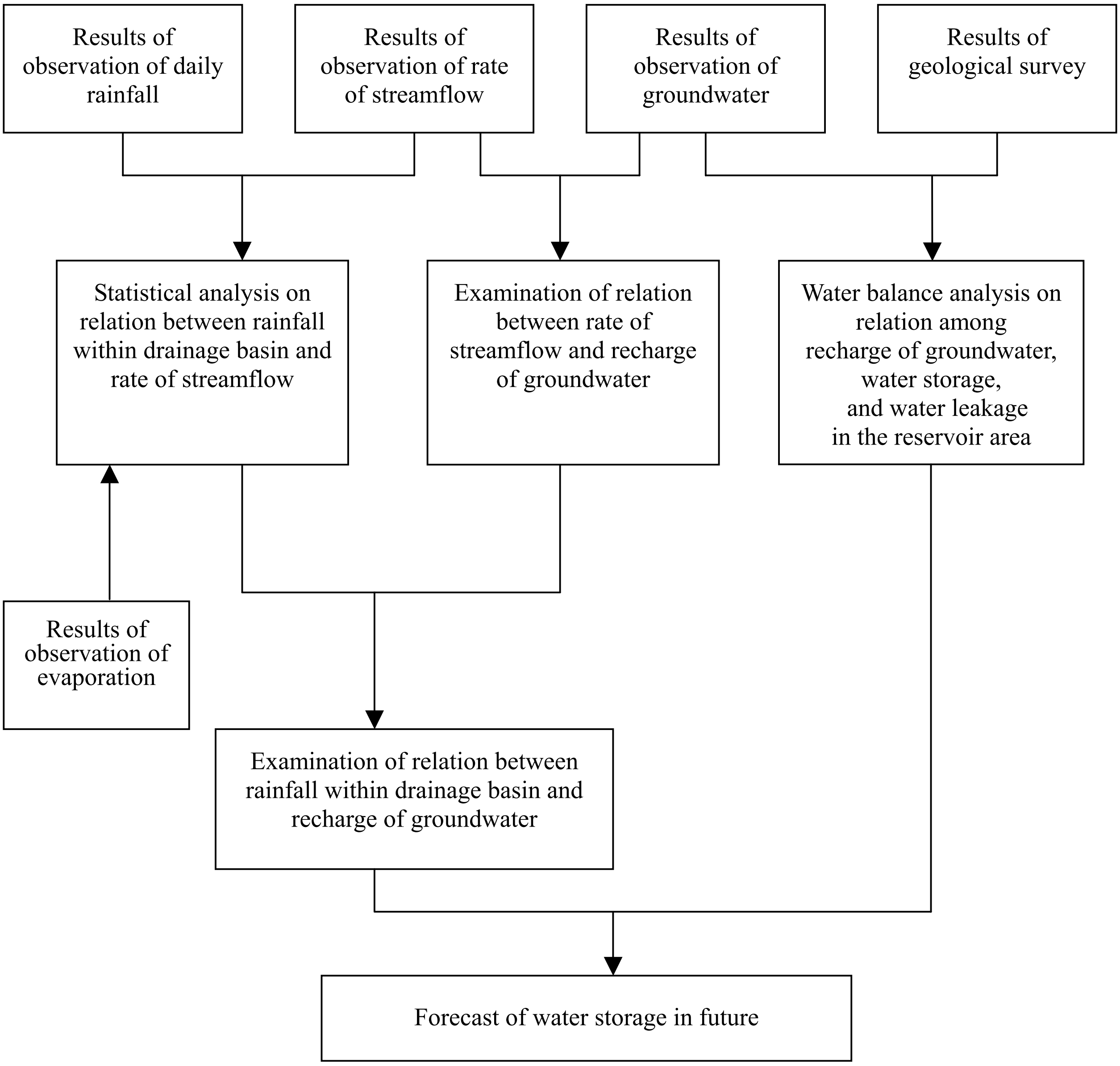

Fig.6.7: Flowchart of analysis of the water-storage mechanism

(1) Relation between the rainfall within the drainage basin and the rate of streamflow
The statistical analysis of the daily rate of streamflow at the crossing point of the Kolongo River with the old main road in Nare Village and of the daily rainfall (*) within the Kolongo River basin provided the relationship shown in Fig. 6.8.
(*The rainfall within the drainage basin was estimated from the rainfall data measured in Nare/Koulikare, Ouanobian, Noka and Kaya.)

