17. A　SOLUTION TO THE WATER PROBLEM OF SUB-SAHARAN AFERICA TAKE BAMAKO CITY MALI AS AN EXAMPLE

Yang TIAN[1*],Tadashi YAMADA[2]

[1]Gradute School of Science and Engineering,Chuo University
(1-13-27 Kasuga,Bunkyo-ku,Tokyo 112-8551,Japan)
[2]Gradute School of Science and Engineering,Chuo University
(1-13-27 Kasuga,Bunkyo-ku,Tokyo 112-8551,Japan)
* E-mail: *denyo@civil.chuo-u.ac.jp*

The Sub-Saharan Africa area is a typical zone with many developing countries which always suffer from lots of problems including food shortage, accessiable water shortage, poor sanitation condition, lack of fundermental infrastructure, etc. These severe scenarios are partly due to the natrual condition(most of this area are belonged to tropical area, rare and unbalanced rainfall,etc.) and partly due to the social condition(some countries are politically unstable and suffer from finiancial problems,etc.).

In this paper,we take Bamako City which is the capital of Mali as an example to try to find a new way to solve the water problem under severe condition as mentioned above with limited financial support. In detail, for hardware,we designed the water supply and wastewater drainage system; for software, we designed the Integrated Social Enterprise (ISE) to construct,operate,maintain and manage the water and wastewater system.

Key Words :*Sub-Saharan Africa, Bamako, water supply, sanitation, hardware design, software design , ISE*

1. BACKGROUNG OF BAMAKO CITY

Bamako is the capital city of Mali in west Africa with a rapid population growth speed. Due to the rural exodus and high birth rate since the 1960s, Bamako is being one of the fastest growing cities in Africa. According to a census carried out in 2009, the population of Bamako City beyonds 1.8 million.

However ,the urban infrastructure and amenities, especially water supply and wastewater treatment system of Bamako is severely unsufficient, especially for the poor communities, mainly reside in the south of this city.

River Niger cross the city from esat to west, seprating the city to north and south part. The north part is consisted with 4 communes, i.e. Commune I ~IV;and the south part is consisted with 2 communes, i.e. Commune V~VI. The population distributation is showed as in Table 1.

The formerly urbanized districts located on the left bank and developed between 1883 and 1960. These encompass the government and business districts which date back from the colonial era. The recently urbanized districts belonging to a second generation and developed between 1960 and 1970 on the shorelines of both of the riverbanks. Most of the plush residential districts belong to the category. The peripheral district consisting of slums.

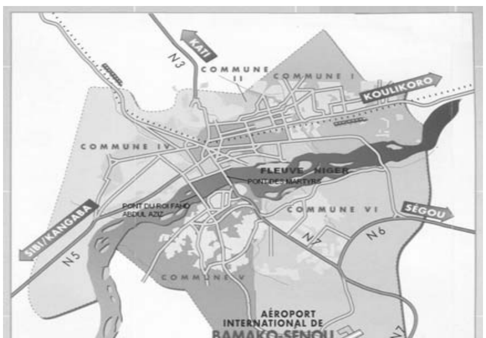

Fig.1 Map of Bamako City

Table 1 Area and demographics of Bamako in 2009

	Commune I	Commune II	Commune III	Commune IV	northern zone	Commune V	Commune VI	southern zone	total
population	335,407	159,805	128,872	300,085	924,169	414,668	470,269	884,937	1,809,106
area (km2)	35	18.3	20.7	42	116	42	87	129	245
population density	9583.06	8732.51	6225.70	7144.88	7966.97	9873.05	5405.39	6859.98	7384.11

(1) Topograph

Bamako City is situated on the Niger River floodplain. The southpart of Bamako city is relatively flat, however, in the north there is an escarpment. As is showed in Fig.2.

(2) Climate

There are 2 main seasons in Bamako, i.e. the rainly season and the dry season . Rainly season ranges from May to Oct.,and dry season ranges from Nov. to April.

Though yearly rainfall reaches 1000mm, due to this kind of climate, the rainfall is temporally unevevn as showed in Table-2.

(3) Water information

Accessible water supply is unsufficient quantatively, in addition,water resource quality is serious .Besides, used water are rarely treated which makes contribution to the severe sanitaionary and healthy scenario.

