REPUBLIC OF SENEGAL
NATIONAL OFFICE OF SANITATION OF SENEGAL
NATIONAL AGENCY FOR PUBLIC CLEANING OF SENEGAL

THE PROJECT FOR TREATMENT OF SEWAGE, RAINWATER AND WASTES IN KAOLACK CITY IN THE REPUBLIC OF SENEGAL

FINAL REPORT

Volume II: Main Report

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD
EARTH AND HUMAN CORPORATION

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COMPOSITION OF FINAL REPORT

Volume I	**:**	**Summary**
Volume II	**:**	**Main Report**
Volume II	**:**	**Main Report** **Drawings and Design Notes**

Currency Exchange Rates used in "Part I Master Plan" of this Report

EUR	1.00	= FCFA 655.957 = USD	1.305	= JPY	109.545
USD	1.00	= FCFA 502.649 = EUR	0.766	= JPY	83.943
JPY	100.00	= FCFA 598.823 = USD	1.191	= EUR	0.913

(As of December 2012)

Currency Exchange Rates used in "Part II Feasibility Study" of this Report

EUR	1.00	= FCFA 657.071 = USD	1.326	= JPY	130.100
USD	1.00	= FCFA 495.455 = EUR	0.754	= JPY	98.100
JPY	100.00	= FCFA 505.051 = USD	1.019	= EUR	0.769

(As of August 2013)

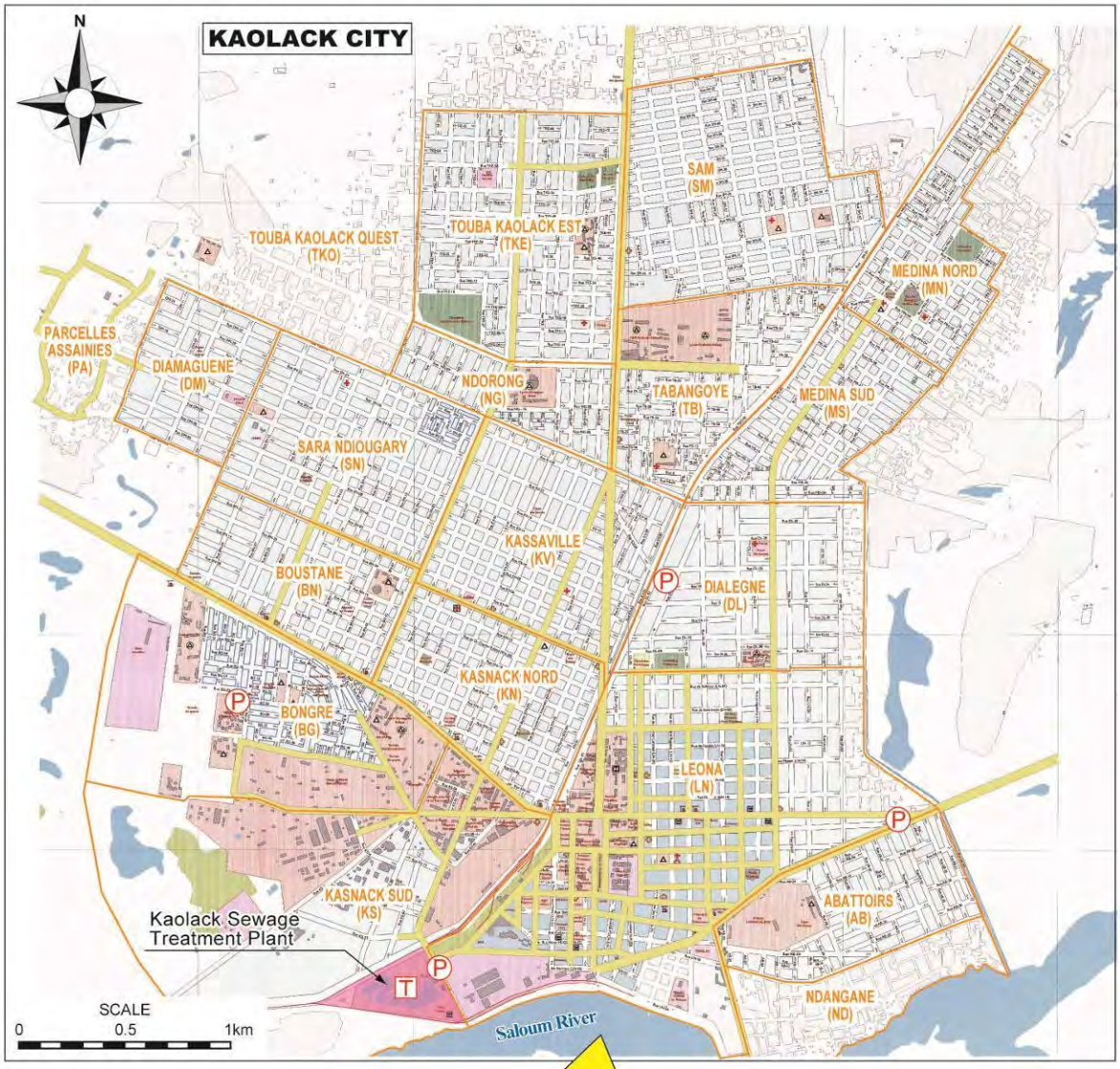
Note: Tables and figures without indication of source(s) were made based on the data/information collected directly or analyzed independently by JICA Expert Team.

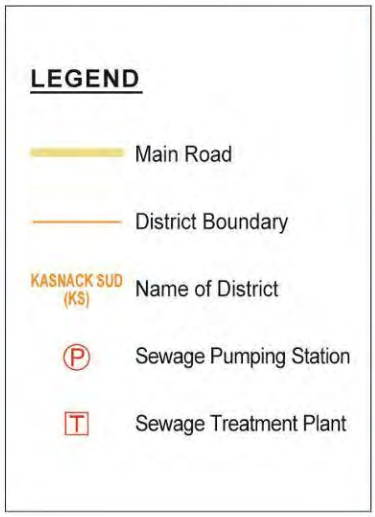
COMPOSITION OF VOLUME II: MAIN REPORT

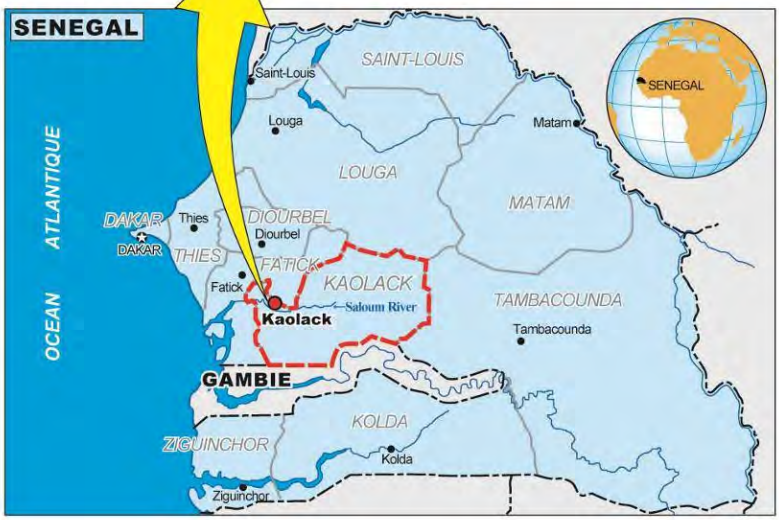
LOCATION MAP
PHOTOGRAPHS
ABBREVIATIONS
EXECUTIVE SUMMARY

Part I MASTER PLAN

Part II FEASIBILITY STUDY







LOCATION MAP

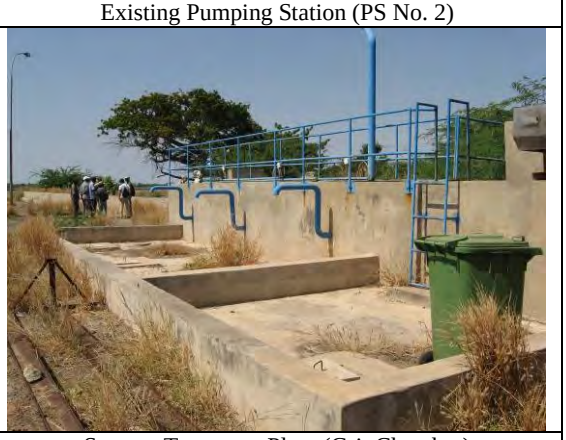
Wastewater Discharged into Road

Manual Pipe Cleaning Work

Vacuum Cleaning Trucks with Water Jet

Existing Pumping Station (PS No. 2)

Existing Pumping Station (PS No. 3)



Sewage Treatment Plant (Grit Chamber)

Sewage Treatment Plant (Aerated Lagoon)

Sewage Treatment Plant (Maturation Lagoon)

PHOTOGRAPHS (SEWERAGE/SANITATION)

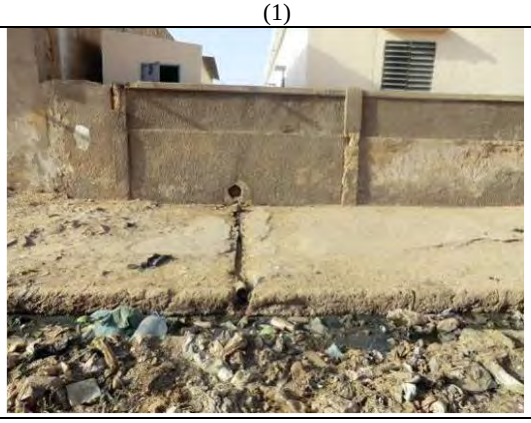
Inundation Condition (Lowland Area)

Inundation Condition (No Drainage System Area)

Drainage by Mobile Pump

Illegal Dumping of Solid Waste and Sediment in Drain (1)

Illegal Dumping of Solid Waste and Sediment in Drain (2)



Sewer Pipe from Residence to Drainage Ditch

Excavated Earth Canal

Obstacles in Open Drain

PHOTOGRAPHS (DRAINAGE)

Abandoned Waste Transfer Site (1)

Abandoned Waste Transfer Site (2)

ROC, Donkey Truck

Illegal Waste Disposal Site (by ROC)

Illegal Waste Disposal Site (Medina Mbaba)

Hazardous Medical Wastes (Bongre)

Existing Final Disposal Site
(Mbaolakhoune Village)

Proposed Final Disposal Site
(Mbaolakhoune Village)

PHOTOGRAPHS (SOLID WASTE)

ABBREVIATIONS

(upper line: English, lower line: French)

Organizations, Programs and Projects

ADB	:	Asian Development Bank
BASD	:	Banque Asiatique de Développement
ADM	:	Municipal Development Agency
	:	Agence de Développement Municipal
AfDB	:	African Development Bank
BAD	:	Banque Africaine de Développement
AGETIP	:	Public Works and Employment Agency
	:	Agence d'Exécution des Travaux d'Intérêt Public contre le sous-emploi
ANAMS	:	Senegal National Meteorological Agency
	:	Agence Nationale de la Météorologie du Sénégal
ANSD	:	National Statistics and Demography Agency
	:	Agence Nationale de la Statistique et de la Démographie
APROSEN	:	National Agency for the Cleanliness of Senegal
	:	Agence Nationale pour la Propreté du Sénégal
APROFES	:	Association for the Promotion of Senegalese Women
	:	Association pour la Promotion de la Femme Sénégalaise
ASDES	:	Senegalese Association for Fair and Common Development
	:	Association Sénégalaise pour un Développement Equitable et Solidaire
BOAD	:	West African Development Bank
	:	Bank Ouest Africaine De Developpement
BTC	:	Belgian Technical Cooperation
CTB	:	Coopération Technique Belge
CBO	:	Community-Based Organization
OCB	:	Organisation Communautaire de Base
CDQ	:	Committee for the District Development
	:	Comité de Développement de Quartier
CODEKA	:	Committee for Development of Kaolack City
	:	Comité de Développement de la Commune de Kaolack
CRD	:	Regional Development Committee
	:	Comité Régional de Développement
DEEC	:	Directorate of Environment and Classified Establishments
	:	Direction de l'Environnement et des Etablissements Classés
DREEC	:	Regional Division of Environment and Classified Establishments
	:	Direction Régionale de l'Environnement et des Etablissements Classés
DTGC	:	Department of Geographical works and Mapping
	:	Direction des Travaux Géographiques et Cartographiques
EU	:	European Union
UE	:	Union Européenne
GIE	:	Economic Interest Group
	:	Groupements d'Intérêt Economique
IDA	:	International Development Association
	:	Association internationale de développement
IDB	:	Islamic Development Bank
BID	:	Banque Islamique de Développement
IMF	:	International Monetary Fund
FMI	:	Fonds Monétaire International
IU	:	Implementation Unit
	:	Unité de mise en œuvre
JICA	:	Japan International Cooperation Agency
	:	Agence japonaise de coopération internationale

LVIA	:	Lay Volunteers International Association
	:	Association internationale des volontaires laïcs
MEF	:	Ministry of Economy and Finance
	:	Ministère de l'Économie et des Finances
MEPN	:	Ministry of Environment and Nature Protection
	:	Ministère de l'Environnement et de la Protection de la Nature
ONAS	:	National Office of Sanitation of Senegal
	:	Office National de l'Assainissement du Sénégal
PAER	:	Kaolack Regional Environmental Action Plan
	:	Plan d'Action Environnemental Régional de Kaolack
PAQPUD	:	Dakar Peri-urban On-site Sanitation Program
	:	Programme d'Assainissement Autonome des Quartiers Périurbains de Dakar
PCLSLB	:	Project of Social Housing and Slum Prevention
	:	Projet de Construction de Logements Sociaux et de Lutte contre les Bidonvilles
PEPAM	:	Millennium Drinking Water and Sanitation Program
	:	Programme d'Eau Potable et d'Assainissement du Millénaire
PLT	:	Long Term water supply Project
	:	Projet eau à Long Terme
PMU	:	Project Management Unit
UGP	:	Unité de Gestion de Projet
PNAE	:	National Environmental Action Plan
	:	Plan National d'Action pour l'Environnement
PNGD	:	National Program for Solid Waste Management
	:	Programme National de Gestion des Déchets
PRECOL	:	Program of Strengthening and Equipping Local Government
	:	Programme de Renforcement et d'Equipement des Collectivités Locales
PSE	:	Water Sector Project
	:	Projet Sectoriel Eau
S/C	:	Steering Committee
C/P	:	Comité de Pilotage
SDE	:	Senegalese Water
	:	Sénégalaise Des Eaux
SENELEC	:	Senegal Electric Power Supply Company
	:	Societé Nationale d'Électricité
SONES	:	National Water Company of Senegal
	:	Société Nationale des Eaux du Sénégal
SOPROSEN	:	Company for the Cleanliness of Senegal
	:	Société pour la Propreté du Sénégal
SRA	:	Regional Sanitation Service
	:	Service Régional de l'Assainissement
STC	:	Service Technique Communal
	:	Service Technique Communal
T/C	:	Technical Committee
C/T	:	Comité Technique
UCG	:	Solid Waste Management Coordination Unit
	:	Unité de Coordination de la Gestion des déchets solides
UN	:	United Nations
ONU	:	Organisation des Nations Unies
UNDP	:	United Nations Development Programme
PNUD	:	Programme des Nations Unies pour le Développement
WB	:	World Bank
BM	:	Banque Mondiale

Technical Terms

AL	:	Aerated Lagoon
LA	:	Lagunage Aéré
ASP	:	Activated Sludge Process
PBA	:	Procédé à Boues Activées
BOD_5	:	Biochemical Oxygen Demand
DBO_5	:	Demande Biologique en Oxygène
B/S	:	Balance Sheet
	:	Bilan
COD_{Cr}	:	Chemical Oxygen Demand
DCO	:	Demande Chimique en Oxygène
EA	:	Environmental Audit
AE	:	Audit Environnemental
EIA	:	Environmental Impact Assessment
EIE	:	Etude d'Impact sur l'Environnement
HRT	:	Hydraulic Retention Time
TRH	:	Temps de Rétention Hydraulique
IEC	:	Information, Education and Communication
IEC	:	Information, Education et Communication
OD	:	Oxidation Ditch
FO	:	Fossé d'Oxydation
P/L	:	Profit-and-Loss
	:	Profits et pertes
RC	:	Reinforced Concrete
	:	Béton armé
SEA	:	Strategic Environmental Assessment
EES	:	Evaluation Environnementale Stratégique
SLSC	:	Standard Least Squares Criterion
	:	Critère des moindres carrés standard
STP	:	Sewage Treatment Plant
STEP	:	Station d'Epuration des eaux usées
SWM	:	Solid Waste Management
GDS	:	Gestion des Déchets Solides
TSS	:	Total Suspended Solids
	:	Total des Solides en Suspension
T-N	:	Total Nitrogen
	:	Azote total
T-P	:	Total Phosphorus
	:	Phosphore total
T/S	:	Transfer Site
	:	Site de transfert (relais)
PET	:	Polyethylene Terephthalate
	:	Polyéthylène Téréphtalate
PS	:	Pumping Station
SP	:	Station de Pompage
PVC	:	Polyvinyl Chloride
	:	Polyvinylchloride

Others

CM	:	Cubic Meter
	:	Mètre cube
DPES	:	Document of Economic and Social Policies
	:	Document de Politique Economique et Sociale
DSRP	:	Poverty Reduction Strategy Paper
	:	Document de stratégie pour la réduction de la pauvreté

EIRR	:	Economic Internal Rate of Return
TREI	:	Taux de Rentabilité Eonomique Interne
E/N	:	Exchange of Notes
	:	Echange de Notes
FC	:	Foreign Currency
	:	Monnaie étrangère
FCFA	:	Franc of the African Financial Community
	:	Franc de la Communauté Financière Africaine
FIRR	:	Financial Internal Rate of Return
TRFI	:	Taux de Rentabilité Financière Interne
F/S	:	Feasibility Study
E/F	:	Etude de Faisabilité
GDP	:	Gross Domestic Product
PIB	:	Produit Intérieur Brut
GNI	:	Gross National Income
RNB	:	Revenu National Brut
IEE	:	Initial Environmental Assessment
EEI	:	Evaluation Environnementale Initiale
IRR	:	Internal Rate of Return
TRI	:	Taux de Rendement Interne
JET	:	JICA Expert Team
EEJ	:	Equipe d'Experts de la JICA
L/A	:	Loan Agreement
A/P	:	Accord de Prêt
LC	:	Local Currency
	:	Monnaie locale
LPSERN	:	The Environment and Natural Resources Sector Policy Letter
	:	Lettre de Politique Sectorielle de l'Environnement et des Ressources Naturelles
MDGs	:	Millennium Development Goals
OMD	:	Objectifs du Millénaire pour le Développement
M/P	:	Master Plan
	:	Plan Directeur
NPV	:	Net Present Value
VAN	:	Valeur Actuelle Nette
NGO	:	Non-governmental Organization
ONG	:	Organisation Non Gouvernementale
O&M	:	Operation and Maintenance
	:	Exploitation et maintenance
OP	:	Operational Policy
PO	:	Politique Opérationnelle
ROC	:	Garbage Transportation by Carts
	:	Ramassage des Ordures par Charrettes
SCF	:	Standard Conversion Factor
FCS	:	Facteur de Conversion Standard
TOR	:	Terms of Reference
	:	Termes de Référence
USD	:	United States Dollar
	:	Dollar des Etats-Unis
VAT	:	Value Added Tax
TVA	:	Taxe à la Valeur Ajoutée
WTP	:	Willingness-To-Pay
VDP	:	Volonté De Payer

EXECUTIVE SUMMARY

Background and Objectives of the Study

1. Kaolack City is one of the major cities in the Republic of Senegal with a population of about 270,000 in 2012. Its poor sanitary and environmental condition is the result of improper treatment of sewage, rainwater and solid wastes. However, the Master Plan of sanitary and environmental conditions formulated in 1979 has never been updated. To improve the sanitary and environmental conditions, revision of the Master Plan has become necessary. In parallel with the 1979 Master Plan, a sewage treatment plant and a sewer network have been constructed in the early 1980's. A primary drainage canal network has been constructed as well, but only in the central part of the city.

Regarding solid waste management, the deterioration of equipment has been so serious that the collection rate remained at 25% in 2007. Although three transfer stations and one final disposal site exist in the city, all of them employ the open dumping method and there are also no heavy equipment for land-leveling and truck scales. The situation is getting worse, not only due to the type of hauling system, but also because of the lack of proper transfer and disposal sites.

Considering the situation in Kaolack City, the Government of the Republic of Senegal (hereinafter referred to as "the Government of Senegal") had requested assistance from the Government of Japan. In response to the request, the Government of Japan had decided to conduct the "Project for Treatment of Sewage, Rainwater and Wastes in Kaolack City". Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), which is the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, has jointly undertaken the Project with the authorities concerned in the Government of Senegal. The project was commenced in November 2011 and was completed in March 2014.

2. The objectives of the project are:

(1) To review the existing planning and current condition of sewerage, stormwater drainage and solid waste management in Kaolack City;

(2) To compile the Master Plan of sewerage, stormwater drainage and solid waste management in Kaolack City;

(3) To conduct a Feasibility Study for highly prioritized areas; and

(4) To transfer relevant skills and technologies to personnel concerned in Senegal in the course of the Study.

Current Condition in the Project Area

3. **National Economy:** Senegal's per capita GDP was USD 1,119 in 2011, still below the USD 1,136 in 2008 when Senegal started experiencing the influence of the worldwide economic recession in 2008 - 2009. The per capita GDP was some lower than the mean of Sub-Saharan African developing countries. Senegal had not recovered from the 2009 decline in 2011, which widened the difference with Sub-Saharan Africa.

Before such economic recession in 2008 - 2009, Senegal's inflation rate has been increasing rapidly, for instance, 5.6% in 2007 and 6.5% in 2008, but it showed a negative figure of -1.5% in 2009. It has always been lower than that of the mean of Sub-Saharan African developing countries, similar to the situations in economic growth. Senegal's inflation rate is 3.2% in 2011.

4. **Counterpart Organizations of ONAS, APROSEN and Kaolack City:** ONAS is a government agency under the Ministry of City Planning and Sanitation, and it is responsible for sanitation. It was established in 1996, with the planning of projects on wastewater and stormwater infrastructures, the management of such projects, operation and maintenance of wastewater and stormwater facilities, development of on-site sanitation systems, and management of sanitation fee as its major responsibilities. The annual budget of ONAS was reported at some 6 billion FCFA in 2010. The total number of staff was 182 in 2009.

   APROSEN was established in 2010 under the supervision of the Ministry of Living for technical matters and the Ministry of Finance for financial matters. APROSEN aimed to establish and maintain a clean living environment by ensuring constant monitoring. Its major missions were to ensure all activities of public cleansing, collection, transport and disposal of solid waste on behalf of the local governments; to manage all equipment and infrastructure for waste management; to support the government in legislating solid waste management; and to conduct studies for the improvement of living conditions. APROSEN was, however, abolished, and its functions and employees were absorbed by the Ministry of Regional Planning and Local Government.

   In Kaolack City, the number of staff was 280 (196 males; 84 females) as of December 2011. The Mayor of the City is elected from among the City Councilors by mutual voting. The City Council has 70 councilors elected by the city residents for a term of 5 years. Being closely related to the drainage improvement works and solid waste management, the Civil Engineering Division has 79 personnel. In the recent three years, 2009 to 2011, the average budgetary expenditure of Kaolack City was around 1.6 billion FCFA.

5. **Meteorology:** The Kaolack Climatological Station under ANAMS has been observing meteorological conditions for a long time. Among the observed rainfall data, probability analysis is made for stormwater management planning using the annual maximum daily rainfall monitored for 14 years from 1998 to 2012. Compared with the probable rainfall intensity curves prepared for Dakar, the following formulae were developed: 2-year: $I = 3{,}451.2 / (T+36.9)$; 5-year: $I = 4{,}638.8 / (T+36.9)$; 10-year: $I = 5{,}427.8 / (T+36.9)$; where, I is rainfall intensity in mm/hour, and T is the rainfall duration in minutes.

   In the entire period of the 2012 rainy season, the JICA Expert Team (JET) had set the monitoring instrument at the roof of the project office and observed short duration rainfall at 10-minute intervals. Based on the observation results, 10-year design storm with 3 hours duration is proposed for the stormwater management in Kaolack City.

6. **Water Supply:** In Kaolack City, groundwater is pumped up from deep wells by 4 pumping stations and supplied to households, as well as commercial and administrative facilities, from 3 water towers. The existing and near future expansion service areas are about 19.5 km^2 and 6.6 km^2, respectively. The expansion work needs 1 additional pumping station and 1 water tower. In 2011, daily average of water consumption was calculated at 17,950 m^3/day, of which domestic use was 14,515 m^3/day and commercial use was 3,435 m^3/day. Ratio of commercial to domestic in the 5 years ranges between approximately 0.20 and 0.25.

7. **Sewerage:** Since 1980, sewer networks are installed following the previous sewerage Master Plan. The present service area is 303 ha located in the central part of Kaolack City. Furthermore, 1 project of PRECOL with network coverage of 92 ha is in progress in the northeastern part of the city. There are 5 pumping stations, including the new station being constructed by PRECOL. Since the sewer pipes of asbestos concrete have been installed in the 1980's, aging and deterioration of the pipes have taken place. Thus, replacement or restoration works for the PVC pipes are urgent issues on the sewer network in Kaolack City.

   A Sewage Treatment Plant (STP) of lagoon type with an initial capacity of 2,000 m^3/day has also been constructed and it started operation in 1981. From the year 2006, construction of an aerated lagoon with a maximum capacity of 6,000 m^3/day was commenced with assistance

from IDB by replacing one of the existing lagoons to augment the STP's capacity. Unfortunately, construction of the aerated lagoon was not completed and not completely handed over by IDB, so that it did not become operational. Some of the aerators in the aerated lagoon were turned over, and a part of waterproof sheets were torn out. Under the situation, the remaining 5 ponds are the ones being operated at present. The capacity of the lagoon could be recovered to 1,000 m^3/day, if the improvement of a discharge weir and desludging of all the ponds were made, based on the evaluation of JET.

Based on the monthly report of ONAS Kaolack, inflow to the STP is estimated to be about 1,000 to 2,000 m^3/day. As the results of such conditions, outflow from the STP could not comply with discharge criteria of BOD_5, COD, TSS, and so on. This fact indicates that rehabilitation or upgrading of the STP is urgent.

8. **Stormwater:** Urban storm drainage canals had existed in some city center areas, prior to the 1979 Master Plan. After formulation of the said Master Plan, major parts of the existing stormwater drainage network were installed in the central area of Kaolack City from 1980s. Kaolack City had constructed a total length of 19.96 km of drainage network, consisting of 12.38 km long open drains and 7.58 km long covered drains. The existing drainage system covers 7.79 km^2 of the central area of Kaolack City.

   Most of the open drains are clogged with sediment and various kinds of refuse. Garbage disposal into the canals, as well as sediment accumulation, had heavily affected the flow capacity of canals. In the dry season, the stagnated water composed of mainly domestic wastewater deteriorates, providing offensive odor and bad scenery, and worsening the urban environment.

   Habitual flooding and the long-lasting stormwater stagnation outside of the existing drainage network occur in the rainy season. About 10 habitual flooding areas have been identified, so that the newly proposed improvement plan shall focus on these areas.

9. **Solid Waste:** In the solid waste management by Kaolack City, the deterioration of equipment for collection and transportation has been so serious that the waste collection rate remained at 25% in 2007, covering only the central part and the markets in the City. This condition is getting worse due to the lack of hauling vehicles, so that the collection rate was reduced to 12% in 2010 and around 6% in 2012.

   The current waste collection system including pre-collection is mainly carried out by ROCs or donkey-carts system (about 90%), and wastes are mostly disposed at illegal dumping sites in the city. Part of the wastes generated at the markets and bus stations are collected by the city services (about 10%) and transported to the temporary final disposal site at Mbadakhoune. There are many illegal waste disposal areas in the residential areas of the city. There is a final disposal site for the city, but it employs the open dumping method, and there are no heavy equipment for land-leveling and truck scales at the site.

   Kaolack City formulated a Master Plan of Solid Waste Management (SWM) in 2008 with technical assistance from APROSEN. The Master Plan was not, however, implemented due to financial constraints. The IDB thus integrated the Master Plan for Kaolack City into the 4 major urban solid waste management projects which formed the IDB SWM Project.

10. **Environmental and Social Conditions:** There are flood prone areas in Kaolack City called "tannes/spots". The districts of Dialegne and Medina are located at the tannes/spots, where environmental and hygienic conditions are unwarranted. The sandy soil and groundwater table (high and salty) are critical in the city. According to CARITAS, the construction of hygienic facilities is difficult in some districts. For instance, installation of septic tanks is disturbed by sand and high groundwater table (less than one meter depth) especially in Medina Mbaba, Abattoirs and Touba Kaolack districts. Salty groundwater causes rusting of the tanks and other construction materials.

Regarding social conflicts, troubles erupt among truck drivers transferring solid wastes and the residents around the final disposal site in Mbadakhoune. Residents in the peripheral areas claim that the wastes from the city center are carried to the outskirts. The trucks carry the wastes during the night in order to avoid the protesting local residents. The city office can not intervene in the disputes because it could not officially provide a final disposal site. The illegal disposal sites spreading across the city area also face similar problems. The neighboring communities are requesting closure of the disposal sites of ROCs (supported by NGOs and EU). The communities claim that offensive odor and flying garbage are brought to them by the wind. Discharge of septage is another conflict with the rice farmers in Sing Sing. The trucks carrying sludge into the field might hinder the cultivation of farmlands and thus bring negative impacts on the neighboring people's hygiene.

Overall Planning Concept

11. **National Development Context:** Since the Senegal Government shouldered a heavy debt in the year 2000, the government implemented programs through its comprehensive strategy of poverty reduction. The "Document of Growth Strategy for Reduction of Poverty (DSRP-I)" defining the planning period of 2003 to 2005 was prepared to improve the growth targets of the program of post devaluation and to correct its negative incidences with the social and political development plans.The incidence of poverty is still relatively high and the distribution of income remains particularly uneven in Senegal. These facts invite more vigorous measures to reduce poverty and clearly underline the challenge to the redistribution of fruits of the growth.

During the period of 2006 to 2010 stipulated in the DSRP-II, the strong growth expected of the GDP and the quality improvement of people's living standard were hardly attained due to the food and energy crises, and the economic depression in 2008. The projections of poverty carried out over the period of 2005 to 2009 thus suggested stagnation of the indicators of poverty, and the growth rate of GDP per capita showed only 0.5% on average a year.

Based on the assessment of the implementation of the DSPR-II, the five-year national strategy called "Document of Policy on Socio-economy (DPES)" was formulated, targeting the period of 2011 to 2015. Regarding sanitation improvement, the DPES set the target access rates of 63% in rural areas and 78% in urban areas in 2015. According to the DPES evaluation, the actual access rate of 63.1% in 2010 was attained in entire urban areas in Senegal. There is lack of statistical data, but the present access rate in Kaolack City might range from 50 to 65% according to the officials of relevant offices and the NGOs. The target access rate of 78% in 2015 could not be achieved in Kaolack City, considering the present situation of improvement activities.

12 **Planning Concept:** The target year of the Millennium Development Goals (MDGs) has been set at the year 2015, and UNDP is now developing the next stage of the MDGs. The visions on Kaolack environmental infrastructure improvement under the Master Plan shall cover the improvement concepts of the MDGs and the national development context.

The visions for Kaolack urban environmental infrastructural improvement are "Access to sustainable urban environmental infrastructures and services augments beyond the Millennium Development Goals in a reasonable and equitable manner in the territory of Kaolack City." Following the improvement visions, the overall improvement objectives for the Kaolack urban environment are, as given below.

- To promote the proper management of solid and liquid wastes and stormwater in an integrated and effective manner to enhance the urban environment through improvement and updating of the urban environmental infrastructures and supporting the daily public services for sewerage treatment and solid waste collection and disposal;

- To develop the urban stormwater management to alleviate the recurrent flooding in the habitual flood-prone areas during the rainy season;
- To improve the institutional framework of the sectors managing sewage including wastewater treatment and sewerage network, stormwater and solid waste for their smooth and sustainable implementation;
- To promote positive changes of people's behavior on sanitation and solid waste disposal through the people's awareness campaign and participatory activities; and
- To finally realize the sound urban environment of the Kaolack City by producing synergistic effects through the above-mentioned comprehensive approaches.

13. **Target Year and Planning Area:** The target year of the Master Plan has been set at the year 2030 as discussed between the Senegal counterparts and the JICA preliminary survey mission. The original project area has been defined as the entire area of Kaolack City as also discussed simultaneously. Practically, the actual planning area shall be the urban areas consisting of the districts. Thus, the planning area is defined as the city center described below, having the area of 19.82 km^2.

From the technical nature of the three study components, namely; wastewater, solid waste and stormwater, the planning area shall follow the district boundary for solid waste management, the natural drainage boundary for stormwater management, and some intermediate ones between natural and administrative boundaries for wastewater management. Therefore, each component has to define slightly different planning areas.

14. **Population Projection:** Kaolack City had its estimated population for 2012 based on the reports of the District Chiefs in 2012. The "City Center" is defined here as the districts located in the area where the City has been developing so far, and have high population density. Project components which require large amounts of funds will mainly be considered for this area as "Target Area" for efficient investment. As a result, the population estimate in 2012 has been agreed among the steering committee members as 270,000 in all the city and 245,000 in the city center.

Considering the growth rate of population of each district in the past and some cap of the density of 300 persons/ha, the future population is projected in 5-year intervals. The projected population in 2030 is 403,000 in all the city, and 382,000 in the city center.

Sewerage/Sanitation System Improvement Plan in the Master Plan

15. **Target Structures:** The target structures for the Master Plan are the sewage treatment plant (STP) and the sewer network. Both structures have been constructed mainly in the early 1980's. Although the STP was planned to be upgraded by the IDB supported project with the aerated lagoon in 2006, the project was not completed and the STP's capacity was reduced from the original 2,000 m^3/day to 1,000 m^3/day. Thus, the existing STP is now under overload situation against sewage inflow.

On the other hand, the sewer network built of asbestos concrete in the early 1980's has also deteriorated. Thus, rehabilitation work is necessary for the proper functioning of the network as well as the network's expansion in line with the improvement of the STP.

16. **Planning Conditions:** Planning conditions have been set in a manner of stepwise improvement based on the review of present conditions and population projection results. Major conditions are as summarized below.

(1) Projected Population: Based on the population projection results by district, the sewered population is estimated in the alternatives of sewer network expansion plan in line with the STP improvement alternatives. For instance, the sewered population in 2030 is estimated at 178,000 to 379,000 among the three alternatives.

(2) Wastewater Generation: Using the number of sewered population, domestic water consumption of 70 l/capita in 2030 for instance and wastewater generation ratio of 85%, wastewater amount is computed. Wastewater generation is estimated at 75 l/capita/day in 2030.

(3) Sewer Network Connection Ratio: Connection ratio in the sewer network is assumed at 50% in 2012 and increasingly to 100% in 2030.

(4) Pollution Loading: Pollution load of BOD, as a typical parameter, is set at 40 g/capita/day in 2030.

17. **Planning Process:** Three alternatives of STP improvement have been examined, including dependent sewer network expansion. These are: (1) combination of lagoon and aerated lagoon; (2) aerated lagoon; and (3) oxidation ditch. By comparing the number of sewered population based on their treatment capacity, construction cost, and operation and maintenance cost, the aerated lagoon has been selected as the optimum plan, which was approved in the Steering Committee Meeting held in December 2012.

Improvement of sewer network related to the above optimum plan is composed of three work items: (1) installation of new trunk sewer, 27.7 km long; (2) rehabilitation and replacement of existing asbestos sewer pipes, 8.0 km long; and (3) rehabilitation of existing 5 pumping stations and installation of 4 new pumping stations.

During the entire period of project implementation and its operation, a certain area outside the coverage of the sewer network and the residents without connection to the network remain relying on the on-site sanitation system such as septic tank. Disposal of septage desludged from those septic tanks is an urgent environmental and social issue in Kaolack City as described in Item 10, Environmental and Social Conditions. Therefore, a septage treatment plant is planned inside the STP. Pre-treated septage could be discharged into the improved lagoon system, and be treated together with the wastewater collected by the sewer network.

18. **Implementation Plan, Project Cost:** With regard to the stepwise improvement of sanitation, three phases are considered, namely; Phase 1 is until 2020, Phase 2 is from 2021 to 2025, and Phase 3 is from 2026 to 2030. Phase 1 mainly consists of: (1) improvement of existing lagoon system, installation of septage treatment plant, installation of new aerated lagoon system beside the existing STP; (2) related sewer network rehabilitation/expansion of trunk sewer; and (3) construction of 3 new pumping stations and rehabilitation of 3 existing pumping stations. Phase 2 mainly consists of branch sewer installation and Phase 3 mainly contains (1) upgrading of lagoon system to aerated lagoon; (2) related sewer network rehabilitation/expansion of trunk and its branch sewer; and (3) construction of 1 new pumping stations and rehabilitation of 5 existing pumping stations.

The total project cost amounts to 75,897 million FCFA at the 2012 price level, in which 64,619 million FCFA is the local currency portion and 11,278 million FCFA is the foreign currency portion.

19. **Economic and Financial Evaluation:** Economic evaluation has been made using project benefit as calculated by the willingness-to-pay (WTP). Based on the interview survey results, three cases of WTPs were set up; (i) 500 FCFA/capita/month as the average, (ii) 1,000 FCFA/capita/month and (iii) 202 FCFA/capita/month (weighted average). EIRR was calculated at 2.2% for the WTP of 500 FCFA, 9.1% for the WTP of 1,000 FCFA and -9.3% for the WTP of 202 FCFA since its benefit is too low.

Regarding financial analysis, the main objective is to examine the investment efficiency of the component of the Master Plan from the viewpoint of project implementation body using cost-benefit analysis in the case where it can be applied. Project benefits are the revenues from sewerage charges, i.e., 8% of water supply charge presently collected from those connected to the water supply system disregarding connection to the sewerage system.

Sewerage charge is applied to all the people for the purpose of the benefit calculation. FIRR cannot be calculated with the base case because the benefit is too low, which means sewerage charge is set at a very low level. FIRR is 0.0% if the sewerage charge is increased to 13.6 times.

20. **Priority Project:** Based on the above-mentioned Phase 1 project, the following priority projects have been selected from the viewpoint of necessity of early implementation and quick effects:

(1) STP Improvement: Rehabilitation of existing lagoon, construction of new aerated lagoon and septage treatment plant.

(2) Sewer Network: Rehabilitation of deteriorated sewer pipes, construction of new trunk sewer, construction of 3 new pumping stations, and rehabilitation of 3 existing pumping stations.

Stormwater Drainage Management in the Master Plan

21. **Target Area:** Habitual flooding and long-lasting stormwater stagnation mainly occur outside of the existing drainage network in the rainy season. About 10 habitual flooding areas have been identified. No significant habitual flooding, but only small stormwater stagnation, occurs in the central area of the existing drainage network. Furthermore, the existing drainage canals have adequate flow capacities, if proper maintenance is made periodically, based on the evaluation of drainage capacity.

Thus drainage improvement shall be focused on the areas outside of the existing drainage network where habitual flooding occurs every year. These target areas are broadly divided into three parts, north, west and southeast, outside of the central area.

22. **Planning Conditions:** Planning conditions have been set in a manner of stepwise improvement based on the review of present conditions and technical adaptability. Major conditions are as summarized below.

(1) Design Scale: Based on the observation results in the 2012 rainy season, 10-year design storm with 3 hours duration has been adopted for the stormwater management in Kaolack City.

(2) Design Rainfall: Comparing probable daily rainfalls of Kaolack with those of Dakar, the following formula has been developed in 10-year storm, modifying the probable rainfall intensity curves prepared for Dakar: $I = 5{,}427.8 / (T+36.9)$; where, I is rainfall intensity in mm/hour, and T is the rainfall duration in minutes.

(3) Design Discharge: Since the sub-catchment areas are less than 10 km^2, the rational formula is applicable and suitable to such small catchments. The computation process of peak discharges using the rational formula is quite easy and simple, because it is limited to the two parameters of runoff coefficient and rainfall intensity depending on concentration time needed.

23. **Planning Process:** Three structural alternatives of drainage improvement have been examined. These are: (1) Stormwater drainage by drains and pumps from 5 sub-catchments including the central area following the natural topography; (2) Stormwater drainage by drains, pumps and retention ponds from 3 integrated sub-catchments; and (3) Stormwater drainage similar to Alternative 2 from 3 sub-catchments. Compared as to reliability of mechanical and electrical facilities, financial viability of construction cost, magnitude of environmental adverse impacts, and flexibility for future expansion, Alternative (3) has been selected as the optimum plan.

The selected optimum plan is composed of 3 drainage areas: north, west and southeast areas. In the north drainage area, drains of 10.09 km in length, 1 pumping station and 1 retention pond with storage capacity of 42,300 m^3 are to be constructed. On the other hand, in the west

drainage area, drains of 12.25 km in length, 1 pumping station and 1 retention pond with storage capacity of 70,000 m^3 are to be constructed. Furthermore, drains of 1.82 km in length are to be constructed in the southeast drainage area, and the existing drains of 3.87 km in length are to be rehabilitated in the central area. The total project cost amounts to 84,002 million FCFA at the 2012 price level, in which 73,516 million FCFA is the local currency portion and 10,486 million FCFA is the foreign currency portion.

24. **Implementation Plan:** Considering stepwise improvement of stormwater drainage, three phases have been considered; Phase 1 is until 2020, Phase 2 is from 2021 to 2025, and Phase 3 is from 2026 to 2030.

Phase 1 contains construction of drains, pumping stations and retention pond excluding the northeastern part of drains in the north drainage area. Phase 2 contains (1) rehabilitation of existing drains in the central area; (2) construction of drains, pumping stations and retention pond excluding drains in the upper part of the west drainage area; and (3) construction of drains in the southeast drainage area. Phase 3 contains the remaining works; namely, (1) the northeastern part of drains in the north drainage area; and (2) the upper part of drains in the west drainage area.

25. **Economic and Financial Evaluation:** Economic evaluation has been made using project benefit as calculated by attenuation effects of inundation damage. The benefit of the drainage component is the reduction of down time of economic activities due to inundation. Economic down time is estimated by the estimated inundation depth. It is assumed that the severest inundation of 70 cm lasts about 1 to 2 weeks and others last pro rata. This down time is converted to economic value with per capita GDP projection. Finally, the total benefit is calculated together with the multiplier effect. EIRR has been calculated at 6.7%. Although this figure is less than 12.0% of social discount rate, the project seems fully reasonable considering that it is an infrastructure development.

Regarding financial analysis, solution or mitigation of stormwater drainage is one of the tasks of the municipal or national government, which should be implemented as infrastructure development. Thus, all costs should be managed by government budget, so that it is inappropriate to collect charges from the residents. It means that it is inappropriate to calculate the benefit for the purpose of the financial analysis.

26. **Priority Project:** The projects proposed for Phase 1 in the Master Plan have been selected as the priority projects. The project components for Feasibility Study are the construction of drains, pumping stations and retention pond excluding the northeastern part of drains in the north drainage area.

Solid Waste Management in the Master Plan

27. **Kaolack City SWM Plan by APROSEN:** Kaolack City formulated its Master Plan for solid waste management (SWM) in 2008 with technical assistance from APROSEN. The target year of the plan was the year 2010. The major work components are as enumerated below:

(1) Pre-collection: The ROC system should be replaced gradually by tricycles in 3 years.

(2) House-to-House Collection: Tri-motorized cycles should be introduced to collect and transport solid wastes to the transfer stations.

(3) Transfer Station: Transfer stations should increase from 3 to 4.

(4) Hauling System: Skip truck, container tractors and dump truck should be employed for hauling the stored solid waste to the final disposal site.

(5) Final Disposal Site: A concrete site location has not been decided yet, but sanitary landfill was proposed for final disposal treatment.

The Master Plan in 2008 was not implemented by the city government due to financial constraint.

28. **IDB Project:** The IDB-supported SWM project covers the 4 major cities: Dakar, Kaolack, Tivaouane and Touba. The estimated cost for Kaolack is about 9 million USD (or 4.5 billion FCFA). The project contains the following work components:

(1) Infrastructure Development (5.40 million USD): Construction of sanitary landfill, transfer station and 20 collection points.

(2) Waste Collection and Transport Equipment (1.45 million USD): 2 dump trucks, 3 poly-bucket trucks, 1 ordinary truck, 2 tractors, etc.

(3) Institutional and Consulting Services (0.52 million USD): municipal tax and reform, training of municipal technical department staff, and public awareness.

(4) Project Management (0.44 million USD): implementation support, support to project management unit, etc.

(5) Contingency: 1.17 million USD.

29. **Recommendations for the IDB Project:** The following are the recommendations based on the review of the APROSEN Master Plan and the IDB Project.

(1) As of November 2013, IDB has been waiting for the response regarding the bank's proposal for the project. The new government should make a good decision for early implementation of the project.

(2) It is recommended that during implementation of the Kaolack SWM project supported by IDB, the progress should be monitored carefully and all necessary actions should be taken immediately to realize its completion.

(3) The number of required equipment for SWM listed by IDB seems to be for an urgent SWM work of the short-term period only and not for the mid- or long-term plan phase of SWM for Kaolack City. The number of heavy equipment might be for about 5 years only and not more than that. Therefore, it is recommended that an overall SWM plan study shall be required for the estimation of number of required equipment needed for an integrated and scaled SWM plan of the mid- or long-term plan phases for Kaolack City in parallel with project implementation.

(4) Since there seems to be no skilled mechanics at the workshop of the City Government, it is needed that some training practices at the workshop are required for mechanics, with a certain number of tools and mechanical equipment and knowledge.

(5) For the completion and sustainability of project implementation, all the necessary parties concerned such as central and local government agencies, state companies, CDQ, NGOs, and so on should be involved and take all necessary actions immediately.

30. **Recommendations for Overall SWM in Kaolack City:** Preliminary study has been made on the SWM in Kaolack City after reviewing the Master Plan made by APROSEN and the document on the IDB project. Based on the preliminary study, overall recommendations are proposed as below.

(1) It is expected that in order to replace the ROC system with tricycles, the economy should be more activated and infrastructure development including road pavement work for the sandy bare way is needed progressively. ROC system operation and maintenance should be carefully monitored by Kaolack City.

(2) There has been no study on a drainage system to the Saloum River from the final disposal area at Mbadakhoune. A study on the drainage system for the sanitary landfill facility is thus required for further implementation to prevent the rainwater in the site from affecting the disposal site.

(3) In order to improve the current SWM system in the city, strong involvement of all government offices, related agencies, residents, NGOs and private sectors concerned is needed in the IEC campaigns to enhance their capabilities.