(2) Relation between the rate of streamflow and the recharge of groundwater
From the rate of streamflow measured in 2000 and 2001 and the estimated recharge of groundwater, the following relationship was presumed:

Recharge of groundwater = about 10 to 15% of the amount of streamflow (*) from July to October
(*Rate of streamflow at Nare Village)

(3) Relation between the rainfall within the drainage basin and the recharge of groundwater
The relationships given above in (1) and (2) make it possible to estimate the recharge of groundwater from the rainfall measured within the Kolongo River basin.

(4) Dimensions of the reservoir area of subsurface dam
The survey of a longitudinal profile of the reservoir area showed that the slope of the ground surface was 0.65/1000. The digging of the observation wells also revealed that the thickness of the fossil valley sediment (water storage layer of subsurface dam) in the reservoir area was not very different from that at the dam site. Therefore, assuming that the slope of the bottom of the reservoir layer is equal to that of the ground surface, the dimensions of the reservoir are estimated as follows:

- Width of the reservoir area: About 150 m on average (lowest estimate)
- Maximum extent of the reservoir area: 13.4 km upstream of the dam
- Maximum groundwater level: -3 m below ground surface
- Volume of the reservoir layer: About 9,000,000 m^3
- Maximum water storage capacity: 1,800,000 m^3 (assuming that the effective porosity of the reservoir layer is about 20%)

(5) Results of water balance analysis in the reservoir area
From the results of water balance analysis on recharge of groundwater, water storage and water leakage, the water storage state in the reservoir area of the subsurface dam was estimated as shown in Table 6.5.

Table 6.5: Change in water storage state by the subsurface dam

(m^3)

	(1) Recharge of groundwater	(2) Water leakage	Increase in reserved water (1) - (2)	Total amount of reserved water at the end of the dry season
In the rainy season of 1998	1,200,000		(1,200,000)	(1,200,000)
At the end of the dry season of 1999		990,000	210,000	210,000
In the rainy season of 1999	1,200,000		(1,200,000)	(1,410,000)
At the end of the dry season of 2000		990,000	210,000	420,000
In the rainy season of 2000	750,000		(750,000)	(1,170,000)
At the end of the dry season of 2001		990,000	－240,000	180,000
In the rainy season of 2001	1,200,000		(1,200,000)	(1,380,000)
At the end of the dry season of 2002		990,000	210,000	390,000
Total	4,350,000	3,960,000	390,000	390,000

Note: Water storage by the subsurface dam actually started in the rainy se

(6) Forecast of water storage in the future

As Table 6.5 shows, the water leakage from the reservoir area of the subsurface dam is estimated to be about 990,000 m^3 per year. Therefore, when an extraordinary drought occurs as in 2000, reserved water at the end of the dry season of the following year will decrease compared with the previous year.

However, assuming that these droughts are extremely rare and the annual recharge of groundwater on average is about 90% that observed in 2001 (about 1,200,000 m^3), i.e. 1,100,000 m^3, the water storage in the future will change in the following way:

1) With the recharge of groundwater (the increase in reserved water) during the rainy season, the reservoir layer of the subsurface dam will be "full" in the rainy season of 2005. The reserved water will then be about 1,800,000 m^3.

2) However, due to water leakage from the reservoir layer, the reserved water will decrease to about 800,000 m^3 at the end of the dry season of 2006 (until the beginning of the following rainy season).

3) With the recharge of groundwater of 1,100,000 m^3 during the rainy season of 2006 as assumed, the reserved water will reach the maximum capacity of about 1,800,000 m^3, and the excess water of about 100,000 m^3 will overflow the crest of the subsurface dam.