1) Water resources and water supply

a) water mangement

The Ministère des Mines, de l'Energie et de l'Eau (MMEE – Ministry of Mining,Energy, and Water) is responsible for the supply of drinking water and electricity.And Energie du Mali is the sole official water producer and distributor.

b) water source

Water source of Bamako City is as described below.

・The city water supply system pumping the water from the Niger river in the upper part of Bamako and distributing it after treatment to the population.But household connected to potable water is 26% ;

・The water collected straight from the river and streams without any specific treatment;

・The traditional wells, usually shallow (2 to 10m deep), tapping the groundwater, the groundwater is presently very polluted in the old district as well as in the densely populated new districts. 55% of the population of Bamako uses wells which are often poorly constructed and are situated close to latrines and sewers;

・The deep bore-holes tapping the sheet-water from the fractured grits through solar powered pumps (hand-activated pump).

Fig.2 Topographic map of Bamako city

Table 2 Rainfall of Bamako from 1950-2000

month	Jan	Feb	Mar	Apr	May	Jun	
rainfall(mm)	0.6	0.7	2.1	19.7	54.1	132.1	
month	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Ave
rainfall(mm)	224.1	290.2	195.9	66.1	5.2	0.5	991.3

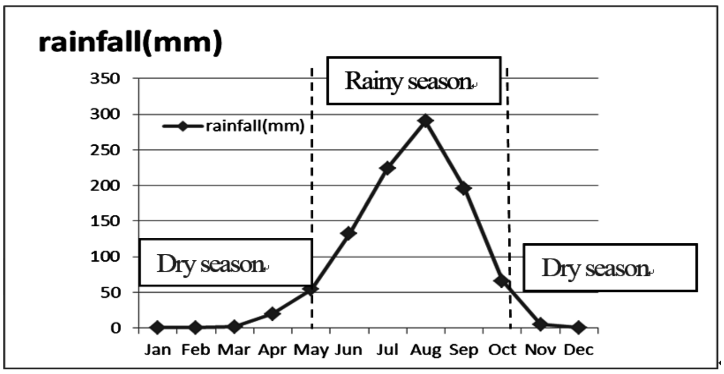

Fig.3 Rainfall of Bamako from 1950-2000 and 2 seasons

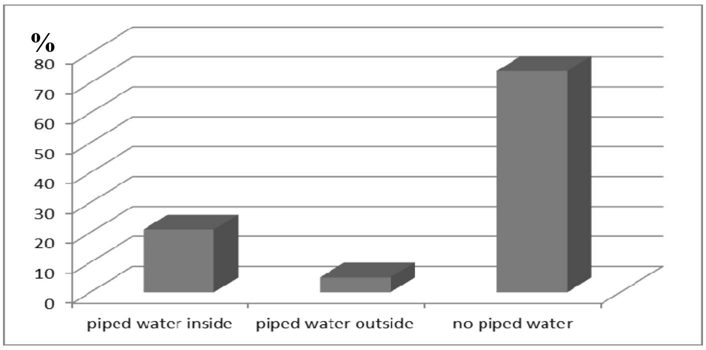

Fig.4 Percentage of household connected to potable water in Bamako

c) the current problems of water supply
- inadequate transmission capacity
- limited water storage capacity
- low and uneven development of access through household connections
- insufficient pressure

2) Water quality

a) surface water

The Niger River is the main water source of Bamako, however ,at the same time it's the dumping ground for chemical wastes from medium and small-scale industries and receives runoff from one of the city's main cemeteries. This pollution occurs above the drinking water intake pumping station.

b) ground water

Groundwater in Bamako is highly polluted by pesticides, metals (above all mercury and lead) and other chemical substances. The nitrate content ranges from 0.1% to 1.7%, i.e. three times the WHO standards (NEAP/CID 1997).

3) Wastewater treatment

The public sewage treatment of Bamako in 2000 is only 1.5 %.
- 98.5% of domestic sewage discharged into individual facilities;
- 32% of the population uses septic tanks and 66.5% latrines;
- Less than a quarter of all schools and educational establishments have septic tanks, and 50% use latrines.

As a result, health problems have arisen from poor sanitation caused by improper or non- existent wastewater collection and treatment.

