# 1. General description of the Model Project to Combat Desertification and evaluation of its results

## 1-1 History and aim of the project

The United Nations Convention to Combat Desertification, adopted in 1994 and put into force in 1996, attaches importance to the use of technologies suitable to local conditions in its implementation.

With particular interest in the technology of the "subsurface dam", which has been developed operationally in Japan, the Ministry of the Environment of Japan conducted the "Model Project to Combat Desertification" to examine, from the viewpoint of both hardware and software, the applicability of this technology under local conditions for the effective exploitation and use of groundwater resources that is invaluable in desertified areas.

In arid and semi-arid areas where desertification continues, surface water and deep groundwater has been focused on in the exploitation of water resources.

In general, surface water is exploited by means of "surface dams". However, a surface dam implies the submergence of a vast land area, and consequently raises problems such as the destruction of environment and the forced migration of the local people. In addition, if it is constructed in flat peneplain in arid or semi-arid areas, the reservoir area of the surface dam, which is large compared with its depth, makes the evaporation rate very rapid. Thus, it cannot work as a "water storage dam" in the dry season when the need for water is the greatest in the year.

In addition, the exploitation of deep groundwater raises a sustainability problem due to its limited volume. There can also be a problem of salinization when the salt concentration of the groundwater is high. In addition, the exploitation of deep groundwater, which is usually conducted point by point, tends to result in the concentration of population and livestock animals, and consequently to accelerate desertification.

To avoid these problems inherent in the exploitation of surface water or deep groundwater, it is necessary to consider the possibility of the exploitation of shallow groundwater, which exists at a shallow depth under ground and flows at a relatively high rate. To exploit shallow groundwater, "subsurface dams" have aroused interest recently. They are the facilities that retain and store groundwater using a dam body. In Japan, this technology is being developed as a new means to exploit water resources in isolated islands that have no large river. In comparison with the surface dam, the subsurface dam has the advantages of having no submerged land area and no risk of collapse because it is constructed under ground. In arid areas, there may be other advantages such as low water loss by evaporation, and less risk of the proliferation of parasites. However, a subsurface dam is accompanied by difficulties in site selection that require an accurate grasp of the hydrogeologic conditions. It is also handicapped by its low effectiveness in water storage, because water is stored in pores in geological strata.

In this project, we chose a subsurface dam for storing shallow groundwater as a means of exploiting water resources in arid and semi-arid areas, and decided to verify its applicability under local conditions in West Africa suffering from chronic drought.

## 1-2 Execution of the project

This project was carried out from 1995 to March 2003.

(1) Selection of the site country
The United Nations Convention to Combat Desertification notes that serious drought and

desertification has tragic consequences, particularly in Africa.

In this project, Burkina Faso was selected from the Sahel region as a country that meets the following conditions:

1) A country seriously affected by desertification
2) A country with relatively large areas with aquifers of shallow groundwater
3) A country whose political situation is stable

(2) Survey to select the project site, from 1995 to 1996
The interpretation of satellite images and aero-photographs, as well as preliminary exploration, was carried out at 35 sites in the central and the northern part of Burkina Faso, which are areas affected by desertification, to narrow the possible sites for the project. On the basis of the results of electric soundings, test drillings, observations of groundwater level and socio-economic research, Nare Village, Tougouri District, Nametenga Province was finally selected for the project site of the subsurface dam.

(3) Construction of facilities for the demonstration study of a subsurface dam, from 1997 to 1998
Construction of the subsurface dam was carried out during the dry season from November 1997 to June 1998, on the Kolongo River in Nare Village.

Thereafter, during the dry season after October 1998, water-pumping and supply facilities, a small-scale surface dam with water gates, wells for groundwater observation, a pilot farm and other facilities were set up.

(4) Conduct of relevant demonstration studies, from 1999 to 2000
Along with the observation of the water storage state, the following studies were carried out to examine effective groundwater usage and its impact on the environment (in particular, on vegetation):

- Observation of groundwater
- Meteorological observation (mainly of rainfall)
- Observation of rate of streamflow
- Agricultural pilot studies
- Vegetation research

(5) Additional observations, from 2001 to March 2003
In the initial plan, the duration of this project was 6 years (1995 to 2000). However, as the rising speed of groundwater level was lower than expected, it was necessary to continue the observation to verify the effectiveness of the subsurface dam. The project was thus prolonged for 2 years, and the observation of groundwater and rainfall was continued.