(4) A transfer station center for composting and recycling for Kaolack City should be established in the suburban area of the city.

Priority Projects Selected in the Succeeding Feasibility Study

31. **Priority Projects:** The following priority projects in the succeeding Feasibility Study have been selected among the structural components in the Master Plan:

(1) Sewerage and Sanitation Improvement: Rehabilitation of existing lagoon, construction of new aerated lagoon and septage treatment plant, and related rehabilitation of sewer pipes and construction of new trunk sewer, construction of 3 new pumping stations and rehabilitation of 3 existing pumping stations.

(2) Stormwater Drainage Management: Construction of drains, pumping stations and retention pond excluding the northeastern part of drains in the north drainage area.

Organizational Setup for Project Implementation

32. **Related Organizations:** A lot of organizations are involved in the Project, aiming to improve the environmental and sanitary conditions in Kaolack City. These are mainly the Ministry of Hydraulics and Sanitation, Kaolack City, and the government agencies and urban entities attached to the ministries. Non-governmental organizations as well as community-based organizations are also in the field.

33. **Necessary Organizational Setup:** According to the result of the examination on organizations/actors related to the Project and consultation with ONAS Kaolack and Kaolack City, the organizational setup for project implementation can be recommended to basically consist of the Steering Committee, the Technical Committee and the Implementation Unit (IU) for each project component, namely; sewerage and stormwater drainage.

The Steering Committee (SC) has to be chaired by the Governor of Kaolack Region to ensure a higher level of coordination and policy support. It shall be comprised of representatives of the related agencies in charge of urban development, sanitation, environment and local governments. The Technical Committee (TC) shall supervise the project from the technical viewpoint and assist the SC on technical issues. An Implementation Unit (IU) shall be setup at the implementation stage for each project component, namely; sewerage and stormwater drainage. The IUs shall be composed in the implementing agencies, namely; ONAS Kaolack and Kaolack City. Both IUs shall be supervised by the SC as well as the TC. Detailed tasks of IUs shall be drafted in the preconstruction stage, considering the actual conditions of implementation.

Sewerage and Sanitation Improvement Project in the Feasibility Study

34. **Project Component:** The project consists of (1) sewer network improvement of new construction with length of 12.86 km, and replacement with length of 5.61 km; (2) pumping stations of three new stations, one station by rehabilitation and two stations by replacement of equipment; and (3) sewage treatment plant improvement with a capacity of 12,000 m^3/day by new aerated lagoon, and with a capacity of 3,000 m^3/day by rehabilitation of existing lagoon, and septage treatment plant installation with a capacity of 70 m^3/day.

35. **Preliminary Design:** Target year has been set at the year 2020. Updated topographic and soil data were obtained through site survey for the preliminary design. Particular attention is

paid to design items, as follows: (1) Submergible type of pump is adopted for the pumping stations in due consideration of similar type as already utilized in the existing stations; and, (2) Comparative study on expansion area of sewage treatment plant is made between two alternatives: one is the area adjacent to the existing plant and the other one is a part of the army shooting range. After comprehensive evaluation mainly from construction cost, environmental impact, ease of operation and maintenance works, the adjacent area is determined as the expansion area of sewage treatment plant.

The designed facilities are: (1) The sewered area of 5.8 km^2 covering 29% of Kaolack City Center, and the sewered population of 64,000 estimated in 2020 covering 20% of population in the city center in 2020; and (2) The Sewage treatment plant consisting of rehabilitated lagoons with 3,000 m^3/day of treatment capacity, newly installed aerated lagoons with 12,000 m^3/day of capacity, and septage treatment plant with 70 m^3/day of capacity.

36. **Project Cost:** The total project cost amounts to 31,713 million FCFA at the 2013 price level, in which 25,162 million FCFA is the local currency portion and 6,551 million FCFA is the foreign currency portion.

37. **Economic and Financial Evaluation:** Economic evaluation has been made using project benefit as calculated by willingness-to-pay (WTP), similar to the examination in the Master Plan. EIRR is calculated at 5.2% for WTP of 500 FCFA, 13.3% for WTP of 1,000 FCFA and -4.2% for the WTP of 202 FCFA since its benefit is too low.

FIRR cannot be calculated with the base case similarly to the Master Plan study, because the benefit is too low, which means that sewerage charge has been set at a very low level. FIRR will be 0.0% if the sewerage charge is increased to 10.5 times and 12.0% (equal to Social Discount Rate) if 35.5 times.

38. **Environmental Impact Assessment:** There is no serious adverse effect of strong intensity, wide extent and major importance. Even though the extent is limited to the local level, some significant adverse effects have been identified, such as traffic jams and accidents and destruction of public infrastructure during the construction period, and contamination of soil and surface/groundwater and odor nuisance during the operational period.

Against these impacts, mitigation/minimizing measures and monitoring plan have been proposed in the report. For instance, against odor nuisance, the proposed mitigation/minimizing measures are the rearrangement of aerated lagoon system to avoid the spread of offensive odor, and dense tree planting encompassing the sewage treatment plant. Furthermore, its monitoring plan is the interview with the inhabitants around the plant.

39. **Implementation Program:** The Implementation Program has been formulated considering feasible construction procedure to complete all the construction works by the target year 2020. The work components and their work periods are: (1) Commencement of the project in November 2014; (2) Fund arrangement and procurement of consultant for 12 months from 2014 to 2015; (3) Detailed design and tendering for 18 months from 2015 to 2017; and (4) Construction work for 30 months from 2017 to 2019.

40. **Project Evaluation:** The priority projects of sewerage and sanitation improvement have been evaluated as follows:

(1) Sanitation condition in the area would be improved gradually and significantly in combination with branch sewer installation. Construction of septage treatment facilities would be beneficial also to the people in the on-site sanitation area.

(2) Technologies applied to pumping station and sewage treatment plant are technically sound in operation and maintenance because all the proposed pumping stations use the submergible type of pump which is already applied to the existing pumping stations. Furthermore, the sewage treatment plant is designed based on lagoon and aerated lagoon which are the most simplified treatment methods.

(3) No resettlement is required since all proposed facilities are constructed and/or installed under public roads or in empty areas.

Stormwater Drainage Management Project in the Feasibility Study

41. **Project Component:** The project consists of: (1) box culvert installation with length of 8.28 km; (2) pumping stations with 5 units of submersible pump; and (3) retention pond with a storage capacity of 39,000 m^3.

42. **Preliminary Design:** Design scale has been set at 10-year storm, and the topographic and soil data were newly obtained through site survey for the preliminary design. Particular attention were paid to design items, as follows: (1) Submergible type of pump is adopted for the pumping stations considering that similar types are already utilized in the existing stations; and (2) Retention pond is planned in order to upgrade the artificial flood storage pond from natural ponding area in the rainy season. The project is designed particularly considering safety against accidental falling of children.

As of 2012, the drainage area of 7.8 km^2 covers 26% of the Kaolack City Center. After completion of the Project, the drainage area will increase up to 13.2 km^2, of which the coverage will increase up to 61% in 2020.

43. **Project Cost:** The total project cost amounts to 37,640 million FCFA at the 2013 price level, in which 31,480 million FCFA is the local currency portion and 6,160 million FCFA is the foreign currency portion.

44. **Economic and Financial Evaluation:** Economic evaluation has been made in a similar manner as the Master Plan. EIRR has been calculated at 3.1%. Although this figure is less than 12.0% of social discount rate, the project seems fully reasonable, considering that it is an infrastructure development.

Regarding financial analysis, solution or mitigation of stormwater drainage is one of the tasks of the municipal or national government, which should be implemented as infrastructure development. Thus, all costs should be managed by governmental budget and hence inappropriate to collect charges from the residents. It means that it is inappropriate to calculate the benefit for the purpose of the financial analysis.

45. **Environmental Impact Assessment:** There will be no serious adverse effect, i.e., of strong intensity, wide extent and major importance. The extent is limited to the local level and some of the significant ones are the traffic jams and accidents as well as the destruction of public infrastructure during the construction period, and injury or falling accidents during the operational period.

Against these impacts, mitigation/minimizing measures and monitoring plan are proposed in the report. For instance, against injury or falling accidents, the proposed mitigation/ minimizing measures are to maintain the fence constructed along the boundary of the retention pond. Furthermore, its monitoring plan is the observation by inhabitants around the pond.

46. **Implementation Program:** The Implementation Program has been formulated considering the feasible construction procedure to complete all the construction works by the target year 2020. The work components and their work periods are: (1) Commencement of the project in November 2014; (2) Fund arrangement and procurement of consultant for 12 months from 2014 to 2015; (3) Detailed design and tendering for 18 months from 2015 to 2017; and (4) Construction work for 36 months from 2017 to 2020.

47. **Project Evaluation:** The priority projects of stormwater drainage management have been evaluated as follows:

(1) Inundation area in the north area of Kaolack is reduced to one-tenth by installing the proposed drainage system.

(2) Proposed stormwater conveyance system comprised of box culvert is better than the open channel, to prevent people from dumping garbage to the drainage channels. As a result, sanitary condition in the project area would improve.

(3) Proposed box culvert, pumping station and retention pond are technically sound in operation and maintenance, because no complicated technologies are applied.

(4) No resettlement is required, since all proposed facilities are constructed and/or installed under public roads or in empty areas.

Conclusion and Recommendation

Conclusion

48. In Kaolack City, sewerage system, consisting of sewer network, pumping station and sewage treatment plant, has been in operation since 1980s. The sewerage facilities, in particular sewer pipes, are however gradually deteriorated due to aging and the sewage treatment plant is overloaded by poor maintenance and lack of augmenting treatment capacity. In addition, house connection rate in the sewered area still remains low due to high connection fee.

49. In order to improve sewerage and sanitation condition in Kaolack City, three alternatives are selected and compared in the Master Plan with evaluation criteria of: sewered population; ease of operation and maintenance/reliability; operation and maintenance cost; environmental impact. Kaolack City is, as a result, divided into two areas: (i) sewerage area and (ii) on-site sanitation area, with 66% and 34% in population for the target year of 2030, in consideration of technical, institutional and financial level of ONAS Kaolack, which is main implementation body.

50. Based on the planning setup, the Master Plan proposes sewage treatment facilities with total capacity of 21,000 m^3/day applying aerated lagoon method to treat wastewater generation from sewerage area and septage treatment facilities for benefit of on-site sanitation facilities users. Feasibility Study is then conducted targeting trunk sewer, pumping station and sewage treatment plant including rehabilitation of existing lagoon and new construction of aerated lagoon and septage treatment facilities in the expansion area for the target year of 2020.

51. Kaolack City is vulnerable to floods and stormwater because of its low-lying topography, hydrological conditions and no proper drainage systems. There are some habitual flooding areas. The flood and inundation affected residents, causing traffic and disturbing commercial activities in Kaolack City. Habitual flooding occurs in the depressed topography so that its lowest elevation without stormwater drainage system causes further difficulty to drain out flooded stormwater. The Kaolack City Hall had already installed a drainage system consisting of drainage pipes, open canals and manholes in the city center only. However, the drainage open canals require improvement because they have mostly lost their original drainage capacities by the heavy deposits of solid waste/silt illegally dumped into drainage open canals.

52. The Master Plan proposes, as the most effective drainage improvement measures, the construction of new drainage facilities for the severe inundation areas and the recovery and improvement of the original drainage capacities by dredging and re-construction of drainage open canals.

53. The proposed Master Plan and Priority Projects for the Kaolack City are effective in terms of technical, economic, social and environmental aspects for drainage improvement in the Kaolack City. By the implementation of the proposed drainage improvement plan, the severe inundation area will significantly be reduced and improved. It is recommended for the Government of the Senegal to take immediate actions for the implementation of the proposed measures, because the Kaolack City is very important economically and socially in the country.

54. As for SWM in Kaolack City, some recommendations on issues for further implementation of SWM are given based on the review of the APROSEN Master Plan and the IDB project.

Recommendation

55. Various issues have been encountered in the course of the Master Plan formulation and the Feasibility Study. In order to realize the sound urban environment drawn by the Master Plan and the Feasibility Study for the selected priority projects, these issues shall be solved in an integrated manner involving wide stakeholders. Thus, the following recommendations shall be given to accelerate the project realization.

Expectation of Synergy Effects

56. This new Master Plan is the first challenge to improve the overall urban environmental issues in Senegal, integrating the environmental element, such as wastewater, stormwater and solid wastes. There are 3 planning components proposed in the Master Plan in accordance with the urban environmental element, namely; sewer/sanitation system improvement, stormwater drainage management, and solid waste management. Since these plans are closely related and affect each other, they shall be implemented simultaneously in order to produce synergistic effects and realize the sound urban environment in Kaolack City.

According to the information from the Kaolack City Government as of November 2013, the solid waste management project funded by the IDB will commence soon. Even though the project focuses on short-term improvement of solid waste issues encountered in Kaolack City, the present situation of scattered garbage and the many locations of illegal dumping sites inside of the city will be improved through the project's implementation. Furthermore, the garbage accumulated in the drainage canal system will be periodically excavated and transported to the final disposal site using the procured heavy equipment and hauling trucks, contributing to the restoration and recovery of the existing drainage system.

Following such improvements in the urban environment, the proposed sewerage system including sewer treatment plant, septage treatment plant and sewerage network, is constructed in the time sequence. The wastewater issues as well as human waste disposal negatively affecting the residents' living condition could be solved through the improved and well-functioning sewerage system. Finally, if the proposed stormwater drainage system is constructed, the urban environment could be improved, completely.

The above-mentioned improvement mechanism utilizing structural measures can enhance or uplift the living conditions as well as the urban environment through their synergistic effects. As a result, the present downward spiral to deterioration of urban environment could change to upward spiral to sound urban environment of Kaolack City.

Sewerage and Sanitation Improvement

57. Since wastewater inflow to the STP is already overloaded to the treatment capacity of it, it is most urgent to rehabilitate the malfunctioning lagoon system, to extend the plant adding an upgraded treatment method (aerated lagoon) and to install the septage treatment plant additionally. After completion of this treatment system, sewer network improvement and expansion could be much easier.

58. Branch sewer installation is not included in the priority projects. However, the installation of branch sewer is indispensable to optimize the major facilities such as trunk sewer, pumping stations and sewage treatment plant. ONAS is responsible for the installation of branch sewers, it should look for the financial source for the installation. The financial support may come from donors such as the WB and/or the Government of Senegal through ADM, which involved in the funding of related sewerage projects in Kaolack. The schedule of branch sewer installation will be very challenging to ONAS, based on the construction volume for each year (about 100 ha) and the latest historical achievement of branch sewer installation. For example, about 90 ha was achieved with funds from the WB and 92 ha in the PRECOL

area by ADM from 2003 up to the present. Under the circumstances, ONAS would require an extraordinary effort and involvement to secure funds from the available donors and/or the Government of Senegal in order to install the branch sewer network, more than ever.

59. Considering low connection ratio of sewer network in Kaolack City, house connection of sewer network should be accelerated by financial assistance of Government of Senegal to optimize the sewerage system.

60. The septage desludged from the septic tanks of households without connection to the sewer network is illegally disposed to the dry riverbed even in the dry season due to poor accessibility to the disposal pond. The environment in the areas surrounding the disposal site of Sing Sing District is getting worse every year. Furthermore, the frequency of desludging the septic tanks might become higher compared with the common septic tank in the other area due to the very poor infiltration capacity of soils in Kaolack City. Therefore, the installation of septage treatment plant is also indispensable in Kaolack City

61. Administrative guidance by ONAS as well as Kaolack City to the companies providing desludging service, is strongly recommended to make them utilize septage treatment facilities and thus to reduce their desludging service charge to each household.

62. Along with the financial assistance of house connection and administrative guidance, public awareness of sewerage system and sanitation facilities is essential. It is recommendable to disseminate information to the inhabitants about advantage of sewer connection or septic tank installation, advantage of desludging and cost reduction of desludging by the installation of septage treatment facilities in sewage treatment plant.

63. At present, ONAS Kaolack records operation and maintenance activities of sewerage facilities such as sewer pipe, pumping station and sewage treatment plant in the Monthly Report. On the other hand, ONAS has no well-organized ledger including information on the exact location of sewer pipe, manhole and house inlet, invert level of pipes and covering and so on. In parallel with the implementation of the project, well-organized ledger shall be formulated using the base map and design drawings prepared in the project.

Stormwater Drainage Management

64. The construction works of the new drainage facilities such as drainage box culverts, pumping station and the retention pond, shall be conducted according to the proposed schedule in order to prevent/mitigate the damages caused by floods and inundation in the Kaolack City. The Priority Projects identified in the Master Plan shall require immediate actions, and be conducted duly according to the schedule.

65. The existing stormwater drainage facilities are composed of open drains, covered drains and manholes. Most of the drains could not meet their discharge capacities because of heavy deposits caused by illegal dumping of solid waste. Therefore, it is strongly recommended to conduct the proper maintenance works such as cleaning and dredging for the existing drainage.

66. At present, the annual maintenance work plan of the STC includes only drainage length to be cleaned. The STC doesn't have existing drainage map and specific data of drainage lines. In order to conduct the proper operation and maintenance work, the cleaning plan will be needed and base map and database will be necessary to prepare the cleaning plan. Therefore, it is recommended to prepare the base map and database for drainage facilities.

67. Most of the existing open canals are simply excavated earth canals in unsustainable condition. Therefore, they get easily damaged and collapse. These open canals have large flow capacities so that they are considered as key facilities of the stormwater drainage system and should be sustained by proper rehabilitation, because they have been working effectively in improving the stormwater drainage.

68. Public participation should be promoted by enhancement of public awareness for stormwater drainage management in order to improve and maintain the drainage facilities including various community-involved activities.

69. The implementing agency shall be decided and organize a coordination committee for the implementation of the Master Plan and Priority Projects, because the implementation of the Master Plan and Priority Projects shall require various concerned central and local government agencies and stakeholders.

70. As designed on the stormwater drainage network in the Master Plan, big investment is necessary to install complete drainage system due to flat topography. Meanwhile portable pumps are utilized for draining inundated stormwater in the habitual flooding areas in the rainy season. Two pumps, which were procured through Japan's Program Grant Aid for Environment and Climate Change, are also well working for this purpose in the 2013 rainy season. Such solutions could bridge between inconvenience situations of habitual flooding and necessary big investment as urgent immediate measures.

Solid Waste Management

71. IDB will support the structural solid waste management system in Kaolack City. In addition, United Nations Industrial Development Organization (UNIDO) utilizing Global Environmental Facility (GEF) would assist the solid waste management in Kaolack City including domestic, medical and industrial wastes, according to recent information. The garbage issues are central in the vicious cycle worsening urban environment, due to clogged canals with thrown garbage, producing offensive odor and deteriorated scenery. Thus the solid waste management could be an engine for synergy effects of enhancing the urban environment, if its management system is well working through proper collaboration of both projects.

72. The ROC system is working as the pre-collection process of house garbage. Unless the road conditions particularly the alley conditions are upgraded with asphalt pavement in parallel with the activation of the regional economy, the solid waste management system has to rely on the ROC system for the pre-collection of wastes. Until then, the workable integration of the ROC owners, reasonable coverage of ROC service, and capacity development of ROC drivers are necessary.

73. Transfer stations are to be constructed to upgrade the existing illegal dumping sites. Firstly, land ownership shall be solved for land utilization as transfer stations. Afterwards, a well-functioning management system for the stations shall be established in a sustainable manner.

74. The hauling system for solid waste from the transfer stations to the final disposal site is also needed to be managed in a sustainable manner with enough budgets.

75. After construction of the final disposal site, a site as a sanitary landfill using heavy equipment is also needed to be managed in a sustainable manner with enough budgets.

76. Heavy equipment used for solid waste management will normally deteriorate due to the various kinds of waste. Therefore, the workshops shall be upgraded or new ones established for the repair of damaged heavy equipment and hauling trucks. In addition, the workers shall be trained to improve their skill in managing the workshops, properly.

Necessity of People's Awareness of the Environment and their Participation

77. People's habit of throwing garbage indiscriminately into the canals or the roadsides is one of the obstacles to the enhancement of urban environment. Although IEC (Information, Education and Communication) campaigns are done by the NGOs, community associations and the City Government, clear effects do not appear in the environment. Such kinds of efforts should be made incessantly in order to eradicate the undesirable habit permanently.

Participatory activities in a community are also effective to enhance the environment. Residents can help clean the roadsides and open spaces and fill the small-scale depressed lands with soil brought from nearby higher places to solve the small-scale inundation in the rainy season. In parallel with these activities, educational activities to change their consciousness are crucial to develop people's interest in improving the environment through their own efforts.

Strengthening of the Main Actors in Urban Environmental Improvement

78. The main actors in the urban environmental improvement are Kaolack City and ONAS Kaolack. Both organizations have similar weaknesses in implementation capability; that is, budgetary constraint and lack of human resources. Against budgetary constraint, there might be no rapidly effective solution except for the central government to increase its subsidies to the local governments and the government-affiliated organizations.

Structural reform needs a long period, such as taxation and charging system for the collection of sewerage charges. Regarding lack of human resources, some capacity development projects and activities shall be requested from the donors to enhance the actor's poor capacity, by increasing the number of skilled technicians and engineers in the urban environmental management field, in particular.

Immediate tasks of implementation/responsible agencies

79. Implementation/responsible agencies for the urban environmental improvement as targeting in the Project are ONAS and Kaolack City. In order to realize the sound urban environment which the Master Plan and the Feasibility Study delineated, immediate tasks of the both agencies are summarized below.

Agencies	Fields	Immediate Tasks
ONAS	Sewerage Improvement (Sewerage Treatment Plant and Sewer Network)	Year 2014 to 2015 To implement the projects in the both fields, ONAS will find the suitable donors and will prepare the fund arrangement to them.
	Stormwater Management	
Kaolack City	Solid Waste Management	After the year 2014 Through the IDB project for about four years, Kaolack City will establish the solid waste management system, and will make an effort of capacity development and necessary budgetary arrangement to keep the sustainability for the system after completion of the project.

PART I MASTER PLAN

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

WITH ABOUT 270,000 INHABITANTS IN 2012, KAOLACK CITY IS ONE OF THE MAJOR CITIES IN T SENEGAL. HOWEVER, SEWAGE, RAINWATER AND WASTES HAVE NOT BEEN PROPERLY TREATED HYGIENIC ENVIRONMENT. ON THE OTHER HAND, THE MASTER PLAN OF HYGIENIC ENVIRONMENT SINCE ITS FORMULATION IN 1979. THUS, TO IMPROVE THE HYGIENIC ENVIRONMENT, REVISION OF NECESSARY.

AS FOR THE TREATMENT OF SEWAGE AND RAINWATER, THE WASTEWATER TREATMENT PLAN CONSTRUCTED IN 1981 (INITIAL TREATMENT CAPACITY: 2,000 m^3/DAY) IS OPERATIONAL, BUT THE AERATED LA CONSTRUCTED WITH ASSISTANCE FROM IDB IS NOT OPERATIONAL BECAUSE IT WAS NOT HAND ADDITION, CONDUITS AND DRAINAGE CANALS ARE ONLY PARTLY BUILT. THE TOTAL LENGTH IS WHICH CAN BE CONNECTED TO THE CONDUITS AND DRAINAGE PIPES REMAINS AT ONLY 15,000 F

WITH REGARD TO WASTE MANAGEMENT, THE DETERIORATION OF EQUIPMENT IS SO SERIOUS T REMAINED AT 25% IN 2007. ALTHOUGH THREE TRANSFER STATIONS AND ONE FINAL DISPOSAL S CITY, ALL OF THEM EMPLOY THE OPEN DUMPING METHOD AND THERE IS NO HEAVY EQUIPMENT WELL AS TRUCK SCALES. AT PRESENT, SOME IMPROVEMENT WORKS ARE BEING IMPLEMENTED SITE.

CONSIDERING SUCH CONDITIONS IN KAOLACK CITY, THE GOVERNMENT OF THE REPUBLIC OF S REFERRED TO AS "THE GOVERNMENT OF SENEGAL") HAD REQUESTED ASSISTANCE FROM THE GO RESPONSE TO THE REQUEST, THE GOVERNMENT OF JAPAN HAD DECIDED TO CONDUCT THE "PRO SEWAGE, RAINWATER AND WASTES IN KAOLACK CITY." ACCORDINGLY, THE JAPAN INTERNAT AGENCY (HEREINAFTER REFERRED TO AS "JICA"), WHICH IS THE OFFICIAL AGENCY RESI IMPLEMENTATION OF TECHNICAL COOPERATION PROGRAMS OF THE GOVERNMENT OF JAPAN, H THE PROJECT WITH THE AUTHORITIES CONCERNED IN THE GOVERNMENT OF SENEGAL. THE PROJ NOVEMBER 2011 AND COMPLETED IN MARCH 2014.

1.2 STUDY OBJECTIVES

THE OBJECTIVES OF THE STUDY WERE:

(1) TO REVIEW THE EXISTING PLANNING AND CURRENT CONDITIONS OF SEWERAGE, RAINWATE WASTE MANAGEMENT IN KAOLACK CITY;

(2) TO COMPILE THE MASTER PLAN OF SEWERAGE, RAINWATER DRAINAGE AND SOLID WAS KAOLACK CITY;

(3) TO CONDUCT A FEASIBILITY STUDY FOR HIGHLY PRIORITIZED AREAS; AND

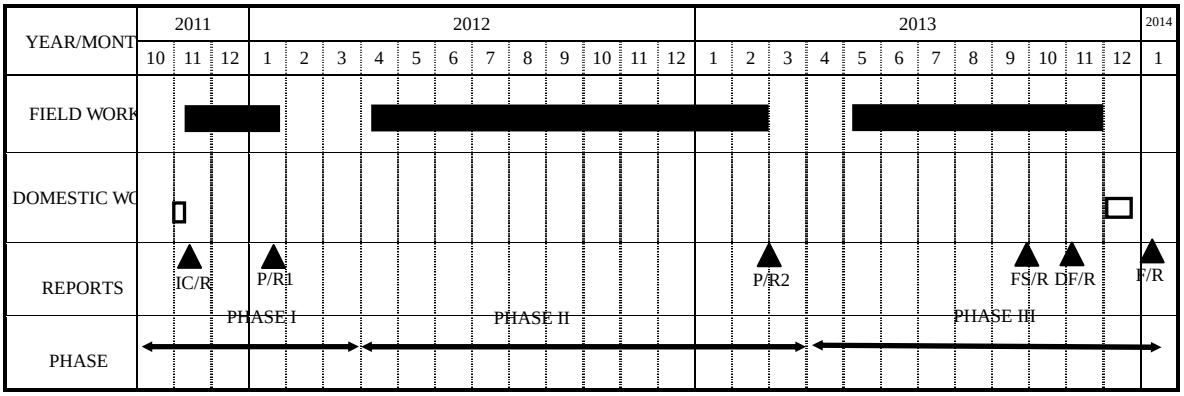
(4) TO TRANSFER RELEVANT SKILLS AND TECHNOLOGIES TO PERSONNEL CONCERNED IN SENE STUDY.

1.3 STUDY AREA

THE STUDY COVERS THE ENTIRE AREA OF KAOLACK CITY IN SENEGAL.

1.4 STUDY SCHEDULE

THE STUDY WAS TO BE CARRIED OUT IN ACCORDANCE WITH THE SCHEDULE SHOWN IN FIG. 1.4.1. THE STUDY PERIOD WAS ABOUT 24 MONTHS. VARIOUS REPORTS WERE TO BE SUBMITTED PERIODICALLY, AS SHOWN



LEGEND : IC/R: INCEPTION REPORT; P/R1: PROGRESS REPORT 1; P/R2: PROGRESS REPORT 2; DF/R: DRAFT FINAL REPORT
F/R: FINAL REPORT

PHASE I : COLLECTION OF BASIC INFORMATION ON SEWERAGE, RAINWATER DRAINAGE AND SOLID WASTE MANAGE

PHASE II : COMPILING OF MASTER PLAN OF SEWERAGE, RAINWATER DRAINAGE AND SOLID WASTE MANAGEMENT

PHASE III: FEASIBILITY STUDY ON THE HIGHLY PRIORITIZED PROJECTS

FIG. 1.4.1 OVERALL STUDY SCHEDULE

CHAPTER 2. BASIC STUDY

2.1 OUTLINE OF KAOLACK CITY

2.1.1 GENERAL

KAOLACK CITY, THE CAPITAL OF THE KAOLACK REGION, IS LOCATED AT ABOUT 190 KM TO THE
CITY, WITH CROSSOVER POINTS OF NATIONAL ROAD ROUTE NO. 1 FROM EAST TO WEST, AND RO
FROM NORTH TO SOUTH IN SENEGAL. IN ADDITION, THE CITY HAS ROADS LINKING WITH TH
BORDERS: MALI, GAMBIA, GUINEA AND GUINEA BISSAU. LOCATED ALONG THE RIGHT BANK OF
CITY HAS THE LAND AREA OF 145.14 KM^2. TOPOGRAPHICALLY, KAOLACK CITY IS VERY FLAT AND, GEOLOGIC
AND SALTY SOILS DOMINATE IN THE ENTIRE CITY AREA.

2.1.2 POPULATION

(1) ADMINISTRATIVE STRUCTURE

KAOLACK CITY IS UNDER THE FOLLOWING ADMINISTRATIVE STRUCTURE IN THE KAOLACK R
INTO 43 DISTRICTS (THIS NUMBER IS BASED ON THE DATA IN 2012 PROVIDED BY KAOLACK C
OF DISTRICTS DIFFERS AMONG THE RELATED DOCUMENTS, PARTLY BECAUSE THE DISTRICT
CITY HAVE BEEN MODIFIED IN LINE WITH THE URBANIZATION.

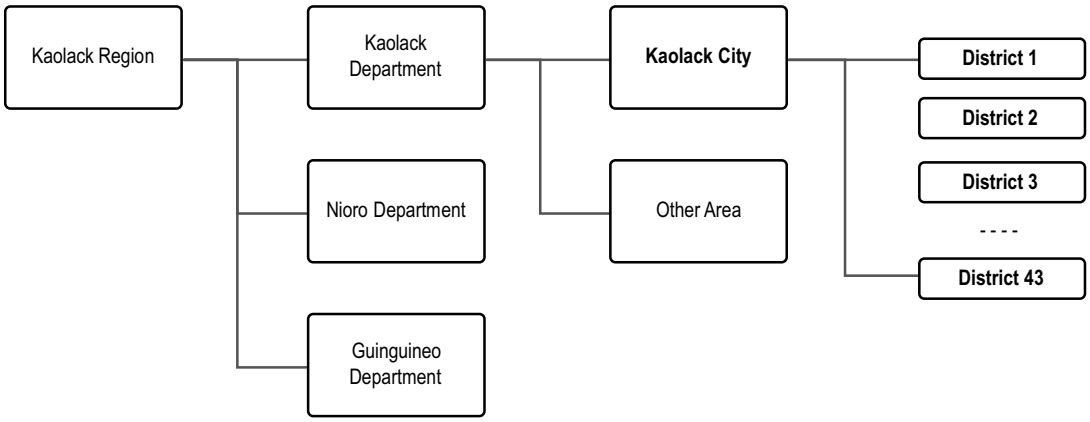


FIG. 2.1.1 ADMINISTRATIVE STRUCTURE OF KAOLACK REGION

(2) POPULATION DATA

POPULATION DATA FOR KAOLACK CITY HAVE BEEN COLLECTED FROM SEVERAL SOURCES. S
NOT NECESSARILY SIMILAR, THEY HAVE BEEN COMPARED AND EXAMINED IN DETAIL.

(A) NATIONAL CENSUS

NATIONAL CENSUS IN SENEGAL HAS BEEN TAKEN THREE TIMES, NAMELY; IN 1976, 1988, AN
SUPPOSED TO BE MADE IN EVERY 10 YEARS IN ACCORDANCE WITH THE REGULATION, B
CONDUCTED ON SCHEDULE. ANOTHER CENSUS WAS PLANNED TO BE CONDUCTED BY TH
THE RESULTS WERE SUPPOSED TO BE ANNOUNCED IN THE FIRST QUARTER OF 2014.

THE POPULATION OF KAOLACK WAS 150,961 IN 1988 AND 174,366 IN 2002. THE COMPOSITIO
CITY OR THE DISTRICTS IN THE CITY WAS CHANGED IN 2002 DUE TO THE EXPANSION OF T
ANNUAL AVERAGE GROWTH RATE WAS 1.03% BETWEEN 1988 AND 2002. ACCORDING TO TH
THE GROWTH RATE OF THE NATIONAL POPULATION IN THE URBAN AREA IS AROUND 3% O
AND 2002. THUS, THE GROWTH RATE OF KAOLACK CITY SEEMS TO BE EXTREMELY LOW.

DETAILED PROJECTION RESULTS OF THE NATIONAL CENSUS IN 1988 AND 2002 ARE SHOWN
TABLES.

TABLE 2.1.1 POPULATION PROJECTION OF KAOLACK CITY

	2008	2009	2010	2011	2012	2013	2014	2015
POPULATION	178,243	183,076	188,929	193,899	199,541	204,968	210,483	216,078
GROWTH RATE (%)	-	2.71	3.20	2.63	2.91	2.72	2.69	2.66
NATIONAL GROWTH RATE (%)	2.69	2.68	2.66	-	-	-	-	-

SOURCE: STATISTIC DEPARTMENT, MINISTRY OF ECONOMY AND FINANCE, AND THE WORLD BANK

(B) APROSEN

THE APROSEN REPORT, ETUDE POUR LA MISE EN OEUVRE OPERATIONNELL D'UN SYSTEME DE GESTION DURABLE DES DECHETS SOLIDES DANS LA VILLE DE KAOLACK, 2007, HAS ESTIMATED THE POPULATION OF KAOLACK CITY SHOWING THE BA CALCULATION. IT DIVIDED THE POPULATION INTO MALES AND FEMALES AND APPLIED DIFFERE IT ESTIMATED THAT THE MALE POPULATION WAS 47% AND THE FEMALE WAS 53%, AND THE G WERE 2.7% AND 2.9% RESPECTIVELY, WHICH MEANS THAT THE TOTAL GROWTH RATE WAS 2.81 0.027 + 0.53 × 0.029). THE ESTIMATION WAS MADE BY APPLYING THESE FIGURES TO THE CENSUS I 1988. THE RESULTS ARE SHOWN IN THE FOLLOWING TABLE.

TABLE 2.1.2 POPULATION PROJECTION BY APROSEN

	2002	2003	2004	2005	2006	2007	2008	2009	2010
POPULATION	222,346	228,583	234,996	241,588	248,366	255,334	262,498	269,863	277,435
GROWTH RATE (%)	2.81	2.81	2.81	2.81	2.81	2.81	2.81	2.81	2.81

SOURCE: APROSEN, ETUDE POUR LA MISE EN OEUVRE OPERATIONNELL D'UN SYSTEME DE GESTION DURABLE DES DECHETS SOLIDES DANS LA VILLE DE KAOLACK, 2007

(C) UNHABITAT

THE UNHABITAT REPORT, SÉNÉGAL: PROFILE URBAIN DE KAOLACK, 2009, ALSO MADE POPULATION ESTIMATION FOR KAOLACK CITY SHOWING THE BASIS OF CALCULATION. IT SIMI SAME GROWTH RATE OF 3.5% TO THE CENSUS DATA IN 1988. THE RESULT FOR 2003 SHOWN IN TH 259,282. THE RESULTS APPLYING THE SAME GROWTH RATE TO THE OTHER YEARS ARE SH FOLLOWING TABLE.

TABLE 2.1.3 POPULATION PROJECTION BY UNHABITAT

	2002	2003	2004	2005	2006	2007	2008	2009	2010
POPULATION	250,514	259,282	268,357	277,749	287,471	297,532	307,946	318,724	329,879
GROWTH RATE (%)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50

SOURCES: UNHABITAT, SÉNÉGAL: PROFILE URBAIN DE KAOLACK, 2009 AND JET

(D) SOCIO-ECONOMIC REPORT

THE SOCIO-ECONOMIC REPORT, SITUATION ÉCONOMIQUE ET SOCIALE DE LA RÉGION DE KAOLACK, 2009, SHOWS THE ESTIMATION RESULT ONLY FOR 2008. SINCE IT WAS ISSUED B STATISTICS DEPARTMENT, IT SIMPLY INTRODUCED THE PROJECTION MADE BY THE DEPARTME

(E) COMPARISON AMONG ESTIMATIONS

TABLE 2.1.4 COMPARISON OF POPULATION DATA, 1988-2010

	1988	2002	2003	2008	2010
CENSUS	150,961	174,366	-	-	-
GROWTH RATE	1.03%		-	-	-
PROJECTION BY STATISTICS DEPT.	-	-	-	178,243	188,929
GROWTH RATE	-	0.37%			3.2%
APROSEN	150,961	222,346	228,583	262,498	277,435
GROWTH RATE	2.81%				
UNHABITAT	-	-	259,282	307,946	329,879
GROWTH RATE	3.5%			3.5%	3.5%
WHOLE NATIONAL GROWTH RATE	3.02%	2.67%	2.71%	2.69%	2.66%
NATIONAL URBAN GROWTH RATE	3.80%	3.16%	3.19%	3.30%	3.29%

SOURCES: STATISTIC DEPARTMENT, APROSEN, UNHABITAT AND THE WORLD BANK

2.1.3 WATER SUPPLY

SDE, WHICH IS A PRIVATE COMPANY, OPERATES AND MAINTAINS ALL THE WATER SUPPLY FACIL
CONTRACT WITH SONES IN KAOLACK CITY. THE SOURCE OF WATER SUPPLIED IN KAOLACK CIT
WHICH IS PUMPED UP FROM DEEP WELLS AND SUPPLIED TO HOUSEHOLDS AS WELL AS C
ADMINISTRATIVE FACILITIES FROM WATER TOWERS AFTER DISINFECTION BY CHLORINE, WIT
FUTURE EXPANSION SERVICE AREA OF ABOUT 6.6 KM^2 WAS SHOWN IN **TABLE 2.1.5** AND **FIG. 2.1.2**

ACCORDING TO THE DATA FROM JANUARY 2007 TO AUGUST 2011 PROVIDED BY SDE, WATER CO
CITY HAS BEEN GRADUALLY INCREASING DUE TO RAPID URBANIZATION AS SHOWN IN **TABLE 2.1.6** AND **FIG. 2.1.3 (LEFT)**. IN 2011, DAILY AVERAGE OF WATER CONSUMPTION WAS CALCULATED AT 17,950 M^3/DAY, OF WHICH 14,515 M^3/DAY WAS FOR DOMESTIC AND 3,435 M^3/DAY WAS FOR COMMERCIAL USE. RATIO OF COMMERC
DOMESTIC USE IN THE 5 YEARS RANGES FROM APPROXIMATELY 0.20 TO 0.25.

TABLE 2.1.5 MAJOR FACILITIES OF WATER SUPPLY IN KAOLACK CITY

DEEP WELL	EXISTING /PROPOSED	CONSTRUC-TION YEAR	DEPTH OF WELL (M)	PUMP CAPACITY (M^3/H)	WATER TOWER NO.	HEIGHT (M)	TANK VOLUME (M^3)
F1	EXISTING	1980	75	180	R1	18	800
F2		1986	80	200			
F3		1990	180	200	R2	20	800
F4		1961	300	140	R3	20	1,200
F5	PROPOSED	-	UNKNOWN	152	R5	UNKNOWN	UNKNOWN
F6		-	UNKNOWN	152	R6	DITTO	DITTO

SOURCE: SDE

NON-REVENUE RATES IN KAOLACK CITY REACH TO ABOUT 20%, WHICH IS RELATIVELY LOW
DEVELOPING COUNTRIES AND MONTHLY VARIATIONS OF WATER SUPPLY IS RECORDED AT
MAXIMUM/MINIMUM) IN 2012, ACCORDING TO SDE.

SINCE THE SDE ONLY RECORDS THE NUMBER OF CONTRACTS, DOMESTIC WATER CONSUMPTION
ESTIMATED BY JET USING: (I) THE NUMBER OF CONTRACTS PROVIDED BY SDE; AND (II) THE AV
INHABITANTS PER CONCESSION IN KAOLACK CITY. AS FOR THE AVERAGE NUMBER OF INHABITA
VALUES WERE EMPLOYED FOR THE CALCULATION:

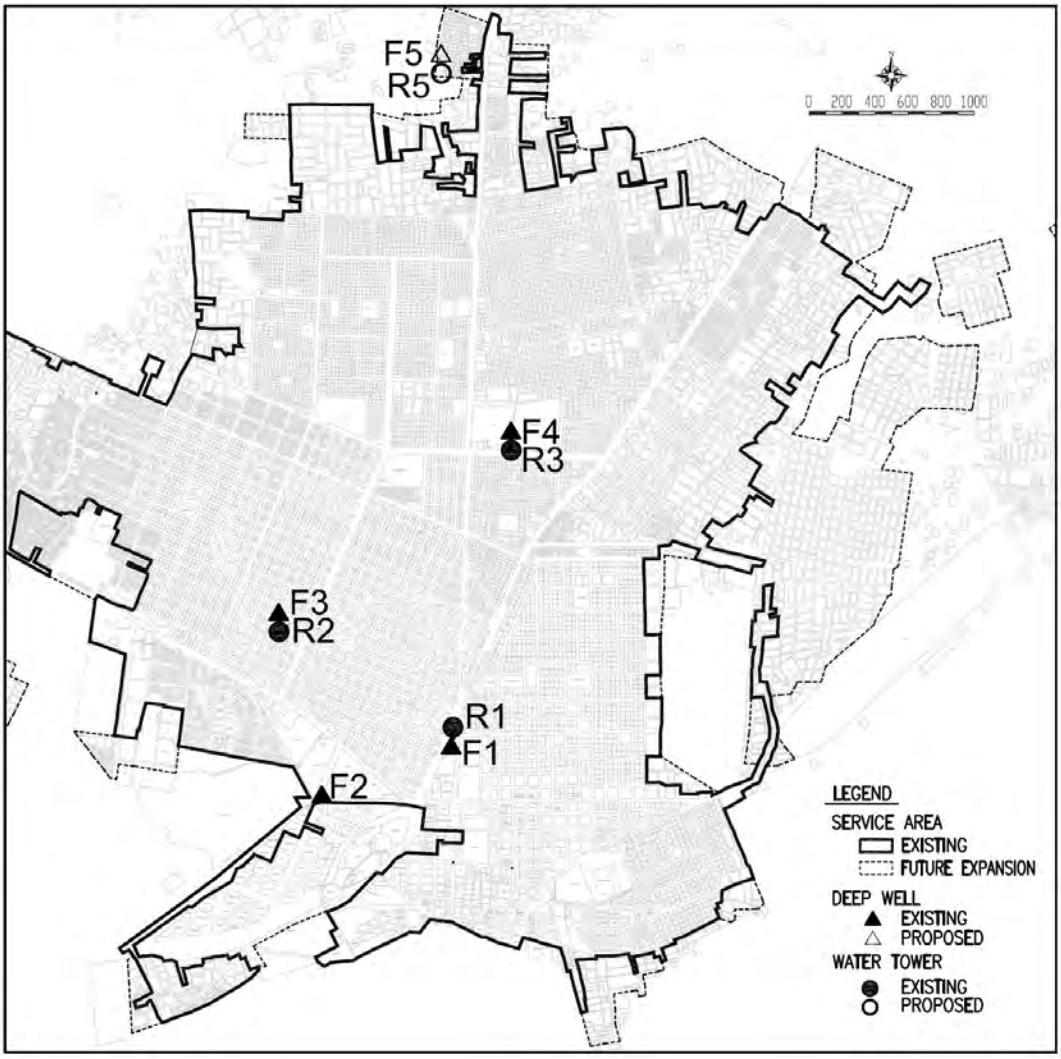
- CASE-1:10.3 PERSON/CONCESSION
  BASED ON THE CENSUS IN 1988, STATISTICS DEPARTMENT OF MINISTRY OF ECONOMY AND FI
- CASE-2:16.0 PERSON/CONCESSION
  BASED ON THE DATA IN SWM M/P OF KAOLACK CITY AND APROSEN IN 2007

THUS, THE DOMESTIC WATER CONSUMPTION PER CAPITA OF 70 AND 45 L/CAPITA/DAY, AS WELL
58 L/CAPITA/DAY IN 2011 IS ESTIMATED AS SHOWN IN **FIG. 2.1.3 (RIGHT)**

TABLE 2.1.6 DAILY AVERAGE WATER CONSUMPTION IN KAOLACK CITY(2007-2011)

	UNIT	2007	2008	2009	2010	2011
DOMESTIC	M^3/DAY	9,845	10,195	10,615	14,326	14,515
COMMERCIAL[1]	M^3/DAY	2,373	2,229	2,076	3,654	3,435
TOTAL	M^3/DAY	12,218	12,424	12,691	17,980	17,950
RATIO OF COMMERCIAL TO DOMESTIC	RATIO	0.241	0.219	0.196	0.255	0.237

NOTE 1) COMMERCIAL INCLUDES CONSUMPTION FOR ADMINISTRATIVE USE.
SOURCE: SDE



NOTI THIS MAP SHOWS THE CENTRAL PART OF KAOLACK CITY ONLY. PROPOSED TOWER (R6), WHICI
LOCATED AT DAROU RAHMATI DISTRICT, ARE NOT SHOWN IN THE MAP BECAUSE INFORMATION ON THE EXACT LO
AVAILA

FIG. 2.1.2 SERVICE AREA AND LOCATION OF MAJOR FACILITIES OF WATER SUPPLY IN KAOL

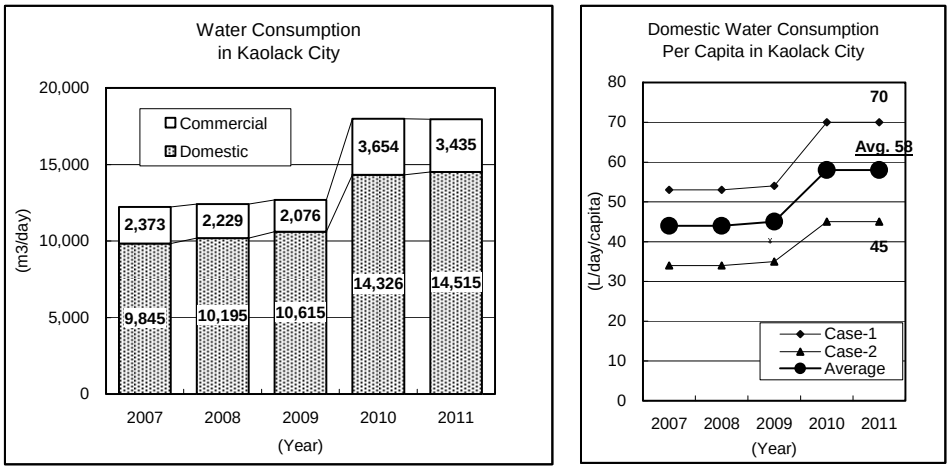


FIG. 2.1.3 TREND OF WATER CONSUMPTION IN KAOLACK CITY

WATER QUALITY OF THE SUPPLIED WATER IN KAOLACK CITY IS SHOWN IN THE FOLLOWING TA
CONCENTRATIONS OF CL AND TH, WHICH IS MAINLY DUE TO SALINITY IN THE GROUND.