2. HARDWEAR DESIGN FOR WATER AND WASTEWATER SYSTEM

(1) Hardware design for water supply system

1) Goal of water supply design

access to potable water 100%

a) provide whole some water to the consumers for drinking purpose.

b) supply adequate quantity to meet at least the minimum needs of the individuals.

c) make adequate provisions for emergencies
- fire fighting
- Festivals
- meeting
- Etc.

d) make provision for future demands due to
- increase in population
- increase in standard of living
- storage and conveyance

e) prevent pollution of water at source, storage and conveyance

f) maintain the treatment units and distribution system in good condition with adequate staff and materials

g) design and maintain the system that is economical and reliable

2)Water demand

a) types of water demands
- Domestic water demand

Table 3 Domestic water demand for Bamako

	Drinking	Cooking	Bathing	Clothes washing	Utensils washing	House washing	total
water consumpation (L/cap/d)	5	5	55	20	10	10	135

- Industrial demand

depends on the type of industries, 20 to 25% of t he total demand

of the city.
- Institution and commercial demand
- Demand for public use
- Fire demand
- Loses and wastes

15% of total quantity of water is made to compensate for loses and wastes.

b) per capita water demand

Table 4 Per capita water demand for Bamako

	Domestic purpose	Industril use	Public use	Fire fighting	Losses wastage	total
water consumpation (L/cap/d)	135	40	25	15	55	270

c)total water demand

・Per capita demand

q= 270L/c/d

・Population

m=200million (taking the population growth in to consideration)

Total water demand

Q=qm= 540,000㎥/d

3) Development of water supply infrastructure

a) Construction of pumping station on the banks of River Niger;

b) New construction of a 400000 ㎥/d capacity water treatment plant with a warning mechanism for quality monitoring;

c) Laying of large-diameter transfer pipes;

d) Construction of water storage tanks with capacity ranging from 2 000 ㎥/d to 10 000 ㎥/d ;

e) Construction of drinking water distribution networks, the old pipes to be rehabilitated ;

f)Construction of standpipes, including low-cost connections(especially on the north bank of bamako) and normal home connections.

(2) Sepreated design for north and south bank of the Niger River

As the infrastructure for north bank where traditional downtown locates is relatively completed ,while the south bank which suffers water shortage with many slums and the poor has an insufficient infrastructure for water and wastewater system.It is necessary to design the water system separately,i.e. in this design, we will design different system for north and south bank, though main focus will be paid to the south .

Water demand for north and south is showed in Table 5.

(3) Water supply system for north bank

Designed water supply capacity

・Expected population:1million

・Water demand for north

Qn:540,000/2=270,000㎥/d

・Current water supply capacity:

Q0=20,000x80%=160,000㎥/d

・Designed water supply capacity:

Q=Qn-Q0=270,000-160,000=110,000㎥/d

Table 5 Water demand for north and south

District	Population	Area (km2)	Water demand (m3/d)		
			total	current	designed
North Bank	924,169	116	270,000	160,000	110,000
South Bank	884,937	129	270,000	40,000	230,000

1) Water treatment plant

A new water treatment plant(WTP) with a capacity of 110,000㎥/d will be built. RSF method (rapid sand filter) will be used for water treatment in this plant.

The plant will be located in the upstream of the Niger River on the north bank. And raw water will be pumped comes from the Niger River. To balance the temporally uneven precipitation, water from a reservoir(dam) using gravity are transported to the water treatment plant as well.

2) Water supply pipe system

The pipes that are under use currently will be maintained and made full use of. And new pipes which are necessary and important will be constructed. The final water supply pipe system for north bank will be a traditional ring shape.

(4) Water drainage system for north bank

1) Wastewater treatment plant

At the end of the water drainage syetem, a new wastewater treatment plant(WWTP) will be built. Activated sludge process(ASP) will be used in the WWTP to treat the wastewater.

2) Water drainage pipe system

A main drainage pipe along the north river bank will be built. Branch pipes will be built according to the distribution of domestic and industrial zone. And the water drainage pipe system will be a tree shape.