(6) Completion of the project
The project was finished in March 2003 with positive results. The Permanent Secretariat of the National Council for the Environment and Sustainable Development (S.P.CONEDD) of Burkina Faso requested that the facilities for the demonstration studies be left to improve and develop the living conditions of the local people. This request was accepted with the hope that these facilities will continue to contribute to combating desertification and to the sustainable development of Nare Village and the whole of Burkina Faso.

## 1-3 Organizational framework of the project

This model project to combat desertification was carried out under the organizational framework shown in Fig. 1.1.

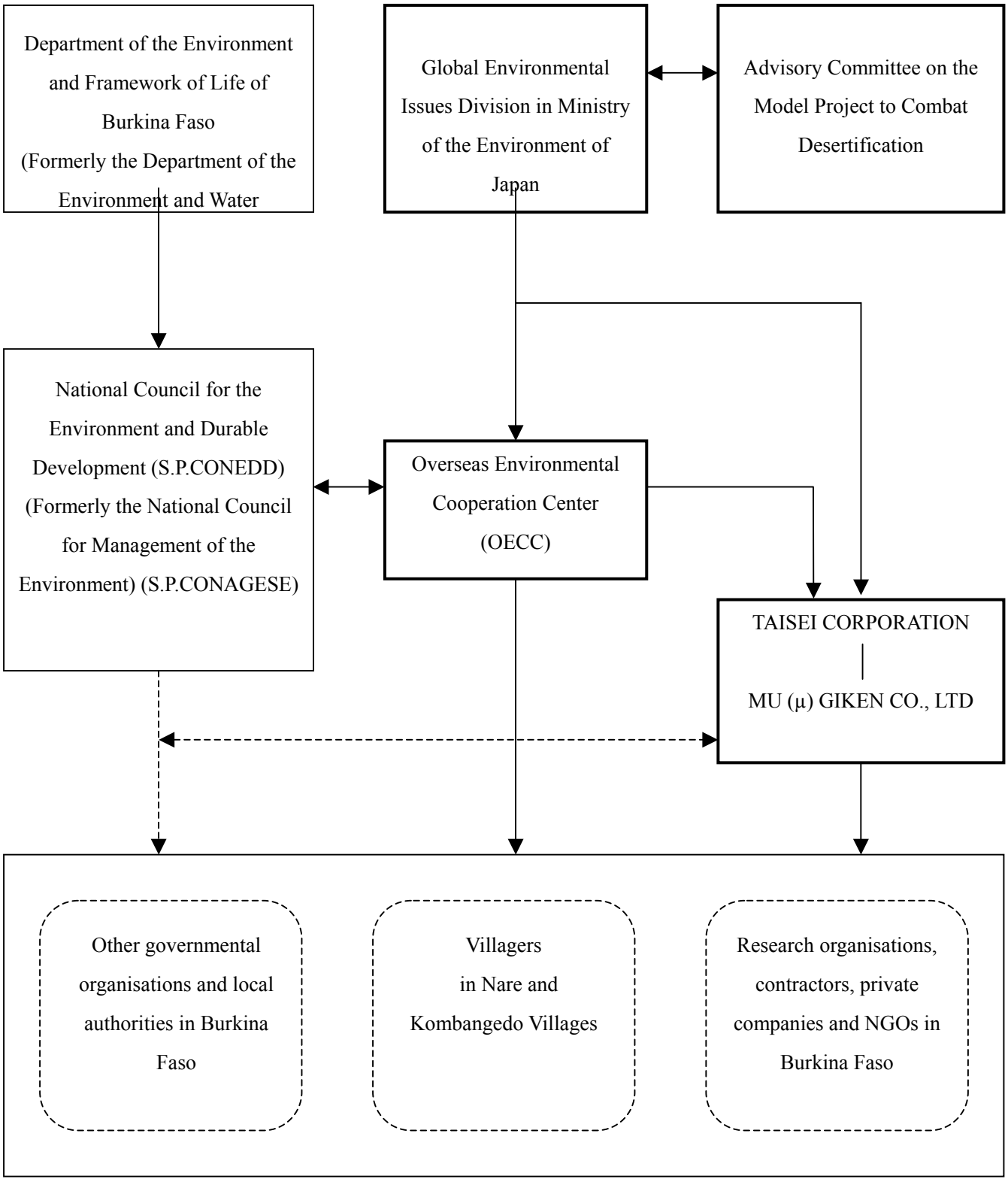


Fig. 1.1: Organizational framework of the project

## 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.