TABLE 2.1.7 WATER QUALITY SUPPLIED IN KAOLACK CITY

PARAMETER	UNIT	LOCATION			
		F1	F2	F3	F4
CONDUCTIVITY	µS/CM	1,950	2,030	2,030	2,000
PH	-	8.22	8.07	7.98	7.99
TURBIDITY	NTU	1.47	0.28	0.40	0.58
HARDNESS	MG/L	52	52	48	52
CL	MG/L	369	412	398	412
HCO_3^-	MG/L	470.9	441.6	436.8	429.4
SO_4^{2-}	MG/L	72	66	78	78
NO_3^-	MG/L	3.6	2.2	2.7	2.4
NO_2^-	MG/L	0.011	0.006	0.011	0.013
PO_4^{3-}	MG/L	0.35	0.29	0.22	0.34
FE	MG/L	0.06	0.01	0.03	0.02
F^-	MG/L	3.13	2.47	2.43	2.53

SOURCE: SDE, MONITORED IN OCTOBER 2012

2.1.4 METEOROLOGY

(1) DATA AND SOURCE

A CLIMATOLOGIC STATION EXISTS IN KAOLACK CITY AT 16° 04' LONGITUDE, 14° 08' N LATITUDE, AND 6 M IN ALTITUDE. IN THE KAOLACK STATION, THERE ARE 2 KINDS OF METEOROLOGICAL DATA SUMMARIZED LONG-TERM METEOROLOGICAL DATA FOR THE PERIOD OF 1971 TO 2000, AND THE OTHER ON THE MONTHLY METEOROLOGICAL OBSERVATION SHEET FROM 1998 UP TO THE PRESENT. THE FOLLOWING IS A PRESENTATION OF THE METEOROLOGICAL FEATURES OF KAOLACK CLOSELY RELATED TO TEMPERATURE AND RAINFALL, UTILIZING THESE 2 KINDS OF METEOROLOGICAL DATA.

FURTHERMORE, SHORT DURATION RAINFALL IN 10 MINUTE INTERVALS WAS OBSERVED BY T RAINY SEASON IN 2012. UTILIZING BOTH DAILY AND SHORT DURATION RAINFALL, THE DESIG FOR STORM DRAINAGE IMPROVEMENT IN THIS PROJECT.

(2) LONG-TERM MONTHLY TEMPERATURE AND RAINFALL

LONG-TERM MONTHLY TEMPERATURE AS MAXIMUM, AVERAGE AND MINIMUM VALUES ANI ARE SUMMARIZED IN **TABLE 2.1.8** AND IN **FIGS. 2.1.4** AND **2.1.5.** AS THEY INDICATE, THERE ARE 2 DISTINC

[1] REFERENCE: METEOROLOGICAL DATA FOR THE PERIOD 1971-2000, KAOLACK METEOROLOGICAL STATION
[2] TABLE OF CLIMATOLOGY FOR THE PERIOD 1998-2011, KAOLACK REGIONAL STATION

LOCAL CLIMATES: THE DRY SEASON FROM DECEMBER TO APRIL RESULTING FROM NORTHEAST W THE RAINY SEASON FROM JUNE TO OCTOBER RESULTING FROM SOUTHWEST SUMMER WINDS. THE OF ABOUT 560 MM MAINLY OCCURS BETWEEN JUNE AND OCTOBER. THE MAXIMUM TEMPERATU 35°C AND MINIMUM OF ABOUT 25°C ARE APPROXIMATELY CONSTANT IN THE WET SEASON, W MAXIMUM TEMPERATURES OF ABOUT 35 TO 40°C AND MINIMUM OF ABOUT 20°C, IN THE DRY SEAS

REGARDING MONTHLY RAINFALL, 40% OF THE ANNUAL AMOUNT OCCURS IN AUGUST, AND AB CONCENTRATES FOR ONLY 3 MONTHS, JULY TO SEPTEMBER.

TABLE 2.1.8 MONTHLY TEMPERATURE AND RAINFALL AT KAOLACK CLIMATOLOGIC ST

MONTH	TEMPERATURE (°C)			RAINFALL
	MAXIMUM	AVERAGE	MINIMUM	(MM)
JANUARY	34.4	26.0	17.6	1.0
FEBRUARY	37.1	27.9	18.7	1.0
MARCH	38.8	29.4	20.0	0.0
APRIL	40.3	30.7	21.1	0.0
MAY	39.8	31.0	22.2	3.0
JUNE	37.2	30.6	23.9	31.0
JULY	34.7	29.6	24.4	122.0
AUGUST	33.3	28.7	24.1	222.0
SEPTEMBER	33.7	28.8	23.9	139.0
OCTOBER	36.2	29.9	23.6	40.0
NOVEMBER	37.1	29.0	20.9	1.0
DECEMBER	34.6	26.2	17.8	1.0
TOTAL				561.0

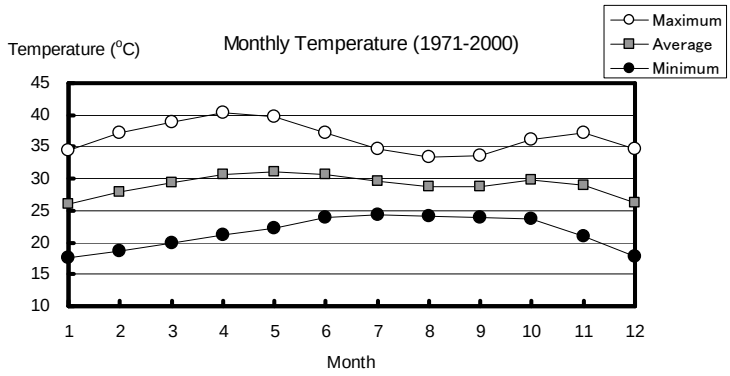


FIG. 2.1.4 MONTHLY TEMPERATURE FOR 30 YEARS FROM 1971 TO 2000 AT KAOLACK CLIMAT STATION

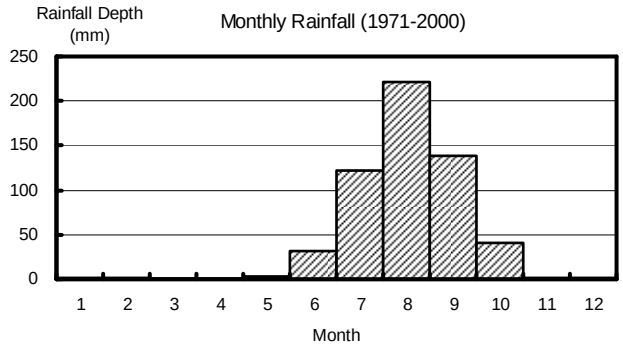


FIG. 2.1.5 MONTHLY RAINFALL FOR 30 YEARS FROM 1971 TO 2000 AT KAOLACK CLIMATOL STATION

(3) RECENT DAILY RAINFALL

AS DESCRIBED IN (1), THE OTHER DATA SOURCE IS MONTHLY METEOROLOGICAL OBSERVATI
15 YEARS FROM 1998 TO 2012. **TABLE 2.1.9** SUMMARIZES ANNUAL RAINFALL AND ANNUAL DAILY M
RAINFALL FOR THIS PERIOD. **FIG. 2.1.6** REPRESENTS THE VARIATION OF ANNUAL RAINFALL FOR 14 YEARS, A
FACT THAT THE 3 PARTICULAR YEARS OF 1999, 2006 AND 2010 RECEIVED HIGHER AMOUNTS C
OTHER YEARS. FURTHERMORE THE AVERAGE OF ANNUAL RAINFALL IS CALCULATED AT 655
COMPARED TO THE ANNUAL RAINFALL AMOUNT OF 560 MM FOR THE PERIOD OF 30 YEARS F
THE ANNUAL RAINFALL OF 655 MM MIGHT HAVE BEEN THE BIGGER AMOUNT COMPUTED. THI
IS NOT SO CLEAR SINCE THE AVAILABLE DATA ARE LIMITED. THUS MORE PRECISE AN
DATA/INFORMATION SHALL BE NECESSARY FOR THIS PURPOSE.

TABLE 2.1.9 ANNUAL RAINFALL AND ANNUAL DAILY MAXIMUM RAINFALL AT KAOLACK CLIMATOLOGIC STATION

YEAR	ANNUAL RAINFALL (MM)	MAX DAILY RAINFALL (MM)
1998	433.9	31.5
1999	877.8	86.3
2000	732.0	92.1
2001	623.8	87.3
2002	567.0	78.1
2003	535.7	53.9
2004	579.9	57.5
2005	762.5	(MISSING)
2006	802.9	122.3
2007	488.0	45.3
2008	639.8	52.5
2009	740.9	60.1
2010	852.8	66.0
2011	535.3	49.3
2012	-	68.4
AVERAGE	655.2	67.9

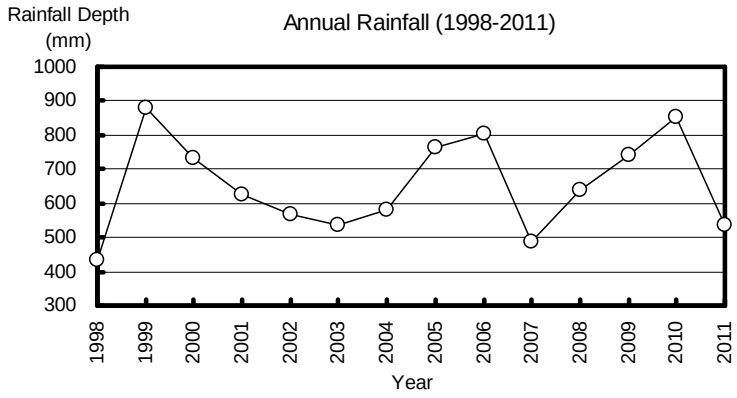


FIG. 2.1.6 ANNUAL RAINFALL STATION FROM 1998 TO 2011 AT KAOLACK CLIMATO

FIG. 2.1.7 SHOWS THE ANNUAL MAXIMUM DAILY RAINFALL SERIES FOR THE PERIOD OF 1998
TIME SERIES, DATA MISSING OCCURS IN THE WET SEASON OF 2005, AND THE MAXIMUM D
122 MM TOOK PLACE IN 2006 DURING THIS PERIOD. FURTHERMORE AVERAGE ANNUAL MAXIM
IS COMPUTED AT 67.9 MM.

ANNUAL MAXIMUM DAILY RAINFALL, WHICH IS THE CLOSEST RELATED TO THE FLOODIN
MOST FREQUENTLY IN AUGUST, WITH A FREQUENCY OF 64% (9 YEARS IN 14 YEARS). THUS A
REGARDED AS THE PEAK MONTH OF FLOODING AS WELL AS MONTHLY RAINFALL.

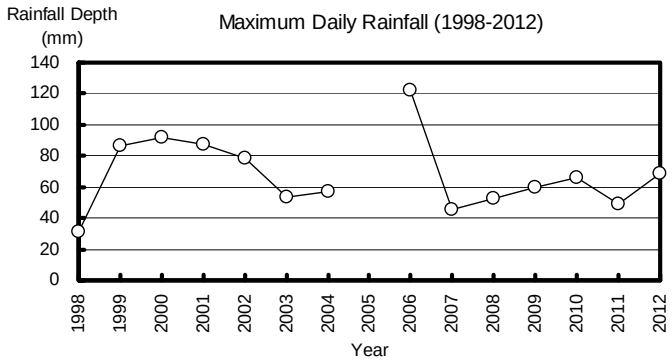


FIG. 2.1.7 ANNUAL MAXIMUM DAILY RAINFALL FROM 1998 TO 2012 AT KAOLACK CLIMATO STATION

(4) PROBABILITY ANALYSIS OF DAILY RAINFALL AND PRODUCING RAINFALL INTENSITY CURV

UTILIZING RECENT DAILY RAINFALL DATA, PROBABILITY ANALYSIS WAS MADE FOR CLARIFIC RAINFALL AMOUNT AND COMPARING THE PROBABLE DAILY RAINFALL IN THE MORE PRECISELY THE CAPITAL CITY OF DAKAR. THE FITNESS OF PROBABLE DISTRIBUTION IN RAINFALL DATA SE **TABLE 2.1.10** WERE EXAMINED IN COMPARISON WITH THE FOLLOWING THREE PROBABLE DISTRIBUT

- GUMBEL,
- LOG PEARSON TYPE III, AND
- LOG-NORMAL.

AS SHOWN IN **FIG. 2.1.8**, BOTH PROBABLE DISTRIBUTION CURVES OF GUMBEL AND LOG-NORMAL REPRESENT THE OBSERVED DATA DISTRIBUTION. PROBABLE DAILY RAINFALL COMPUTED[2] AS REFERENCE ARE TABULATED BELOW. THE STANDARD LEAST SQUARES CRITERION (SLSC) IS EM PARAMETER TO QUANTIFY THE FITNESS BETWEEN OBSERVED DATA AND PROBABLE DISTRIB EXPRESSED BY THE FOLLOWING EQUATION;

$$SLSC = \sqrt{\xi^2} \ / \ |s_{0.99} - s_{0.01}|$$

$$\xi^2 = (1/N)\ \Sigma(s_I - s^*_I)^2$$

WHERE, $s_{0.99}$ AND $s_{0.01}$ ARE NORMALIZED VARIATES CORRESPONDING TO NON-EXCEEDANCE PROBABIL AND 0.01 AS ORDER STATISTICS, RESPECTIVELY, AND N IS A SAMPLE SIZE OR NUMBER OF SAMPLE DATA AS ORDER STATISTICS, AND s^*_I IS NORMALIZED EXPECTATIONS DERIVED FROM AN APPL PROBABLE DISTRIBUTION.

IN GENERAL, THE SLSC VALUE OF LESS THAN 0.03 TO 0.04 COULD BE REGARDED AS GOOD FITNE OBSERVED DATA AND A PROBABLE DISTRIBUTION. ESTIMATED SLSC VALUES ARE MORE OR LESS S IN GUMBEL IS 0.027, THE ONE IN LOG PEARSON TYPE III IS 0.031, AND THE ONE IN LOG-NORMAL IS EVEN THOUGH THE DIFFERENCE OF ESTIMATED VALUES AMONG THREE DISTRIBUTIONS IS QUITE DISTRIBUTION AS THE MINIMUM VALUE OF SLSC, WHICH MEANS BEST FITNESS, IS ADOPTED FOR T OF STORMWATER DRAINAGE IN KAOLACK CITY.

TABLE 2.1.10 PROBABLE DAILY RAINFALL IN KAOLACK CITY REFERRING TO THE VALU IN DAKAR CITY

RETURN PERIOD	PROBABLE DAILY RAINFALL FROM PROBABLE DISTRIBUTION			PROBABLE DAILY RAINFALL IN DAKAR
	GUMBEL	LOG PEARSON TYPE III	LOG-NORMAL	
2-YEAR	63.8	65.0	64.3	66.2
5-YEAR	85.7	86.3	86.7	97.2
10-YEAR	100.2	99.4	101.4	117.7

[3] THE STUDY ON URBAN DRAINAGE AND WASTEWATER SYSTEMS IN DAKAR CITY AND ITS SURROUNDINGS, JICA, 1994

RETURN PERIOD	PROBABLE DAILY RAINFALL FROM PROBABLE DISTRIBUTION			PROBABLE DAILY RAINFALL IN DAKAR
	GUMBEL	LOG PEARSON TYPE III	LOG-NORMAL	
30-YEAR	122.0	117.9	123.4	148.7
50-YEAR	132.0	126.1	133.5	162.9

UNIT: MM

DESIGN SCALE WAS EXAMINED IN THE FOLLOWING CLAUSES. REGARDING PROBABLE RAINFA
A BASIC PARAMETER IN STORMWATER IMPROVEMENT PLANNING, THESE INTENSITY CUR
THROUGH THE FOLLOWING CONSIDERATION;

- THERE ARE NO AVAILABLE SHORT-DURATION RAINFALL DATA IN KAOLACK CITY, ANI
AVAILABLE.
- ON THE OTHER HAND, SHORT-DURATION RAINFALL AS WELL AS DAILY RAINFALL HAV
DAKAR INTERNATIONAL AIRPORT, AND PROBABLE RAINFALL INTENSITY CURVES WE
PREVIOUS JICA STUDY USING THOSE DATA.
- ONLY COMPARABLE PARAMETERS OF RAINFALL BETWEEN KAOLACK AND DAKAR ARE I
- THUS SIMPLIFIED APPROACH OF MODIFYING THE RAINFALL INTENSITY CURVES OF
APPLICABLE THROUGH COMPARISON OF PROBABLE DAILY RAINFALL IN DAKAR AND KA
- ASSUMING THAT PROBABLE RAINFALL INTENSITY IS IN PROPORTION TO DAILY RA
FOLLOWING FORMULA COULD BE INTRODUCED: $I_{KAOLACK} = \alpha \cdot I_{DAKAR}$, WHERE I IS RAINFALL INTENSIT
(MM/HR), AND α IS DAILY RAINFALL RATIO (PROBABLE DAILY RAINFALL IN KAOLACK / PROBABLE DAILY
RAINFALL IN DAKAR). α VALUES ARE ESTIMATED AT 0.96 IN 2-YEAR, 0.88 IN 5-YEAR AND 0.
10-YEAR.
- AS AN OBSERVATION RESULT IN THE 2012 RAINY SEASON, THE OBSERVED SHORT-DURAT
ARE DEPICTED IN **FIG. 2.1.11** TOGETHER WITH PROBABLE RAINFALL CURVES. THE FIGURE SH
TENDENCY BETWEEN OBSERVED AND ESTIMATED ONES SO THAT IT IMPLIES THAT
ADEQUATE.

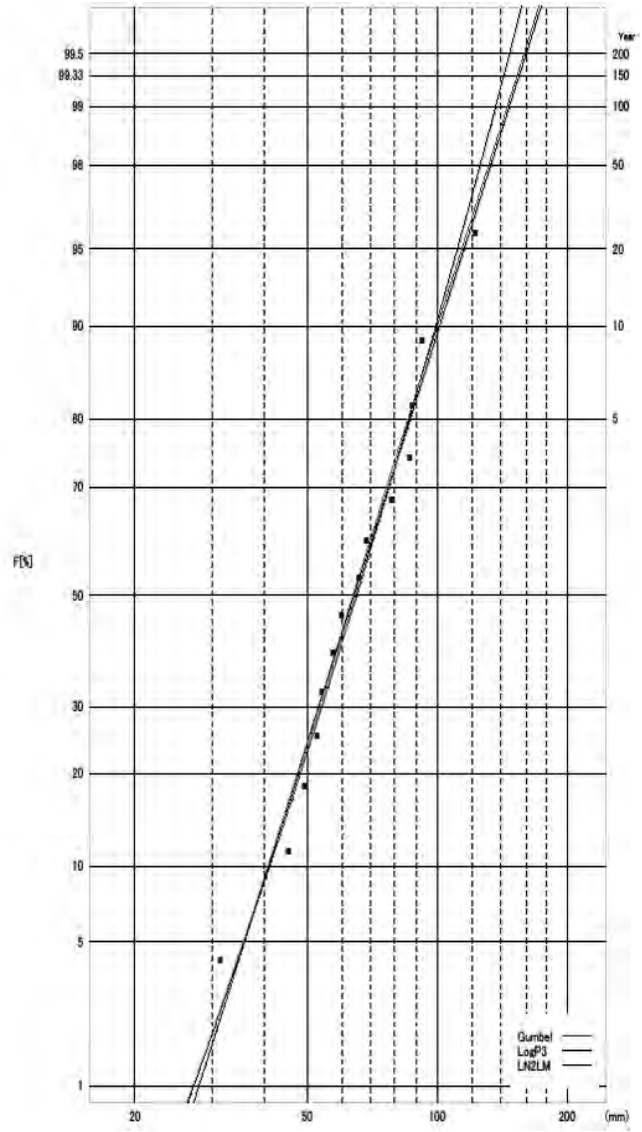


FIG. 2.1.8 ANNUAL MAXIMUM DAILY RAINFALL AND PROBABILITY DISTRIBUTION CURVES A

AS A RESULT, THE FOLLOWING PROBABLE RAINFALL INTENSITY CURVES COULD BE APPLIED T
UTILIZING THE CURVES PRODUCED FOR DAKAR CITY. WHERE, T IS RAINFALL DURATION IN MINUT

- 2-YEAR: I = 3,451.2/(T+36.9)
- 5-YEAR: I = 4,638.8/(T+36.9)
- 10-YEAR: I = 5,427.8/(T+36.9)

(5) SHORT-DURATION RAINFALL MONITORED IN THE 2012 RAINY SEASON

IN THE BEGINNING OF THE 2012 RAINY SEASON, EARLY JUNE, THE PROJECT TEAM INSTALLED A RA
ON THE ROOF OF THE PROJECT OFFICE IN KAOLACK, AND STARTED TO MONITOR SHORT-DUR
INTERVALS OF 10 MINUTES. **FIG. 2.1.9** DEPICTS 24-HOUR RAINFALL OBSERVED IN THE 2012 RAINY SEASON, F
JUNE TO OCTOBER. THE FIGURE INDICATES A GOOD COINCIDENCE OF RAINFALL OCCURRENCE
COMPARED WITH DAILY RAINFALL OBSERVED AT THE KAOLACK METEOROLOGICAL STATION.

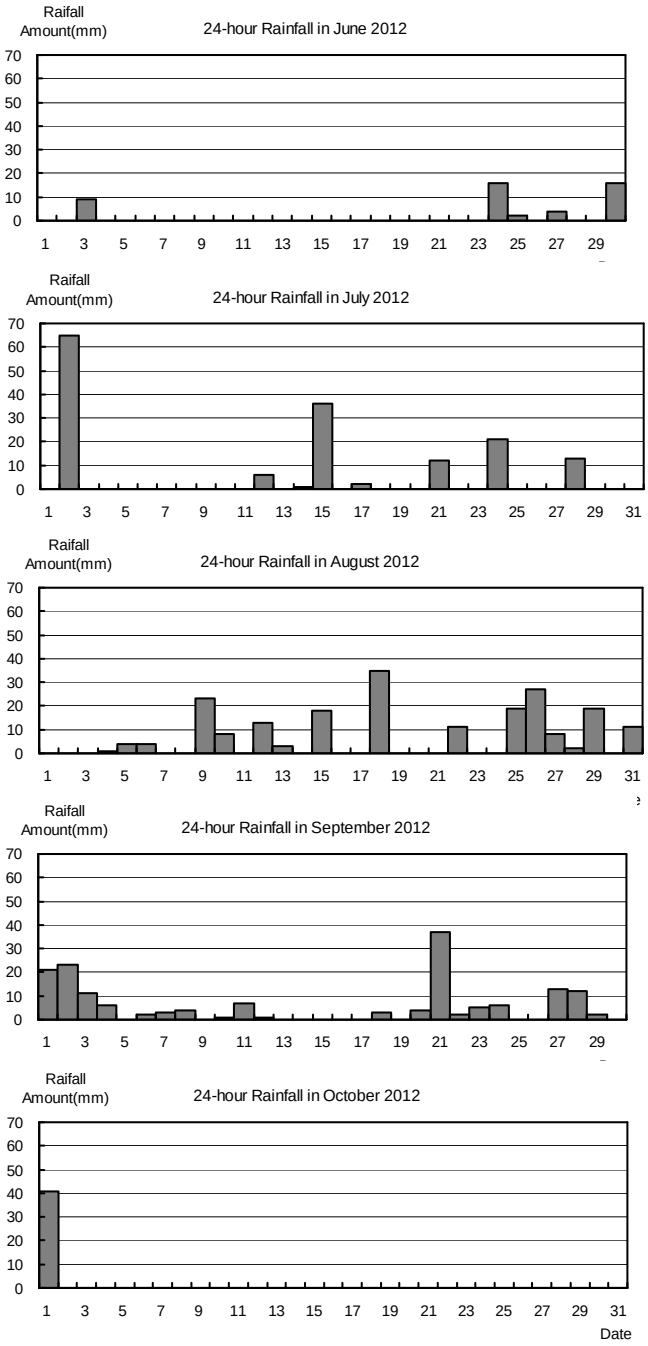


FIG. 2.1.9 24-HOUR RAINFALL OBSERVED IN THE 2012 RAINY SEASON

FIG. 2.1.10 SHOWS HOW LONG THE MAJOR LOCAL STORMS CONTINUE. THE FOLLOWING A CRITERIA OF MAJOR CONSECUTIVE RAINFALL EVENTS FOR DEPICTING THE FIGURE.

- 24-HOUR RAINFALL EXCEEDS 10 MM
- ONE STORM EVENT IS DEFINED AS CONTINUOUS RAINFALL HAVING A BREAK OF NO 30 MINUTES.

THE FIGURE INDICATES THAT MOST OF THE STORM EVENTS STOPPED WITHIN 3 TO 4 HOUR (70%) OF THE EVENTS SUBSIDED WITHIN 150 MINUTES, AND 87% OF THEM SUBSIDED WITHIN THE STORMS ORIGINATED FROM SMALL-SCALE WEATHER DISTURBANCES SO THAT THE SHOWERS WOULD OCCUR FREQUENTLY IN THE RAINY SEASON BUT WOULD LAST FOR A SHO AMOUNT OF TOTAL RAINFALL.

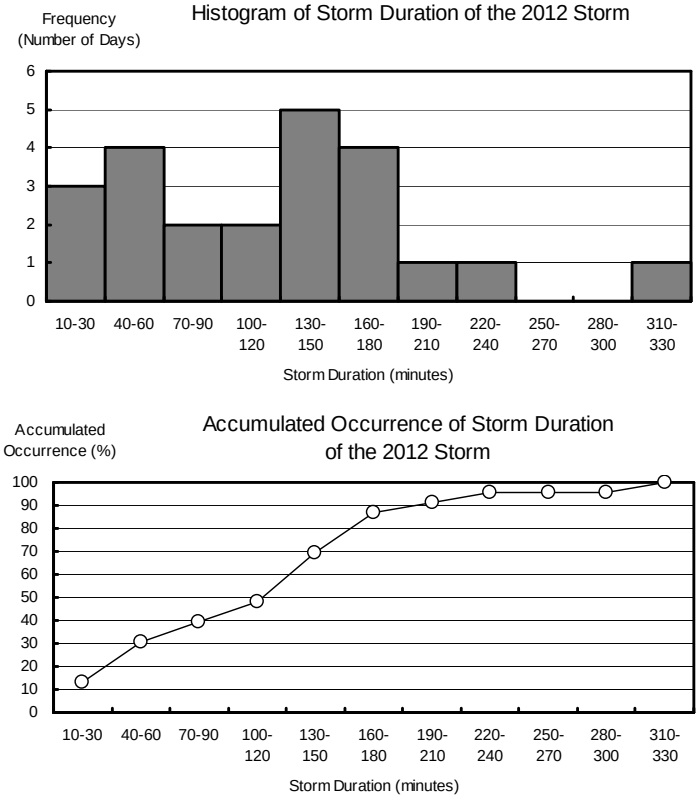


FIG. 2.1.10 HISTOGRAM AND ACCUMULATED OCCURRENCE OF MAJOR STORM DURATIO IN THE 2012 RAINY SEASON

ACCUMULATED RAINFALL AMOUNTS WITH TIME IN RELATIVELY STRONG STORM EVENTS WIT BIGGER THAN 20 MM ARE SHOWN IN **FIG. 2.1.11** IN COMPARISON WITH THE ACCUMULATED RAINFALL AMO ESTIMATED USING PROBABLE RAINFALL INTENSITY CURVES IN 2-YEAR, 5-YEAR AND 10-YEAR RE PROVIDED IN THE PREVIOUS CLAUSE THROUGH THE PROBABILITY ANALYSIS.

IN THE 2012 RAINY SEASON, FLOODING OCCURRED MORE SERIOUSLY THAN THE NORMAL YEAR, A LOCAL GOVERNMENT OFFICIALS IN KAOLACK. THE BIGGEST STORM EVENT IN JULY 2 INDICA DURATION RAINFALL AMOUNTS FOR PERIODS SHORTER THAN 70 MINUTES ARE BIGGER THAN T STORM, WHILE RAINFALL AMOUNTS FOR PERIODS LONGER THAN 70 MINUTES ARE LESS THAN THA FOLLOWING ENUMERATED FACTS, 10-YEAR DESIGN STORM WITH 3 HOURS DURATION COULD BE DESIGN STORM FOR THE KAOLACK DRAINAGE IMPROVEMENT WORKS.

- THE 2012 FLOODING EVENTS SEVERELY AND FREQUENTLY OCCURRED IN KAOLACK CITY CO NORMAL YEARS,
- MOST OF THE STORM EVENTS IN KAOLACK OCCURRED IN A SHORT DURATION OF LESS THAN
- SAFETY LEVEL OF 10-YEAR RETURN PERIOD IS NEEDED TO PREVENT FLOODING OCCURRENCE REFERRING TO THE MONITORED DATA IN THE 2012 RAINY SEASON; AND
- 10-YEAR LEVEL OF PROTECTION IN URBAN STORM DRAINAGE IS REGARDED AS SIGNIFICA DEVELOPING COUNTRIES.

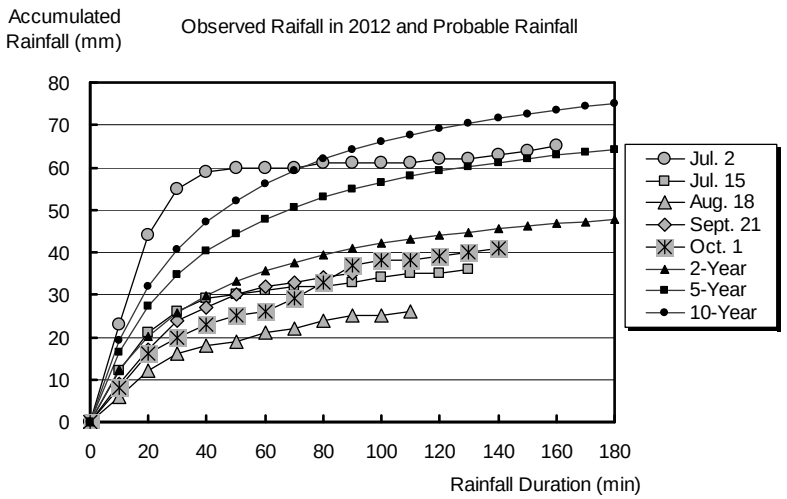


FIG. 2.1.11 COMPARISON BETWEEN MONITORED STORM EVENTS IN THE 2012 RAINY S AND PROBABLE RAINFALL INTENSITY CURVES

2.1.5 OTHERS

(1) SALOUM RIVER AND SURFACE WATER

SALOUM RIVER, WHOSE FLOW AND WATER LEVEL IS INFLUENCED BY TIDES, IS LOCATE BOUNDARY OF KAOLACK CITY, RECEIVING WASTEWATER AND STORMWATER COLLECTED IN TREATED WATER FROM KAOLACK STP. UNFORTUNATELY NO DATA OF STREAM FLOW AN AVAILABLE BUT ITS WIDTH OF ABOUT 300 M AND LARGE-SCALE CARGO SHIPPING SALT SHOW WATER IS LARGE ENOUGH TO DILUTE THE TREATED WATER OF KAOLACK STP.

SINCE THE ENVIRONMENTAL WATER QUALITY STANDARD IS NOT SET UP FOR SALOUM RIVE STP'S CONDITION WITH THE DISCHARGE CRITERIA IN "SENEGALESE STANDARDS NS 05-061 WASTEWATER: DISCHARGE STANDARDS", BOD$_5$=40 MG/L, COD$_{Cr}$=100 MG/L, TSS=50 MG/L AND FECAL COLIFORM=2,000 CFU/100ML.

IN KAOLACK CITY, SURFACE WATER IS NOT AVAILABLE EXCEPT FOR SALOUM RIVER. BUT TH SALOUM RIVER IS NOT SUITABLE FOR DRINKING AND AGRICULTURAL USE DUE TO HIGH S INSTEAD, THE WATER IS INTRODUCED TO SALT FARM TO PRODUCE SALT.

(2) IRRIGATION

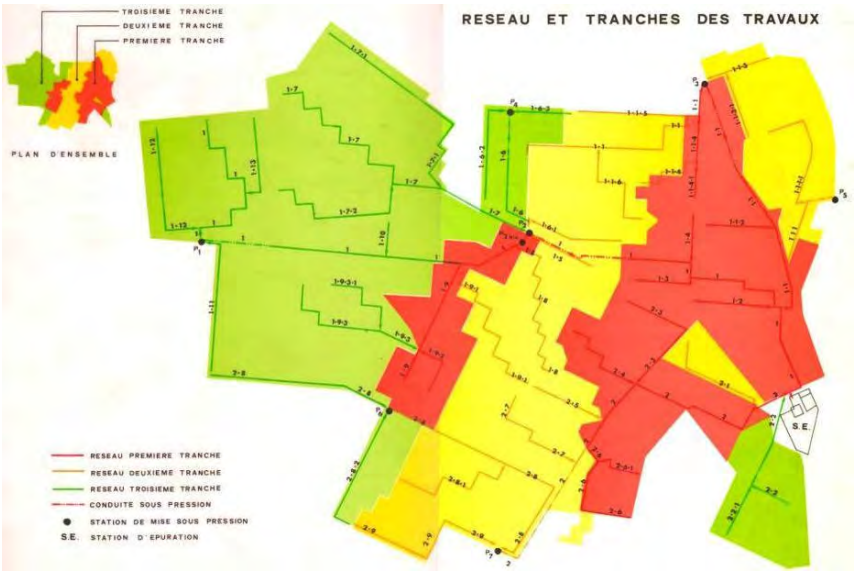
IN KAOLACK CITY, IRRIGATION SYSTEM IS NOT DEVELOPED. ON THE OTHER HAND, SMA UTILIZED FOR SMALL-SCALE FARMING.

2.2 SEWERAGE

2.2.1 SEWER NETWORK

(1) DEVELOPMENT PROCESS OF SEWER PIPE NETWORK IN KAOLACK CITY

The previous sewerage master plan[4] was formulated in 1982 with the target year 2000, based on the study results on urban hygiene infrastructure development in Kaolack conducted in about 1980. In the master plan, sewer network would have been developed for 20 years with the following 3 phases: (i) First Phase until 1980; (ii) Second Phase until 1990; and (iii) Third Phase until 2000, as shown in **FIG. 2.2.1.** Only the existing sewer network of 16.5 km, which was installed in the 1980's, remained without expansion until the succeeding sewer network expansion projects in **TABLE 2.2.1**commenced in the 2000's. The sewered area of the WB's project is about 90 ha and that of IDB is unclear.



Note: Left side of the figure faces the north.
Source: Sewerage M/P in 1980s

FIG. 2.2.1 SEWER PIPE NETWORK DEVELOPMENT PLAN PROPOSED IN 1982

TABLE 2.2.1 PROJECTS FOR EXPANSION OF SEWER PIPE NETWORK FROM 2003

Project Title	Year	Contents of Project (planning)		Donor
PLT (Programme eau à Long Terme)	PLT-1 :2003 PLT-2 :2005	Sewer network expansion : 16km	House connections : 1,044 houses	World Bank (WB)
PSE (Programme Sectoriel Eau)	2005	Sewer network expansion : 7km		
IDB Project (Projet d'Infrastructures d'assainissement des Eaux usees a Kaolack et Louga et des Euax Pluviales a Saint Louis)	2006	Sewer network expansion Connection b/w houses to sewer network Procurement of portable pump facilities Renewal of existing pumping station		Islamic Development Bank (IDB)

Note: House connection is the facilities of connecting pipe from sewer pipe to each household including house inlet.
Source: Interview with ONAS

Some developed areas of the projects mentioned in the table above are not functioning because they have not been connected to the existing sewer network due to shortage of construction budget and lack of contractor's capacity.

As of 2012, another development project of sewer network was in progress as a part of PRECOL (Programme de Renforcement et d'Equipment des Collectivities Locales), which is funded by

[4] This Master Plan was formulated by the Department of Sewerage Services, Ministry of Hydraulics (Ministère de l'Hydraulique, Direction de l'Assainnissement), with the financial assistance from the Government of Italy.

ADM. Population of this area in 2012 is estimated at 15,400. This project consists of the following works:

- Sewer pipe installation ϕ315 mm: 5.65 km
  ϕ250 mm: 3.86 km
  ϕ200 mm of force main: 1.04 km
- Connection work between sewer network and 651 houses
- Construction of a new pumping station in Médina Baye District
- Sewer pipe connection between Pumping Station No.2 and unconnected area in the previous projects

After completion of PRECOL, sewer network will be developed as **FIG. 2.2.2**

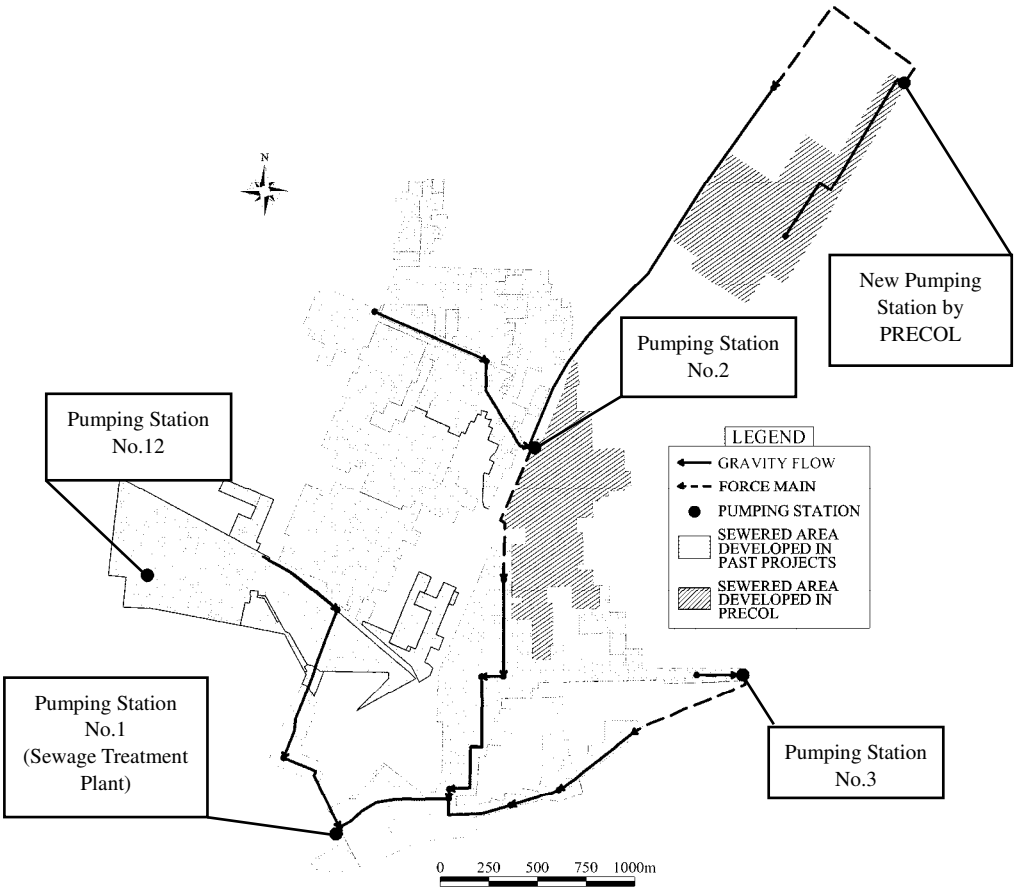


FIG. 2.2.2 SEWERED AREA AND SEWER PIPE NETWORK AFTER PRECOL

(2) PRESENT STATUS OF SEWER NETWORK

(A) EXISTING SEWER PIPES

Length of existing sewer pipes including PRECOL are summarized in **TABLE 2.2.2**. The existing sewer pipes in Kaolack City have been installed mainly in the 1980's based on the previous M/P, and these pipes are made of Asbestos Concrete. Deterioration of the pipes has taken place due to aging after 30 years or more of installation.

TABLE 2.2.2 LENGTH OF EXISTING SEWER PIPES INCLUDING PRECOL

Type of Pipe		Developed	Pipe material	Length of Pipe (km)	Remarks
Trunk Sewer	ϕ 700 mm	1980s	Asbestos Concrete	0.01	Significant deterioration by aging
	ϕ 600 mm			2.61	
	ϕ 500 mm			1.85	

Type of Pipe		Developed	Pipe material	Length of Pipe (km)	Remarks
	ϕ 400 mm			1.33	
	ϕ 300 mm			0.77	
	Total Length of Trunk Sewer			6.58	
Branch Sewer	Dia. ≤ 250 mm	1980s	Asbestos Concrete	26.38	Used with maintenance
		2003 -	PVC	18.16	Connected in PLT, PSE
				6.07	Connected in PRECOL
				1.68	Not yet connected (Abattoirs District)
	Total Length of Branch Sewer (connected)			50.61	
Force Main	ϕ ≤ 300 mm	1980s	Asbestos Concrete	1.39	for P2, P3
Sewer Pipe (PRECOL)	ϕ 315 mm	PRECOL	PVC	5.65	Newly installed
	ϕ 250 mm			3.86	
	ϕ 200 mm (Force Main)			1.04	

Source: ONAS and JET

In Kaolack, each household has to bear the cost of house connection (connecting pipe from sewer pipe to each household including house inlet) and the pipe from house inlet to inside of household. Cost of the house connection is 150,000 FCFA with the pipe length of less than 25 m and the cost increases depending on the length. Typical cost of the pipe from house inlet to inside of household reaches 50,000 to 100,000 FCFA. These costs of house connection create a financial burden for each household considering average each household's income of about 1.5 million FCFA/year, which is based on Socio-economic survey conducted by JET.

According to ONAS, in the PRECOL project area, for example, ADM bore all the cost of house connections and thus many households were connected to the sewer network. In Saint Louis, connection rates drastically increased because the city government bore the cost of house connections.

(B) EXISTING PUMPING STATIONS

The existing pumping stations (PS) are listed in **TABLE 2.2.3**. PS No. 1 is at STP, to pump up the conveyed wastewater. PS No. 2, No. 3, No. 12 and the new PS are installed as force main.

TABLE 2.2.3 EXISTING PUMPING STATIONS

Name of PS	No.1	No.2	No.3	No.12	New PS by PRECOL
Number of installed pumps	2	2	2	2	2
Construction year of PS	1980s (1st phase development)				2012
Year of installation of existing pumps	2004	2003	2003	2009	
Capacity of pumps installed (m^3/hr)	114.2 79.51	50.0 26.0	19.8 29.0	14.4 8.4	54.0 × 2
Power (kW)	5.9 5.9	22.0 22.0	5.9 5.9	1.6 1.6	6.0 × 2[2)]
Generators for emergency	equipped	equipped	not equipped	not equipped	equipped
Operational hours of pumps (hrs/day)	D/S: 12-16[1)] R/S: 24	5	1.5	2	not yet operated
Operational method	Automatic	Automatic	Automatic	Automatic	

Note: 1) D/S: dry season from October to May, R/S: rainy season from June to September
2) estimated by JET based on design conditions of PS

Source: Monthly Report by ONAS Kaolack,

(C) MAINTENANCE WORKS OF SEWER NETWORK

Monthly major maintenance works implemented in 2011 and 2012 are listed in **TABLE 2.2.4** based on the "Monthly Reports" prepared by ONAS Kaolack.

TABLE 2.2.4 RECENT MAJOR MAINTENANCE WORKS IN THE KAOLACK SEWER NET

Month		Unblocking Work				Repair Work	
		Pipe Network		Clearing Work			
		Trunk Sewer	Branch Sewer	Manual	Hydro-dynamic	Replacement of Concrete Manhole Cover	Installation of Cast Iron Manhole Cover
2011	January	15	7	22	0	8	2
	February	10	19	26	3	0	0
	March	6	2	8	0	5	0
	April	6	5	7	4	1	3
	May	10	5	11	4	0	5
	June	5	19	13	11	0	0
	July	14	4	18	0	2	0
	August	14	24	18	20	0	1
	September	9	8	15	2	0	0
	October	8	16	24	0	0	0
	November	11	10	21	0	0	0
	December	8	7	15	0	1	0
2012	January	10	17	27	0	1	0
	February	13	8	21	0	1	0
	March	13	11	24	0	0	6
	April	3	6	3	6	0	1
	May	3	6	3	6	0	1
	June	12	5	17	0	7	0
	July	24	15	32	7	2	3
	August	13	12	24	1	0	0

Source: Monthly Report issued by ONAS Kaolack, Unit: number of pipes and manholes

The main maintenance work which is being implemented routinely is "unblocking work" of sewer pipes. This work is to clear the clogged portions of sewer network by manual or hydrodynamic methods. Repair of manhole covers is also carried out frequently because the covers made of concrete or cast iron are often broken and lost.

Cleaning work of sewer pipes is carried out by the following process:

- Location and length of sewer pipes to be cleaned were found by ONAS Kaolack based on the collected data from their daily maintenance activities. Annual length of pipes to be cleaned is about 10 km, or about 20% of the total length of sewer network.
- The pipes to be cleaned are first reported to the ONAS headquarters, then the headquarters allocate the annual cleaning budget and decide on the actual length of pipes to be cleaned.
- Based on the budget allocation, cleaning equipment and team are dispatched from the ONAS headquarters, or contracted to private companies.

Cleaning work for small diameter pipes made of PVC is carried out with vacuum truck with water jet (refer to **PHOTO 2.2.1**

PHOTO 2.2.1 VACUUM CLEANING TRUCKS WITH WATER JET

On the other hand, the sewer pipes made of asbestos concrete have significantly aged so that mechanical hydro-pressure by water jet may deteriorate and collapse the pipes. Therefore, cleaning works are made manually by brushing (refer to **PHOTO 2.2.2)**.

PHOTO 2.2.2 MANUAL CLEANING WORK WITH BRUSH

(D) COLLAPSE OF SEWER PIPES

The asbestos concrete pipes were installed in the 1980's and have not been replaced until the present, so that these pipes have deteriorated significantly and some parts of the aged pipes have collapsed. If the size of the collapsed pipe is small, the pipe is replaced immediately by ONAS Kaolack as daily maintenance work. However, if the pipe is large (more than 300 mm in diameter), removal work of collapsed pipes and procurement of new ones will be difficult since pipes are not always stocked in ONAS and it is difficult to procure them in the market in Kaolack.

