1-4 Outline of the facilities for the demonstration studies

The facilities for the demonstration studies in this project were as follows:

(1) Subsurface dam
A subsurface dam with the following characteristics was constructed on the Kolongo River at the Koulikare Quarter in Nare Village:
Type: earth dam
Crest length: about 210 m
Depth of dam: 3.0 to 11.4 m (maximum) below the ground surface

(2) Other experimental facilities
- Water-pumping station operated by solar energy: with 3 water-pumping wells (about 20-m depth) located in the reservoir area, with 1.76 kwp of solar power
- Multi-purpose water-supply stations: water-supply stations for domestic, agricultural and livestock uses
- Pilot farm: 0.25-ha area, located in Kombangbedo Village for cultivation tests of cereals and vegetables by methods such as drip irrigation
- Small-scale surface dam with water gates: 33-m width with 23 water gates, maximum water level being 1.2 m, utilizing the bridge piers of a main road located 1.2 km upstream of the subsurface dam site to recharge groundwater

(3) Facilities for groundwater observation
- Facilities for groundwater observation with automatic water level recorders: at 5 points (The water level recorders were removed in 2001 due to decrepitude.)
- Wells for groundwater observation: 3 boreholes and 2 large-diameter wells
- Wells for water pumping and groundwater observation: 2 boreholes and 4 large-diameter wells
- Sets of piezometers (wells for observation of the hydraulic head): 16 pipes located at 4 points

(4) Meteorological stations (mainly of rainfall)
- Meteorological station in the Koulikare Quarter in Nare Village: a station for the observation of rainfall, evaporation, temperature, humidity, etc.
- Rainfall stations in the Kolongo River basin: 3 stations (the Kossonkore Quarter in Nare Village, Ouanobian Village, and Noka Village)

1-5 Evaluation of the results of the project and prospects

(1) Water storage state
The subsurface dam constructed in this project stores water in the reservoir layer consisting of "fossil valley sediment" and heavily weathered basement rock. According to the calculation using a simplified reservoir model, the extent of the reservoir area, the groundwater level and the volume of the reservoir at its maximum storage capacity are as follows:

- Width of the reservoir area: about 150 m (lowest estimate)
- Length of the reservoir area (upstream distance to which the reserved water extends): 13.4 km
- Maximum groundwater level: -3.0 m (depth below the ground surface)
- Water storage capacity: about 1,800,000 m^3 (with the effective porosity of the reservoir layer estimated to be 20%)

Up to the end of 2002, the groundwater level (depth below the ground surface) varied from -7.0 m at the end of the dry season to -4.2 m at the end of the rainy season, and had not yet reached the maximum level. The reservoir area probably extended 5 or 6 km upstream of the dam, and the volume of reserved water was thus estimated to be about 400,000 m^3 at the end of 2002.

According to the results of an analysis of water balance in the reservoir area, a recharge of groundwater of about 1,100,000 m^3/year is estimated in the rainy season if the rainfall is that of an average year. On the other hand, with leakage of about 1,000,000 m^3/year, the effective increase in the reserved water is estimated to be 100,000 m^3/year.

If the reserved water increases at this rate, it will reach the maximum storage capacity of about 1,800,000 m^3 during the rainy season of 2005. At the end of the dry season of the following year, the volume will fall to 800,000 m^3 because of leakage. Subsequently, the reservoir will follow this cycle with a maximum of 1,800,000 m^3 in the rainy season and a minimum of 800,000 m^3 in the dry season of the following year.

The water leakage is due to infiltration into the basement rock, not due to the insufficient water shut-off ability of the dam body. This means that the infiltrated water is stored in the basement rock.

It should be noted that reserved water using the subsurface dam, via the three "water-pumping wells operated by solar energy", supplies local people with 7.4 m^3 water per day, i.e., roughly 2,700 m^3 water per year.

As noted above, water is being stored gradually although its speed is lower than expected due to unexpected water leakage. It is thus proved that the subsurface dam can supply water even in the dry season. To avoid the problem of water leakage (infiltration into the basement rock), it was necessary to carry out a more detailed hydrogeological survey at the stage of site selection.

(2) Costs

The direct costs of the construction of the subsurface dam and installation of the water-pumping and supply stations were as follows:

- Construction of subsurface dam: 108,595 thousand yen
- Installation of water-pumping and supply stations: 24,900 thousand yen (a part of which is estimated)

The construction of the subsurface dam was wholly supervised by Japanese engineers, but their personnel costs are not included in the above.

(3) Management and maintenance system

The management and maintenance of water resources requires "ownership" by local people and local authorities. As for this subsurface dam, a system to collect a water tax has already set up at the site village to cover the cost of minor repairs to the facilities. However, to maintain the continuous operation of the facilities, it is necessary to set up a longer-term management and maintenance system.

(4) Impact on the environment

No significant impact on the environment, in particular on the vegetation, was noted until the end of 2002, 5 years after the construction of the subsurface dam. It was due, among other things, to the dam site being located near the confluence point of the Kolongo River into a larger river.

(5) Applicability to other areas

This model project is probably a rare study on the exploitation of water resources using a subsurface dam in arid and semi-arid areas. In areas where there are fossil valleys, subsurface dams, using the information and the knowledge obtained from this project, is worth consideration to exploit shallow groundwater to combat desertification.