(5) Water supply and drainage system for south bank

Designed water supply capacity

・Expected population:1million

・Water demand for south

Qn:540,000/2=270,000m^3/d

・Current water supply capacity:

Q0=20,000x20%=40,000m^3/d

・Designed water supply capacity:

Q=Qn-Q0=270,000-40,000=230,000m^3/d

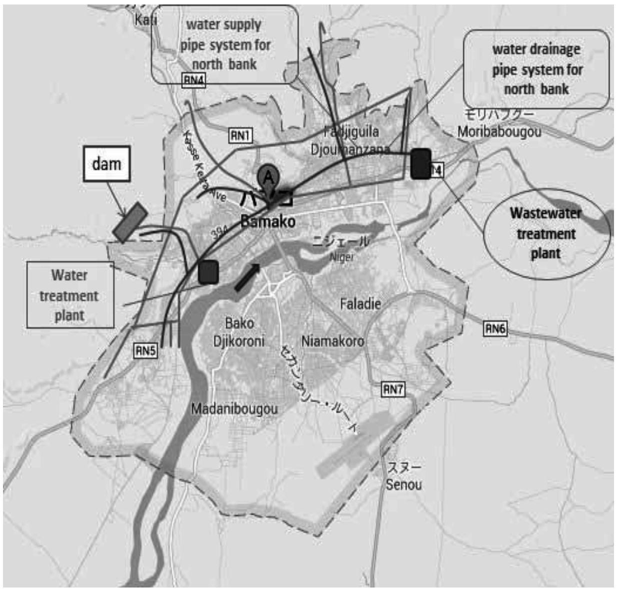

Fig.5 Water supply and drainage system for north bank

1) Open channel

In order to meet the goal of water supply and drainage system with limited financial support. No pipes will be used , on the contrary, to make full use of the abundant labor for of Bamako city, an open channel will be digged across the south bank for the integrated use of water .

2) Compact plant for water and wastewater treatment

The south bank will be divided into 5 zones, each has a distribution point which is compact with water and wastewater treatment.

As for water supply, each compact plant (CP) will be constructed with a capacity of 46,000m^3/d. SSF method (slow sand filter) will be used for water treatment in compact plant. And raw water comes from the open channel.

Treated water from the compact plant will be distributed to users by branch channels using gravity. At the same time, used water will be collected by the by-channels(see Fig.6) which are paralled with the branch channels, and the collected wastewater will be treated in the compact plant before it is discharged to the main channel and finally to the environmental lake which will be discussed later.

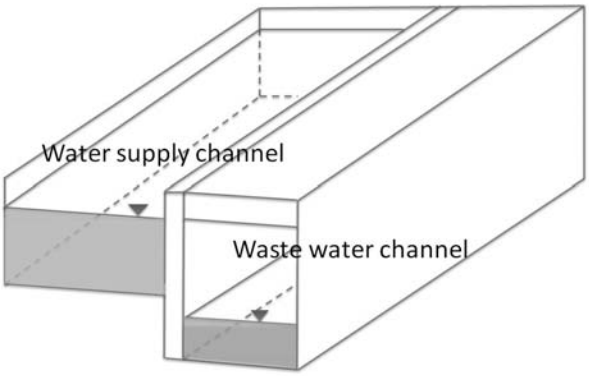

Fig.6 Paralled branch channel for water supply and drainage system

3) Envrionmental lake

At the end of the open channel an environmemtal lake will be digged too for the recycle of water.

The effluent from compact plant will finally run to the environmental lake which enjoys an effective self-purification capacity.And the environmental lake can have other functions which will benefit the city as showed in Fig.7.

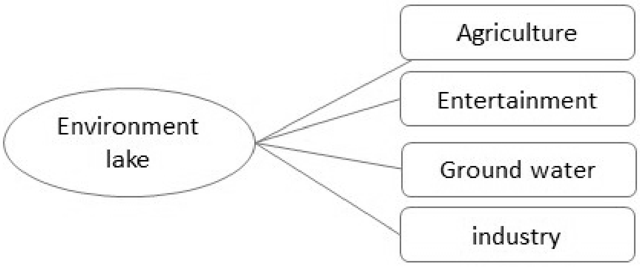

Fig.7 Environmental lake's function

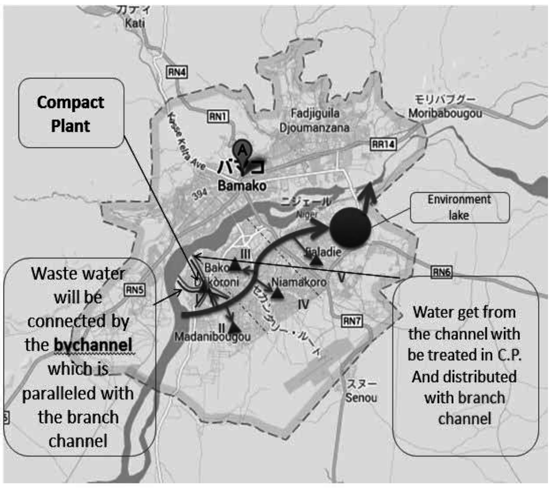

Fig.8 Water supply and drainage system for south bank

3. SOFTWARE DESIGN FOR WATER AND WASTEWATER SYSTEM

(1) Financial resources

As Bamako is a typical African city which suffers from a deficit, for software design, we will develop universal and unique financial resources for water and wastewater system.