The stretches of trunk sewer network indicated in **FIG. 2.2.3** have collapsed and already rehabilitated, but these replaced stretches still have problems due the inadequate size of pipes.

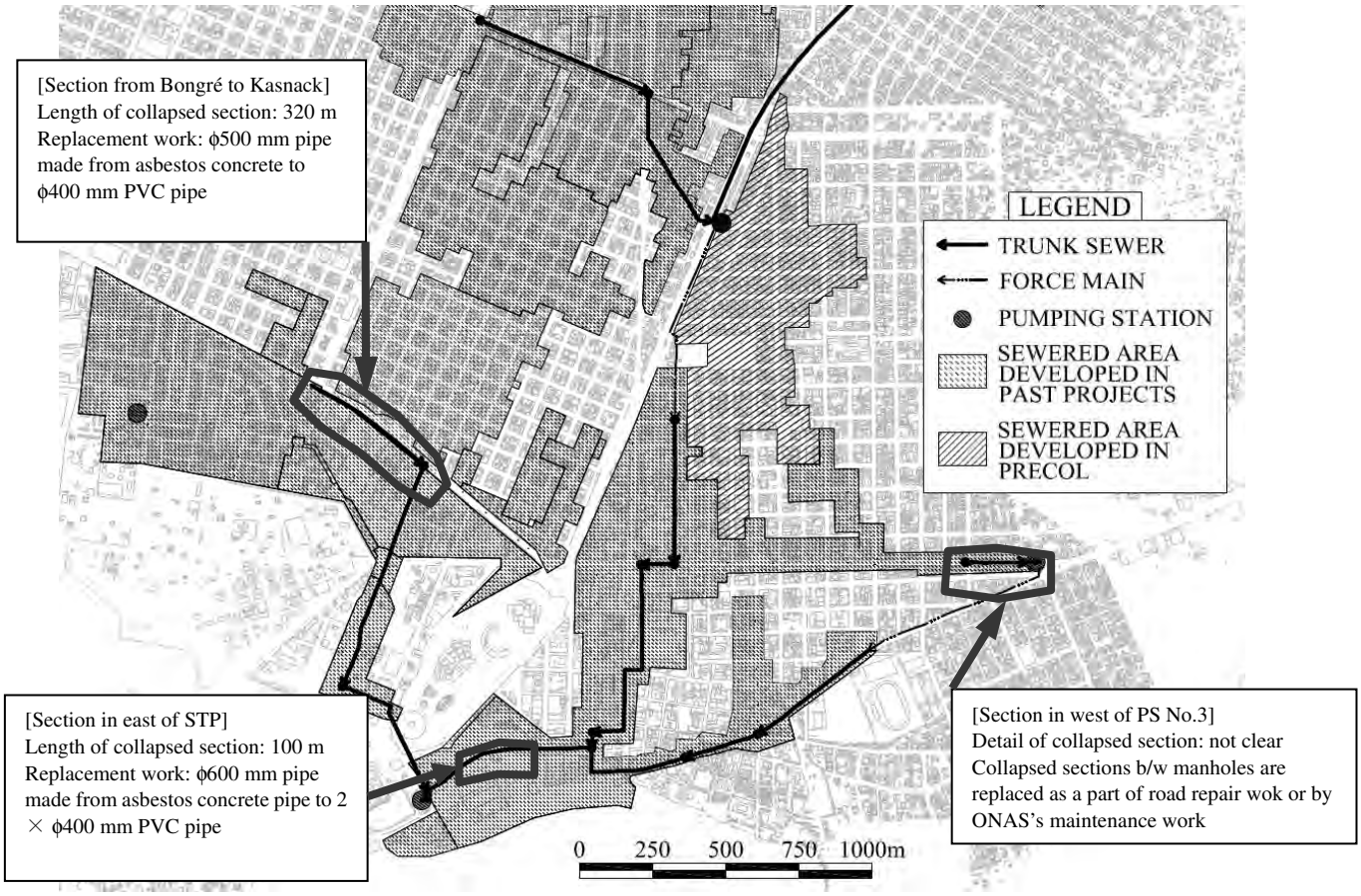


FIG. 2.2.3 PIPE COLLAPSE STRETCHES ON THE TRUNK SEWER NETWORK

(E) INADEQUATE CONSTRUCTION

Inadequate construction works were implemented in the 1980's. The typical section is upstream of PS No. 2. When the trunk sewers in this section were constructed, the necessary depth of trench could not be excavated because of high groundwater level and lack of appropriate temporary works. Thus, the pipes were installed at positions shallower than the design as shown in **FIG. 2.2.4**

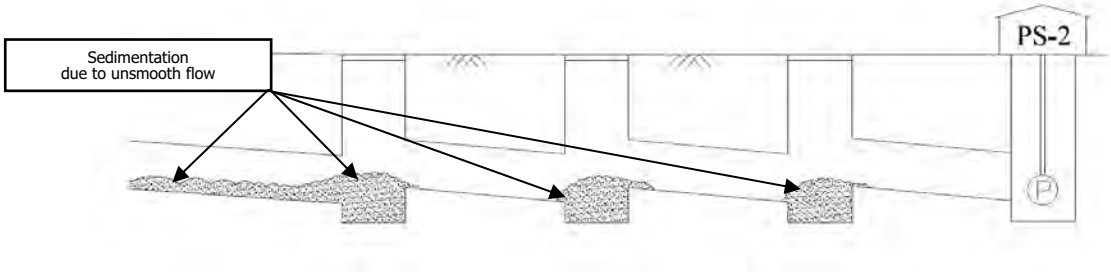


FIG. 2.2.4 ILLUSTRATION OF INADEQUATE CONSTRUCTION WORK AROUND P/S N

As the result of this work, gravity flow of wastewater is obstructed, wastes in wastewater accumulate not only around pits of the manhole in this section but also the upstream section because of unsmooth flow and backwater. These conditions cause increased load of cleaning and maintenance works.

(F) CAPACITY EVALUATION BY HYDRAULIC ANALYSIS

To identify the actual status of existing sewer network and to research deterioration related to hydraulic conditions, capacity evaluation by hydraulic analysis was carried out.

(I) EVALUATION CONDITIONS FOR ANALYSIS

- Population by catchment area of present sewer network (refer to **FIG. 2.2.5**) is estimated using population projection results of 2030.
- Condition of sewer pipes installed in the past projects including PRECOL was evaluated considering the actual status through interview and site survey.
- Capacity evaluation was conducted based on the peak flow in 2030 (158 L/capita/day=75 ×2+75×0.1) based on the description in **SUBSECTION 4.2.3**
- Connection rate: 100%

(II) RESULTS OF THE CAPACITY EVALUATION

The results of capacity evaluation of constructed sewer network are shown in **TABLE. 2.2.5.** Based on the evaluation, the following facts have been clarified.

- Entire section of the existing trunk sewer has enough capacity to convey wastewater generation of existing sewered area in 2030.
- Capacity of existing trunk sewer was designed in the 1980's based on the catchment area which would be developed in the 3-phased projects; however, actual catchment area developed in past projects is limited (refer to **FIG. 2.2.6**). Therefore, wastewater quantities do not reach the designed one.
- Particularly, in Node 2-1 to 2-5, the calculated flows are less than 12% of the capacity of trunk sewers. The capacity evaluation was conducted based on the design population in 2030 but the actual population in the sewered area is much smaller than that of the planned one. Thus, flow velocity in the pipes might be much slower than that of the designed one and accumulation of soils and solid wastes in the pipes becomes so serious, resulting in much maintenance work, and generation of corrosive hydrogen sulfide accelerating deterioration of the sewer pipes.
- In Node 1-9 to 1-10, flow velocities are about half of upstream section (Node 1-8 to 1-9). Such unbalanced velocities could cause waste accumulation in the sewer pipes as well.

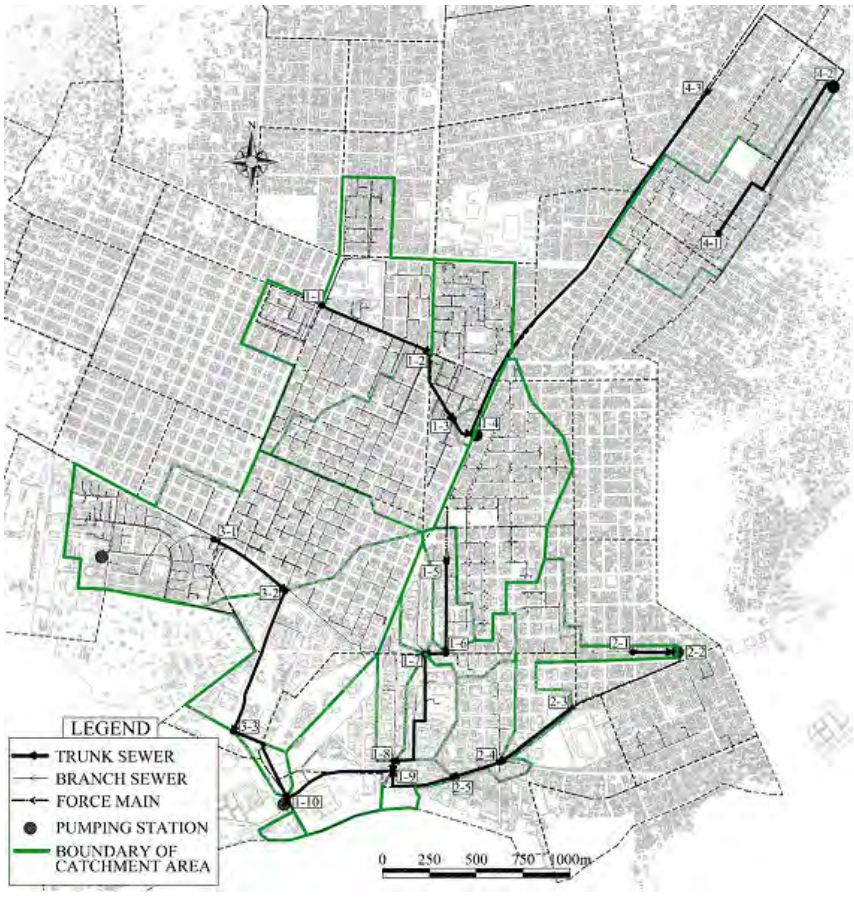


FIG. 2.2.5 SEWERED AREAS OF THE EXISTING NETWORK (AFTER COMPLETION OF PRECOL)

TABLE 2.2.5 RESULT OF CAPACITY EVALUATION OF CONSTRUCTED SEWER NETWORK IN 2

As of 2030, connection rate: 100%

Node		Contributory Population		Peak Flow (l/d)	Design Flow (l/s)	Size (mm)	Length (m)		Gradient (‰)	Full pipe capacity	
From	To	Each	Cumulative			Diameter of Pipe	Each	Cumulative		Velocity (m/s)	Discharge (l/s)
1-1	1-2	25,482	25,482	158	47	400	685	685	1.87	0.72	90
1-2	1-3	11,277	36,760	158	67	500	426	1,111	2.00	0.86	169
1-3	1-4	192	36,952	158	68	500	144	1,255	1.94	0.85	167
1-4	1-5	22,505	71,852	158	131	200	725	1,980	-	-	-
1-5	1-6	1,671	73,523	158	134	600	492	2,472	3.66	1.32	372
1-6	1-7	941	74,464	158	136	600	112	2,584	3.39	1.27	358
1-7	1-8	2,142	76,606	158	140	600	756	3,340	3.70	1.32	374
1-8	1-9	1,059	77,665	158	142	600	52	3,392	4.81	1.51	426
1-9	1-10	9,781	93,389	158	171	600	698	4,090	1.47	0.83	472
1-10	STP	24,363	142,116	158	260	700	10	4,100	2.00	1.08	415
2-1	2-2	2,913	2,913	158	5	300	282	282	2.08	0.63	44
2-2	2-3	0	2,913	158	5	150	666	948	-	-	-
2-3	2-4	678	3,591	158	7	300	491	1,439	6.12	1.07	76
2-4	2-5	1,659	5,250	158	10	400	282	1,721	5.12	1.19	149
2-5	1-9	694	5,944	158	11	400	365	2,086	1.92	0.73	91
inflow to 1-9											
3-1	3-2	18,862	18,862	158	34	500	470	470	2.64	0.99	194
3-2	3-3	5,120	23,983	158	44	500	810	1,280	1.91	0.84	165
3-3	1-10	381	24,363	158	45	600	502	1,782	1.79	0.92	260
inflow to 1-10											
4-1	4-2	12,395	12,395	158	23	315	1,153	1,153	1.00	0.58	45
4-2	4-3	0	12,395	158	23	315	1,042	2,195	-	-	-
4-3	1-4	0	12,395	158	23	315	2,306	4,501	3.00	1.01	79
inflow to 1-4											

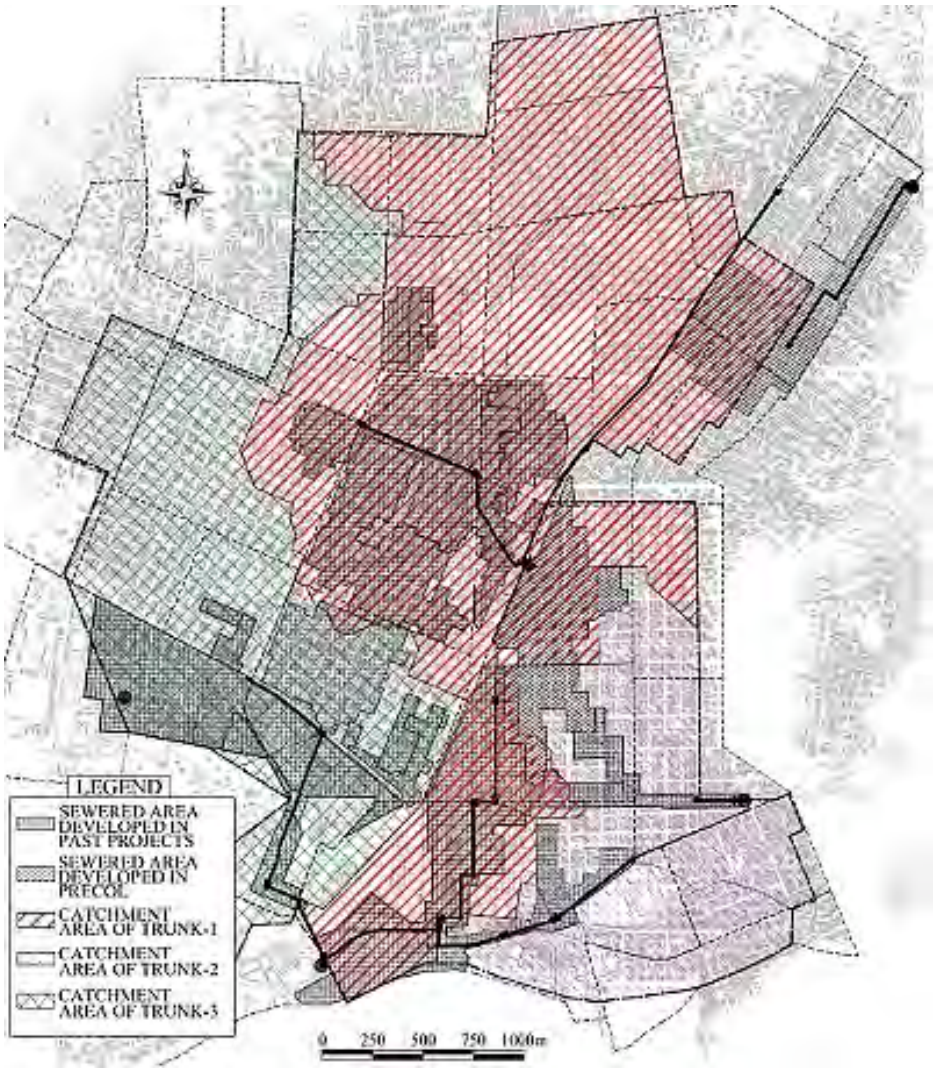


FIG. 2.2.6 COMPARISON OF AREA DESIGNED IN THE 1980S M/P AND EXISTING SEWERED A

(3) PRESENT STATUS AND ISSUES OUTSIDE OF SEWER NETWORK IN KAOLACK CITY

(A) SANITATION CONDITIONS OUTSIDE SEWERED AREA

In Kaolack City, inhabitants living outside the sewer network basically rely on septic tanks for sewage treatment. Those residents periodically have to desludge the accumulated septage at their own cost. However, some residents do not want to bear the cost, resulting in desludging by themselves and disposing the septage to the environment nearby. Those attitudes generate not only sanitary problems but also conflicts between residents.

On the other hand, southeast areas of Kaolack City as shown in **FIG 2.2.7**, being located along the Saloum River and its muddy flat, has suffered high groundwater table. In these areas, installation work of septic tanks could not be easily done due to buoyancy of the concrete body underground. Such situation accelerates worsening the sanitation in the areas. (Refer to **PHOTO 2.2.3**)

To improve the above-mentioned sanitation conditions, expansion of sewer network to the areas may be effective resolution for such issues.

FIG. 2.2.7 AREA WITH HIGH GROUNDWATER TABLE

Wastewater is drained to roads directly without any treatment (in Abattoirs District)

Toilet is located on muddy flat so that excreta is disposed directly to the environment (in Abattoirs District)

PHOTO 2.2.3 SANITATION PROBLEMS CONFIRMED AT SOUTHEAST AREA IN KAOLACK CITY

2.2.2 KAOLACK SEWAGE TREATMENT PLANT

(1) OUTLINE

The Kaolack Sewage Treatment Plant started operations in 1981. According to the Master Plan formulated in 1979, the treatment method is the lagoon type with the initial capacity of 2,000 m^3/day. From the year 2006, construction of the aerated lagoon with the maximum capacity of 6,000 m^3/day commenced with assistance from IDB by replacing one of the existing lagoons in order to augment the capacity. Unfortunately, the aerated lagoon was not completed, and not yet handed over from IDB. Some of the aerators in the aerated lagoon have already been turned over and a part of waterproof sheet has been torn out.

As shown in **FIG. 2.2.8**, the treatment plant consists of pumping station, grit chamber, lagoons and chlorination chamber. The pumping station has 2 units of pumping equipment with capacity of 75 m^3/h and 95 m^3/h. The grit chamber, which was constructed under the assistance of IDB, is located at the subsequent stage of pumping station with its surface area of about 18 m^2. However, the grit chamber is almost filled with sand and sludge since the desludging pumps installed are not functioning and not yet handed over from IDB.

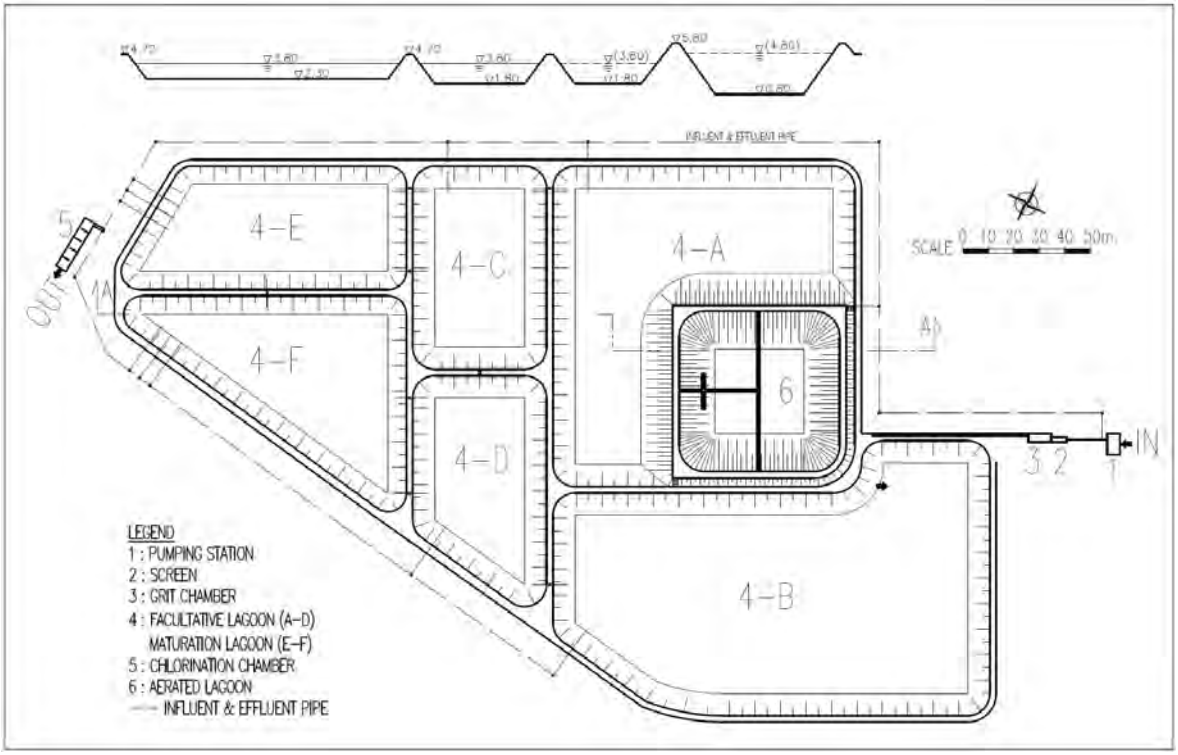


FIG. 2.2.8 GENERAL PLAN OF KAOLACK SEWAGE TREATMENT PLANT

The lagoon is initially comprised of 6 lagoons, of which 4 lagoons are facultative ones and the others are maturation ones. The facultative lagoon of 4-A in **FIG. 2.2.8** is not functioning and dry up since influent pipe of the lagoon was removed when aerated lagoon was constructed. In the facultative lagoons, organic substances as well as suspended solids are removed by biodegradation and/or sedimentation. Residual organic substances not removed in the preceding facultative ponds are degraded and some disinfection is taken place in the maturation ponds. The chlorination chamber, which has a volume of about 40 m^3, might be the device to complete the disinfection. Treated water is finally discharged into the Saloum River.

Initial concept of the lagoon system could not be identified due to the lack of design report/calculation. However, by referring to some as-built drawings, the dimensions of each lagoon could be roughly identified. In the following table, the dimensions (area and depth of lagoons) are summarized along with the estimation of initial Hydraulic Retention Time (HRT) under the condition that allowable depth for sludge is not considered. As shown in the table, the lagoon's HRT is 36 days, which is relatively long and results in an advantage against overloading. However, currently, ONAS has reevaluated the capacity of lagoon system, considering volume reduction arising from the construction of aerated lagoons, low water level due to malfunction of discharge weir installed at the downstream end of lagoons, and sedimentation, Then ONAS set up the actual capacity of the lagoons at 390 m^3/day. Based on JET's evaluation, capacity of the lagoon in which 5 lagoons are operated (4-B, 4-D, 4-C, 4-E and 4-F are used in line), would be recovered to **1,000 M^3/DAY** by improving the malfunctioning discharge weir and implementing desludging of all lagoons.

TABLE 2.2.6 DIMENSION OF LAGOONS AND ESTIMATED HRT

No.[1)]	Type	Area (m^2)	Depth (m)	Volume (m^3)	Inflow (m^3/day)	HRT (days)
4-A	Facultative	12,266	2.00	24,532	2,000	12.3
4-B	ditto	12,417	2.00	24,834	2,000	12.4
4-C	ditto	2,808	2.00	5,616	2,000	2.8
4-D	ditto	2,757	2.00	5,514	2,000	2.8
4-E	Maturation	3,550	1.50	5,325	2,000	2.7
4-F	ditto	4,062	1.50	6,093	2,000	3.0
Total		37,860		71,914		36.0

Note: 1) The numbers correspond to those of **FIG 2.2.8.**

As with the lagoons, the detailed design concept of the aerated lagoon was not available due to the lack of design report/calculation. Therefore, by referring to the tender documents, the outline of the aerated lagoon is as given in the following table.

TABLE 2.2.7 OUTLINE OF AERATED LAGOON

Items		Unit	Contents	Remarks
Target population		People	30,000	
Maximum capacity		m^3/day	6,000	
Influent water quality	BOD_5	mg/l	400	
	COD_{Cr}		800	
	TSS		500	
	Total Kjeldahl nitrogen		110	
	Phosphorus		30	
Influent pollution load	BOD_5	kg/day	1,200	
	COD_{Cr}		2,400	
	Total Kjeldahl nitrogen		330	
	Phosphorus		90	

Source: Tender Documents of IDB

Based on the design drawings, dimensions of the aerated lagoon have been roughly identified and HRT was estimated at 1.3 days as shown in **TABLE 2.2.8**. The estimated HRT is relatively short, considering the typical HRT of the aerated lagoon process ranging from 3 to 6 days which corresponds to the capacity of about 1,500 to 2,500 m^3/day. Therefore, in the alternatives studied under the M/P, the capacity of aerated lagoon was set at **2,000 M^3/DAY** with HRT of 4 days.

TABLE 2.2.8 ESTIMATED HRT OF AERATED LAGOON

No.[1)]	Type	Area (m^2)	Depth (m)	Volume (m^3)	Inflow (m^3/day)	HRT (day)
6	Aerated lagoon	1,980	4.00	7,920	6,000	1.3

Note: 1) The number corresponds with that of in **FIG 2.2.8.**

(2) RECORD OF INFLOW

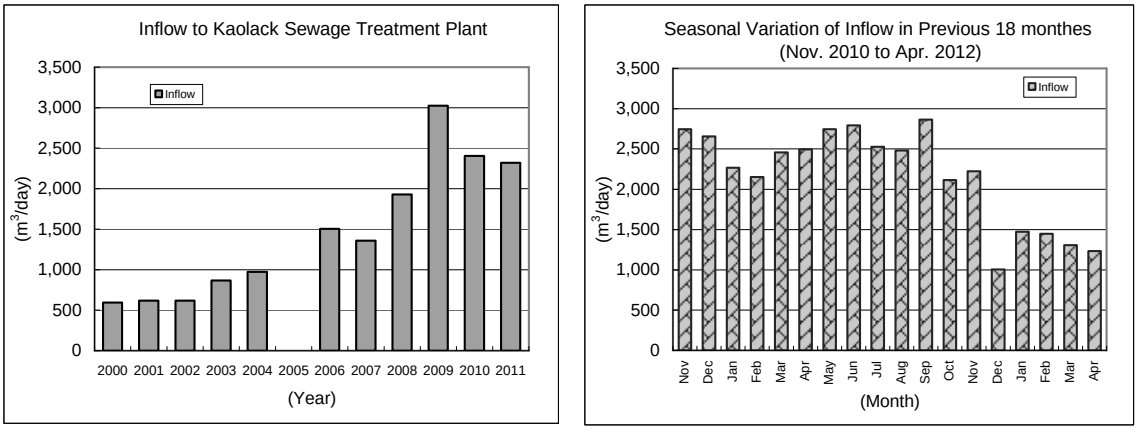
ONAS Kaolack summarizes its operations/activities on a monthly basis and thus compiles a report named "Monthly Report", which includes operation records of pumping stations and sewage treatment plant, management of claims from inhabitants such as clogging of pipes and so on.

Based on the Monthly Report, records of inflow to the treatment plant from the year 2000 to 2011 are as shown in **FIG. 2.2.9** which includes seasonal variation of the previous 18 months. As shown in **FIG. 2.2.9 (LEFT)**, the inflow was stable at approximately 600 m^3/day, from the year 2000 to 2002, which was closely related to the fact that the expansion of sewer network has been stable until 2003. On the other hand, it has been gradually increasing since 2003, with the maximum inflow of 3,024 m^3/day recorded in 2009. Consequently, the treatment plant got overloaded, considering the present capacity of the treatment plant.

With regard to the seasonal variation in **FIG. 2.2.9 (RIGHT)**, inflow in the rainy season generally exceeded 2,500 m^3/day. Increase of inflow to the STP in the rainy season mainly results from stormwater, especially from the flooding area in which stormwater is pumped by portable pumps into the nearest sewer manhole in emergency situations.

- In the Kaolack STP, inflow is not recorded by flow meter but estimated by operation time multiplied by capacity of pumping equipment. Therefore, the estimated inflow is susceptible to the fluctuation of pumping water level.
- Due to the repair work conducted in the end of November 2011, efficiency of pumping equipment has considerably improved and thus operation time decreased since December 2011. Consequently, estimated inflow is smaller than those recorded before the repair work.

Considering the above conditions and the calculation results discussed in "Future demand projection," actual inflow to the STP would range from about 1,000 to 2,000 m^3/day.



Note: Inflow of the year of 2005 is not shown in the figure due to the lack of data.

FIG. 2.2.9 INFLOW TO KAOLACK SEWAGE TREATMENT PLANT

(3) RECORD OF WATER QUALITY

Influent and effluent water of the treatment plant is sampled at about 3 times a year, and its water quality is analyzed in the laboratory of Dakar ONAS. The monitored parameters are 10 in total, which consists of temperature, pH, TSS, COD_{Cr}, BOD_5, T-N, T-P, electric conductivity, salinity, and fecal coliform.

The data of previous 2 years (from December 2009 to December 2011) are summarized in **TABLE 2.2.9**. Of the monitoring data, concentration of salinity has been extremely high, which might be resulting from its high concentration in groundwater and/or drinking water. Electric conductivity, which is closely related to salinity, has been also high. As for water temperature, it has been constantly high-level, which might be suitable for biodegradation.

Average concentrations of BOD_5, COD_{Cr} and TSS in 2011 are 377, 765 and 477 mg/l, which results in the ratio of BOD_5 : COD_{Cr} : TSS of about 1.00 : 2.00 : 1.25 (this ratio is employed in the M/P to estimate concentration of COD_{Cr} and TSS).

TABLE 2.2.9 WATER QUALITY OF KAOLACK SEWAGE TREATMENT PLANT

	Unit		2009	2010			2011			Discharge
			Dec	Jun*1	Sep	Dec	Apr	Oct	Dec*4	criteria
Temp	Celsius	In	30.7	(34.4)	29.5	30.8	33.3	32.0	-	
		Out	26.2	(34.4)	30.0	25.0	29.4	30.3	-	
pH		In	8.13	-	-	-	7.50	7.87	7.76	
		Out	8.48	-	-	-	8.57	8.65	8.16	
TSS	mg/l	In	284	(464)	94	507	304	340	788	
		Out	138	(464)	73	34	160	94	188	50
	Removal rate:%		*51*	*(0)*	*22*	*93*	*47*	*72*	*76*	
COD_{Cr}	mg/l	In	742	(756)	243	960	756	498	1,040	
		Out	306	(756)	148	168	512	162	321	100
	Removal rate:%		*59*	*(0)*	*39*	*83*	*32*	*67*	*69*	
BOD_5	mg/l	In	240	(250)	60	420	240	140	750	
		Out	55	(250)	45	70	120	55	90	40
	Removal rate:%		*77*	*(0)*	*25*	*83*	*50*	*61*	*88*	
T-N	mg/l	In	85	(156)	24	-	305	52	119	
		Out	79	(156)	19	-	154	21	59	30*2
	Removal rate:%		*7*	*(0)*	*21*	*-*	*50*	*60*	*50*	
T-P	mg/l	In	16	(25)	2	-	19	6	19	
		Out	12	(25)	2	-	5	3	12	10*3
	Removal rate:%		*25*	*(0)*	*0*	*-*	*74*	*50*	*37*	
Fecal coliform	CFU /100ml	In	-	(7.60×10^6)	2.00×10^6	1.08×10^7	-	-	-	
		Out	-	(7.60×10^6)	3.00×10^4	3.70×10^5	-	-	-	2.0×10^3
	Removal rate:%		*-*	*(0)*	*99*	*97*	*-*	*-*	-	
Conductivity	µs/cm	In	4,872	(4,590)	3,414	4,975	4,303	5,990	4,950	
		Out	4,994	(4,590)	3,140	5,076	7,120	4,940	4,800	
	Removal rate:%		*-3*	*(0)*	*8*	*-2*	*-65*	*18*	*3*	
Salinity	mg/l	In	2,600	(2,467)	1,800	2,650	2,300	3,100	3,090	
		Out	2,640	(2,467)	1,500	2,700	4,360	2,500	2,990	
	Removal rate:%		*-2*	*(0)*	*17*	*-2*	*-90*	*19*	*3*	

Note: *1: According to ONAS Kaolack, removal was not given to the water quality of outflow since the wastewater was directly discharged to outlet due to desludging at the time of monitoring.
*2 and *3: Evaluation of compliance of T-N and T-P are not included in the Monthly Report of ONAS.
*4: BOD_5, COD_{Cr} and TSS in December 2011 are considerably higher than those of other months, which originate from flushing of sedimentation in the trunk sewers due to rehabilitation works.
Source: Monthly Reports, ONAS Kaolack

The fluctuation of 3 parameters (TSS, COD_{Cr} and BOD_5), which represents the situation of treatment, are shown in **FIG. 2.2.10** in terms of concentration and removal rates.

All the effluent BOD_5, ranging from 45 mg/l to 250 mg/l in the 2 years, exceeded the discharge criteria of 40 mg/l (0% compliance with discharge criteria). However, some data of BOD_5, especially in the dry season, were not so deteriorated although the treatment plant has been overloaded. As for COD_{Cr} and TSS, compliance of 0% and 14% with discharge criteria was achieved in the 2 years. To improve the deterioration of water quality, desludging of lagoons and operation of the aerated lagoon would be an option.

All the fecal coliform number also exceeded the discharge criteria, which might arise from insufficient chlorine dose. With regard to T-N and T-P, compliance of 33% and 50% with discharge criteria was achieved in the 2 years (but those evaluations were given as a reference because T-N and T-P were not included in the evaluated parameters in the ONAS's Monthly Report).

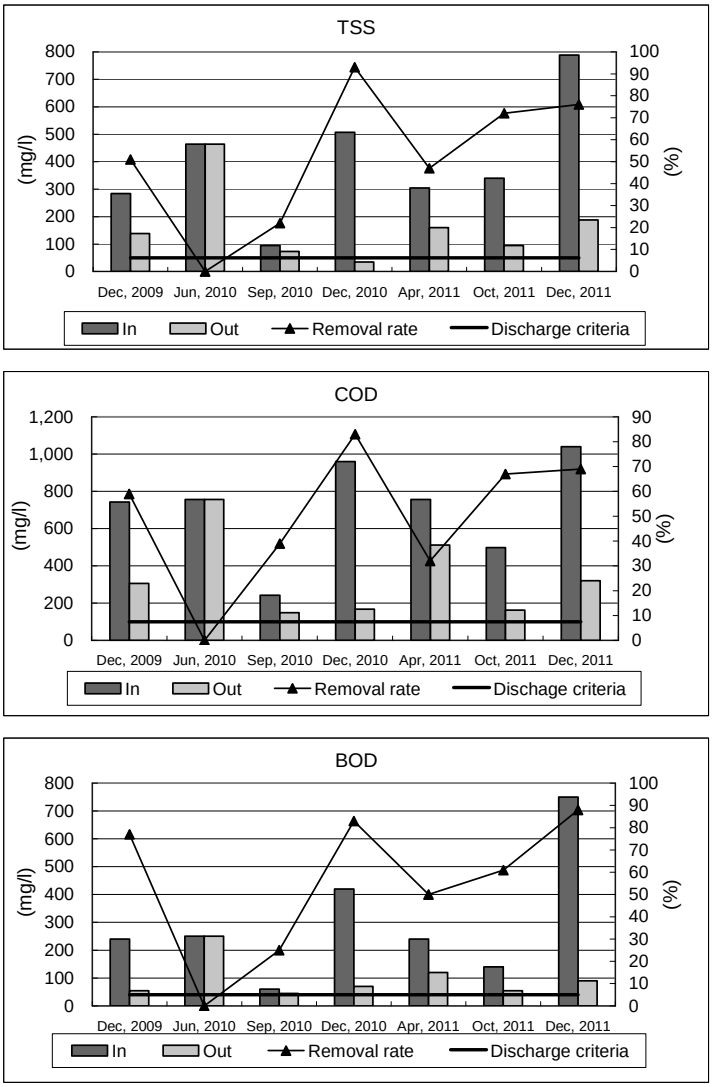


FIG. 2.2.10 INFLOW AND OUTFLOW WATER QUALITY (TSS, BOD, COD) AND REMOVAL RATE

(4) RECYCLING OF TREATED WATER AND SLUDGE

In the IDB's project, treated water is supposed to be introduced to a new reservoir which is constructed next to the treatment plant, and distributed to farmers. However, as with the aerated lagoon, the reservoir was not constructed and distribution of the treated water was not commenced. As for sludge recycle, accumulated sludge in lagoons was desludged in the recent years of 2006 and 2010, and the farmers nearby took small amounts of the sludge free as fertilizer.

(5) INDUSTRIAL WASTEWATER

At present, no factory discharging hazardous industrial wastewater has been identified in and adjacent to the northern urbanized area of the existing sewer network. If industrial facilities which discharge toxic and high concentration wastewater are constructed in the sewerage planning area in the future, their owners should treat their wastewater by installing their own treatment plant in accordance with PPP (polluter-pays principle).

2.2.3 RESULTS OF INTERVIEW SURVEY

(1) GENERAL

In order to collect the actual inhabitants' opinions, complaints and requests for sewerage service, interview survey has been conducted for a total of 100 inhabitants, extracting each 10 households of 10 districts. The target districts of the survey were determined based on the discussion with the Kaolack City and ONAS Kaolack, as indicated in **FIG 2.2.11**

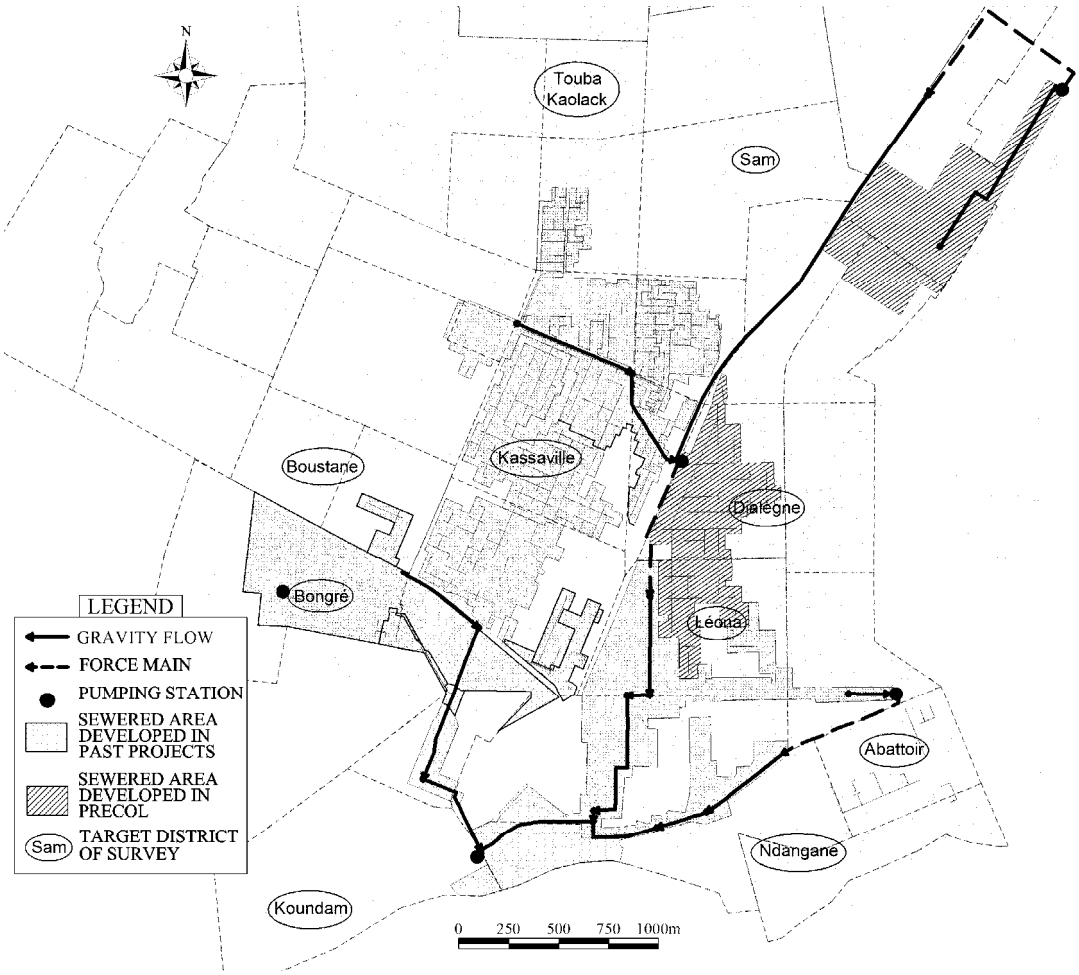


FIG. 2.2.11 LOCATION OF TARGET DISTRICT OF THE INTERVIEW SURVEY

(2) INTERVIEW ITEMS REGARDING SEWERAGE

Interview items of the survey regarding sewerage service condition and request for sewer network expansion is as follows:

a) Have you and your family ever had waterborne diseases such as diarrhea, hepatitis, typhoid, cholera, malaria, dysentery, dengue fever, and so on?
b) Is your house connected to sewer pipes?
c) If your answer to question b) is yes, is the sewer network functional?
d) If your answer to question b) is yes, do you know that sewerage collection and treatment fee is charged as a part of tap water?
e) If your answer to question d) is yes, are you satisfied with the function of sewerage system connected with your house in consideration of the amount of charge?
f) If your answer to question b) is no, will you request connection of your house to the sewerage system?

g) If question f) is yes, how much can you bear for the connection of your family to the sewerage system if you have to bear a part of the connection cost?
h) If your answer to question f) is yes, how much are you willing to pay for sewerage charge per month?

(3) SURVEY RESULTS

The results of the interview survey are listed in **TABLE 2.2.10** The following points have been identified as the present condition and request for sewerage network:

- Not less than seven interviewees in each district, except Léona, Dialègne and Touba Kaolack, answered that their families had waterborne disease.
- 17 interviewees answered that their houses are connected to the sewer network. Nine of these interviewees know the sewerage treatment fee, and five of them are not satisfied with the function of sewerage service compared to the amount of payment.
- The districts where many interviewees request to be sewered are Abattoir (5/10), Ndangane (8/10) and Kassaville (8/9).
- In Boustane, some interviewees answered the sewer network connection and/or monthly maintenance cost is acceptable although they do not request to be sewered. It is supposed that these people may positively accept to be sewered depending on the conditions.
- Especially, the interviewees in Abattoir and Ndanagene answered that they will not only request or accept connection to sewer network but also accept the initial and monthly amounts cost for sewerage utilization.
- In Kassaville District, the sewer network is basically installed, but interviewees' houses are mainly not sewered. On the other hand, interviewees who will request or accept the sewerage cost are dominant (8/9). It is supposed that many inhabitants living around sewer network will request to be connected to the sewer network.
- Interviewees in Sam District will not request to be sewered at all because septic tanks in the district are not affected by high groundwater level and as a result the septic tanks are relatively effective[5].

[5] Sam District includes habitual flooding area as shown in **FIG 2.3.6**. The area is however limited to the northern low-lying area of the district, which is located adjacent to the Nagae Saer District. Thus the septic tanks in Sam District are as a whole effective, according to ONAS.

TABLE 2.2.10 RESULTS OF INTERVIEW SURVEY

District	(a) Water-borne disease?		(b) Connected to sewer network?		(c) Sewer network is functional?		(d) You know charge of sewerage?		(e) Satisfied with sewerage function?		(f) Request to be sewered?		(g) Acceptable initial cost for sewerage?	(f) Acceptable monthly cost for sewerage?
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		
Léona	0	10	4	6	4	0	1	3	1	-	2	4	20% of total 15% of total	10,000 FCFA 15,000 FCFA
Bongré	10	0	9	1	3	6	6	3	1	5	0	1	-	-
Dialègne	4	6	0	10	-	-	-	-	-	-	4	6	50,000 FCFA 5,000 FCFA	2,000 FCFA 1,000 FCFA
Abattoirs	10	0	0	10	-	-	-	-	-	-	5	5	10% of total 5,000 FCFA 10,000 FCFA 15,000FCFA 5% of total	500 FCFA 2,000 FCFA 1,000 FCFA 700 FCFA 5,000 FCFA
Touba Kaolack	4	6	0	10	-	-	-	-	-	-	3	7	50,000 FCFA 50,000 FCFA	1,000 FCFA 1,000 FCFA
Ndangane	9	1	0	10	-	-	-	-	-	-	8	2	100,000 FCFA 20% of total 3,000 FCFA 20% of total 15% of total 50,000 FCFA 15,000 FCFA 15,000 FCFA	1,000 FCFA 2,000 FCFA 500 FCFA 5,000 FCFA 6,000 FCFA 1,000 FCFA 3,000 FCFA 7,500 FCFA
Koundam	7	3	0	10	-	-	-	-	-	-	4	6	-	-
Kassaville	7	3	1	9	-	1	1	-	1	-	6	2	10% of total 10% of total 20% of total 20% of total 25% of total 10% of total 10% of total 20% of total	10,000 FCFA 3,000 FCFA 5,000 FCFA 3,000 FCFA 2,000 FCFA
Boustane[1)]	10	0	3	7	1	2	1	2	1	-	2	5	4,800 FCFA 15,000 FCFA 10,000 FCFA 10,000 FCFA 60,000 FCFA 40,000 FCFA	 4,000 FCFA 1,000 FCFA 5,000 FCFA 5,000 FCFA
Sam	7	3	0	10	-	-	-	-	-	-	0	10	-	-

Note: Survey results in grayed cell include the answer "I do not know"

1) some interviewees in Boustane answer the acceptable cost for sewer network connection and monthly maintenance although they reply not to request to be sewered.

2.3 Stormwater Drainage

2.3.1 History of Stormwater Drainage Improvement

In 1982, "The Urban Storm and Wastewater Sanitation Master Plan in Kaolack[6]" was formulated with the target year of 2000. Both works of urban storm drainage and wastewater sanitation should be set up in the stepwise improvement program in the master plan; namely; 1st phase until 1980, 2nd phase until 1990, and 3rd phase until 2000.

According to the above planning report, combined drainage network already exist in the urban centers of Kaolack City, which consist of lots of canals collecting not only storm water but also domestic wastewater. The master plan utilized such existing canals to connect among them and to widen them. The 1st phase work might be done in such manner. **Fig. 2.3.1** presents the stepwise improvement program of storm water drainage network proposed in 1982.