4) Subsequently, the cycle in which the reserved water reached about 1,800,000 m^3 (maximum water storage capacity) in the rainy season and will decrease to about 800,000 m^3 at the end of the dry season of the following year will be repeated.

In this analysis of water storage by the subsurface dam, the fossil valley sediment and its underlying layer, the heavily weathered layer of basement rock, were modeled as the "reservoir layer". Only the reserved water within them was taken into account, and outflowing groundwater from the “reservoir layer” was regarded as "water leakage". However, leakage to the basement rock is recharge of groundwater in the basement rock from another viewpoint. According to the water balance analysis described above, the total water leakage since the construction of the subsurface dam until the end of the dry season of 2002 was about 4,000,000 m^3. This means that the basement rock had been recharged with a large amount of groundwater. Although all this water may not remain in the basement rock in the vicinity of the subsurface dam, a considerable part of it is possibly stored in the basement rock.

Relation between rainfall on drainage basin X (m^3/day) and the daily rate of streamflow Y (m^3/day) in Nare Village

From May to June: **Y ＝0.022 X ＋29,000** Correlation coefficient = 0.615

From July to October: **Y ＝0.057 X ＋38,000** Correlation coefficient = 0.656

To calculate rainfall within the drainage basin X (rainfall multiplied by catchment area), the following corrected values are used, in which E represents the average daily potential evaporation (mm) for the corresponding month.

Catchment areas A1 and A2: {(Rainfall of 3 days ago - 3.4E) + (Rainfall of 2 days ago - 3.4E)}/2
Catchment area A3: {(Rainfall of 2 days ago - 1.0E) + (Rainfall of 1 day ago - 1.0E)}/2
Catchment area A4: {(Rainfall of 2 days ago - 0.6E) + (Rainfall from 1 day ago - 0.6E)}/2
Catchment area A5: Today's rainfall - 0.6E

* If the "daily rainfall - E" < 0, this is considered equal to zero.

The approximate division of the river basin is as follows:

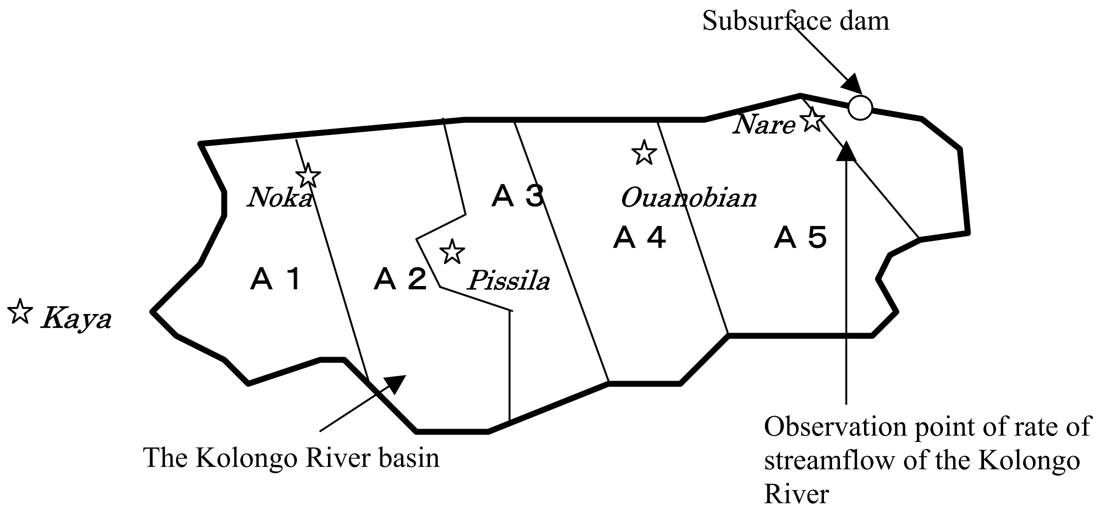

Fig.6.8: Relation between the daily rate of streamflow and rainfall within the drainage basin at observation points in Nare Village on the Kolongo River