The financial resources are show ed in Fig.9.

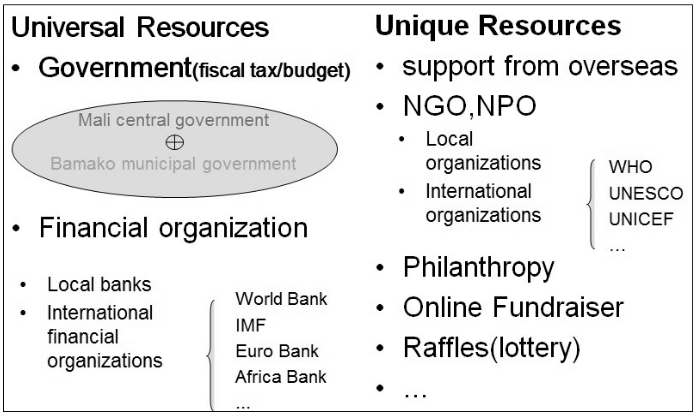

Fig.9 Financial resources for water supply and drainage system

(2) Local resources

Make full use of local resources,
ex. labor,mineral resources ,etc.

(3) Social business

An integrated social enterprise (ISE) will be established to construct,operate,maintain and manage the water and wastewater system of Bamako city.

1) Objectives of ISE

・ access to potable water for Bamako will be 100%;
・sewage treatment rate will be 50%;
・provide water and service with social and environmental concern.

2)Motto of ISE

・ from the citizen
・ by the citizen
・ to the citizen

3)Employment of ISE

ISE will try to make full use of the abundant labor force of the city, in addition, citizen with barriers to work will also be employed.

4)Ownership of ISE

ISE will owned by the the poor or other underprivileged parts of the society who could gain through receiving direct dividens or indirect benefits (as shown in Fig. 10).

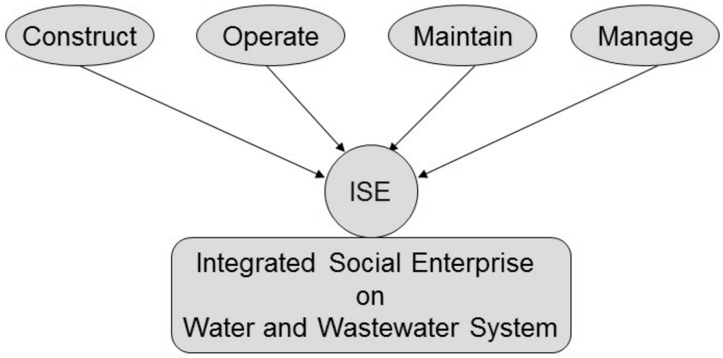

Fig. 10 Function of ISE

4. CONCLUSIONS

(1) This design is for the ground design of Bamako's water supply and drainage system.
(2) Characteristics of hardware design
・ Open Channel for water supply ;
・ Environmental Lake for water circulation;
・ Compact Plant which treat water and wastewater.
(3) Characteristics of software design

Established an Integrated Social Enterprise(ISE) to construct, operate, maintain and manage the water and wastewater system of Bamako City with limited financial resources but effectively.

REFERENCES

1) Cecilia M. Briceño-Garmendia, Carolina Dominguez and Nataliya Pushak.: Mali's Infrastructure: A Continental Perspective,World Bank.
2) Banerjee, Sudeshna, Heather Skilling, Vivien Foster, Cecilia Briceño-Garmendia, Elvira Morella, and Tarik Chfadi.: Ebbing Water, Surging Deficits: Urban Water Supply in Sub-SaharanAfrica.AICD Background Paper 12, Africa Region, World Bank.
3) Ministere de l'Energie, des Mines et de l'Eau.: Republique du Mali. 2009.
4) James Newton.: Kampala Sanitation Master Plan,www.mottmac.com.