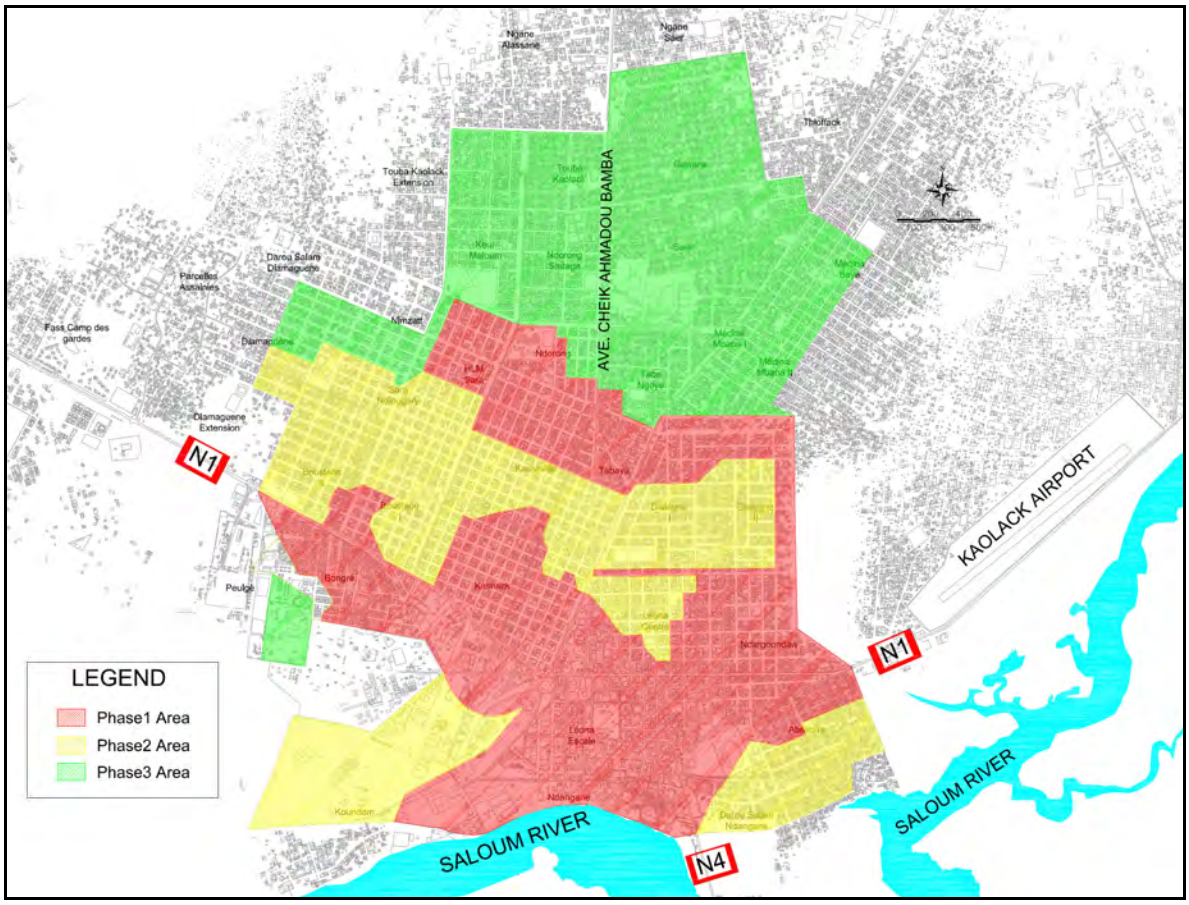


Fig. 2.3.1 Stormwater Drainage Network Improvement Plan Proposed in 1982

The master plan proposed the storm drainage network by analyzing the topography using a precise topographic map at the scale of 1:2,000 with contour lines of 0.5 m interval prepared in 1975, covering only the urban area of Kaolack City. At present however, no precise topographic data is available. Only a brief report on the master plan could be accessed, in particular, on storm water drainage improvement. There are no available design drawings including longitudinal canal profiles and cross sections of canal system as well as the planning details for storm water management. Thus the review works have to face some limitation due to lack of necessary data/information.

[6] This Master Plan was formulated by the Department of Sewerage Services, Ministry of Hydraulics (Ministère de l'Hydraulique, Direction de l'Assainnissement), with the financial assistance from the Government of Italy.

2.3.2 Existing Drainage System

Data on the existing drainage system is very limited. The Kaolack City has a list of the 34 existing drains maintained by the city, however, it has no location map and no specific data such as type, and dimensions including length. Therefore, an inventory survey on the existing drains was carried out to identify in this Study. ONAS has a drainage network map in AutoCAD file, but there is also no specific data. Aside from the 34 existing drains mentioned above, however, some drains are additionally shown in this map. According to Kaolack City, there were earth canals and drainage pipes installed in the past, but it could not find the drainage pipes during the inventory survey. However, Kaolack City requested that the drainage data in the map should be kept for future drainage planning reference.

The list of drains maintained by Kaolack city and the location of existing drains are shown in **Table 2.3.1** and **Fig. 2.3.2**, respectively.

Table 2.3.1 Existing Stormwater Drains

No.	Name/Location	Type	Length (m)	Dimensions (m) Width × Height
1	Total Gas Station Pie Xll 02 ways - kiosk Police Force	covered	775	0.8 × 1.0
2	Police Force - Central Jail-River	covered	820	0.8~1.0 (width)
3	City-Planning - Former Public Work Dept - Police Force - Kiosk	covered	505	0.5 × 0.6
4	Police Force Legion - Relay emissary	covered	300	0.5 × 0.6
5	France Street - River	covered	105	0.4 × 0.4
6	Public Hygiene Service - City Hall Prefect Office - Com. Zone	covered	205	0.5 × 0.6
7	Surroundings of Governor Office - Com. Zone	covered	300	0.7 × 0.6
8	Central Police Station - Central Market - SGBS BANK	covered	360	0.6 × 0.5
9	Blue Bird - Mboutou SOW – Ecoles Street - Central Market	covered	780	0.6~1.1 × 0.6~0.9
10	Canal of De Gaule - Faidherbe Street- River Outlet	covered	225	0.6~0.8 (width)
11	Inside the Central Market	covered	-	-
12	Nioro Kanene way - Health Center Diarama	covered	210	0.8~1.0 (width)
13	Former Bata - Dalao Street - Faidherbe Street	covered	270	0.8 (width)
14	Daloie Street - Wood Market - River	covered	105	0.6 × 0.6
15	SGBS – ISENCY – River Outlet	open	475	0.6~0.8 × 0.6~0.8
16	Annexe Valdiodio - Municipal Tax Department - River	covered	110	0.6 × 0.6
17	Lamine Gueye Staduim - former Nioro Lorry Park - Trade Department	covered	225	0.8 × 0.8
18	South Leona I - Aoussou Band	open	865	0.6~2.0 × 0.6~0.7
19	South Leona II - Aoussou Band	open	615	0.6~1.5 × 0.5~0.7
20	South Leona III – Aoussou Band	open	610	0.6~0.7 × 0.6
21	South Leona IV - Aoussou Band	open	610	0.7 × 0.5
22	Mengue Ndour Avenue – Ndargoundao - Outlet	open	825	1.1~2.0 × 0.4~0.6
23	Cheikh Ibra Fall Avenue - Court of Justice	covered	365	0.6 (width)
24	RNI Cheikh Ibra Fall - Court of Justice	covered	1,150	0.6~1.35 (width)
25	Fishery Services - Cheikh Ibra Fall Avenue	covered	90	1.35 (width)
26	Nioro Way Cheikh Ibra Fall Corner - Cope School	open	325	0.4 × 0.6
27	New Lorry Park of NIORO - Outlet (River)	covered	280	0.8~1.0 × 0.8~1.0
28	Medina Baye Crossroads - Mingue Ndour	covered	400	1.0~1.5 × 1.0~1.2
29	Canal of Thies Street (grave yard) - Aoussou Band	open	1,055	1.2~1.4 × 0.3~0.7 5
30	Canal of Niary Tally - Canal of Coeur de Ville	open	195	0.6~1.2 × 0.3~0.6
31	Big Emissary of Aoussou Band	open	1,680	5.3 × 0.8
32	Big Emissary of HLM Sara - Total Gas Station of Dialegne First Bridge	open	2,450	2.2~3.9 × 0.4~0.7
33	Big Emissary of Nimzatt - Gossas Main Road - Coeur de Ville Avenue	open	2,245	2.4~3.5 × 0.4~1.5
34	Canal Coeur de Ville Main Road - Second Bridge of Medina - Emissary of Aoussou Band	open	430	0.8~1.5 × 0.4~0.7

Source: Inventory Survey by JICA Expert Team 2012

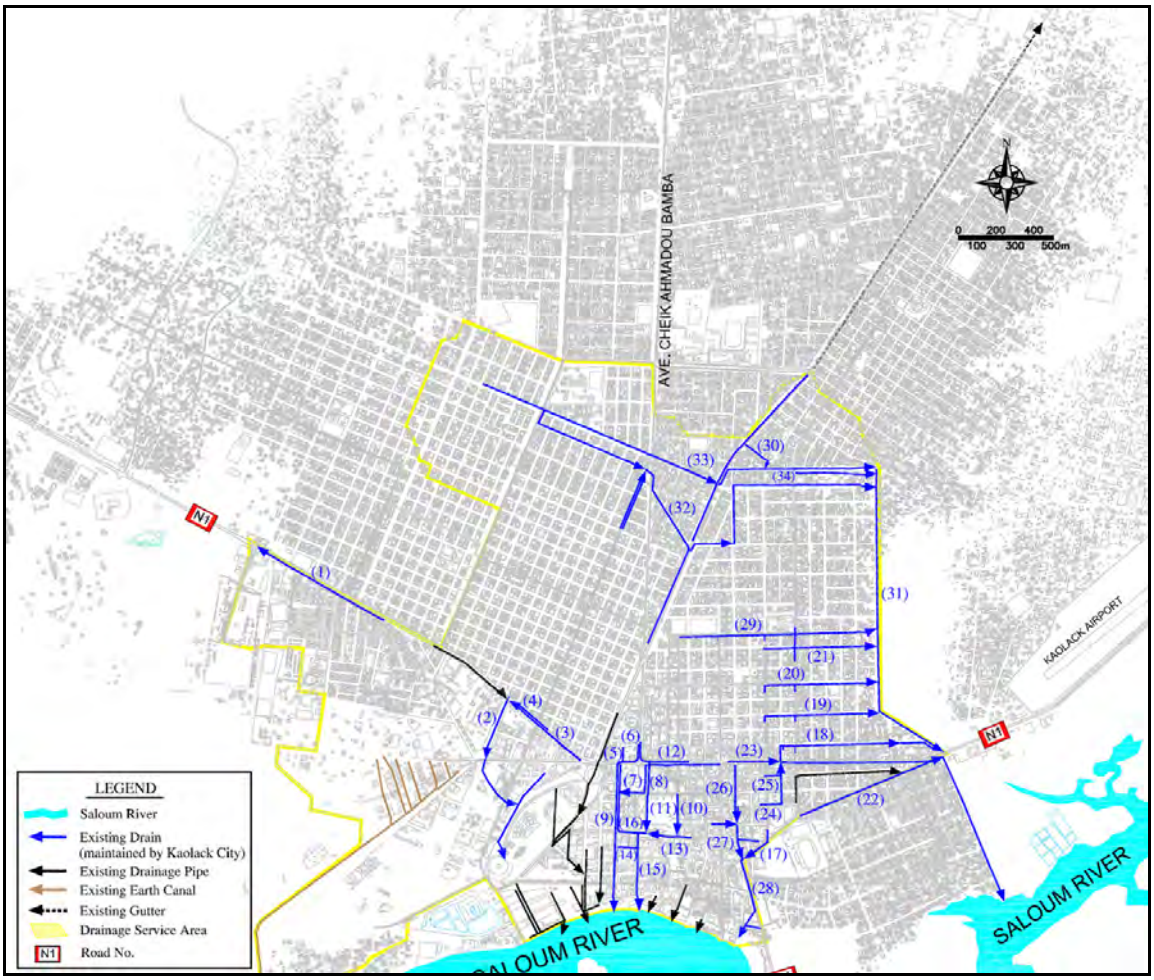


Fig. 2.3.2 Existing Drainage Networks

The storm water drainage network is installed in the central part of Kaolack City. The installed drains have the total length of 19.96 km, consisting of 12.38 km long open drains and 7.58 km long covered drains. The existing drainage system of 19.96 km long covers 7.79 km^2 of the territory of Kaolack City.

Most of the open drains are clogged with sediment and various kinds of refuse as shown in **Photo 2.3.1**. Garbage disposal into the drains as well as sediment accumulation strongly affects their flow capacity.

(1) Drain No. (32)

(2) Drain No. (21)

Photo 2.3.1 Open Drains Clogged with Sediment and Refuse

A number of sewers are connected to the open drains as shown in **Photo 2.3.2**. In the dry season, water mainly composed of domestic wastewater becomes stagnant, resulting in the worsening urban environment due to offensive odor and bad scenery.

(1) Drain No. (18)

(2) Drain No. (19)

Photo 2.3.2 Sewer Pipe from Residence

The existing open drains are partially excavated earth canals which are unsustainable due to encroachment as shown in **Photo 2.3.3**.

(1) Drain No. (34)

(2) Drain No. (31)

Photo 2.3.3 Excavated Earth Canal

The original cross section of open drains is reduced due to obstacles as shown in **Photo 2.3.4**. In the rainy season, storm water cannot flow through the existing drainage system due to the clogged situation.

(1) Drain No. (33)

(2) Drain No. (33)

Photo 2.3.4 Obstacle in Open Drain

2.3.3 Maintenance of Drainage Networks

The Kaolack City is responsible for the maintenance of drainage networks. STC (Service Technique Communal) of Kaolack City is in charge of operation and maintenance works. STC has a total of 99 personnel as shown in **Fig. 2.3.3**.

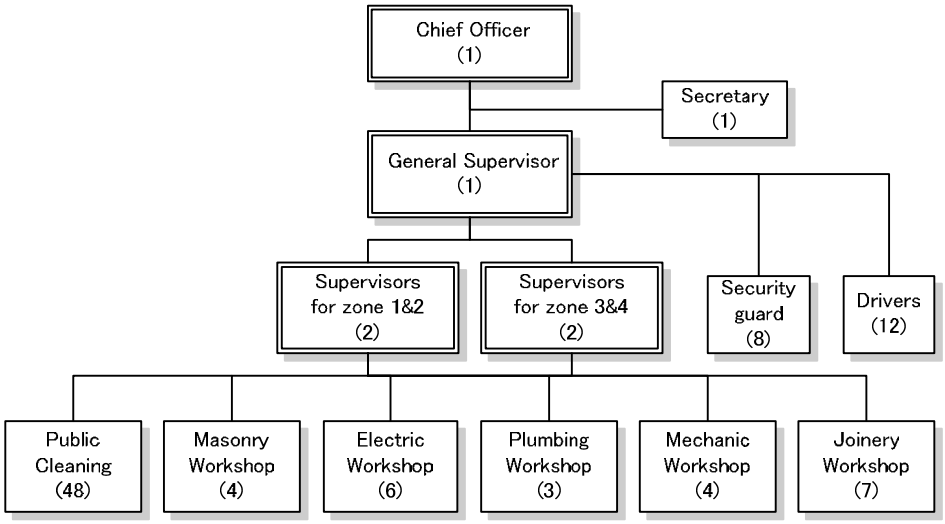


Fig. 2.3.3 Organizational Chart of STC

STC does not have the budget of the department. Basically, STC has a budget for each item in charge such as road repair, public light and building maintenance, however, they don't have item for cleaning of drainage networks. According to STC, cleaning costs are expenditures from miscellaneous.

STC has a maintenance plan to clean the drainage networks once a year before the rainy season; however, it does not have any mechanical equipment for the cleaning work and due to budgetary limitation, STC contracted the services of a private company selected by tender. The contractor conducts cleaning works by using backhoe, truck and manpower. The cost of the cleaning work was about 10,400,000 FCFA in 2011. The cleaning work consists of removal of garbage and hauling it to a dumping site. According to the explanation of Kaolack City, the cleaning work was contracted out for about 10,400,000 FCFA in 2011 but only 4,548,192 FCFA was paid in 2011 and the remaining amount was paid in 2012. The realization rate of the cleaning budget is 30 - 50% in last three years due do low tax revenue. Details are discussed in the F/S part.

2.3.4 Flooding Condition

In Kaolack City, there is no monitoring system for flooding conditions such as inundation depth and inundation duration; therefore, records on past flood disasters are very limited. A flooding condition survey has thus been carried out to clarify the flooding condition through interview survey with households.

(1) Interview Survey on Flooding Condition

JET had discussed the flooding condition with STC, ONAS and a fire station. Habitual flooding areas have been identified based on the result of the discussions and a field survey was conducted. Based on the result of the investigations, JET was able to determine the target area for the interview survey, as shown in **Fig. 2.3.4**. There are 10 habitual flooding areas and the interview survey was conducted on 10 households in each habitual flooding area. The total number of households subjected to the interview was thus 100 in total.

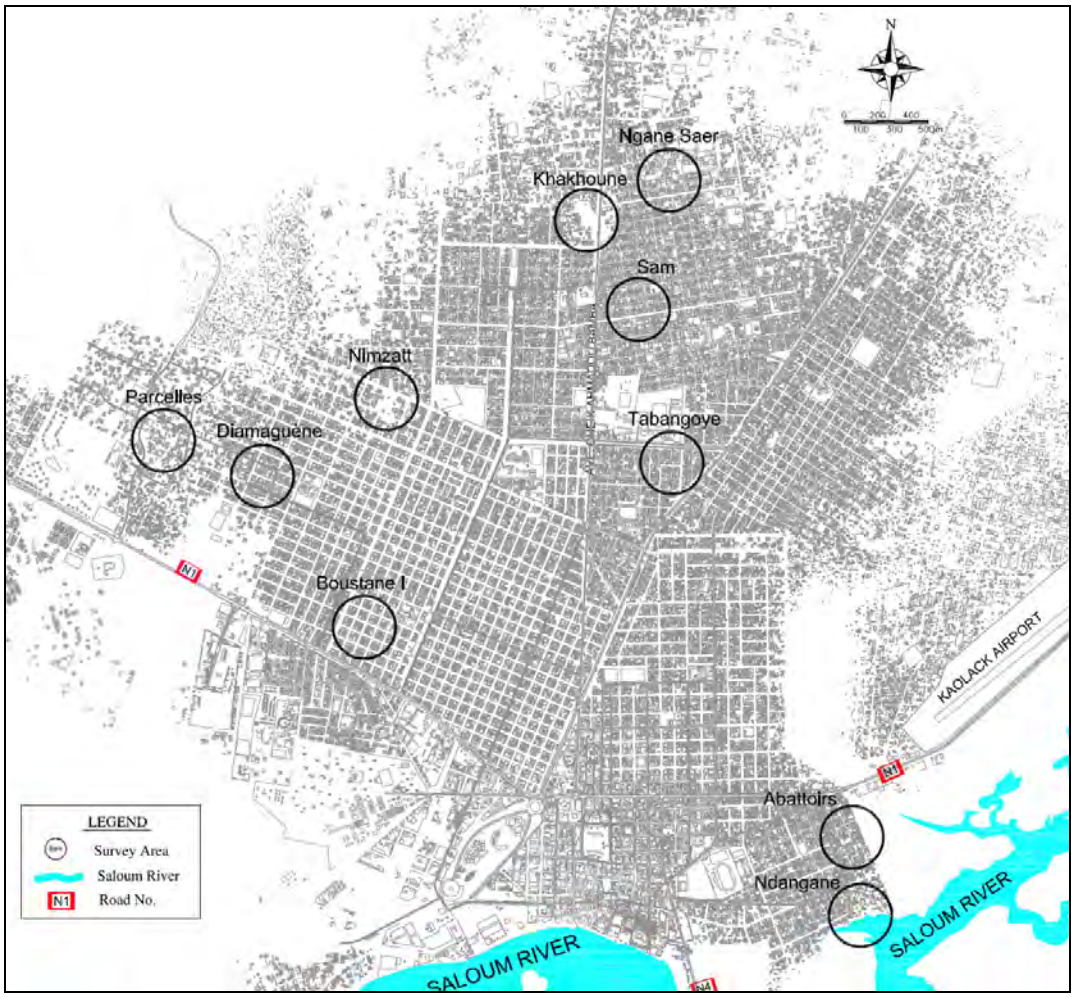
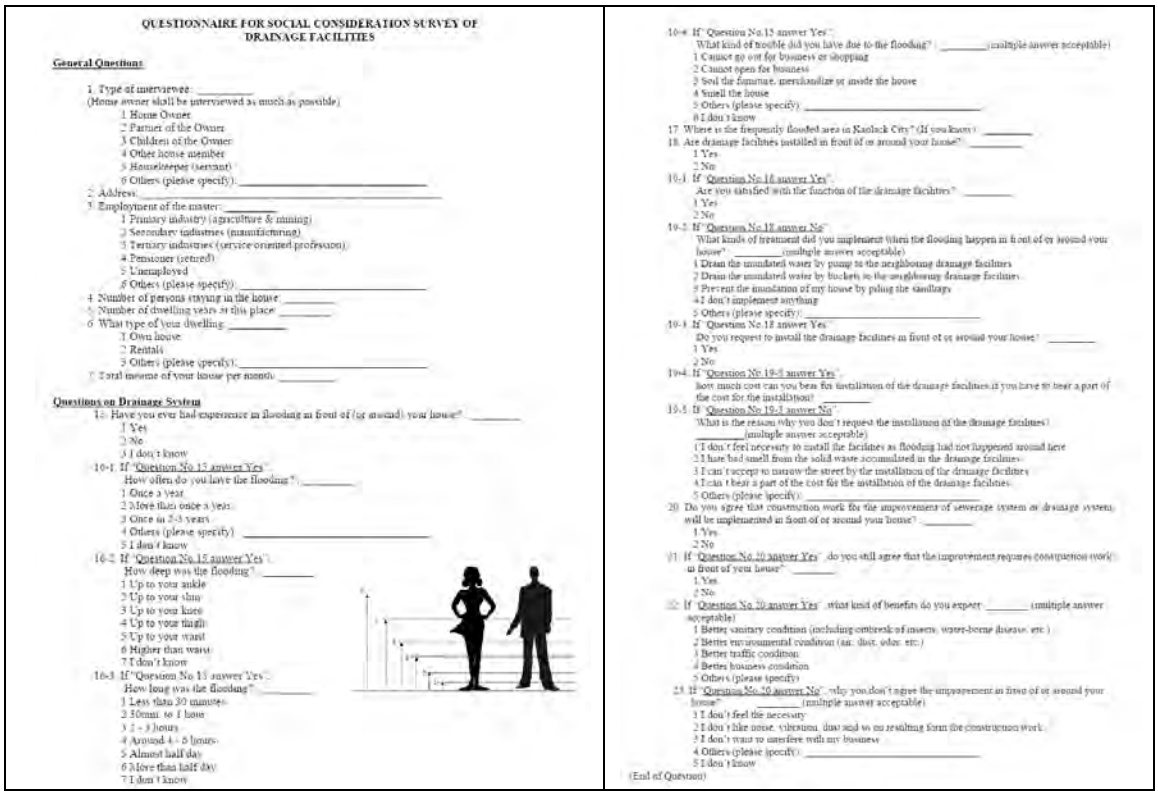


Fig. 2.3.4 Location of Flooding Condition Survey

The interview survey was conducted using the questionnaire shown in **Fig. 2.3.5**.



QUESTIONNAIRE FOR SOCIAL CONSIDERATION SURVEY OF DRAINAGE FACILITIES

General Questions

1. Type of interviewee: _____
(House owner shall be interviewed as much as possible)
1 House Owner
2 Partner of the Owner
3 Children of the Owner
4 Other house member
5 Housekeeper (servant)
6 Others (please specify): _____
2. Address: _____
3. Employment of the master: _____
1 Primary industry (agriculture & mining)
2 Secondary industries (manufacturing)
3 Tertiary industries (service-oriented profession)
4 Pensioner (retired)
5 Unemployed
6 Others (please specify): _____
4. Number of persons staying in the house: _____
5. Number of dwelling years at this place: _____
6. What type of your dwelling: _____
1 Own house
2 Rental
3 Others (please specify): _____
7. Total income of your house per month: _____

Questions on Drainage System

10. Have you ever had experience in flooding in front of (or around) your house? _____
1 Yes
2 No
3 I don't know

10-1. If "Question No.10 answer Yes":
How often do you have the flooding ?: _____
1 Once a year
2 More than once a year
3 Once in 2-3 years
4 Others (please specify) _____
5 I don't know

10-2. If "Question No.10 answer Yes":
How deep was the flooding ?: _____
1 Up to your ankle
2 Up to your shin
3 Up to your knee
4 Up to your thigh
5 Up to your waist
6 Higher than waist
7 I don't know

10-3. If "Question No.10 answer Yes":
How long was the flooding ?: _____
1 Less than 30 minutes
2 30min. to 1 hour
3 2 ~ 3 hours
4 Around 4 ~ 5 hours
5 Almost half day
6 More than half day
7 I don't know

10-4. If "Question No.10 answer Yes":
What kind of trouble did you have due to the flooding? : _____(multiple answer acceptable)
1 Cannot go out for business or shopping
2 Cannot open for business
3 Soil the furniture, merchandize or inside the house
4 Smell the house
5 Others (please specify) _____
6 I don't know

17. Where is the frequently flooded area in Kaolack City? (If you know) : _____
18. Are drainage facilities installed in front of or around your house? : _____
1 Yes
2 No

18-1. If "Question No.18 answer Yes":
Are you satisfied with the function of the drainage facilities? : _____
1 Yes
2 No

18-2. If "Question No.18 answer No":
What kinds of treatment did you implement when the flooding happen in front of or around your house? : _____(multiple answer acceptable)
1 Drain the inundated water by pump to the neighbouring drainage facilities
2 Drain the inundated water by buckets to the neighbouring drainage facilities
3 Prevent the inundation of my house by piling the sandbags
4 I don't implement anything
5 Others (please specify) : _____

18-3. If "Question No.18 answer Yes":
Do you request to install the drainage facilities in front of or around your house? : _____
1 Yes
2 No

19-4. If "Question No.19-3 answer Yes":
how much cost can you bear for installation of the drainage facilities if you have to bear a part of the cost for the installation? : _____

19-5. If "Question No.19-3 answer No":
What is the reason why you don't request the installation of the drainage facilities?
_____(multiple answer acceptable)
1 I don't feel necessity to install the facilities as flooding had not happened around here
2 I hate bad smell from the solid waste accumulated in the drainage facilities
3 I can't accept to narrow the street by the installation of the drainage facilities
4 I can't bear a part of the cost for the installation of the drainage facilities
5 Others (please specify) : _____

20. Do you agree that construction work for the improvement of sewerage system or drainage system will be implemented in front of or around your house? : _____
1 Yes
2 No

21. If "Question No.20 answer Yes", do you still agree that the improvement requires construction work in front of you house? : _____
1 Yes
2 No

22. If "Question No.20 answer Yes", what kind of benefits do you expect: _____ (multiple answer acceptable)
1 Better sanitary condition (including outbreak of insects, water-borne disease, etc.)
2 Better environmental condition (ex. dust, odor, etc.)
3 Better traffic condition
4 Better business condition
5 Others (please specify)

23. If "Question No.20 answer No", why you don't agree the improvement in front of or around your house? : _____ (multiple answer acceptable)
1 I don't feel the necessity
2 I don't like noise, vibration, dust and so on resulting form the construction work
3 I don't want to interfere with my business
4 Others (please specify) : _____
5 I don't know

(End of Question)

Fig. 2.3.5 Questionnaire for Flooding Condition Survey

(2) The Survey Results

Seventy respondents corresponding to 70 percent of the total number of interviewees replied that they had experienced flooding in front of their houses. The interviewees who had experienced flooding in front of their houses mentioned that flooding frequently occurs in a year, as shown in **Table 2.3.3**.

The experienced flood depth ranges from ankle to knee deep. Around 87 percent of the interviewees who had experienced flooding mentioned that the depth was up to the shin (approximately 20 cm) or higher. The experienced flood duration ranged from 2-3 hours to more than 1 day. Around 53 percent of the interviewees who experienced flooding mentioned that duration was longer than 1 day.

Table 2.3.2 Experience of Flooding in Front of House

Answer	Yes	No	Do not know	Total
Number of Respondents	70	30	0	100
Weight (%)	70	30	0	100

Table 2.3.3 Frequency of Flooding

Answer	Once a year	More than 1 time a year	Once in 2 or 3 years	Others	Do not know	Total
Number of Respondents	6	59	0	4	1	70
Weight (%)	9	84	0	6	1	100

Table 2.3.4 Depths of Flood

Answer	Up to ankle	Up to shin	Up to knee	Up to thigh	Up to waist	Higher than waist	Total
Number of Respondents	32	29	9	0	0	0	70
Weight (%)	46	41	13	0	0	0	100

Table 2.3.5 Duration of Flood

Answer	Less than 30 min	30 min to 1 hour	2-3 hours	Around 4-6 hours	Almost half day	1 day	More than 1 day	Do not know	Total
Number of Respondents	0	0	8	5	16	4	37	0	70
Weight (%)	0	0	11	7	23	6	53	0	100

Details of the flooding condition in which half or more interviewees replied are shown in **Fig. 2.3.6**

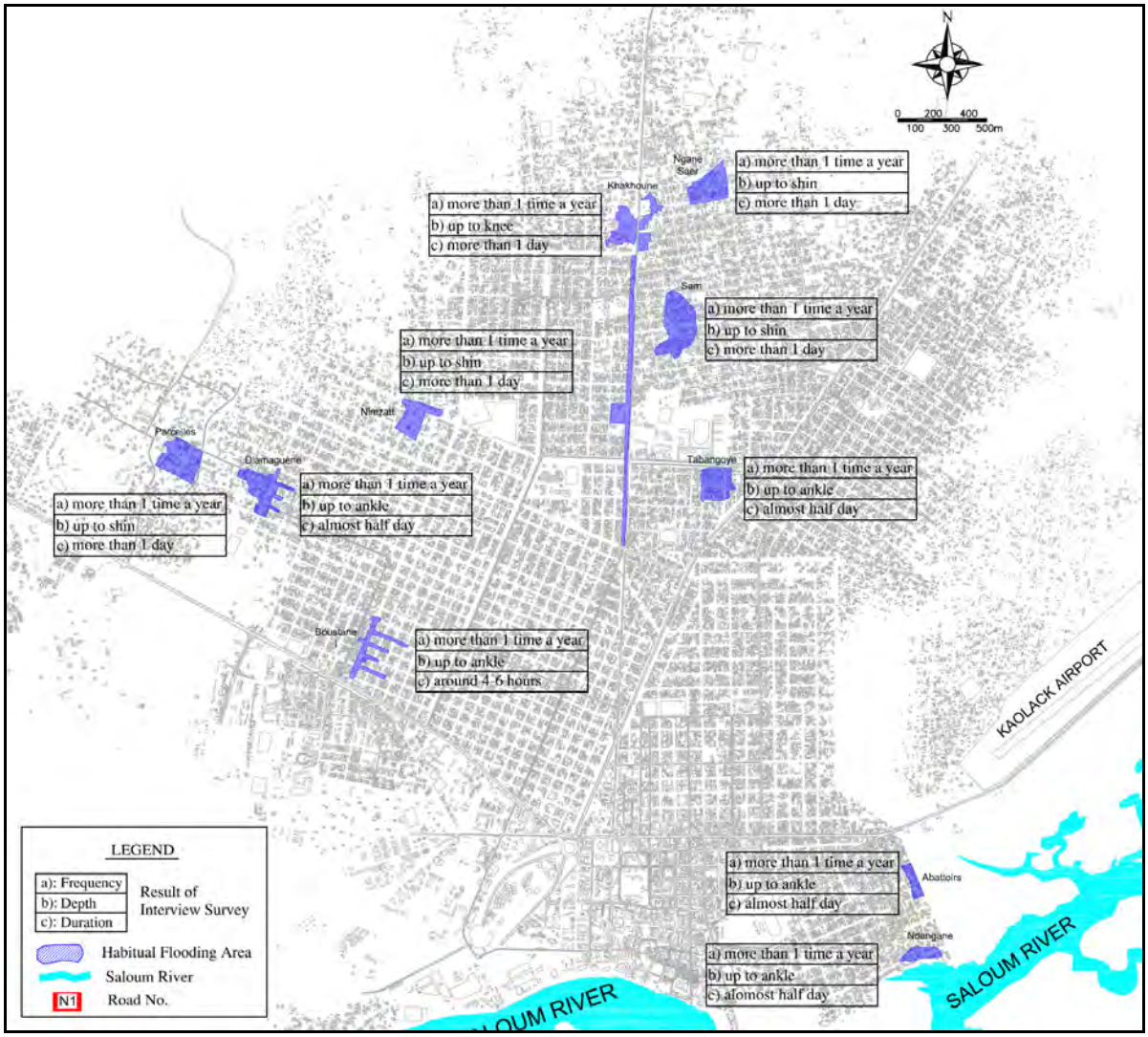


Fig. 2.3.6 Result of Flooding Condition Survey

2.4 Solid Waste Management

2.4.1 Introduction

In Kaolack City, the deterioration of equipment for the collection and transportation of solid waste is so serious that the waste collection rate remained at 25% in 2007, covering only the central part and markets in the City, and it is now getting worse. There are many illegal waste disposal areas at the residential areas in the City. There is a final disposal site for the City, but it has employed the open dumping method, and there is no heavy equipment for land-leveling and truck scales at the site.

On the other hand, the Master Plan of Solid Waste Management (SWM) was prepared by APROSEN for Kaolack City in 2008. The City government had endorsed the master plan, and had intended to undertake the SWM in accordance with the plan. Thus, to improve the hygienic environment including SWM for the City, review and preparations for recommendation of the master plan are necessary.

In this section, the problems and issues to be solved about SWM in Kaolack City are presented. In general, solid waste is divided into 3 items, namely; (i) domestic solid waste; (ii) industrial waste; and (iii) medical hazardous waste. In this report, item (i), domestic solid waste, is addressed in detail, but items (ii) and (iii) shall be surveyed as described in detail in **Chapter 6.**

2.4.2 Current Condition and Issues of the SWM in Kaolack City

Through the first field work from 23 November 2011 to 18 December 2011 in Phase I, JET devoted to the collection of data and information from the related offices and agencies in Kaolack City, and conducted field investigation to recognize emerging issues of existing waste collection and transportation system, condition of illegal waste disposal sites, waste generation/composition, final disposal site and so on.

(1) Current Operation of SWM in Kaolack City

(a) Organization and Budget

In Kaolack City, waste operation including collection, transportation and final disposal by the city services covers only the city's administrative area. The city has so far no plan of privatization of the SWM operation.

In the City Government of Kaolack, the Technical Services Division is in charge of SWM issues as shown in the organizational chart (**Fig. 2.4.1**). The Services has 7 sections, namely; Clean-Up and Road Construction, Electricity, Wood Work, Masonry Work, Mechanical, Drainage, and Open Space. The Clean-Up and Road Construction Section has jurisdiction over not only SWM but also construction works of roads/streets under contract basis by contractors. This Section has 66 staff in total, consisting of 55 permanent staff and 11 daily employees. The Section subdivides the city into 4 zones (No. 1 to No. 4) for waste operation and road construction, which cover 25 districts for waste operation purpose including public markets, fish market, schools, cemetery, bus station, etc. In each zone, the Section provides a supervisor and workers for collection and transportation of wastes.

As for the annual budget of the city, some funds for SWM are allocated from general revenue sources. Annual budgets and expenditures for the SWM section from the fiscal years of 2004 to 2011 are shown in **Table 2.4.1**. As shown in the table, the gross budget of the year 2010 was 2,493 million FCFA and the budget for Technical Services was 368 million FCFA or 14.8% of the gross budget. Budget for the Clean-Up & Roads (Waste services) of 2010 was 242 million FCFA or 65.7% of Technical Services. Further, 126 million FCFA, or 52.2% of the budget, was expended for the Clean-up/Roads Section. There is no detailed breakdown of each budget and expenditure in the following table.

Table 2.4.1 Annual Revenue and Expenditure for SWM Section in Kaolack City

Fiscal Year	Gross Budget for City Gov't (1)	Budget for Technical Services Section (7 Sections) (2)	Budget for Clean-up & Roads (Waste Management Section) (3)	Expenditure for Clean-up & Roads (Waste Management Section) (4)	(2)/(1) %	(3)/(2) %	(4)/(3) %
2004	2,125,003,544	523,000,264	456,800,685	66,289,579	24.6	87.3	14.5
2005	2,127,184,598	453,040,137	379,385,049	73,655,088	21.2	83.7	19.4
2006	2,505,802,980	423,725,459	341,886,473	81,838,986	16.9	80.7	23.9
2007	Not available due to Inspection						
2008	2,180,988,146	414,214,795	311,916,062	102,298,733	19.0	75.3	32.8
2009	2,615,191,282	330,401,805	156,736,545	173,665,260	12.6	47.4	110.8
2010	2,492,773,400	368,172,372	241,877,639	126,294,733	14.8	65.7	52.2
2011	2,051,000,000	362,250,015	223,325,809	138,926,206	17.7	61.6	62.2

Source: Technical Services, Kaolack City

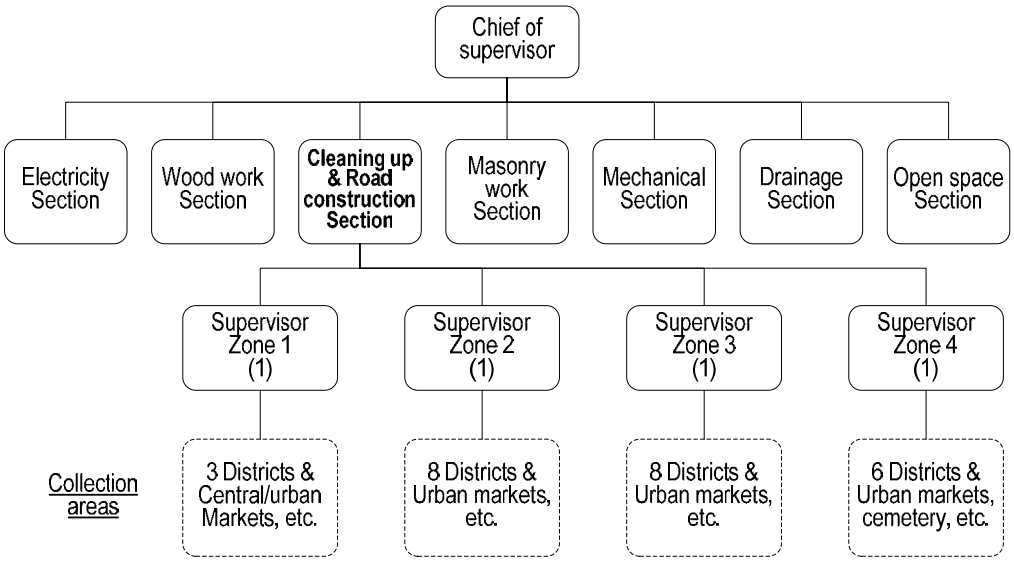


Fig. 2.4.1 Organization Chart of Kaolack City in the Field of SWM

(2) Master Plan

Kaolack City formulated its Master Plan for SWM in 2008 with technical assistance from APROSEN, and prepared the report called the "Study for the Operational Implementation System of Solid Waste sustainable Management in Kaolack City, Volume I & Volume II, 2007 & 2008".

The master plan set up the overall objective of SWM for the City, as well as the objective of the respective sectors, including road/street cleaning, pre-collection and collection, final disposal, and IEC (Information and Educational Campaign), as summarized in the following table. According to the Technical Services Division, the 2008 Master Plan is being used as the comprehensive plan of SWM for the City.

Table 2.4.2 Objective of the 2008 - Master Plan of Kaolack City

Overall Objective	To realize a technically possible, financially feasible and sustainable SWM for the city.
Road/Street Cleaning	To keep city roads and streets clean.
Collection	To ensure the application of selectable waste collection means as well as transportation means to a final disposal site.
Final Disposal	To ensure the construction of a technically possible and environmentally feasible final disposal site in accordance with the related laws and ordinances.

Source: Kaolack City

(3) Collection and Transportation System

In 2007, the collection system by the City covered only 5 districts of the city, namely, Leona, Kasnack Noro, Kasnack Sud, Kassaville, and Bongre including central market areas. At that time, the City had 5 compactors (capacity 16 m^3, each) for collection and transportation system. Out of 5 compactors, 4 compactors were used for covering 5 districts and 1 compactor for central markets. The total waste generation of Kaolack City in 2007 was estimated at about 125 ton/day based on a specific generation of 0.49 kg/person/day and collection rate was 30 ton/day. On the other hand, in 2010, the city has only 2 compactors (capacity 20 m^3, each) for covering the same collection areas of 5 districts including central markets, as shown in **Table 2.4.3**.

This reveals that the collection rate of 25% in 2007 reduced to 12% or waste generation of 17 ton/day in 2010. According to the information that there were two compactors by the contractual private service provider in 2011 but one was broken, the collection rate could drop to only 6% in the entire city area of Kaolack.

Table 2.4.3 Waste Generation and Collection in 2007 and 2010

Year	Waste Generation [1)] (ton/day)	Amount Collected (ton/day)	Collection Rate (%)	Collection Equipment	Coverage Area
2007	125	30	25	5 compactors (capacity: 16 m^3/vehicle)	Leona, Kasnack Noro Kasnack Sud, Kassaville Bongre, including central markets
2010	136	17	12	2 compactors (capacity: 20 m^3/vehicle)	

Note [1)]: Waste generation is calculated using specific generation of 0.49 kg/person/day
Source: APROSEN, Kaolack City

Due to the very poor collection system of waste in the city at present, some non-governmental organizations (NGOs) have made up groups and collect the charge fee of 750[7] FCFA per household for waste collection in some districts. However, in the pre-collective process, some of them carry pre-collected wastes by donkey-truck and dump them at illegal waste sites in the districts of the City.

The current waste collection and transportation system in Kaolack City is categorized into the following two ways:

Table 2.4.4 Current Waste Collection and Transportation System in Kaolack City

Area	Stage		
	Pre-collection (each household)	Collection (each household to a final disposal site or transfer site)	Transportation to the final disposal site in Mbadakhoune
City's services for waste collection and transportation are available	By city compactors (2 units) by service provider in 2011, covering the areas of 5 districts only and 7 public markets and 2 bus stations.	By city compactors (2011) By a rental truck (2012)	By city compactor to the final disposal site by service provider (2011). By a rental truck (2012)
City's services are not available; the services are provided by private groups (associations, etc.)	By donkey-trucks (ROC system)/ monocycle	Illegal dumping sites in the city	No transportation to the final disposal site

(4) Transfer Site

The transfer sites are the tentative stockyards to store domestic wastes directly transported by

[7] This value is minimum, compared with the average monthly waste collection fee of 1,000 FCFA/ household in Kaolack.

manual or donkey-trucks (ROC system) as the pre-collection system. There are 3 transfer sites for SWM which are in the city districts of Diamaguene Extension, Ndargoundaw (Down Dialegne) and Ngane Saer respectively (refer to **Fig. 2.4.2**). However, two of the transfer sites, Diamaguene Extension, Ndargoundaw (Down Dialegne), are not functional and only the Ngane Saer transfer site is being operated at present.

The first plastic recycling plant in Kaolack City was built in Koundam District in 2001 with Japanese grant aid and technical cooperation from an Italian NGO (LVIA, Lay Volunteers International Association). The plant became profitable after CODEKA and GIE joined the business management in 2007. It has 15 employees involved in the business of chipping plastic materials of about 200 to 250 kg per day. The plastic recycling unit sends the chipping plastic materials to a plastic factory in Dakar for recycled products such as plastic chairs, bowls, waste baskets, etc.

Table 2.4.5 Existing Transfer Site in Kaolack City (as of Nov. 2011)

Transfer site	Name of District at site	Construction year	Collected Materials for Recycling	Investor	Remarks
Diamaguene	Diamaguene Extension	1992	-	CARITAS (NGO)	After the city failed to manage the transfer operation, the facility structure became too old and deteriorated due to salt damage.
Dialegne	Ndargoundaw (Down Dialegne)	1996	-	World Vision (NGO)	Not functional after the city stopped truck operation due to non-supply of fuel.
Ngane Saer	Ngane Saer	2005	Hard plastic (PHD)	LVIA, CARITAS (NGO)	Scanty operation seems go on

Source: JET, APROSEN Kaolack

Abandoned Transfer Site
(Diamaguene Extension District)

Abandoned Transfer Site
(Ndargoundaw (Down Dialegne) District)

Transfer Site
(Ngane Saer District)

Photo 2.4.1 Transfer Site

(5) Illegal Waste Disposal Sites

JET carried out the field survey on waste disposal site in late November and early December 2011 where domestic wastes are disposed in the city residential areas. There are so far 12 major illegal waste disposal sites in Kaolack City as shown in the following table.

Table 2.4.6 Illegal Waste Disposal Sites in Kaolack City (as of December 2011)

No.	Illegal waste disposal site	Name of District at disposal	District/ area where waste comes from	Remarks
1.	Diamaguene (near lake of Blonchard)	Boustane	Boustane (BN), Sara Ndiougary (SN), Diamaguene (DM), Parcelles Assaineis (PA)	Open dump The oldest disposal site Disposal started in 1990.
2.	Ndangane (Sortie de Kaolack vers Nioro)	Leona (LN)	Fish-market, Vegetables-fruits market, Ndagane (ND)	Open dump
3.	Dialegne	Dialegne (DL) or Leona (LN)	Dialegne (DL), Leona (LN)	Open dump
4.	Touba Kaolack Extension	Touba Kaolack Ouest (TKO)	Touba Kaolack Ouest (TKO), Touba Kaolack EST (TKE)	Open dump
5.	Khakhoune (near Lake of Khoune)	Sam (SM)	Sam (SM), Touba Kaolack EST (TKE)	Open dump
6.	Bongre Near Lake along (Avenue Diogoye Basile Senghour (BN 02)	Bongre (BG)	Bongre (BG), Kasnack Sud (KS)	Open dump
7.	Waste disposal site near lake	Bongre (BG)	Unknown	Open dump
8.	Waste disposal site near the road Pres Gare rouliere Dakar	Bongre (BG)	Boustane (BN), Bongre (BG)	Open dump
9.	Koundam	Koundam	Koundam	Open dump
10.	Medina Mbaba	Media Sud	Medina Mbaba	Open dump
11.	Gawane	Gawane	Sam, Gawane, Thioffack	Open dump
12.	Mimzatt	Touba Kaolack Ouest	Touba Kaolack Ouest	Open dump

Source: JET, APROSEN Kaolack

Some flood-prone areas like the districts of Dialegne, Medina, etc., are low-lying depressions. In these districts, low-income residents try to protect their houses against flooding by elevating the ground level or banking around houses, using wastes instead of soil materials in the rainy season. For this purpose, in general, soils are sold at about 5,000 FCFA/15 to 20 m^3.

On the other hand, APROSEN carried out the field investigation survey on waste disposal sites in the 4 cities. The result of the study is compiled in the report called as "Identification of Illegal Waste Disposal, Kaolack, Diourbel, Bambey and Joal, September 2011" as shown in **Table 2.4.7**.

Table 2.4.7 Results of Survey on Disposed Waste Volume in Cities

Locality	Number of disposal site	Waste Volume in Estimate (m^3)
Kaolack	**71**	**24,353**
Diourbel	100	157,001
Bambey	54	15,399
Joal	11	12,975
Total	236	209,728

Source: Identification of Illegal Waste Disposal, Kaolack, Diourbel, Bambel and Joal, September 2011, APROSEN

Illegal Waste Site - Diamaguene

ROC, Donkey Trucks - near Diamaguene

Drain Fully Clogged with Wastes - Ndangane

Illegal Waste Disposal Site - Ndangane

Illegal Waste Disposal Site with ROC - Bongre

Hazardous Medical Waste - Bongre

Illegal Waste Disposal Site - Touba Kaolack

Illegal Waste Disposal Site - Medina Mbaba

Photo 2.4.2 Conditions of SWM in Kaolack City

(6) Final Disposal Site

For the sustainable SWM of Kaolack City, there is an existing final disposal site officially located at Mbadakhoune Rural Community in Kaolack Region[8], which is located adjacent to Kaolack City (Thioffack District), as shown in **Fig. 2.4.2**. The site has been utilized as sand quarry for construction works until 2009 and an open dump used by trucks (compactors) of the city in late 2011. There are no environmental regulations against fire at the site, as well as the segregation of wastes such as medical equipment, drug bins and containers. Also, there are no structural facilities like fence, control office, as well as heavy equipment like bulldozers, wheel-loaders for the preparation of final disposal. According to Kaolack City, only 2 registered compactors can enter the site for waste disposal. At the time of the field survey, about 10 waste-pickers were collecting valuable waste materials such as iron, hard plastics, etc.

In September 2011, Kaolack City and Mbadakhoune Rural Community made a verbal agreement on the land use as a final disposal site at Mbadakhoune. No formal agreement between the 2 parties has yet been executed on the right to use the land as the new final disposal site of Kaolack City. It means that up to date the city has no official disposal site. According to Kaolack City, the formal document is still being prepared for signing by the 2 parties.

There is an ongoing project supervised by APROSEN Kaolack. Presently, the excavation work for a new hole (100 m × 40 m) of 3 m depth has commenced and construction work of 1 km access road with drainage system is in progress. The hole is to be used as a temporary sanitary landfill to dispose the wastes transported from Kaolack City until a permanent disposal site is designed and constructed by APROSEN. Kaolack City is not to be involved in the financial cost for the construction of final disposal site due to its limited resources.

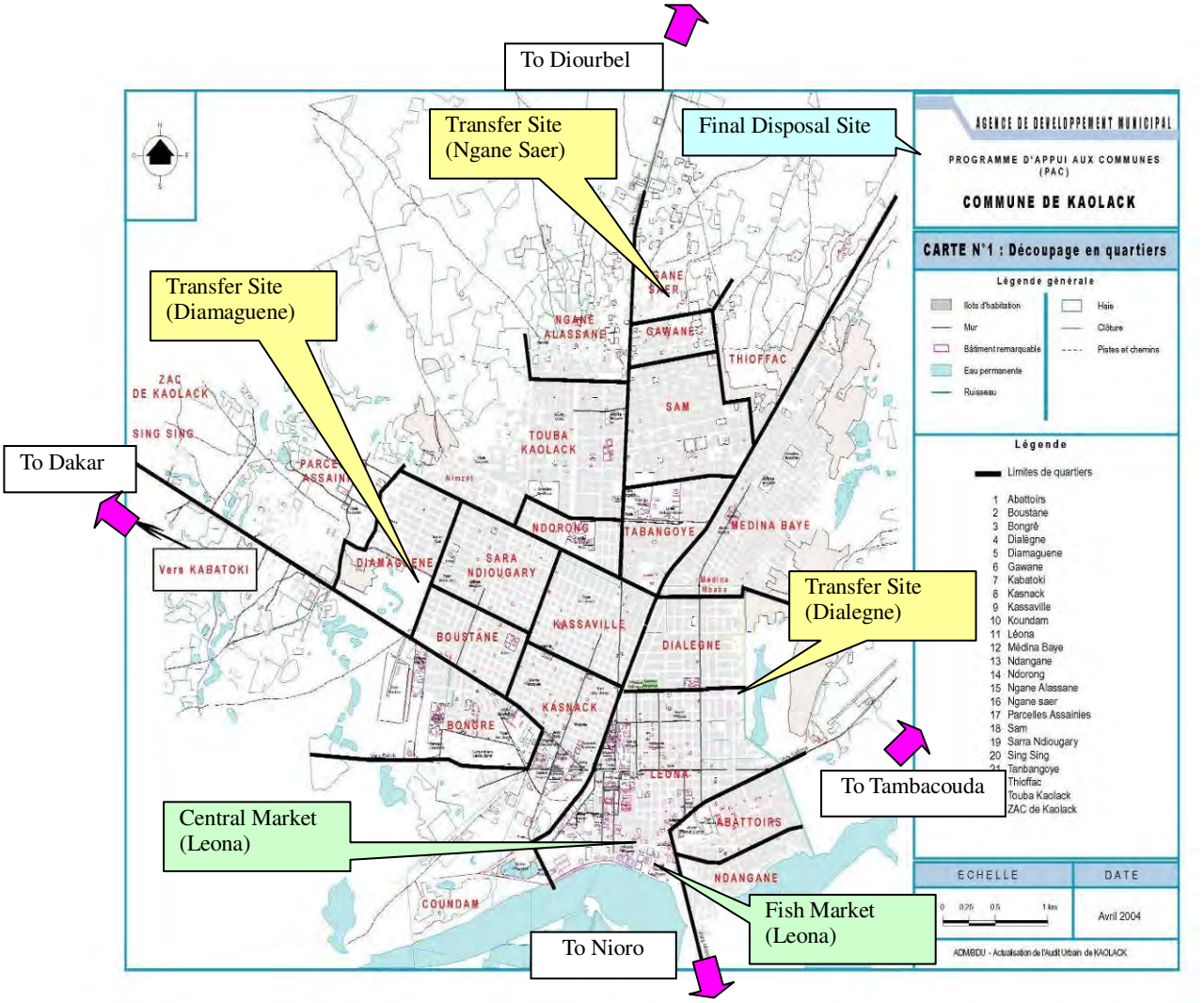
Existing final disposal site
(Mbaolakhoune village)

Proposed final disposal site
(Mbaolakhoune village)

Photo 2.4.3 Final Disposal Site

Pre-collection, collection and transportation, transfer sites, and final disposal site for SWM in Kaolack City have been described above. The locations are as indicated in **Fig. 2.4.2**.

[8] Mbadakhoune Rural Community in Kaolack Region is located in "Other area" in **Fig.2.1.1**.



Source: ADM, Kaolack City, APROSEN Kaolack

Fig. 2.4.2 Location Map of Final Disposal Site and Transfer Sites in Kaolack City

Kaolack City has not promoted the campaign for recycling activity to the public very well, and there is so far no plan to do it. However, there are several small-scale recycling groups in the districts which collect waste materials of hard plastics and send them to the plastic recycling factory in Koundam District. Collected recyclable hard plastic materials are washed and chipped by a machine and send them to a recycling factory in Dakar since there is no such factory for recycling of plastic materials in Kaolack City.

As for IEC (Information, Education and Communication) activities, annual cleanliness movements were carried out for the environmental campaigns in 2007, 2008 and 2009 by the city communities including Kaolack City, Kaolack Region, APROSEN, NGO, students, volunteers, etc. There were no such activities in 2010 and 2011.

(7) Industrial Wastes and Medical Hazardous Wastes

(a) Industrial Waste

In Kaolack City, the following 4 major factories are operational at present:

- SUNEOR : Peanut cooking oil
- NOVASEN : Peanut cooking oil
- SALIN DU SALOUM : Salt
- USINE KOUDAME : Plastic products

According to the Technical Services Division of the Kaolack City Government, industrial wastes shall be controlled and disposed adequately in accordance with the Environment Code of Senegal. This matter shall be followed up by JET.

(b) Hazardous Medical Wastes

There is one major hospital (El Hadji Ibrahima Niass) and several small clinics and health care centers in Kaolack City. Further information shall be obtained from the hospital by JET as described in **Chapter 6**.

(8) Issues Requiring Solutions

- With the current poor heavy equipment, the Kaolack City Government cannot undertake waste collection, transportation and disposal services in the whole city area. Financial problems of the City Government are very serious.
- In districts where the City government services cannot be served, the current pre-collection method by donkey-trucks, monocycle or wheelbarrow shall be enhanced, but waste disposal shall be allowed only in officially designated sites.
- Private associations or groups doing pre-collection by donkey-trucks, monocycle or wheelbarrow shall be well organized.
- Illegal disposal sites shall be controlled well by the administrators.
- Transfer site system shall be enhanced and new transfer sites shall be established.
- Waste transportation system between transfer sites and the final disposal site (in Mbadakhoune Rural Community) shall be covered in the overall SWM system in the city.
- Solid waste management shall be carried out by APROSEN in line with the master plan and the newly modified combination of conventional pre-collection system (by donkey-trucks, monocycle or wheelbarrow) and the mobile collection and transportation system (by compactors) should be implemented.
- The final disposal site shall be adequately designed to accommodate all the wastes generated in the city for the target year 2030.
- To improve the current SWM system in the city, all the concerned stakeholders such as government offices, APROSEN, related agencies, residents, NGOs, and private sectors shall be involved in the enhancement of their capabilities through the IEC campaign.
- A legal approach is required to enforce the institutional and human resource management program of the City Government.

2.4.3 Collected Data and Documents related to SWM in Kaolack City

Documents collected by JET during Phase I are as tabulated below.

Table 2.4.8 List of Collected Documents and Data related to SWM in Kaolack City

No.	Title (Original language)	(English version)	Author	Published year
1.	GOM dans les villes secodarires du SENEGAL	The management of the household refuse in the secondary cities of Senegal	Gret, LVIA, Pact	June 2006
2.	Profil urbain de Kaolack	Urban profile in Kaolack	UN HABITAT	2009
3.	Programme de nettoiement de Kaolack	Cleaning programme in Kaolack City	APROSEN	2010
4.	Conseil interministeriel sur l'assainissement de la ville de Kaolack	Inter department Council The cleansing of the commune of Kaolack	Regional Government	Oct. 2008
5.	Etude pour la mise en oeuvre operationnelle d'un systeme de gestion durable des dechets Solides dans la Kaolack- Tome I	Study for the operational implementation system of solid waste sustainable management in Kaolack City – Stage I	Ereco, GES CONSEIL APROSEN	Nov. 2007
6.	Etude pour la mise en oeuvre operationnelle d'un systeme de gestion durable des dechets Solides	Study for the operational implementation system of solid waste sustainable management in	Ereco, GES CONSEIL APROSEN	Sept. 2008

No.	Title (Original language)	(English version)	Author	Published year
	dans la Kaolack- Tome II	Kaolack City – Stage II		
7.	Amélioration de la Gestion des Déchets Solides Urbains au Sénégal - RAPPORT N°2 : DOCUMENT DE PROJET -	Improvement of Urban solid waste management in Senegal - Report No.2 : Document of Project -	IDB	Dec. 2010
8.	Extrait du document evaluation du projet avec BID	Extract from the evaluation document of IDB project	IDB	Dec. 2010
9.	Islamic Development Bank Annual Report 1431H (2010)	IDB Annual Report 1431 (2010)	IDB	2010
10.	Republique du Senegal Loi portant Code de l'environnement	Environment Code, Senegal	Republic of Senegal	2001
11.	Indentification de Depots Sauvages Kaolack, Diourbel, Bambel et Joal	Identification of Illegal Waste Disposal Kaolack, Diourbel, bambel and Joal	APROSEN	Sept. 2011

2.5 Environmental and Social Considerations

2.5.1 Laws and Guidelines on Environmental Considerations

(1) Laws on Environmental Impact Assessment

The National Environmental Code (Law No. 200 01, January 15, 2001) of Senegal, Chapter V, Impact Study, Articles 48 to 54 stipulate the mandates of Impact Studies on environment. Firstly, Article 48 stipulates the three definitions of Impact Studies as follows:

Strategic Environmental Assessment (SEA)

Strategic Environmental Assessment is to assess the impacts from environmental decisions made in policies, plans and programs and their alternatives, regional and sectoral studies.

Environmental Impact Assessment (EIA)

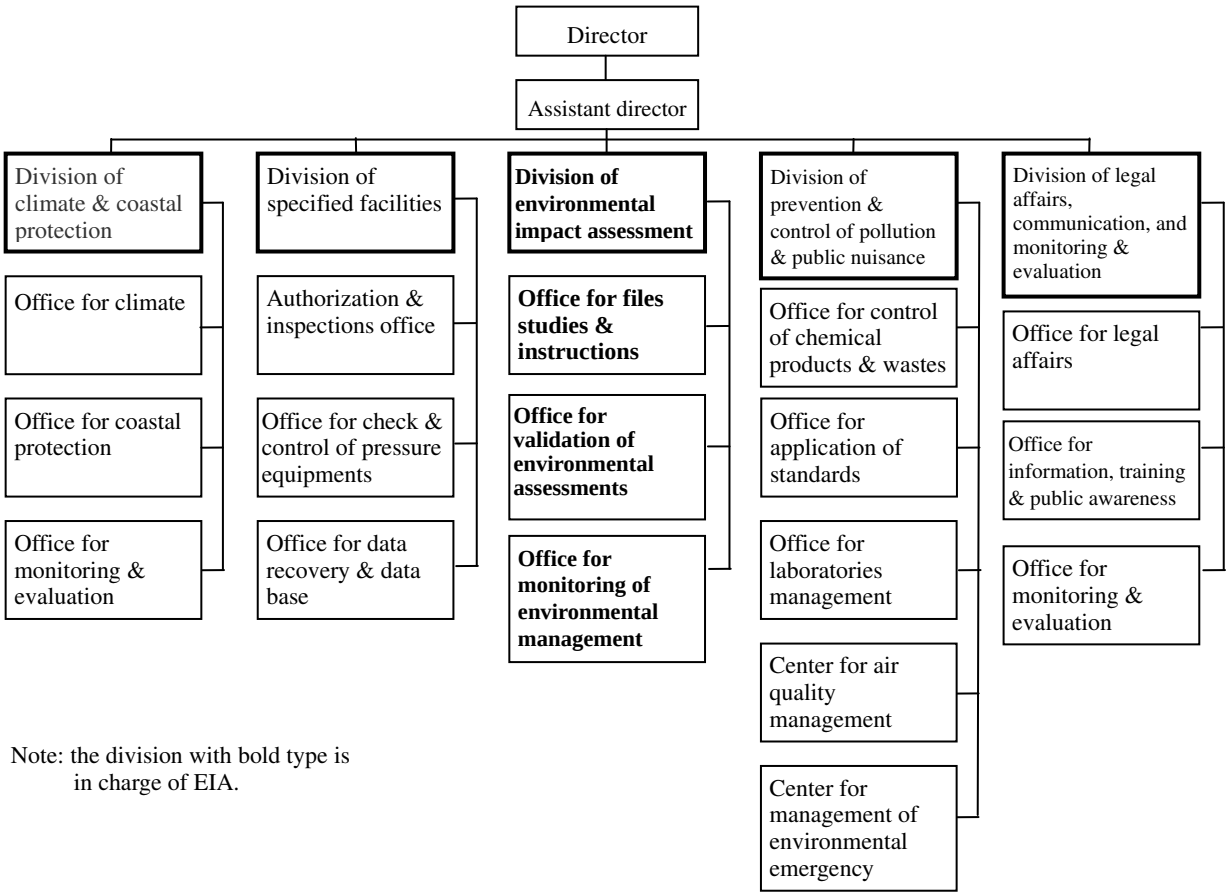
The impact assessment on the environment is the procedure that examines the consequences, both positive and negative, that a project or program development proposed will have on the environment and ensure that these effects are properly taken into account in the design of the project or program.

Environmental Audit (EA)

Environmental audit is a management tool that includes systematic, documented and periodic assessments, and an objective evaluation of how organization, management and equipment work in order to safeguard the environment.

Secondly, Article 49 provides the authorized procedure of implementation of impact studies and the study report that should be submitted to DEEC (Direction de l'Environnement et des Etablissements Classees/Directorate of the Environment and of Classified Establishments) in the Ministry of Environment, Protection of Nature, Retention Ponds and Artificial lakes (MEPLBA: Ministre de l' Environment, de la Protection de la Nature, des Bassins de retention et des Lacs Artificiels).

According to the World Bank Report (Senegal Country Environmental Analysis, 2008), "The DEEC is in charge of implementing Governmental environmental policy, legislation and environmental regulations, environmental assessments, protection, monitoring, compliance, and surveillance, aiming at ensuring that natural resources managed rationally."



Note: the division with bold type is in charge of EIA.

Source: Website of DEEC

Fig. 2.5.1 Organizational Structure of DEEC

Articles 38A to 44A of the Environmental Code, Part II, also stipulate the administrative procedures for environmental impact studies on environmental impacts, including the means of environmental impact studies (Article 39R). The scope and categories of environmental impact studies (Article 40R) are the following:

Category 1: Projects are likely to have significant impacts on the environment; a study assessing the impacts on the environment will include environmental considerations in the economic and financial project analysis, and this category requires an environmental analysis assessment.

Category 2: For projects that have limited impacts on the environment, the impacts can be mitigated by implementing measures or changes in their design; this category is the subject of an initial environmental review.

The list of projects and programs are shown the Annex to the Environmental Law in Senegal (The Environmental Laws).

Category 1: List of projects and programs for which a detailed EIA is compulsory

1- Projects and programs liable to cause great modifications in the exploitation of renewable resources;
2- Projects and programs that modify profoundly the agricultural and fishing practices;
3- Exploitation of water resources;
4- Infrastructure works;
5- Industrial activities;
6- Extractive and mining industries;
7- Hydroelectric and thermal energy production or extension;
8- Waste management and elimination;
9- Manufacture, transport, storage and use of pesticide or any other dangerous or toxic product;
10- Hospital and educational facilities (big scale);
11- New buildings or considerable improvement of road network or rural track;
12- Projects implemented in ecologically weak areas and preserved ones;
13- Projects that might have negative effects on fauna and flora species in peril, their critic living conditions or prejudicial consequences for biological diversity;
14- Population dislodging (moving out and resettlement)

Category 2: List of projects and programs requiring an initial environmental analysis (IEE)

1- Small and medium agro-industrial companies;
2- Rehabilitation or modification of small scale existing industrial facilities;
3- Linking electric wires;
4- Irrigation and drainage at a small scale;
5- Renewable energy (except hydroelectric dams);
6- Rural electrification;
7- Projects for housing and trade;
8- Rehabilitation or maintenance of road network or rural tracks;
9- Tourism;
10- Urban and rural water supply and sanitation;
11- Recycling factories and household wastes disposal unit;
12- Surface water irrigation projects between 100 to 500 ha, and groundwater irrigation ranging between 200 to 1000 ha;
13- Intensive cattle breeding (more than 50 animals), poultry farming (more than 500 animals);
14- Extraction and treatment of non metallic minerals, energy producers and aggregates (marbles, sand, gravel, shale, salt, potash and phosphate);
15- Preserved areas and conservation of biologic diversity;
16- Energy effectiveness and energy conservation

Moreover, in the Senegalese Nomenclature of Classified Facilities (2007) completing and clarifying the Environmental Laws, the following table shows the facilities related to sanitation and water treatment, as well as waste management.

Table 2.5.1 Required EIA by Classified Facilities

Facilities	Type of classified facilities	Type of required EIA	Required procedure prior to the start
Sanitation and water treatment (Capacity of daily treatment of wastewater)	More than or equal to 5000 population equivalent	EIA	Authorization
	More than 500 and less than 5000 population equivalent	IEE	Authorization
Waste management (Whatever capacity)	Sorting or grouping facility of waste towards elimination	EIA	Authorization
	Waste elimination, treatment and valuation facility	EIA	Authorization
	Incineration and co-incineration facilities	EIA	Authorization
	Landfill	EIA	Authorization

The difference of procedures between EIA and IEE is described in Title I, Chapter II and Chapter III of the Environmental Laws (Decree No. 2001-282 of April 12, 2001). Also, the Reference Guideline for Sectoral Environmental Impact Assessment (2006) explains the detailed procedures for Environmental Impact Assessment.

As shown below, the Article L 13, Part II, Chapter I, in The Environmental Laws describes, one of the examples of difference of regulation between category 1 and category 2 facilities as follows:

> "Facilities placed in the **first class** should be the subject, before their construction or installation, of an authorization issued for development by order of the Minister in charge of environment in the conditions fixed by decree. This authorization is mandatorily followed to keep at least a radius of 500 m of distance of homes, buildings usually occupied by third parties, public buildings and areas for housing, a stream, a lake, a communication channel, a water catchment."
>
> "Facilities placed in the **second class** should be subject, before their construction or installation, of a declaration addressed to the Minister in charge of the Environment, which issues a receipt in conditions fixed by decree."
>
> "The development must renew its application for authorization or the statement in case of transfer, or extension or significant modification of facilities. In case of transfer of rights for development, the new development is required to make a declaration addressed to Minister in charge of environment."

The Environmental Laws explicitly mentions the importance of people's participation and public hearing through the process of Environmental Impact Study, as explained in Articles 52 to 54, Chapter V, Part II. Moreover, regarding the disclosure of EIA as described in Article 6R, Chapter II, Title VI, Part III, The Environmental Laws stipulate as follows:

"The application for authorization of facilities in the first class is the subject of a public inquiry caused by a decision of the related Governor of the region for a period of 15 days. "

The launching of this survey is announced five days in advance:

(1) By the posters which indicate the system on the survey should mention the date of commencement and duration of the survey, reference and publicize finally, if there is a space, treatment method and disposal of waste water and gas;

(2) By notices introduced in newspapers and commercial on the channels of radio broadcasting and National TV."

Article 43A and 44A describe the roles of the Technical Committee. The Technical Committee is a unit of environmental impact administration and management, which supports the Ministry of Environment and Protection.

In addition, the related orders and guidelines on environmental impact studies are as shown in **Table 2.5.2**.

Table 2.5.2 Ministerial Orders and Guidelines on Environmental Impact Studies

Name	Date of Issue	Contents
MINISTERIAL ORDER No. 9468-MJEHP DEEC	28 November 2001	Regulating public participation for the Environmental Impact Studies
MINISTERIAL ORDER No. 9470-MJEHP DEEC	28 November 2001	Detailed conditions for issuing an approval for the pursuit of activities relating to environmental impact
MINISTERIAL ORDER No. 9471 MJEHP DEEC	28 November 2001	Detailed terms of reference impact studies
MINISTERIAL ORDER No. 9472 MJEHP DEEC	28 November 2001	Contents of the report of Environmental Impact Assessment
Reference Guide for Sectoral Environment Impact Assessment	November 2006	Detailed procedures for Environmental Impact Assessment
Senegalese Classified Nomenclature for Protection of Environment	March 2007	Categorization of facilities and activities for Environmental Impact Studies

Source: DEEC, JET

(2) The Environmental Laws and Human Settlement Laws/Guidelines

Regarding human settlement, Articles 28 and 29, Chapter I, Part II, of The Environmental Laws stipulated that environmental services are subject to consultation for comments before approval.

On the other hand, The Law No76-66 of 2 July 1976 on the State-owned Property Code, for instance, states that "Public property includes drainage canals, water and sewer pipes as well as easements of public utility including right of way, settlement support and movement easements required by the setting up, maintenance and operating of facilities and works above referred to."

The SEA report[9] emphasizes that Senegal well manages the combination of national and international standards of resettlement practice such as Operation Manual of the World Bank Safeguard Policy (OP4.12 Involuntary Resettlement). The OP4.12 objectives are as follows:

(a) Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs.

(b) Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs.

(c) Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre–displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

The JICA Guidelines for Environmental and Social Considerations recommend avoiding involuntary resettlement as follows:

- Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. When, after such examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed up on with the people who will be affected.

Furthermore, in case of large-scale involuntary resettlement, the JICA Guidelines advise:

[9] In accordance with Senegalese environmental laws and regulations, the SEA study was conducted by JET with an authorized consultant (iDEV) by DEEC from December 2011 to December 2012. This study included survey on environmental framework applicable to the project, environmental profile of project area, evaluation of environmental impact of the project, as well as environmental and social management framework plan

- For projects that will result in large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP4.12 Annex A.

According to the SEA Report, land allocation of the Project can be done in different ways depending on its status:

- Land in the domain of individuals is expropriated for public purposes through a quite formal procedure (Law 76-67 of July 2, 1976 on exploitation for public purpose) giving financial compensation in cash or in kind in some cases.
- Land situated in urban areas is subject to the same procedure.
- For land within the state area, their availability does not lead to difficulties.
- Land situated within the territory areas are managed by rural councils.

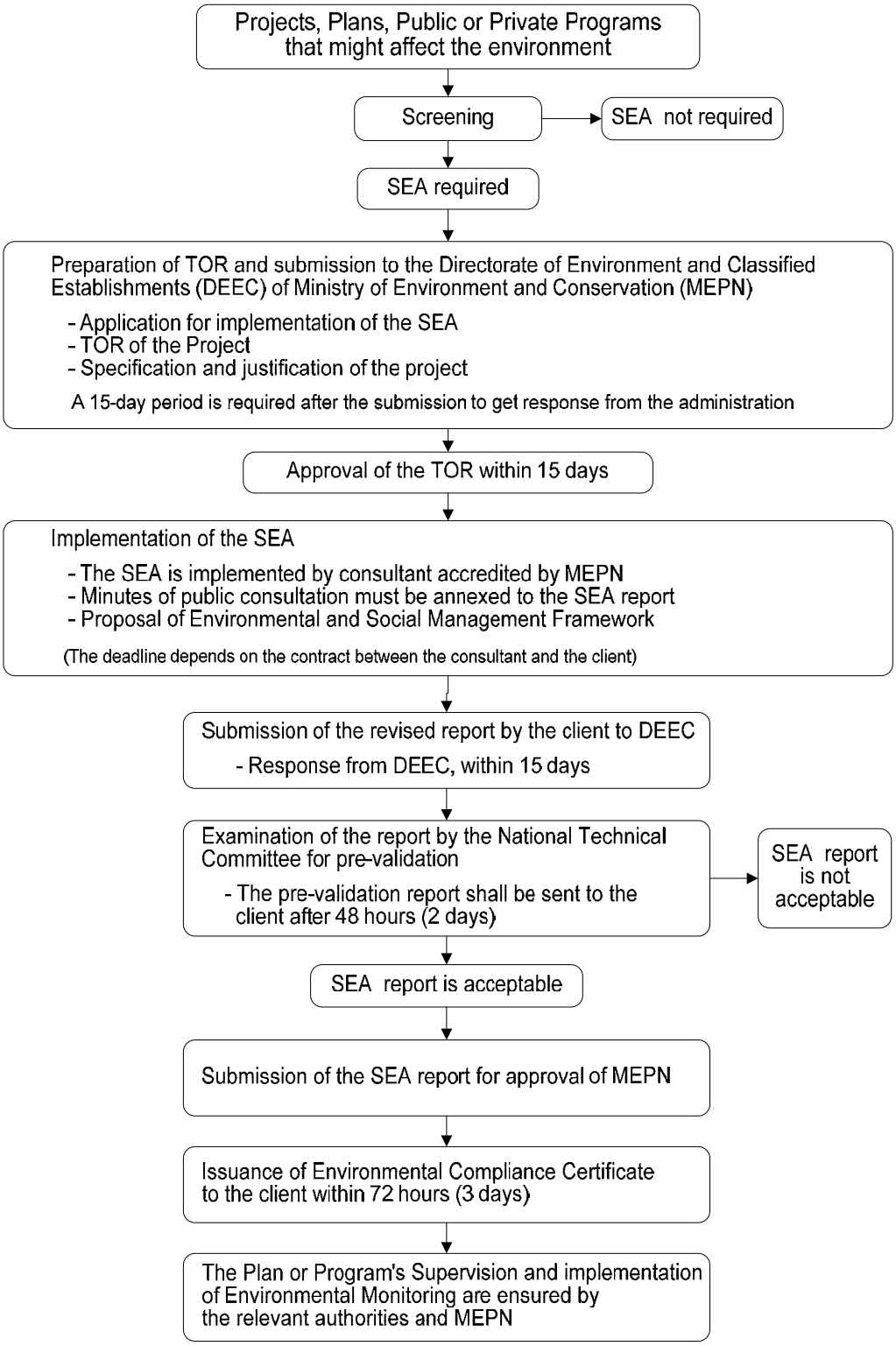
2.5.2 SEA/EIA Process

According to the DEEC website (http://www/denv.gouv.sn), 37 environmental consulting firms and 19 individual consultants have been officially accredited to implement EIA activities in 2011. Most of them are located in Dakar (Senegal), but some companies are stationed in other countries such as France, Burkina Faso, Mali, and Canada.

The difference of procedures between EIA and SEA is not explained in the Reference Guide for Sectoral Environment Impact Assessment. In addition, the detailed steps for implementation of EIA/SEA are not suggested in the reference. Therefore, the flow charts of procedures of EIA and SEA were confirmed by JET as shown in **Fig. 2.5.2** and **Fig 2.5.3**. The charts show that the main difference between SEA and EIA is the public hearing process (holding of public hearing and preparation of report by DEEC within 48 hours), which is only included in the EIA process.

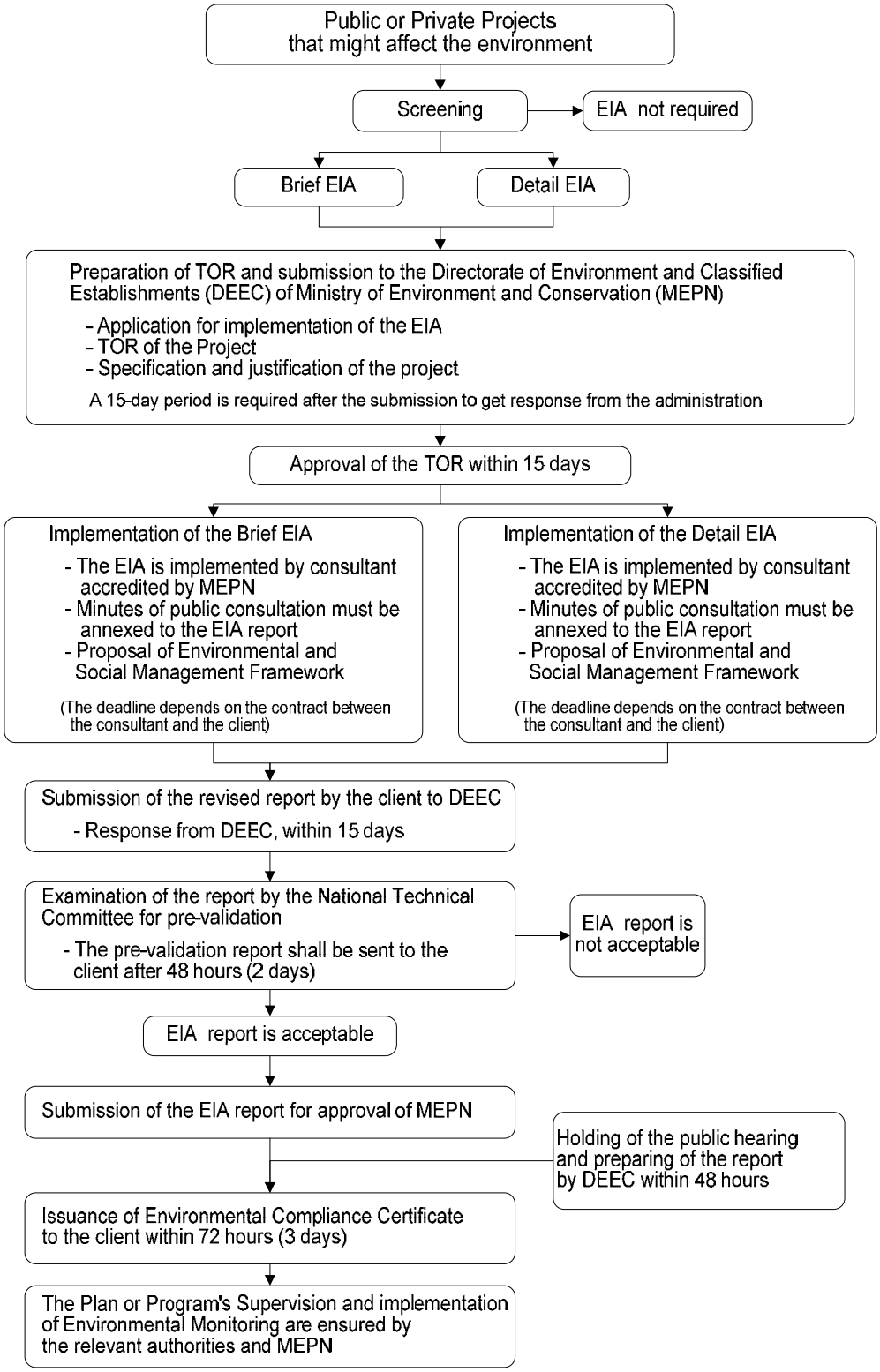
There is no official application form of SEA/EIA submission to DEEC and/or Regional DEEC (DREEC). Usually, a TOR of SEA/EIA is prepared on the basis of the project document submitted together to DEEC/DREEC by the client and the registered consultant. However, the place of submission of the TOR is not fixed to DEEC and/or DREEC.

It is recommended by DREEC in Kaolack that copies of the TOR and other documents on EIA/SEA shall be submitted to the regional government office because the office has the responsibility to chair the regional technical committee on environmental impacts studies. Therefore, JET submitted the TOR and application form for SEA to DEEC on the 2nd of January 2012. Copies of these documents have been submitted to DREEC and the Governor's Office in Kaolack as well.



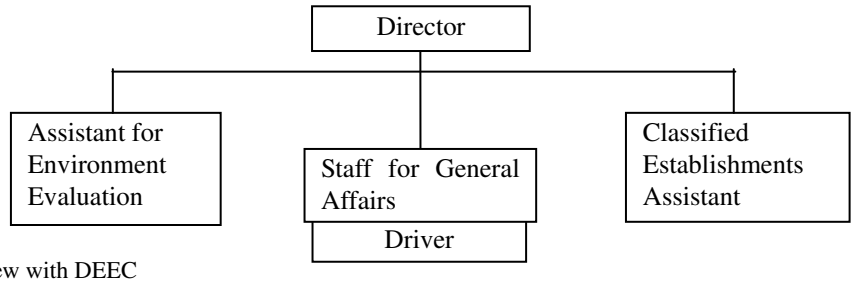
Source: Interview with DEEC

Fig. 2.5.2 Procedure of Strategic Environmental Assessment (SEA)



Source: Interview with DEEC

Fig. 2.5.3 Procedure of Environmental Impact Assessment (EIA)



Source: Interview with DEEC

Fig. 2.5.4 Organizational Structure of DREEC in Kaolack

2.5.3 Environmental Plan and Policy in Senegal

(1) National Environmental Plan

Following the elaboration of the **PNAE** (The National Environment Action Plan) in 1997, Senegal's environmental policy was defined in **The Environment and Natural Resources Sector Policy Letter (LPSERN 2009-2015)**. Approved in 2009, this letter defines the strategic directions and areas of intervention in the field of environment and natural resources thus contributing to the implementation of the PRSP, the Growth Strategy Accelerated (SCA) and the MDGs.

Based on a finding of the environmental sector, the overall goal of environmental policy is to ensure sound management of the environment and natural resources to contribute to the reduction of poverty in a sustainable development perspective. Three strategic directions with areas of intervention for each orientation have been identified to achieve this goal.

1) Improve a basic knowledge of the environment and natural resources

- Collection, regular updating and sharing of basic information about the environment and natural resources
- Interconnection of information systems on the environment and natural resources
- Studies and Research / Development

2) Strengthen the fight against the current trend of degradation of environment and natural resources in accordance with international conventions relating thereto

- Fight against deforestation and land degradation
- Conservation of biodiversity and management of wetlands
- Environmentally sound management of chemicals and wastes and the fight against pollution and nuisances
- Fight against coastal erosion
- Adapting to climate change and promoting sustainable production and consumption
- Restoration and recovery of degraded physical environments

3) Strengthen the institutional and technical capacities of the stakeholders in the implementation of conservation actions of the environment and natural resources

- Technical training, recycling and environmental education
- Development of agro-forestry pasture
- Development of aquaculture
- Promotion of private investment

According to the SEA Report, **The Environment and Natural Resources Sector Policy Letter (LPSERN 2009-2015)** identifies among legal constraints the inadequacy of legislation related to household solid waste, industrial and dangerous wastes, namely, biomedical waste management.

(2) Kaolack Regional Environmental Action Plan (PAER) 2011-2015

The main contents of the Action Plan are as follows:

Global Objective:

(a) To promote participatory and sustainable management of environment and natural resources in the region.

Specific Objectives:

(b) To promote sustainable and equitable management of natural resources.

(c) To improve the quality of life in the region.

(d) To contribute to poverty reduction through sustainable management of environment and natural resources.

(e) To enhance adaptation to climate change.

The Action Plan suggests four main challenges and development namely;

1) Sustainable land
* Fight against soil degradation
* Fight against salinization
* Fight against gully

2) Sustainable management of natural resources
* Sustainable management of forest resources
* Integrated management of water resources
* Protection of wetlands in the region

3) Adaptation/mitigation to Climate Change
* Adaptation of Agriculture and Livestock to Climate Change
* Housing Adaptation to Climate Change
* Regional contribution to Reducing Emission from Deforestation and forest Degradation (REDD)
* Access to the region in flexible mechanism of United Nations Framework Conventions on Climate Change (UNFCCC) and other opportunities

4) Sanitation
* Sustainable management of garbage
* Sustainable management of domestic wastewater
* Fight against floods

It is reconfirmed that the JICA Project is highly consistent with the PAER. Especially, Challenge 4, Sanitation, has exactly the same contents as the Project, so that relevance of the Project is very high.

2.5.4 Socio-Economic Situation in Kaolack Region/City

(1) Economic Activities

The Kaolack Regional Environmental Action Plan (PAER) 2011-2015 describes that Kaolack Region is ranked among the five poorest regions of Senegal. The living conditions of population are relatively difficult, and the region's poverty rate is over 40%.

The main economic activities in Kaolack City are trade and transport. However, animal husbandry, fishing and craft industry also contribute to the economy of the city (APROSEN 2007).

The main factories are as follows:

* SUNEOR (former SONACOS: the National Society of Oilseeds Marketing in Senegal) produces vegetable oils.
* SNSSS (New Society of Salt Farm in Sine Saloum) produces large amounts of iodized salt.

According to the SEA Report, the primary sector of Kaolack City contributes to only 4.1%, the secondary sector employs 30.7%, and the tertiary sector dominates the local economy at 65.2% of salaried workers. However, the employment level is still weak and largely dominated by the informal sector which represents 75% of urban jobs.

(2) Ethnic Groups

Kaolack is close to Gambia and shares the same Wolf, Flani, Serere or Mandingue ethnic groups (Plan Senegal). It was informed that mixed ethnic groups are living together in the many districts such as, Boustane, Dimaguene, Tuba Kaolack, Medina Mbaba 2, Nderagoundaw, Abattoir, Koundam and other districts in Kaolack City. Existing minority groups or minority group residential areas have not been identified through stakeholders' interviews so far.

(3) Land Location and Protected Areas

The city is distinguished in the following five urban units by the APROSEN report in 2007:

1) Leona and Kaolack-City

   In this urban unit, almost all of the administrative and commercial areas are concentrates in Koundam and Abattoir–Ndangane as well as in the industrial area.

2) Central Districts

   This unit consists of Bongre, Kassavile, Dialegne, and Nedina Matar. City HLM (Habitats with Modern Rent) of Bongre and the military camp also belong to this unit.

3) Northern Periphery Districts

   This unit includes Sara Ndiougary and Boustane, Ndorong, Taba Goye, Medina 1 and Medina 2, Sam and Touba Kaolack. These districts are characterized by low population density and lack of socio-economic, cultural facilities.

4) Northwestern Periphery Districts

   This unit is made up of the districts of Lydiane/Serere and Kabotoki; primarily rural characteristics.

5) Irregular Districts

   These districts are the last set up in the Northwestern, North and Northeast peripheries of Kaolack, which includes Sama Moussa, Sing-Sing, Ngane Alassane, Ngane Saer and Thioffac.

The central market is located in Leona District (with 525 shops and 186 restaurants), and local markets are also located in districts such as Medina District (the SEA Report).

Due to urbanization, legal and illegal occupation has been expanding to the north and northeast part of Kaolack City. Also, the number of districts has been increasing rapidly. It was reported as 17 in 2007 (APROSEN) which more than doubled at 38 districts in 2011 (City Government). The City Government has a resettlement plan for the people living in flood affected areas, namely; to move them to Sing Sing District, but the proposed resettlement site has the problem of salinization.

Regarding the natural protected areas in the Kaolack Region, there are ten forest areas which cover 16,465 ha, and five forests (5,490 ha) are located in Kaolack Prefecture (4 in Ndiafate City and 1 in Kanohe City). According to DREEC in Kaolack, there are no classified protected areas such as protected forest, national parks and so on in Kaolack City. However, it is emphasized that Saloum River is important for wildlife and tourism, and the mosque in Medina is also a major cultural heritage in Kaolack City (PAER). On the other hand, according to the City Government, a water

conservation and vegetable cultivation project is ongoing in Ngane Alassane District, but the area has not been delineated yet.

Furthermore, according to the PAER 2011-2015, Kaolack/Kahone and Kaolack/Ndiaffate riverside areas provide opportunities for eco-tourism and hunting activities. Medina Baye Mosque is an important historical and cultural heritage as well.

2.5.5 Stakeholders for Environmental and Social Considerations

A large number of state and non-state organizations have been participating in environmental improvement activities in Kaolack City. Especially, waste management programs have been implemented by various stakeholders. CODEKA (Committee for Development of Kaolack City) is the general development committee for coordination of state and non-state office activities. Regional offices of ONAS, DEEC, APROSEN, Prefecture (an agent of the national government for Kaolack Department) and the City Office are in charge of official environmental management. The official core unit is CDQ (Committee for District Development). There are 36 districts in Kaolack City and each district has a CDQ. However, the number of districts and CDQs has been increasing due to the expansion of Kaolack City, and according to CODEKA, unofficially about 40 CDQs likely exist in the city.

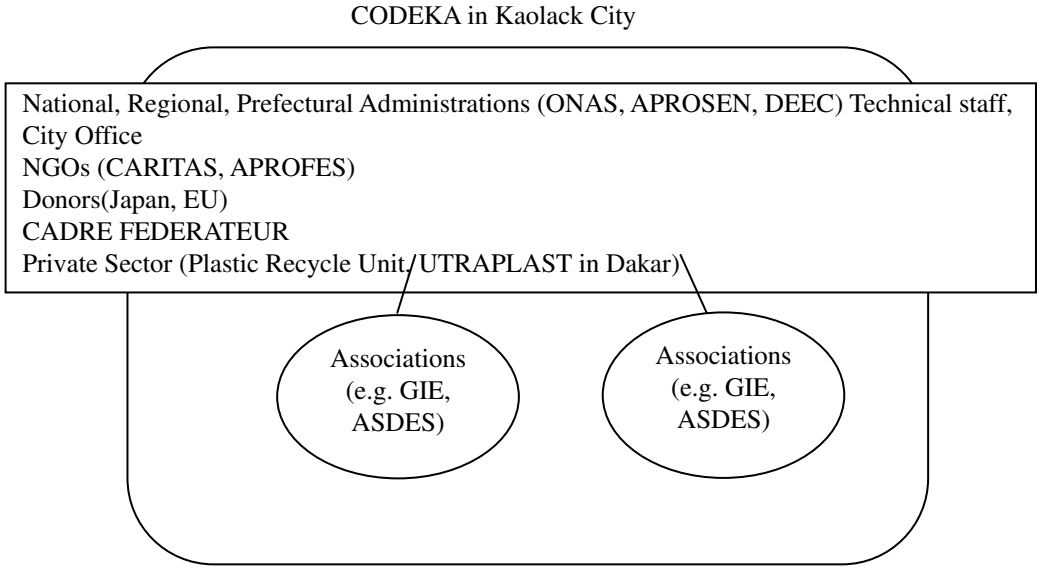
CADRE FEDERATEUR was formulated by the government in 2009 in order to improve hygienic conditions for local people, which involves 11 CDQs and 7 associations. There are 4 environmental model districts (Medina Baye, Leona, Boustane and Abbatoirs) called as "Eco-Quartier."

There are several kinds of associations engaged in waste management. For instance, ASDES (Senegalese Association for an Equitable and Interdependent Development) has been collecting wastes and conducting advocacy activities under the EU project (participatory hygiene improvement) with NGO (CARITAS). One of GIEs (Economic Interest Group), named as Li Geey Diarinu, which is a member of CADRE FEDERATEUR, also works with CARITAS in the waste management program.

Furthermore, some GIEs are managing a plastic recycling unit in Bongre District which was constructed with Japanese grant aid in 2001 and technical cooperation from Italian NGO: LVIA (Lay Volunteers International Association). There are approximately 60 GIEs in Kaolack City. Therefore, it might be very difficult to identify each and every GIE activities.

NGOs are also playing important roles on the improvement of environment. For example, CARITAS has been working with EU and CDQs on environmental projects, such as collecting plastics for recycling, installing of septic tanks, and training of local people, and APROFES (Association for the promotion of Senegalese women) has been training young women in hygiene program in Ndangane District.

The private sector is a major actor on the recycling of plastics not only in Kaolack but also in other cities of Senegal. The plastic recycling unit in Kaolack City sells the plastic tips to UTRAPAST (a private company located in Dakar) through an NGO (LVIA). The factory of UTRALPAST has been producing water reservoirs, septic tanks, and so on from collected plastic tips since 2002. The company purchased 12 tons of hard plastic tips from NGOs last year. These private firms have been contributing to improve environment, and also generate income for local people. For instance, the recycling unit in Kaolack has 18 employees, and UTRALPAST has 25 workers (15 fulltime and 10 part-time workers). Moreover, the water reservoirs and septic tanks produced by UTRALPAST are sold to the local people of Kaolack City at low prices through CARITAS.



Source: Based on interview with DREEC

Fig. 2.5.5 State and Non-State Organizations for Environmental Considerations in Kaolack City

2.5.6 Environmental and Social Conditions in Kaolack City

(1) Natural Conditions

(a) Tannes/Spots

There are flood-prone areas in Kaolack City called "tannes/spots." The report of APROSEN (2007) points out that "the districts of Dialègne and Medina Matar are located on the tannes/spots, where the conditions of habitat and hygiene are 'precarious'."

The APROSEN Report shows the 2 categories of "tannes/spots" as follows:

- The "tannes/spots" grassy located in the rather high sectors (Medina, Diamegueune, Kabatoki, Lyndiane), whose grounds' acidity and salinity remain acceptable, are covered by a thin vegetation with halophytes; and
- Naked "tannes/spots", with strong moisture, dead and deprived of any vegetation. These "tannes/spots" are particularly present at Ndangane, Koundam, Dialegne, and Abattoirs.

(b) Sand and Groundwater

Sandy soil and groundwater (high level and salty) are critical issues in Kaolack City. According to CARITAS, the construction of hygienic facilities is difficult in some districts. For instance, the installation of septic tanks is disturbed by sand and high level of groundwater (less than one meter in depth) especially in Medina Mbaba, Abattoirs and Touba Kaolack districts, and salty groundwater causes rusting of the tanks and other construction materials.

(2) Social Conditions

(a) Utilization of Wastes for Embankment

According to APROSEN in Dakar, some groups of people in Kaolack City do not agree to the removal of wastes from their community since they could easily dig holes to dump and cover them with sand even during the flood period. The APROSEN report (2007) also points out that there are people who buy and use wastes for embankment as protection against floods in the peripheral districts. The people living in tannes/spots might be against wastes collection for the sake of living in the floods.

However, living with wastes is very harmful for human health because the wastes include toxic materials such as medical wastes (sometimes medical wastes involve human body parts). Removing medical wastes from medical facilities is officially regulated (Decree No. 2008 1007 of 18 August; regulating the management of biomedical waste), but it is said that some dealers are trading them. It was gathered from the interviews that people prefer to buy wastes because it is cheaper than sand for embankment. In other words, those people who live with wastes in the spots might be poor people. Moreover, many of those people are living illegally. According to the results of interviews, using wastes for embankment is found in the majority of Kaolack City, such as Nimzatt, Touba Kaolack Extension, Ndangne, Diamaguene, Leona, Abattoirs, Medina Mbaba, Boustane, Dialegne and Ndiago districts.

Some NGOs such as CARITAS and APROFES point out that lack of knowledge and information about the risk of medical wastes cause infection of HIV/AIDS and other diseases. Therefore, NGOs have been implementing campaigns to enlighten communities about waste management.

(b) Conflicts

There are troubles between truck drivers who transfer wastes and residents around the disposal site in Thiofack. People living in peripheral areas claim that wastes from the city center are carried to the outskirts. The trucks carry the wastes during the night to avoid claims from the local people. The main issue is that there is no official final disposal site in Kaolack City. The City Office cannot intervene in the dispute because the office is not able to provide a final disposal site.

The transfer sites also faces similar problems; the neighboring communities opposed to establish and requested to close the transfer sites of ROC (Garbage Transportation by Carts) project (supported by NGOs and EU) because the communities complain about foul odor and flying garbage carried by wind.

Discharging of sludge is another cause of conflict with rice farmers in Sing Sing. The trucks carrying the sludge into the site might hinder the cultivation of farmlands with a negative impact on the neighboring people's hygiene.

(c) Attitude and Education

Despite the various laws and regulations on environmental protection, they might not have been well disseminated. In addition, it might also be very difficult to change people's attitude.

However, several NGOs and associations have been trying to enlighten CDQs for improvement of hygienic conditions through training and radio programs. For instance, ASDES support school cleaning activities, but the constraint is based on traditional gender bias that the cleaning is admitted as women's work, therefore school girls are only ones participating in the project in some schools. The basic educational system also affects the environmental improvement.

Another example is that some people construct their houses without toilets due to lack of knowledge. Such kind of basic issue might not be solved if state and non-state organizations cannot find the cause of problems and educate them appropriately.

(d) Coordination of Stakeholders

A large number of stakeholders have been participating in the cleaning and hygienic programs and projects as written in 2.5.5. However, there is no specific coordination unit for environmental improvement. Fragmentation of organizations might hinder the coordination of hygienic projects in Kaolack City.

(e) Technical Conditions

The plastic recycling unit is one of the best practices for improvement of environment and income generation. Unfortunately, the utilized material is limited only to hard plastics such as

containers of oil, buckets and so on. PET-bottles are not recycled due to the technical and financial perspectives.

Another issue is technology transfer of waste management; ROC project used carts with donkeys which are pointed out inefficiency of implementation in the APROSEN report. The technique was not appropriate to carry large amounts of wastes for long distance to the disposal sites.

Regarding the technical issue on the construction of sewerage systems as written in the Natural Conditions, sand, high level and salty ground water might be some of the constraints on the expansion and maintenance of sewerage networks since the construction and maintenance cost might be higher in the tannes/spots than in the normal areas.

2.5.7 The Way to Forward

Natural conditions might be significant constraints to environmental improvement in Kaolack City. Appropriate technologies and reasonable technical costs are needed to make feasible plans and programs.

Harmless and low-cost alternative materials for embankment should be introduced in tannes/spots areas and firm knowledge and social attitudes are essential to make acceptable plans and programs.

Coordinating stakeholders is important to facilitate procedures for making plans and programs.

Soft component is needed in the plans and programs in order to change attitudes for improvement of hygiene and environment. It should be encouraged that environmental improvement activities are beneficial not only for own health but also for income generation.

The potential of wide range of recyclable resources (metals and PET-bottles) and markets should be investigated not only in Kaolack City but also in Senegal.

	
Tannes/ Spots in Abattoir District	Poster for the Construction of Toilet by CARITAS
	
Plastics Collection Center in Ngane Saer District	CDQ Member in Ngane Saer District
	
Plastics Recycling Unit in Kaolack	Staff of Plastics Recycling Unit in Kaolack
	
UTRAPLAST Office and Factory	Making Water Reservoir in UTRAPLAST

Photo 2.5.1 Usage of Recycled Plastics

2.6 Economy and Organizations

2.6.1 Economic Aspects of Senegal

(1) Document of Strategy for the Growth and the Reduction of Poverty (DSRP) of Senegal

DSRPs were formulated for attaining the Millennium Development Goals (MDGs), namely; the reduction of poverty to a half by 2015 with the assistance of IMF and the World Bank. DSRP I was implemented for 2003 to 2005 and DSRP II for 2006 to 2010.

DSRPs focused on the diagnosis of poverty and set the priorities for poverty reduction, including (i) creation of wealth; (ii) strengthening of capacity and promotion of basic social services; (iii) social protection and management of risks disasters; and (iv) good governance with decentralization and participation.

Due to the exogenous shock to the economy and low productivity of the agricultural sector, the economic growth turned to decline in the last half of the period, 2006-2009. Governmental reform progressed and the basic social services also improved but more efforts are required to attain the MDGs.

Table 2.6.1 Status of Millennium Development Goals as of December 2011

No.	Goals	Status
1	Eradicate extreme poverty and hunger	Possible to achieve if some changes are made
2	Achieve universal primary education	Very likely to be achieved, on track
3	Promote gender equality and empower women	Possible to achieve if some changes are made
4	Reduce child mortality	Very likely to be achieved, on track
5	Improve maternal health	Off track
6	Combat HIV/AIDS, malaria and other diseases	Possible to achieve if some changes are made
7	Ensure environmental sustainability	ditto
8	Develop a global partnership for development	ditto

Source: UNDP

(2) Document of Economic and Social Policies (DPES)

During the 2006-2010 period of the DSRP II, the factors that have enabled a strong GDP growth and improved the quality of life of populations between 1995 and 2005, had been severely affected by the successive food and energy crises, and the economic and financial depression of 2008. The growth rate of GDP per capita is only 0.5% on average per year.

These results for the period 2006-2010 highlighted the fragility of the Senegalese economy and clarified it would take a long-time with its capacity for sustainably improving the living conditions of the population. In addition, new challenges had emerged including: (i) the advent of new emerging countries; (ii) the movement toward clean energy and petroleum substitutes; (iii) the effects of climate change; (iv) increasing applications for food security; (v) the socio-economic changes in Africa; (vi) increasing reference to the precautionary principle and the need for increasingly demanding security; and (vii) gender equality and the empowerment of women.

These challenges required construction of a peaceful democracy, and emergency call to set up a strategy of economic and social development in order to raise the growth potential of the economy to a level allowing smooth or erratic movements to absorb external shocks and thus register the country's development in a sustainable improvement conditions for the life of the population.

Required were economic and social developments such as: (i) strong exports of services and the product diversification; (ii) raising the logistics platform through the development of infrastructure; (iii) effective use of competitive advantages arising from the macroeconomic and sectoral reforms; (iv) appropriate development and implementation of public policies; and (v) a multiform culture promoting social dialogue.

These matters led all players to agree on the need to prepare the new policy package for the five year period 2011-2015. This new strategy, the single reference framework for intervention for all development actors, is part of a long-term vision and opposes all forms of social exclusion. It

calls for an optimal implementation of governance policies at central and local levels to achieve the MDGs in 2015.

DPES is organized as follows: Chapter I describes the pattern of growth, poverty, inequality and the challenges in terms of diagnostic assessment. The Strategy itself is described in Chapter II, through the long-term prospects for 2015 and strategic directions relating to policies, programs and projects that will give shape to the strategy at the macro and sectoral perspectives. Chapter III presents the priorities of the Strategy, and a plan of priority actions. Finally, Chapter IV is devoted to the device in order to ensure effective implementation of the Strategy with presenting the roles and responsibilities of actors and mechanisms to achieve the goals. This chapter also sets the framework for monitoring and evaluation and defines the risk factors related to the implementation of the Strategy.

Table 2.6.2 Related Indicators of DPES (2011-2015)

Indicator		Realized			Target				
		2008	2009	2010	2011	2012	2013	2014	2015
Real GDP Growth (%) (optimistic scenario)		3.7	2.1	4.1	4.8	5.8	6.4	6.7	7.0
Inflation (%)		5.8	-0.9	1.2	≤3.0	≤3.0	≤3.0	≤3.0	≤3.0
Current Account Deficit (% of GDP)		14.2	6.7	6.1	8.2	8.5	7.7	7.6	7.3
Household Access to Improved Sanitation (%)	Urban	63.4	63.6	63.1	70.3	72.2	74.1	76.1	78.0
	Rural	27.5	28.9	29.6	49.0	52.0	57.0	59.0	63.0

Source: Document of Economic and Social Policies (DPES)

(3) GDP

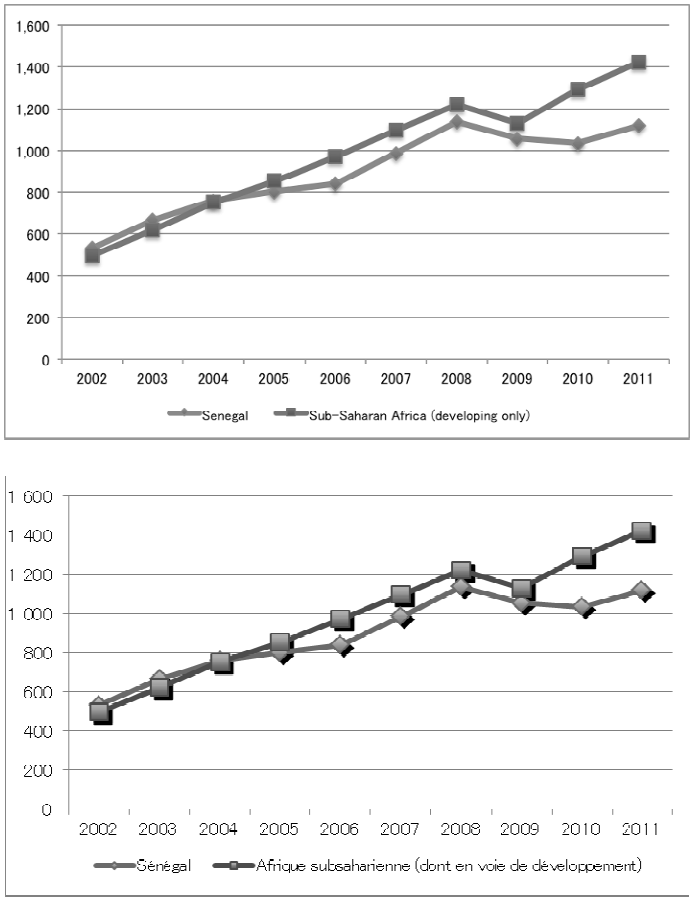
Senegal's per capita GDP is USD1,119 in 2011, which is still below that in 2008 or USD1,136. Senegal experienced the influence of the world economic shock in 2008-2009. It has been some lower than the mean of Sub-Saharan African developing countries. It should be noted that Senegal could not recover from the 2009 decline in 2011, which widened the difference from Sub-Saharan Africa.

Table 2.6.3 Per Capita GDP (Current USD)

	2007	2008	2009	2010	2011
Senegal	986	1,136	1,055	1,034	1,119
Sub-Saharan Africa	1,097	1,220	1,131	1,293	1,424

Source: World Bank

Unit: USD

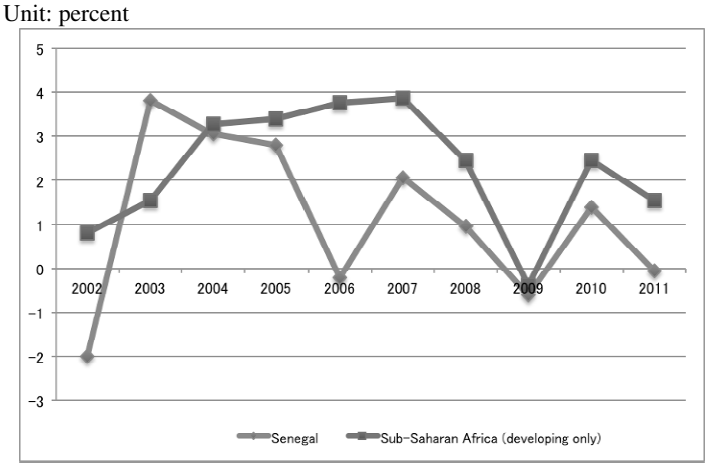


Source: World Bank

Fig. 2.6.1 Change in Per Capita GDP (Current USD)

Senegal showed negative per capita real GDP growth for 4 times in the last 10 years. Per capita growth rate fluctuated although its amplitude had been declining and it was always lower than that of the mean of Sub-Saharan African developing countries.

Unit: percent



Source: World Bank

Fig. 2.6.2 Change in Real GDP Growth

(4) Inflation

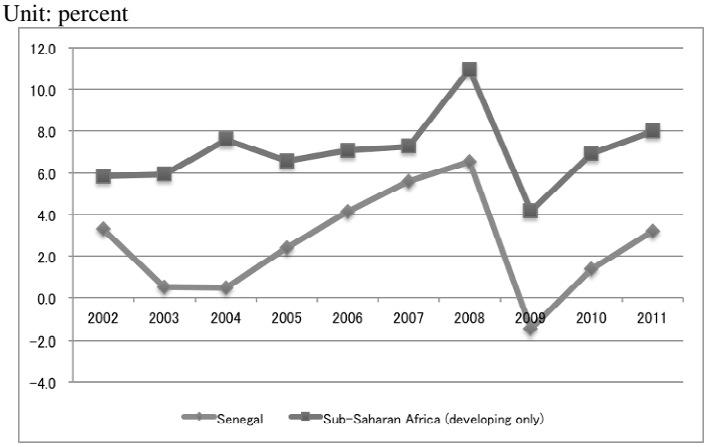
Before the economic shock in 2008-2009, Senegal's inflation rate was increasing rapidly and it showed a negative figure in 2009. It was always lower than that of the mean of Sub-Saharan African developing countries, which is similar to the situations in the economic growth.

Table 2.6.4 Inflation (%, GDP Deflator)

	2007	2008	2009	2010	2011
Senegal	5.6	6.5	-1.5	1.4	3.2
Sub-Saharan Africa	7.3	11.0	4.2	6.9	8.0

Source: World Bank

Unit: percent



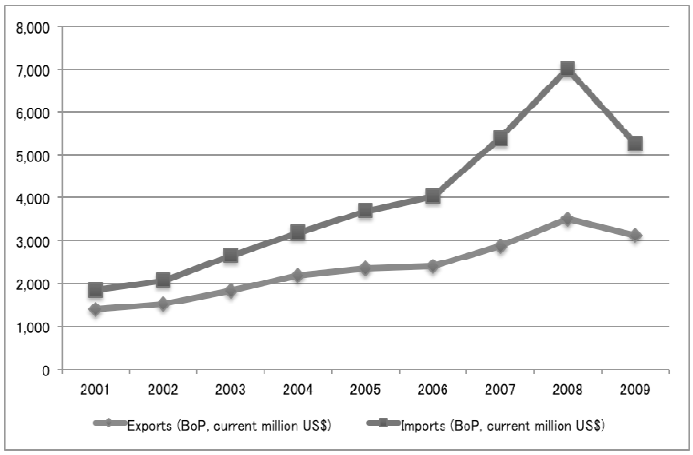
Source: World Bank

Fig. 2.6.3 Change in Inflation (GDP Deflator)

(5) International Balance of Payments

Senegal always showed deficit in balance of payments and its magnitude had been increasing. In addition, its percentage of GDP was increasing before 2009.

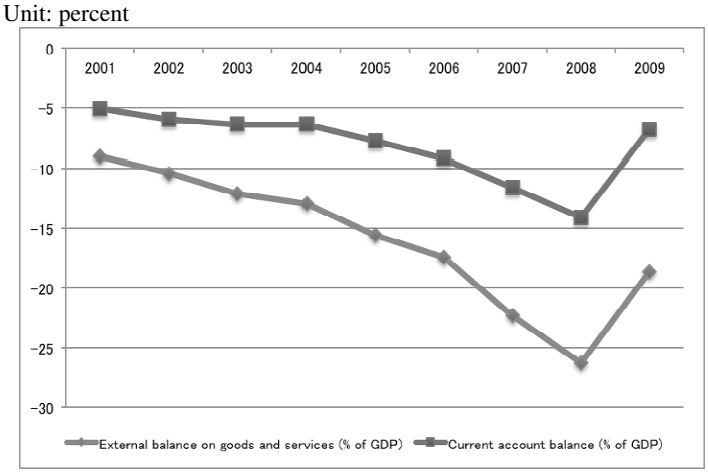
Unit: Current Million USD



Source: World Bank

Fig. 2.6.4 Exports and Imports of Goods and Services

Unit: percent

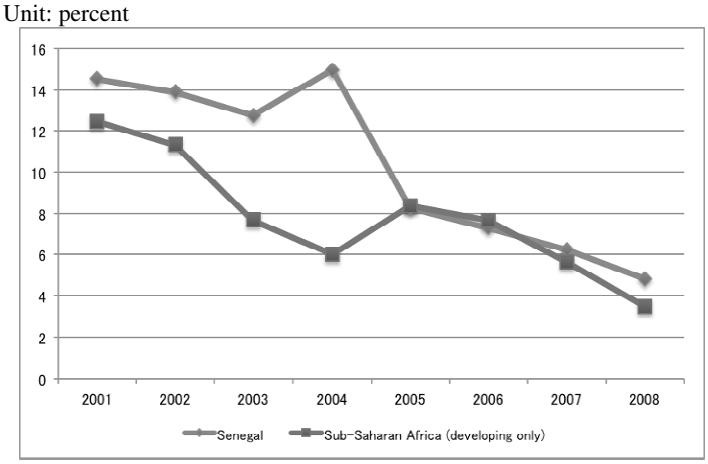


Source: World Bank

Fig. 2.6.5 External Trade Deficit (% of GDP)

The debt service or the sum of principal repayments and interest actually paid as the percentage of exports had been declining and showed similar figures to that of the mean of Sub-Saharan African developing countries in recent years before 2009.

Unit: percent



Source: World Bank

Fig. 2.6.6 Debt Service (% of Exports)

2.6.2 Related Organizations

(1) National Office for Sanitation of Senegal (ONAS: Office National de l'Assainissement du Sénégal)

(a) Mission

ONAS is the governmental agency responsible for sanitation under the Ministry of Hydraulics and Sanitation. It was established in 1996 and based on the law and regulations, its mission consists of the following:

- Planning of projects on wastewater and storm water infrastructure
- Management of the projects
- Operation and maintenance of wastewater and storm water facilities
- Development of on-site sanitation systems
- Utilization of the sludge from wastewater treatment plants

- Management of sanitation fee

(b) Budget

In ONAS budget, ordinary expenses should be covered by sales of its services while investment costs are covered by the government budget. ONAS has to report its operations to the Government every 3 months. In 2010, the balance of ordinary budget showed a deficit.

Table 2.6.5 Ordinary Budget of ONAS in 2010

Unit: FCFA

Budget Code	Item	Budget 2010	Realization	%
	Revenue			
70100	Sales of treated water	5,000,000	1,573,213	31.46
70200	Sales of sludge consolidation	2,000,000	1,234,072	61.70
70300	Branching and extension works	375,000,000	355,943,750	94.92
70400	Sewerage charge	4,960,000,000	4,983,819,787	100.48
70500	Supervision works	12,000,000	602,000	5.02
70700	Issue of estimation	4,000,000	7,422,690	185.57
70800	Connection of social branch	-	1,919,773	-
70900	Tender documents	4,000,000	14,271,200	356.78
71000	Other collateral revenue	60,000,000	66,763,955	111.27
71100	Subsidy	1,200,000,000	1,232,276,517	102.69
71400	Other revenue	2,000,000	1,652,250	82.61
	Revenue Total	6,624,000,000	6,667,479,207	100.66
	Expenditure			
60	Purchases supplies	1,585,200,000	1,737,951,376	109.64
61	Transportation	30,000,000	29,666,765	98.89
62	Outsourcing cost A*1	2,268,000,000	2,745,748,746	121.06
63	Outsourcing cost B*2	813,750,000	985,469,836	121.10
64	Taxes	62,500,000	164,917,376	263.87
65	Other costs	27,000,000	46,693,462	172.94
66	Personnel expenditures	1,440,000,000	1,392,069,309	96.67
67	Financial costs	2,550,000	72,859,093	2,857.22
68	Amortization and provisions	35,000,000	56,155,313	160.44
	Expenditure Total	6,264,000,000	7,231,531,276	115.45
	Balance	360,000,000	-564,052,069	

Notes:
*1 Fees paid to non-professional suppliers
*2 Fees paid to professionals including lawyers, doctors, etc.
Source: ONAS

(c) Organization

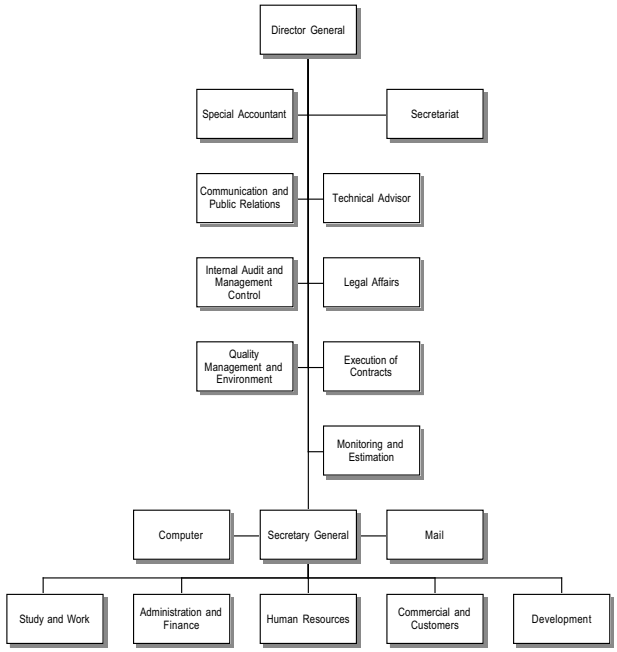
The total number of workers is 182 in 2009. The share of executives is high with over 30% in ONAS personnel and that of laborers is very low.

Table 2.6.6 Number of ONAS Personnel

	2008			2009		
	Male	Female	Total	Male	Female	Total
Executive	47	5	52	52	12	64
Supervisor	60	28	88	75	23	98
Laborer	35	3	38	19	1	20
Total	142	36	178	146	36	182

Source: ONAS

The organizational chart of ONAS is shown in the following figure.



Source: ONAS

Fig. 2.6.7 Organizational Chart of ONAS

(2) The National Agency for Cleanliness in Senegal (APROSEN: Agence nationale pour la Propreté du Sénégal)

(a) Mission

APROSEN was established in 2010 and is under the supervision of Ministry of Living for technical matters and the Ministry of Finance for financial matters. APROSEN aims to establish and maintain a clean living environment by ensuring constant monitoring. Its missions are:

- To ensure all activities of public cleansing, recollection, collection, transport and storage of solid waste on behalf of local governments;
- To develop a pipeline of biochemical waste and slaughterhouse waste for disposal within acceptable environmental conditions;
- To manage all equipment and infrastructure for waste management;
- To support the government to legislate management of solid waste;
- To conduct studies for improvement of living conditions; and
- To provide extensive information and public education on waste management.

(b) Organization

APROSEN consist of 11 management staff and 46 support staff. Detailed staff composition is shown below.

Table 2.6.7 Composition of APROSEN Staff

Management Staff		Support Staff	
Position	Number	Position	Number
Director General	1	Assistant Program Officer	3
Chief Operating Officer	1	Manager	1
Director [1)]	3	Assistant Accountant	1
Controller	1	Operational Assistant	2
Regional Delegate [2)]	4	Secretaries	4
Program Officer	1	Receptionist	1
Total	11	Audio Technician	1
[1)]: Human Resources, Communications and Public Relations, Contracts and Legal Affairs		Drivers	8
		Service Agent	5

Management Staff	Support Staff	
[2)]: St. Louis, Kaolack, Diourbel, Ziguinchor	Security Guard	5
	Cleaning Agent	6
	Other Staff	9
	Total	46

Source: APROSEN

(c) Dissolve of APROSEN

It has been decided by the former political administration that APROSEN is to be dissolved and "La Société pour la propreté du Sénégal" (SOPROSEN) will be created to conduct the actual responsibilities (i.e., collection, transport and dumping) on solid waste management instead of the local governments. The business of APROSEN's solid waste management was planned also to be transferred to SOPROSEN. Since APROSEN was created under a Decree of the President, it was also dissolved by another Decree of the President. On the other hand, the creation of SOPROSEN was decided by the National Assembly. It was originally planned that, firstly, APROSEN would be integrated into Unité de Coordination et de Gestion des Déchets Solides (UCG) with other related agencies as a transition measure and then UCG would be changed into SOPROSEN.

The political administration, however, was changed in March 2012, after APROSEN was dissolved and the law on SOPROSEN's creation was approved by the National Assembly. The new political administration, however, opposed the transfer of activities on solid waste management from the local governments to SOPROSEN. Thus, the creation of SOPROSEN has been suspended.

Programme National de Gestion des Déchets (PNGD) was officially established in July 2013 instead of SOPROSEN. So, the mission regarding solid waste management will be transferred to PNGD, and UCG will be integrated to PNGD as its administrative unit.

PNGD's goal is to support local governments for the improvement of their solid waste management. Its mission includes (1) to revise laws and regulations of the sector, (2) to realize waste management infrastructure development, (3) to reduce illegal damping, (4) to make technical and financial support to local governments, (5) to conduct dissemination and capacity development and (6) to coordinate, monitor and evaluate programs.

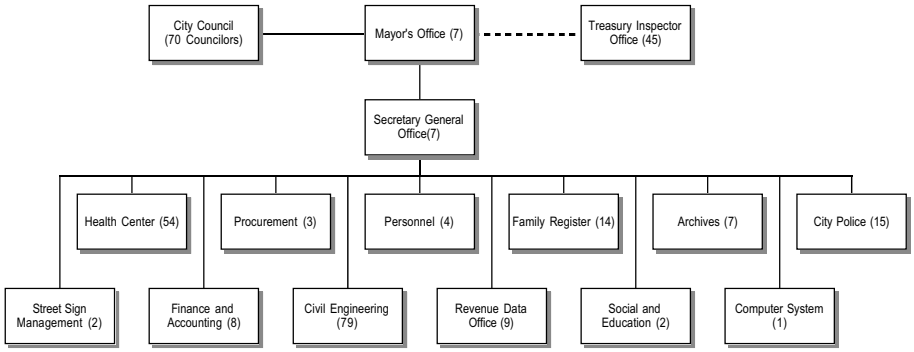
(3) Kaolack City

(a) Organization

The Mayor of the City is elected from among the City Councilors by mutual voting. There are 70 city councilors elected by the residents and their term is 5 years.

The number of staff is 280 (male: 196, female: 84) as of December 2011. There are 2 types of promotions for the staff, namely; periodical promotion and special promotion. In periodical promotion, city staffs are automatically promoted every 2 years. Special promotion is decided by the 8 municipal advisors designated by the Mayor.

Staff recruitment is made only by the Mayor. According to the regulation, city staff cannot be terminated when the Mayor who recruited them is changed by election.



Note: Figures in ( ) are the staff numbers of the offices.
Source: Kaolack City

Fig. 2.6.8 Organization of Kaolack City

(b) Budget

Senegal's fiscal year begins on the 1st day of January and ends on the 31st of December. If the budget in a fiscal year is not totally expended, some of it can be carried over to the next fiscal year. The draft of the budget should be approved by the City Council and then by the Ministry of Economics and Finance (MEF). It can be said that the budget is eventually controlled by the central government. The reason why there are remaining amounts in a budget is that usually the budget is allocated by the MEF to the account of the City Government after several months in the new fiscal year, so that the remaining amount is used for the operating funds including salaries and some other necessary payments in the beginning of the fiscal year.

As can be seen in many other developing countries, even if the draft budget is approved, realized budget or amount of funds actually allocated in the account is usually less than that of the approved. Under this situation, it is very difficult for the City Government to conduct business in accordance with plans, even with the draft long-term plans.

The balance of the forecast should be zero but that of FY 2009 is negative. The reason is not clear.

Table 2.6.8 Budget of Kaolack City

Unit: FCFA

Item	2009			2010			2011		
	Forecast	Realization	%	Forecast	Realization	%	Forecast	Realization	%
Revenue									
Ordinary Revenue									
Treasury advance	-	-		-	125,000,000	-	-	-	-
Carryover	132,693,685	134,322,219	101.2	-	85,810,602	-	124,311,330	124,311,330	100.0
Operating Revenue	146,251,792	91,061,203	62.3	286,947,408	70,994,643	24.7	277,982,894	68,063,147	24.5
Land Use Tax	596,253,827	485,546,650	81.4	614,539,750	492,690,100	80.2	608,718,100	510,352,270	83.8
Local Tax	637,612,638	504,796,740	79.2	722,556,280	522,676,543	72.3	636,324,143	598,420,198	94.0
Municipality Tax	203,022,076	105,185,905	51.8	292,609,329	139,849,039	47.8	184,969,285	122,729,323	66.4
Misclaneous Revenue	75,585,352	31,506,524	41.7	50,121,276	33,257,173	66.4	39,013,231	39,076,985	100.2
Allocation fund	125,970,551	101,714,000	80.7	-	104,000,000	-	94,359,750	94,359,750	100.0
Refunding of Contribution	231,273,684	175,884,975	76.1	254,312,723	154,306,862	60.7	179,681,017	116,403,332	64.8
Ordinary Revenue Total	2,148,663,605	1,630,018,216	75.9	2,221,086,766	1,728,584,962	77.8	2,145,359,750	1,673,716,335	78.0
Investment Revenue									
Carryover	208,667,663	50,232,989	24.1	271,686,634	91,751,767	33.8	228,322,385	19,115,576	8.4
Subsidy	-	14,000,000	-	-	42,000,000	-	7,000,000	7,000,000	100.0
Carryover of subsidy	257,860,014		0.0	-	45,824,480	-	87,824,480	87,824,480	100.0
Investmet Revenue Total	466,527,677	64,232,989	13.8	271,686,634	179,576,247	66.1	323,146,865	113,940,056	35.3
Revenue Total	2,615,191,282	1,694,251,205	64.8	2,492,773,400	1,908,161,209	76.5	2,468,506,615	1,787,656,391	72.4
Expenditure									
Ordinary Expenditure									
Insurance and Allowance	5,000,000	0	0.0	6,100,000	0	0.0	3,100,000	560,210	18.1
Contribution	67,000,000	32,638,650	48.7	368,802,514	73,000,000	19.8	109,862,762	90,500,000	82.4
Mayor's office	219,275,907	147,057,771	67.1	194,715,660	191,120,739	98.2	202,842,690	142,322,950	70.2
General Administraion	276,170,410	246,799,666	89.4	244,750,340	230,949,397	94.4	292,662,083	250,767,539	85.7
Municipal accounting	27,260,506	21,458,245	78.7	58,601,008	28,250,937	48.2	33,012,682	29,713,389	90.0
Municiapl tax office	178,261,091	165,326,606	92.7	183,044,945	165,171,415	90.2	177,440,822	149,700,649	84.4
Slauterhouse, market	788,000	120,000	15.2	2,288,000	620,000	27.1	3,588,000	1,620,000	45.2
Building maintenance	26,195,449	19,119,445	73.0	33,369,438	25,154,422	75.4	82,631,196	68,441,867	82.8
Protection of pople	278,542,954	205,369,445	73.7	187,598,883	167,003,389	89.0	167,599,055	137,002,257	81.7
Road, square, garden	17,547,089	15,285,538	87.1	56,858,654	53,881,559	94.8	63,393,173	45,236,698	71.4
Garbage collection	108,198,560	100,306,810	92.7	81,548,323	76,629,877	94.0	152,226,600	98,014,218	64.4
Workshop and garage	86,846,042	68,297,529	78.6	82,001,105	74,351,395	90.7	83,315,277	64,180,062	77.0
Water service for city facilities	43,145,615	0	0.0	39,075,455	7,231,849	18.5	15,000,000	0	0.0
Sanitary service for city facilities	2,005,795	1,848,650	92.2	1,896,572	1,959,459	103.3	12,746,920	1,985,854	15.6
Public light	72,653,704	23,380,650	32.2	106,792,263	29,812,458	27.9	46,938,045	12,122,122	25.8
Education, youth, sport	140,110,497	105,763,237	75.5	45,409,055	43,478,809	95.7	105,015,706	88,765,893	84.5
Health, hygene	305,985,685	183,459,356	60.0	113,787,354	128,378,473	112.8	220,256,327	162,463,433	73.8
Cemetry and funeral ceremony	4,100,000	1,999,875	48.8	6,050,000	3,000,000	49.6	6,100,000	2,950,000	48.4
Refund to national government	-	-	-	-	95,000,000	-	-	-	-
Festival and public ceremonies	18,938,100	5,938,100	31.4	16,000,000	12,879,180	80.5	7,444,000	4,244,000	57.0
Misclanouse expense	163,684,538	102,873,644	62.8	120,710,563	104,648,507	86.7	131,862,027	105,742,554	80.2
Financial assets	208,667,663	50,232,989	24.1	271,686,634	91,751,767	33.8	228,322,385	19,115,576	8.4
Ordinary Expenditure Total	2,250,377,605	1,497,276,206	66.5	2,221,086,766	1,604,273,632	72.2	2,145,359,750	1,475,449,271	68.8
Extrordinary Expenditure and Investment									
Equipment of administartion	28,795,192	0	0.0	50,187,417	0	0.0	52,688,000	8,815,446	16.7
Road repair	120,247,671	37,284,849	31.0	140,105,525	74,937,427	53.5	113,323,416	10,832,192	9.6
Protaction against disasters	-	-	-	3,000,000	0	0.0	3,500,000	0	0.0
Infrastructure of indusrty, commerce, handicrafts	5,000,000	0	0.0	10,000,000	0	0.0	15,500,000	3,951,938	25.5
Saniary, public hygene activities	12,998,140	9,998,140	76.9	10,123,552	0	0.0	20,310,969	0	0.0
Education, youth, culture, sport	259,860,014	15,106,928	5.8	11,000,000	0	0.0	73,824,480	71,237,188	96.5
Land and coast imroivement	14,820,140	0	0.0	14,820,140	14,820,140	100.0	-	-	-
Acquisition of heavy equipment	17,812,320	2,950,000	16.6	21,000,000	0	0.0	44,000,000	0	0.0
General study	6,994,200	0	0.0	11,450,000	1,994,200	17.4	-	-	-
Extrordinary Expenditure and Investment Total	466,527,677	65,339,917	14.0	271,686,634	91,751,767	33.8	323,146,865	94,836,764	29.3
Expenditure Total	2,716,905,282	1,562,616,123	57.5	2,492,773,400	1,696,025,399	68.0	2,468,506,615	1,570,286,035	63.6
Balance	-101,714,000	131,635,082		0	212,135,810		0	217,370,356	

Source: Kaolack City

CHAPTER 3. OVERALL PLANNING CONCEPT

3.1 National Development Context

The Senegalese Government shouldered a heavy debt in 2000 and hence implemented its comprehensive strategy of poverty reduction. The "Document of Growth Strategy for Reduction of Poverty (DSRP)[1)]," containing policies and programs integrated for economic growth and poverty reduction, was formulated on the basis of increasingly inclusive approach, aiming at ensuring the conditions of a sustainable and durable high economic growth, reducing poverty significantly and reaching the objectives of the Millennium Development (OMD).

The DSRP-I, defining the planning period of 2003 to 2005, was prepared to improve the growth targets of the program of post devaluation and to correct its negative incidences with the social and political development plans. The real GDP growth rate of approximately 5% a year on average between 1995 and 2005 was attained, resulting in a considerable growth of the manufacturing and service sectors. Moreover, the productivity of capital was relatively strong as well as the utilization ratios of production capacities. These results were carried out in a context of control of inflation, of continuous reduction of the deficits as well as public finances of current balance of payment. However, various structural problems continued while the attractiveness of investment to Senegal remained moderate.

The sustained high growth recorded during 1995 to 2005 also resulted in an appreciable reduction of poverty over the same period. The incidences of poverty were still relatively high and the distribution of income remained particularly uneven in Senegal. These facts invited more vigorous measurements to reduce the poverty and clearly underlined the challenge of the redistribution of the fruits of this growth.

During the period 2006 to 2010 of the DSRP-II, the planned strong growth of the GDP and quality improvement of people's living standards was hardly attained due to the crises of food and energy, and the economic and financial depression in 2008. The projections of poverty carried out over the period of 2005 to 2009 thus suggested a stagnation of the indicators of poverty, and the growth rate of the GDP per capita showed only of 0.5% on average a year.

Based on the assessment of the implementation of the DSPR-II, the five-year national strategy, "Document of Policy on Socio-economy (DPES)[2)]," was formulated for the target period of 2011 to 2015. The development process of the DPES over the period of 2011 to 2015 was led by an ad hoc technical committee, various themes' working groups, some regional axes and some commissions of actors for the developments. The development of the priority action plans and the finalization of the matrix of the indicators were broadly discussed from November 2010 to June 2011 in an interactive process which implied the whole actors.

The vision of the DPES is stipulated as "an emerging Senegalese economy and ensuring sustainable development whose benefits are distributed in an integrated manner."

In order to realize this vision, the Strategy 2011-2015 was prepared for transformation and challenges to all the socio-economic actors to receive the benefits from the synergy effects of all the sectors. For this purpose, the following three related and interdependent axes could be expressed:

- Creation of economic opportunities and wealth for the promotion of productive employment and transformation of the economic structures;
- Acceleration of access to the basic social services, social protection and sustainable development; and
- Reinforcement of basic principles of the good governance and promotion of the human rights.

With these three levers, the Strategy focuses on inclusive growth favorable to economic and social development, being driven by a private sector through raising in particular the structural constraints that hamper competitiveness. It focuses on the essential prerequisites to capture investment opportunities, to withstand the external shocks and to take up the challenges for the establishment of a socio-economic and political environment in order to achieve the OMD and good governance.

3.2 National Development Goals on Urban Environmental Infrastructures

As mentioned on the background of socio-economic development in the Senegal in the preceding section, the DSRP-II evaluated the attainment of a target on the urban sanitation of the MGDs in 2004. In the urban centers excluding the capital city of Dakar, only 39% of the households had any type of the sanitation system. In the rural areas, 28% of the households did not have any kind of toilet system for excreta disposal, while most households have equipped some traditional type of latrines which do not meet the international standards.

The DSPR-II set several targets in the social sectors to realize the OMD in 2015. Among them access rates of 59% and 78% to the sanitation system was planned for the rural and urban populations, respectively, as one of the major goals in the "Millennium Drinking Water and Sanitation Programme (PEPAM)." According to the AfDB Senegal 2010-2015[3)], there are clear gaps between urban and rural areas. It reported that current levels of access to sanitation in rural and urban areas revealed significant gaps, 63.4% against 28.9% in 2009.

The DSPR-II simultaneously stipulated the following desirable actions and measurements to achieve the objectives in the field of urban sanitation improvement;

- To improve the access of households to appropriate excreta disposal system;
- To improve the access of households to appropriate wastewater collection and storm water discharge system;
- To improve the access of households to appropriate solid waste management system;
- To positively change the attitudes and behaviors of households for urban environment;
- To improve the institutional and organizational framework with their structural reforms for smooth implementation; and
- To prepare new and appropriate sanitation system that could be easily accessed by the poorest households for improvement of effectiveness of subsidized connection programs.

Furthermore the DPES pointed out the following desirable actions and measures to achieve the objectives in the field of urban sanitation improvement:

- To develop sanitation in urban environments by continuation and acceleration of placement of coverage of PEPAM, particularly, in the reinforcement and construction of wastewater treatment systems;
- To improve the institutional and operational framework of the sanitation sector in urban environment with continuation of the institutional reform in urban environment and improvement of the relationship among all relevant actors in water management; and
- To promote positive changes of people's behavior to sanitation through the implementation of actions and appropriate measures for hygiene and public health on the basis of the communities.

Regarding access rates to the improved sanitation, historical actual and planned figures are as shown in the following table, referring to DSPR II and DPES, and **Fig. 3.2.1** depicts their tendency. The figure clearly shows that the access rates are going to increase continuously by the related projects year by year in both rural and urban areas.

Table 3.2.1 Access Rates to Improved Sanitation System on an Actual and Planned Basis Drawn in DSPR II and DPES

Unit: %

	DSPR II (2006-2010)				DPES (2011-2015)			
	Rural Area		Urban Area		Rural Area		Urban Area	
Year	Historical	Targeted	Historical	Targeted	Historical	Targeted	Historical	Targeted
2000			56					
2001								
2002								
2003								
2004	17		56.7					
2005	17		59					
2006		20		61				
2007		25		63				
2008					27.5		63.4	
2009					28.9		63.6	
2010		40		68	29.6		63.1	
2011						49		70.3
2012						52		72.2
2013						57		74.1
2014						59		76.1
2015		59		78		63		78.0

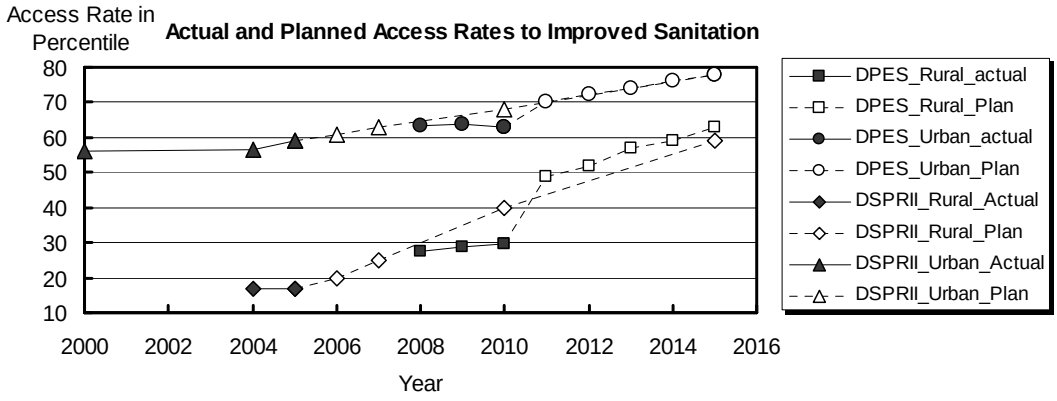


Fig. 3.2.1 Historical Changes of Access Rates to Improved Sanitation in the National Strategies

The above table shows the actual figure 63.1% in 2010 and the target figure of 70.3% in 2011 in urban area. However the present access rate in Kaolack City might range from 50 to 65% according to the officials in the related offices and NGOs. Furthermore, the target access rate of 78% in 2015 could not be achieved in Kaolack City in consideration of the present situation of improvement activities.

3.3 Visions and Objectives of Kaolack Urban Environmental Infrastructure Improvement

The target year of the Millennium Development Goals (MDGs) is set at the year 2015. Since the target year has been drawn, UNDP has been developing the next stage of MDGs. The visions on Kaolack environmental infrastructure improvement shall cover the improvement concepts of the MDGs and the national development context.

Visions for Kaolack Urban Environmental Infrastructure Improvement

"Access to sustainable urban environmental infrastructures and services augments beyond the Millennium Development Goals in a reasonable and equitable manner in the territory of Kaolack City."

Following the improvement visions, the overall improvement objectives of the Kaolack urban environment are as given below.

- To promote the management of solid and liquid wastes and stormwater in an integrated and effective manner to enhance the urban environment through improvement and updating of the urban environmental infrastructures and supporting the daily public services for sewerage treatment and solid waste collection and disposal,
- To develop the urban stormwater management to alleviate the recurrent flooding in the habitual flood-prone areas during the rainy season,
- To improve the institutional framework of the sectors managing sewage including wastewater treatment and sewerage network, stormwater and solid waste for their smooth and sustainable implementation, and
- To promote positive changes of people's behavior on sanitation and solid waste disposal through the people's awareness campaign and participatory activities.

3.4 Project Outcomes and Strategies until 2030

The project focuses on the urban sanitation and environment in Kaolack City, and consists of three components: (1) sewage/sanitation improvement; (2) storm water management; and (3) solid waste management. These three components could create the following outcomes after completion of the subprojects proposed in the master plan.

Sewage/sanitation improvement: Improving the urban sanitation environment through augmentation of capacity of sewage treatment plant, rehabilitation of existing sewer network and expansion of the network, and installation of septage treatment plant.

Storm water management: Providing comfortable urban life without flooding through improvement of drainage capacity of existing drainage canals and installation of drainage facilities in the habitual inundation areas.

Solid waste management: Creating clean urban environment through appropriate management of generated solid waste as well as uncontrolled accumulated solid waste in the urban areas.

These improvement strategies are presented in the following flowchart.

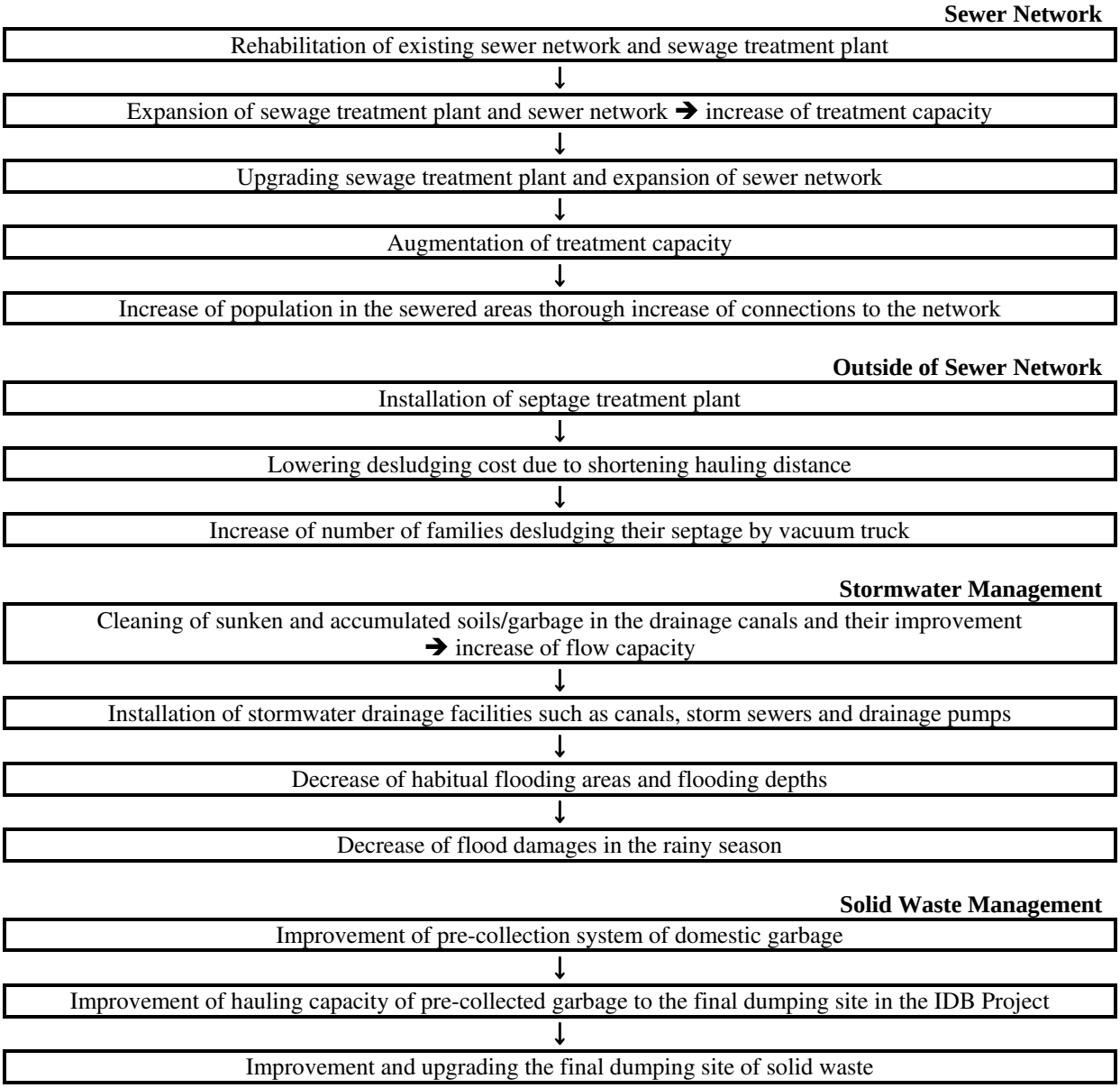


Fig. 3.4.1 Flow Chart of Improvement Strategies of the Master Plan Components

References
1) Document of Growth Strategy for Reduction of Poverty (DSRP-II) 2006-2010, Republic of Senegal, October 2006
2) Document of Policy for Socio-economic Development (DPES) 2011-2015, Republic of Senegal, November 2011
3) Country Strategic Paper 2010-2015, African Development Bank, September 2010

3.5 Planning Frame Setting

3.5.1 Projection of Real Economic Growth Rate

Productions of solid waste are significantly related to the standard of living of the people. Since per capita GDP is a good indicator of the standard of living, future projection of per capita GDP real growth rate is indispensable for formulating the Master Plan. The simplest way of making future projection of per capita GDP is regression analysis of real growth in the past. Thanks to the World Bank, necessary data for such past data is accumulated and easily provided through the website.

Per capita GDP (constant 2000 USD) in 1991 - 2011 is shown below.

Table 3.5.1 Per Capita GDP in the Past

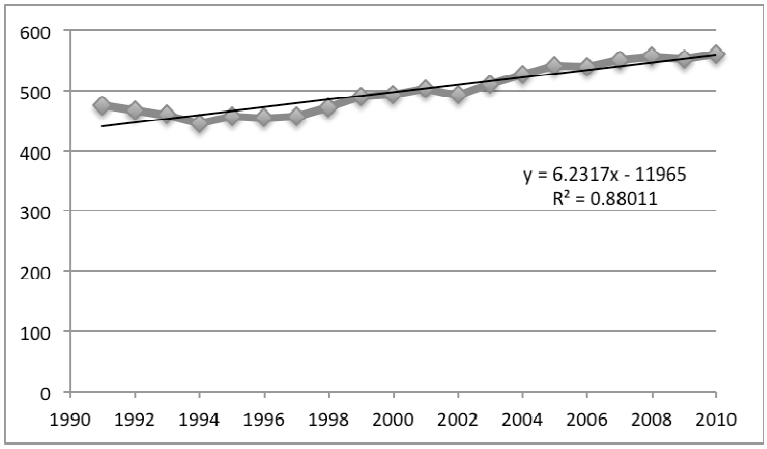
Unit: constant 2000 USD

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Per capita GDP	476	468	460	447	459	456	458	473	491	494
Year	2001	2002	2003	2004	2005	2006	2007	200 8	2009	2010
Per capita GDP	503	493	512	527	542	541	552	557	554	562

Source: The World Bank

The results of regression analysis of per capita GDP (constant 2000 USD) in 1991 - 2010 is as follows:

Unit: constant 2000 USD



Source: JICA Expert Team

Fig. 3.5.1 Results of Regression Analysis of Per Capita GDP

$y = 6.2317x - 11965$
$R^2 = 0.88011$
where,

x: year
y: per capita GDP (constant 2000 USD) in year x
R^2: determination coefficient

Since $R^2 = 0.88011$, which is considerably near "1", this result explains very well about correlation between the two variables. By using this result, future projections of per capita GDP and its real growth rates are made as follows:

Table 3.5.2 Future Projections of Per Capita GDP and Real Growth Rate

Unit: constant 2000 USD

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Per capita GDP	567	573	579	585	592	598	604	610	616	623
Growth Rate	1.11%	1.10%	1.09%	1.08%	1.06%	1.05%	1.04%	1.03%	1.02%	1.01%
Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Per capita GDP	629	635	641	648	654	660	666	673	679	685
Growth Rate	1.00%	0.99%	0.98%	0.97%	0.96%	0.95%	0.94%	0.94%	0.93%	0.92%

3.5.2 Population Projection of Kaolack City in the Future

(1) Estimation of Population for 2012

Kaolack City made an estimation of its population for 2012 based on the reports of District Chiefs in 2012, which is summarized in the following table. This data can be used for the population projection in the future.

The "City Center" is defined here as the Districts that are located in the area, where the City had

been developing so far, and have high population density. Project components which require large amount of funds will be mainly considered for this area as "Target Area" for the efficiency of investment.

Table 3.5.3 Estimation of Population for 2012

No.	District	Concession	Population	City Center
1	Abattoirs	800	8,164	√
2	Bongré	825	7,293	√
3	Boustane I	710	8,164	√
4	Boustane II	520	6,313	√
5	Darou Salam Diamaguene	337	2,721	√
6	Darou Salam Ndangane	1,300	7,837	√
7	Dialègne I	500	7,075	√
8	Dialègne II	440	6,531	√
9	Diamaguène	600	4,898	√
10	Diamaguene Extension	420	3,265	√
11	Fass Camp des gardes	400	4,572	√
12	Gawane	520	7,075	√
13	HLM Sara	120	1,034	√
14	Kabatoki	500	5,007	
15	Kasnack	850	7,619	√
16	Kassaville	700	5,987	√
17	Keur Maloum	500	4,354	√
18	Koundam	300	3,048	√
19	Léona Centre	772	6,531	√
20	Léona Escale	600	4,898	√
21	Lyndiane	300	2,721	
22	Médina Baye	1,500	13,062	√
23	Médina Mbaba I	700	7,293	√
24	Médina Mbaba II	450	4,463	√
25	Ndangane	700	6,857	√
26	Ndargoundaw	500	4,354	√
27	Ndorong	560	5,442	√
28	Ndorong Sadaga	720	7,619	√
29	Ngâdé	150	1,088	
30	Ngane Alassane	500	5,660	√
31	Ngane Saer	300	3,810	√
32	Nimzatt	400	4,136	√
33	Parcelles Assainies	1,100	10,341	√
34	Peulgë	100	1,306	√
35	Sam	1,200	6,749	√
36	Sama Moussa	450	4,354	
37	Sara Ndiougary	1,800	16,327	√
38	Sing-Sing	950	7,837	
39	Taba Ngoye	450	5,769	√
40	Tabaya	200	1,959	√
41	Thioffack	1,100	10,341	√
42	Touba Kaolack	850	9,796	√
43	Touba Kaolack Extension	1,600	16,327	√
	Total	28,294	270,000	

Source: Kaolack City

(2) Projection Method

Projection of population in the future was made in the following steps.

1. Growth rate of population was calculated for each District.
2. Growth rate calculated in Step 1 is applied to the population of each District in 2012.
3. Increase was suspended when the population density reached 300 persons/ha, which was ranked at the largest group of population density in 2012.

Since some Districts had been divided into smaller ones between 1988 and 2012, same growth rate

was applied to the Districts that belonged to the same District in 1988.

(3) Projection Results

Population projection was made for the entire City and for the City Center. As mentioned above, the "City Center" is defined here as the Districts that are located in the area, where the City had been developing so far, and have high population density. Projection results are as follows:

Table 3.5.4 Projection Results

Year	All the City	City Center
2012	270,000	245,000
2015	291,000	270,000
2020	335,000	314,000
2025	373,000	352,000
2030	403,000	382,000

Projection and the actual census results in the past are compared as follows:

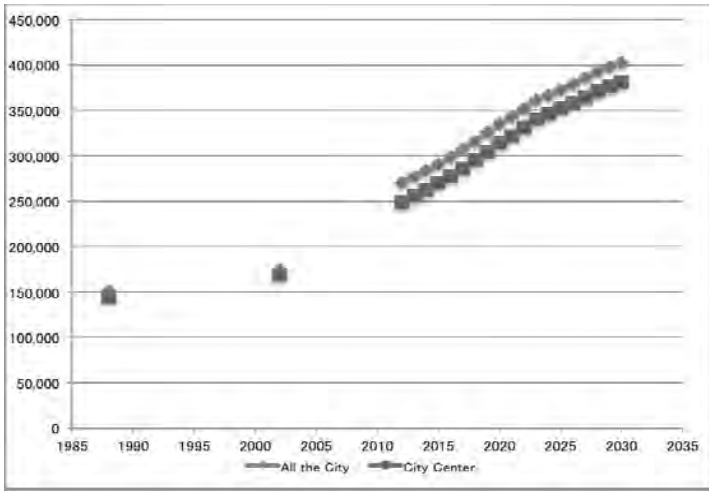


Fig. 3.5.2 Projection and Census Results

Annual growth rates are 1.0% in 1988-2002, 4.5% in 2002-2012 and 2.2% in 2012-2030. Annual growth rates are very low between the two census data and very high between the census data of 2002 and the City's data in 2012 while that in the projection is moderate. On the other hand, the annual growth rate in 1988-2030 is 2.4%. Hence, it can be said that the census data of 2002 is extremely low considering the whole trend of population growth.

(4) Projection by District

Population projection of the City was made for each district of the City Center. Trend of population growth was examined from the viewpoint of population density.

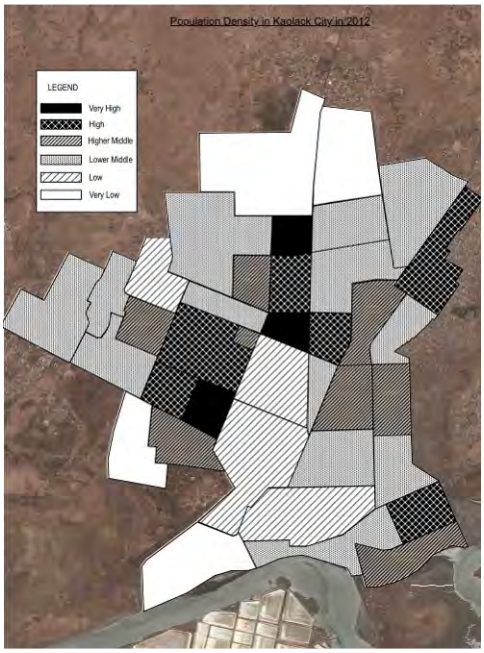


Fig. 3.5.3 Estimation for 2012

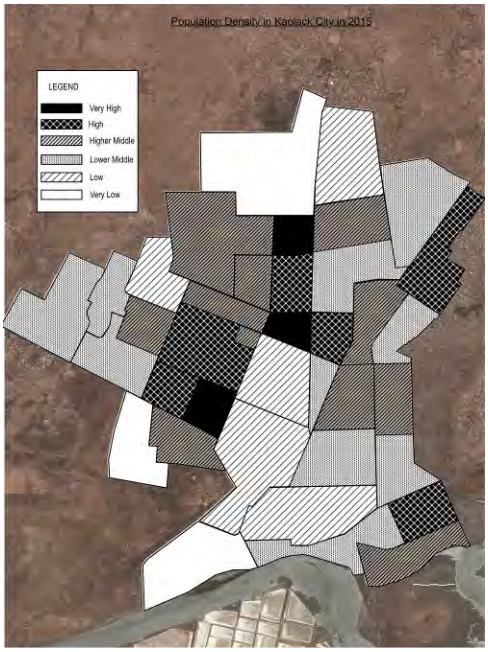


Fig. 3.5.4 Projection for 2015

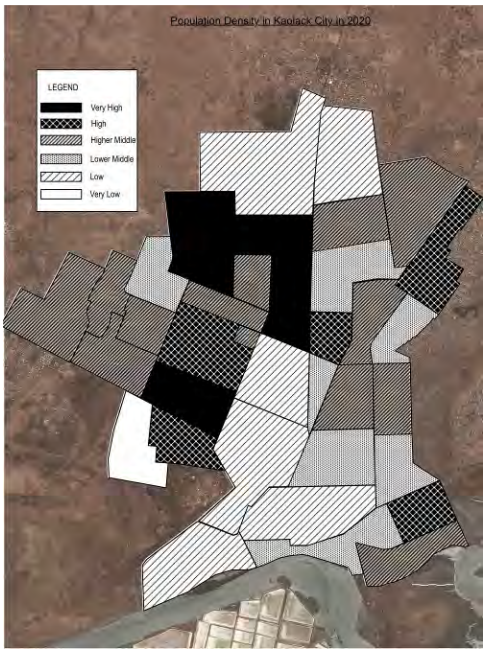


Fig. 3.5.5 Projection for 2020

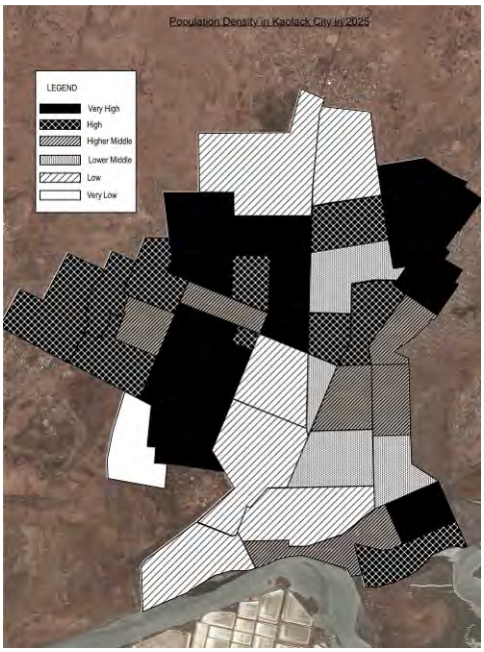


Fig. 3.5.6 Projection for 2025

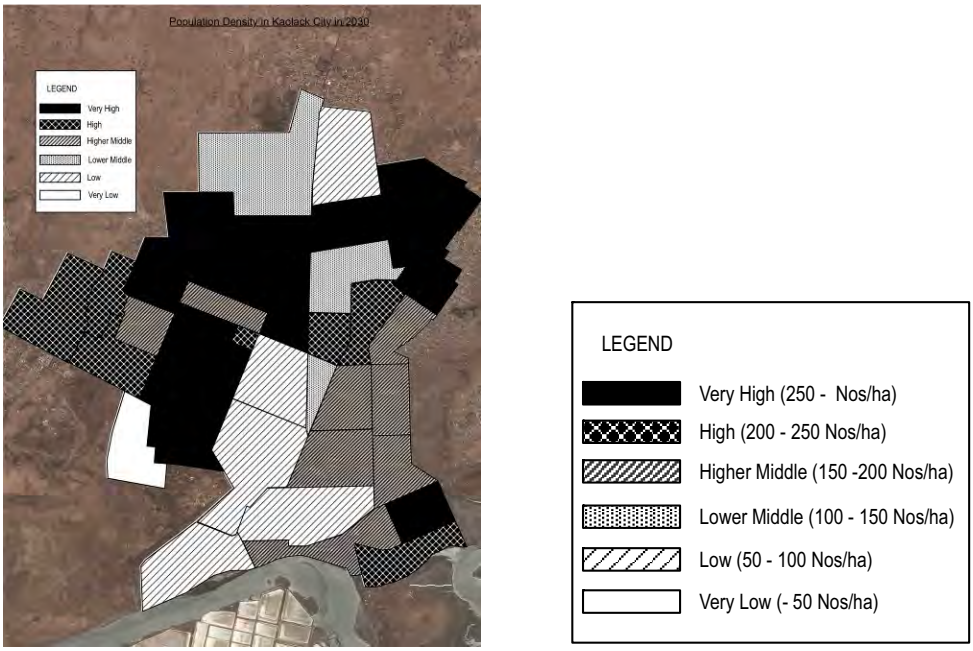


Fig. 3.5.7 Projection for 2030

The trend of population growth was seen as follows:

- Population will increase in the districts located along the two main roads.
- The City Center will expand northward and westward.
- Population in some districts of the City Center, that have been previously developed, will not increase.

CHAPTER 4. SEWERAGE/SANITATION SYSTEM IMPROVEMENT PLAN

4.1 Planning Concept

4.1.1 Planning Objectives

The planning objectives are: (i) to improve and update the present sewerage system (sewer pipe network, pumping stations and treatment plant) considering the applicability of technologies, efficiency of the wastewater collection/treatment, capacity of human recourses in ONAS and cost effectiveness; and (ii) to improve the sanitation condition of the inhabitants, as well as water environment of Kaolack City.

4.1.2 Planning Strategy

In the sewerage/sanitation system improvement plan, the sewered area is set with the following considerations:

- Sewered area is set up, targeting existing service area and high population density area in consideration of their topographical conditions as well as their priorities.
- Sewered area includes areas where on-site sanitation system cannot be installed due to some reasons such as high groundwater level.
- Sewered area is set up to make balance between the wastewater generation of the sewerage planning area and the capacity and land availability of sewage treatment plant.
- On-site sanitation facilities (septic tanks) are proposed for the areas that are not included in the sewerage planning area.

Relations between the considerations in setting up of sewerage planning area are depicted in the following schematic diagram.

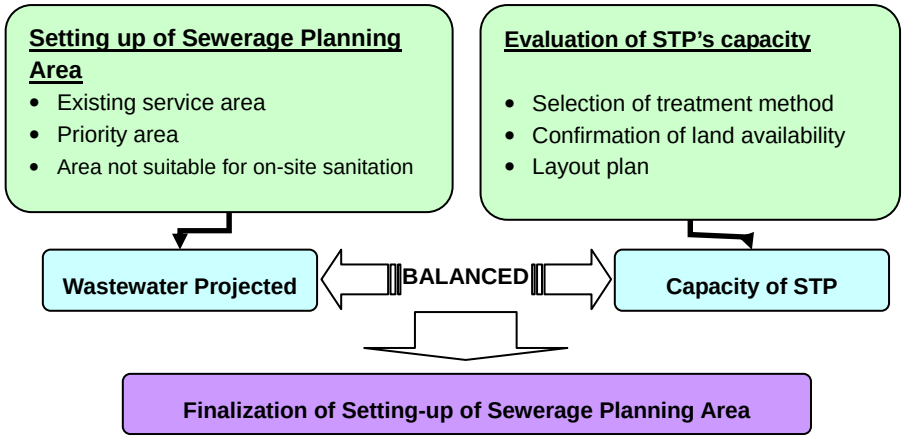


Fig. 4.1.1 Schematic Set-up of Sewerage Planning Area

4.1.3 Target Year

The target year of the Master Plan is 2030. It has to be implemented in three terms, as follows:

- Short-Term for Phase 1 projects by end of 2020
- Mid-Term for Phase 2 projects from 2021 to 2025
- Long-Term for Phase 3 projects from 2026 to 2030

Priority projects are selected from the Phase 1 projects from the viewpoints of degree of urgency, serviced population, as well as technical, financial and environmental considerations in a comprehensive manner.

4.1.4 Organizational and Institutional Improvement

ONAS is now under the Ministry of Hydraulics and Sanitation in the current administration. Staff members of ONAS Kaolack Office include the following:

- Chief: 1
- Administrative Assistant: 1
- Administrative Agent: 1
- Chief of Network Section: 1
- Chief of Station Section: 1
- Team Leader of Network: 2 (team members: 10 <not permanent>)
- Team Leader of Electricity: 1 (team members: 5 <not permanent>)

In the ONAS Kaolack Office, administration is fully controlled by the ONAS Headquarters in Dakar and nothing can be decided by the Kaolack Office except daily routine works. This is not the special case for ONAS and it can be seen in other government agencies such as APROSEN. In the implementation stage of the Master Plan, a project office should be established and authority be transferred to the Kaolack Office to cope with the problems in a timely manner.

The responsibilities of each of these actors have been clarified as follows:

- ONAS is responsible for project execution on the Government's behalf and, as such, (i) supervises implementation of project components; (ii) validates quarterly plans; and (iii) monitors and approves invoices for payment to the project management unit (PMU) and all other providers involved in project execution;
- Project Management Unit (i) handles allotment of the sanitation facilities; (ii) recruits consulting firms, NGOs and Community-Based Organizations (CBOs), and construction companies; (iii) issues payments; and (iv) reports to ONAS;
- Consulting firms carry out technical studies and supervise the construction companies;
- Construction companies perform the work; and
- NGO/CBOs implement the awareness-raising program and generate demand for sanitation services. The effectiveness of this social initiative is one of the key factors of the program's success because it provides a way to stimulate demand, identify and propose appropriate solutions for households, including the poorest among them, and promote sound practices in the area of hygiene and facility maintenance.

4.1.5 Financial Considerations

The sewerage charge is collected together with the water charge (8% of water consumption charge) and it is sent directly from Sénégalaise Des Eaux (SDE) to ONAS Dakar Headquarters. As mentioned above, the ONAS Kaolack Office is controlled by Dakar that it cannot touch the revenue on charges at all. The collection system is effective and efficient to keep the stability of financial base of ONAS. However, this system has no incentive for ONAS to pursue efficiency of management and improvement of service quality. In addition, appropriate level of charge setting should be examined carefully.

According to the Asian Development Bank's research paper, *Setting User Charges for Urban Water Supply, June 2006*, tariffs should at the very least try to meet the five goals: (i) good governance; (ii) financial sustainability; (iii) distributive justice; (iv) economic efficiency; and (v) fair pricing. They can be applied to the sewerage service with some amendments.

(1) Good Governance

Tariffs should be simple, transparent and predictable. These are necessary if users are to accept the tariff change smoothly. Also, changes should be announced well before they take place, and major changes should be introduced gradually.

(2) Financial Sustainability

Utilities should be financially independent and sustainable, be supported by tariff revenues, and their financial obligations be forecasted based on cash needs. In the event that the business makes a deficit, such a loss would finally have to be made up by governmental subsidy whose source is from taxes levied on all the people. As a result, costs would not be allocated on the basis of the benefit received. Consequently, people would perceive cost allocations to be unfair. On the other hand, if such governmental subsidy were to be expected, there would be no incentive for efficient business operation. Thus, if the governmental subsidy is required to stabilize the operation, its gradual reduction should be considered (short-term sustainability).

In addition, utilities require large amounts of capital investment so that the business should be operated from a long-term point of view to fulfill the needs of users in both a timely and appropriate manner. Such long-term sustainability also should be taken into consideration during tariff setting.

(3) Distributive Justice

Sewerage service is one of the basic needs to keep good sanitary conditions of urban life. Thus, support should be extended to help the poor live in good sanitary conditions. ADB encourages using a low charge to the meet the basic needs, with a usage charge above that of the basic needs set on other criteria. While ADB does not detail the level of support, World Bank presented the benchmark for the affordability of households as 1% of their disposable income.

(4) Economic Efficiency

Ideally, services should be supplied at least cost and without losses yielding maximum satisfaction to the society where the resource is being utilized. Although standard economic theory concludes that prices decided in the competitive market are the most efficient ones, sewerage service is usually a monopolized business in order to derive scales of economy, since it requires huge capital investments. Thus, some schemes should be devised to realize production at least cost.

(5) Fair Pricing

The meaning of fairness is vague and ADB does not have an explicit position on fairness. Formally, fairness can be deemed as a benefit principle where everyone should pay the cost with which the service is supplied to himself/herself. From this point of view alone, tariff with cross-subsidy from the rich to the poor, which is the goal of distributive justice, cannot be justified. Thus, fairness should find some compromise to realize distributive justice. In this case, the government is required to persuade relatively rich users to accept distributive justice.

4.2 Future Improvement Frame Projection

4.2.1 Target Area

The target area of sewerage/sanitation system improvement plan, which covers the whole city center of Kaolack City as agreed with ONAS Kaolack through T/C and S/C, is shown in **Fig. 4.2.1**. The total target area is about 19 km^2.

Fig. 4.2.1 Target Area of Sewerage/Sanitation System Improvement in Kaolack City

4.2.2 Population

Sewered population is estimated based on the projected population described in **Sub-section 3.3.2**. Sewerage facilities shall be designed to collect, convey and treat wastewater generation in 2030.

4.2.3 Future Demand Projection

(1) Wastewater Generation per capita

(a) Domestic Water Consumption

As discussed in the "Basic Study," the average domestic water consumption of Kaolack City in 2011 is calculated at 58 L/capita/day. Based on this amount, domestic water consumption for the years 2015, 2020, 2025 and 2030 is projected under the following assumptions:

- Domestic water consumption of 58 L/capita/day increases linearly toward the target year in parallel with the improvement of living standard of the people in Kaolack City.
- A 70 L/capita/day, which is the typical value in the residential area in Kaolack City, is set up for the target year of 2030.
- Interpolation is applied to project the value of 2015, 2020 and 2025 (**Fig. 4.2.2**).

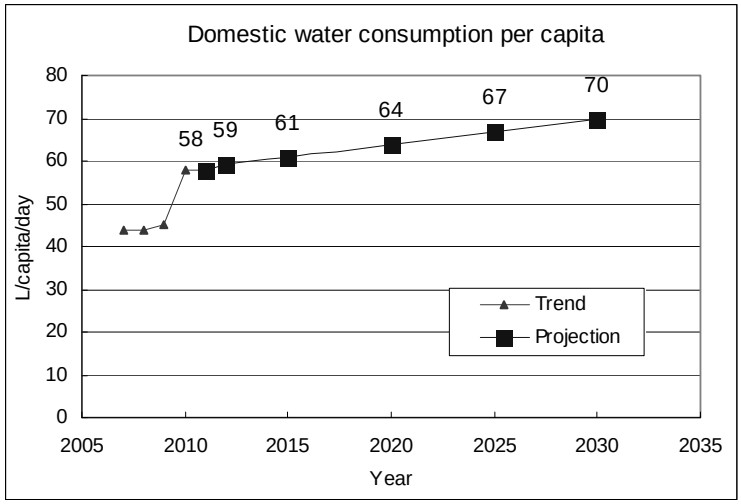


Fig. 4.2.2 Domestic Water Consumption Per Capita in Kaolack City

(b) Commercial and Administrative Water Consumption

Amounts of commercial and administrative water use are estimated based on the maximum ratio of commercial to domestic in the 5 years (2007-2011) which is 0.25 (commercial water consumption corresponds to 25% of domestic use).

(c) Wastewater Generation Ratio

Wastewater generation ratio is introduced to project wastewater generation per capita since a part of water, which is used for gardening, laundry and washing-up in the yard, is not discharged to sewer pipe network. In the M/P, the typical wastewater generation ratio of 85% is employed for wastewater projection.

(d) Groundwater Inflow

In general, in order to design sewerage facilities, groundwater inflow is included in the wastewater generation because small amount of inflow is inevitable especially in the joint portions of pipes and manholes even if their joints are properly designed and constructed. However, it is difficult to estimate the amount of inflow since no data of the inflow in the existing sewer network is available. Therefore, in the M/P, amount of inflow is estimated, using

the same amount of inflow per unit length of sewer pipe applied in "the Study on Urban Drainage and Wastewater Systems in Dakar City and its Surroundings", 1994, JICA. As shown in **Table 4.2.1**, inflow of 171 m^3/day is calculated by multiplying the length of existing sewer pipe by the inflow amount, which corresponds to about 10% of actual wastewater inflow to STP. Thus, the 10% is employed to project groundwater inflow for the period 2015 to 2030.

Table 4.2.1 Setting up of Inflow Ratio

	Diameter (mm)	Existing sewer length (km)	Inflow per unit length (m^3/day/km)	Average covering (m)	Sewers under groundwater (assumed)	Inflow (m^3/day)
Branch sewer	D ≤ 250	44.8	10	1-2	10%	45
Trunk sewer	300 ≤ D	6.3	20	2-3	100%	126
Total		51.1				171

Notes: 1) Typical groundwater level in Kaolack City generally ranges 2-3 m below the ground level, according to the data provided by DGPRE (Directorate of Management and Planning of Water Resources).

(e) Connection Ratio

Connection ratio is discussed in **Section 4.8**.

(f) Summary of Wastewater Generation Per Capita

Based on the above discussions, wastewater generation per capita for the years 2015, 2020, 2025 and 2030 are summarized in the following table.

Table 4.2.2 Summary of Wastewater Generation per Capita

Item	Unit	2012 (Present)	2015	2020	2025	2030	Remarks
Water consumption							
Domestic	lpcd	59	61	64	67	70	(a)
Commercial and administrative	lpcd	15	15	16	17	18	(a)×25%
Total	lpcd	74	76	80	84	88	
Wastewater generation ratio	%	85%	85%	85%	85%	85%	
Wastewater generation [1)]	lpcd	63	65	68	71	75	
Groundwater inflow	%	10%	10%	10%	10%	10%	

Note 1) including commercial consumption

(2) Pollution Load Generation

BOD_5, which represents organic pollution load, is set as the basic parameter to design the treatment plant. In the M/P, the typical BOD_5 load of 40 g/capita/day is set for the target year (this value is also set in the M/P formulated in 1979 and the IDB project). The BOD_5 load of 40 g/capita/day includes pollution load of domestic and commercial use. On the other hand, BOD load per capita of 28 g/capita/day in 2012 is estimated in comparison with annual average BOD of Kaolack STP monitored in 2011 and the wastewater generation per capita. The BOD_5 load per capita of 28 g/capita/day in 2012 seems to be relatively small, but this kind of small value could be obtained from the reasons that: (i) sedimentation tends to take place in the pipes where wastewater per capita remains in low level, (ii) some portion of users discharge their wastewater through their septic tanks (without disconnecting septic tanks). But these phenomena are gradually eliminated and the BOD_5 load per capita reaches 40 g/capita/day in 2030. Concentration of COD_{Cr} and TSS, which is supplementary parameter for designing treatment plant, is estimated, employing a ratio of BOD_5 : COD_{Cr} : TSS = 1.00 : 2.00 : 1.25, monitored in 2011.

The following table summarizes BOD_5 load per capita and concentration of 3 parameters (BOD_5, TSS and COD_{Cr}).

Table 4.2.3 Pollution Load Generation per Capita

Item	Unit	2012 (Present)	2015	2020	2025	2030	Remarks
BOD_5 load per capita	gpcd	28	30	34	36	40	(a)
Wastewater generation	lpcd	63	65	68	71	75	(b)
Groundwater inflow	%	10%	10%	10%	10%	10%	(c)
Concentration							
BOD_5	mg/l	404	420	455	461	485	(d) [1)]
COD_{Cr}	mg/l	808	840	910	922	970	(d)×2.00
TSS	mg/l	505	525	569	576	606	(d)×1.25

Note 1) : (d)=(a)/{(b) × (100+(c))/100} × 1,000

4.2.4 Design Conditions

(1) Sewer Network and Pumping Stations

The sewer network shall be basically designed using the gravity flow. The sewer pipe diameter is designed based on the hourly maximum sewage flow with given allowance in order to cope with the hourly fluctuation and to secure enough flow velocity that will prevent stagnancy and accumulation of wastes and sediments. Major design criteria and calculation formula are listed in **Table 4.2.4**.

Table 4.2.4 Design Criteria and Calculation Formula

Item	Criteria, Formula
Flow velocity formula	Gravity flow: Manning's Formula Pressure flow: Hazen-William's Formula
Flow velocity	From 0.6 m/s to 3.0 m/s
Ratio of peak flow and allowance	Hourly peak flow: 2 times of daily average flow Allowance: (i) more than 100% for pipe diameter up to 600 mm, and (ii) 50% to 100% for diameter of more than 700 mm
Earth covering	Not less than 1.0m
Pipe material	Diameter ≤ 500mm: PVC pipe, n = 0.010 600 mm ≤ Diameter : RC pipe, n = 0.013 Force main: Cast iron pipe, C = 110

(a) Flow Velocity Formula

$v = (R^{2/3} I^{1/2})/n$ (Manning's Formula)

where; v: velocity (m/s), R:hydraulic radius (m) = flow section / wetted perimeter, I:gradient (decimal fraction), n:roughness coefficient

$v = 0.84935CR^{0.63}I^{0.54}$ (Hazen-William's Formula)

where; v: velocity (m/s), C:velocity factor = 110, I:hydraulic gradient (decimal fraction), R:hydraulic radius (m)

(b) Maximum and Minimum Flow Velocity

Flow velocity shall be within the range of 0.6 m/s to 3.0 m/s in order to prevent the accumulation of wastes and sediments, and not to damage the inside of pipe.

(c) Ratio of Peak Flow and Allowance

In the M/P, hourly peak flow is determined to be two times of daily average flow by using the same ratio applied in "The Study on Urban Drainage and Wastewater Systems in Dakar City and its Surroundings", 1994, JICA due to the lack of hourly flow rate data to STP in Kaolack. Capacity of pumping stations shall be designed based on the hourly peak flow.

Allowance shall be considered to determine the diameter of sewer pipes. The allowance is set by referring to the design example in Kaolack including the PRECOL project and "Guideline for Planning and Design of Sewerage Facilities", Japan Sewerage Works Association.

(d) Pipe material

At present in Senegal, PVC pipe is widely applied to sewer pipe with the diameter of not more than 500 mm. PVC pipe is superior to RC pipe in aspects of corrosion resistance, low roughness coefficient, water-tightness, durability and quality control in manufacturing process.

On the other hand, structural strength of PVC pipe is lower than RC pipe, especially with large diameter. In Senegal, RC pipe is adopted with the diameter of not less than 600 mm. For force main, cast iron pipe is applied in consideration of internal pressure.

(2) Sewerage Treatment Plant

Daily average flow is employed[10] for the design of sewage treatment facilities since the treatment methods applied in the Master Plan has relatively long retention time (more than 24 hours) and could absorb hourly and daily fluctuation of inflow. Treatment facilities are designed to meet the discharge criteria in "Senegalese Standards NS 05-061 of July 2001, Wastewater: Discharge Standards": BOD_5=40 mg/l, COD=100 mg/l, TSS=50 mg/l and Fecal coliform=2,000 CFU/100 ml. The treated water is discharged to the Saloum River.

4.3 Development Concept of Sewerage/Sanitation System

4.3.1 Alternative Study for Improvement of Sewerage System

(1) Approach to Selection of Wastewater Treatment Method

Before setting up of sewerage planning area, wastewater treatment method and capacity for Kaolack STP is evaluated and figured out in consideration of land availability.

At present, in Senegal, 9 wastewater treatment plants are in operation, adopting 3 treatment methods, namely; (i) activated sludge process (4 locations); (ii) aerated lagoon (1 location); and (iii) lagoon (5 locations), as shown in the following table. Of the 3 methods, activated sludge process is large in number but is adopted only in Dakar and its major neighboring city, namely, Thies. In addition, some of the activated sludge plants are small in scale; hence, they can be categorized as "community plants." In fact, major cites other than Dakar and Thies adopts lagoon and/or aerated lagoon only.

Table 4.3.1 List of Wastewater Treatment Plant in Operation

Name of STP	Treatment method	Target sewered population	Capacity (m^3/day)
Cambérène	ASP	200,000	19,200
SHS (Guediawaye)	ASP	Unknown	595
Niayes (Pikine)	ASP	do	875
Rufisque	Lagoon	45,403	2,856
Keur saib ndoye (Thies)	ASP/Lagoon	70,000	3,000
Saint-Louis	Lagoon	20,000	600
Saly	Lagoon	600	1,020
Luga	Lagoon	20,000	600
	AL	12,000	720
Kaolack	Lagoon	20,000	390

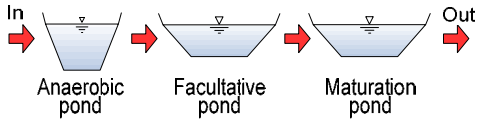
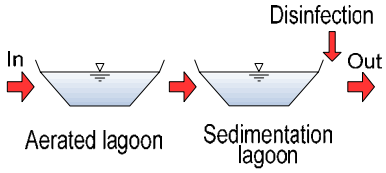
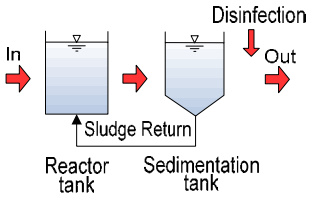
Note; ASP: Activated Sludge Process, AL: Aerated Lagoon
Source: ONAS

Based on the study results, Kaolack STP has difficulties even in operation of lagoons due to sedimentation and malfunction of discharge weir and so on. In addition, aerated lagoons are not operational without being handed over by the donor. Considering those conditions, adoption of conventional activated sludge process is too early for Kaolack. Accordingly, treatment method for

[10] Reference: "Guideline for Application of Technology in Stormwater Management and Sewage Treatment in the Developing Countries", Ministry of Land, Infrastructure, Transport and Tourism, Japan. Seasonal fluctuation of inflow to the STP as shown in **Fig. 2.2.9** will be gradually reduced with the implementation of stormwater management plan proposed in the Master Plan.

Kaolack STP should be evaluated, focusing on lagoon, aerated lagoon and at maximum oxidation ditch (one of the simplified activated sludge process). The following table shows the outline of the three treatment methods.

Table 4.3.2 Outline of the Treatment Methods

Method	Typical Flow Sheet	Salient Features
Lagoon		• Wastewater is treated without machinery. Oxygen is introduced into the lagoon by photonic synthesis and thus wastewater is purified. • Among the three methods, O&M is the easiest and unit cost for treatment is the lowest. On the other hand, land requirement is the largest.
Aerated lagoon		• By installing aerators in lagoons, treatment efficiency is upgraded and reduction in land requirement is achieved compared to Lagoon • O&M is easier than that of OD
Oxidation ditch (OD)		• Endless channel is employed for wastewater circulation. Equipment is simplified and easier O&M is achieved compared to activated sludge process. • Land requirement is smaller than that of aerated lagoon • Construction cost is biggest among the three methods.

(2) Expansion and Capacity of STP

To operate more than one location of STP is not favorable because operation and maintenance becomes inefficient and thus additional staff (team) will be required. In addition, the STP should be located near Saloum River to prevent from installing discharge pump station. Therefore, acquisition of the adjacent area of existing STP is proposed for the augmentation of capacity. The expansion area delineated by broken line in **Fig. 4.3.1**, has 11.3 ha in total. The capacity of the STP is discussed in detail in "Description of the Alternatives".

Application of regulation of keeping at least a radius of 500 m from neighboring houses described in **Subsection 2.5.1**, is consulted in the EIA study of Feasibility Study stage.

Fig. 4.3.1 Existing STP and Proposed Expansion Area

(3) Expansion of Sewer Network

Expansion areas of sewer network, alignment of trunk sewers, and design of sewer pipes have been

studied in consideration of the following:

- Expansion area of sewer network shall be determined considering the boundary of watershed, districts, and present sewered area.
- New sewer network shall be connected to the existing network in order to utilize the existing sewer network including pumping stations, and to minimize the construction cost.
- Capacity of sewer pipes and pumping stations shall be designed to discharge the total quantity of wastewater generation in 2030 with 100% connection.
- New pumping stations shall be constructed in vacant space to avoid the resettlement.

(4) Description of the Alternatives

The following alternatives are selected in consideration of the above discussion. Capacity of STP for the Alternatives is determined considering the maximum expansion area shown in the **Fig 4.3.1**.

(a) No Action

Appropriate interventions will be required in Kaolack City, considering rapid urbanization, as well as present sanitary issues such as low sewer connection, malfunction of sewage treatment plants and inappropriate septage management. Therefore, No action (Alternative 0) is not discussed in detail in this section.

(b) Alternative 1

The expansion of sewered area is set to correspond to the STP's capacity with the treatment methods of lagoon and aerated lagoon[11] (Total capacity, Q=15,000 m^3/day; **Fig. 4.3.5** shows the layout plan). In this alternative, the sewered area covers the southern part of Kaolack City, as shown in **Fig. 4.3.2**. In addition, 3 pumping stations are newly constructed (PS No. 1 North, PS Boustane, PS Darou Salam Ndangane). Furthermore, a new trunk sewer with the total length of 15.0 km including force main is installed.

(c) Alternative 2

The expansion of sewered area is set to correspond to the STP's capacity with the treatment method of aerated lagoon (Total capacity, Q=21,000 m^3/day; **Fig. 4.3.5** shows the layout plan). In this alternative, the sewered area covers the areas of Alternative 1, Touba Kaolack Ndorong Sadaga, Keur Maloum, Gawane and Diamaguène district, as shown in **Fig. 4.3.3**. In addition, 4 pumping stations are newly constructed (same 3 locations as in Alternative 1 and PS Touba Kaolack). A new trunk sewer with the total length of 27.7 km including force main is installed.

(d) Alternative 3

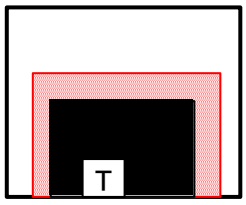
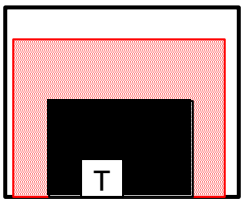
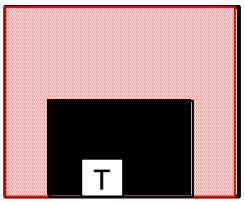
In this Alternative, sewered area covers the whole city center, as shown in **Fig. 4.3.4**. To treat the generated wastewater, oxidation ditch process is employed with the total capacity of Q=32,000 m^3/day (**Fig. 4.3.5** shows the layout plan). In addition, 5 pumping stations are newly constructed (same 4 locations as in Alternative 2 and PS Darou Salam Diamaguène). A new trunk sewer with the total length of 45.1 km including force main is installed.

(5) Outline of Alternatives

The alternatives are summarized in the following table, including construction and operation and maintenance cost. The construction cost for major facilities (trunk sewer, pumping stations and sewage treatment plants) consists of construction works of proposed facilities and rehabilitation. Construction cost of branch sewer includes the cost of branch sewer installation in the expansion and existing unsewered area. Operation and Maintenance (O&M) cost includes cleaning work cost, sludge disposal, electricity bill, personal expense and so on.

[11] Capacity of lagoon system using existing and expansion area is about 7,000 m^3/day and as a result expansion of sewerage area is very limited; therefore, the treatment system of lagoon and aerated lagoon system is applied in this Alternative.

Table 4.3.3 Outline of Alternatives

		Alternative 1	Alternative 2	Alternative 3
Schematic diagram of setting up sewered area				
Sewered area (ha)		1,020	1,340	1,930
New trunk sewer (km)		15.0	27.7	45.1
Number of new P/S		3	4	5
Treatment Method and capacity (m^3/day) in STP		Lagoon : 3,000 Aerated lagoon : 12,000 Total : 15,000	Aerated lagoon: 21,000 Total : 21,000	Oxidation ditch: 32,000 Total : 32,000
Sewered population in 2030		178,000	252,000	379,000
Wastewater projection in 2030 (m^3/d)		14,685	20,790	31,270
Coverage Ratio (%)[1]	Sewerage system	47%	66%	99%[2]
	On-site sanitation	53%	34%	1%
Construction cost (mil. FCFA)	Trunk Sewer	5,950	8,954	14,170
	Pumping stations	2,316	3,148	4,671
	STP[3]	6,042	9,459	22,065
	Sub-total	14,308	21,561	40,906
	Brunch sewer[4]	11,757	17,720	28,875
	Grand total	26,065	39,281	69,781
O&M cost (mil. FCFA)	Sewer network & PSs[5]	375	504	750
	STP[3]	433	741	1,255
	Total	808	1,245	2,005

Legend: T :STP ■ : Existing service area ▭ : Expansion area ▭ : Boundary of ctiy center

Note:
1) Coverage ratio of sewerage system is percentage to total population of 382,000 in City Center.
2) Coverage is not 100% because some part of the city cannot be feasibly covered by sewerage system mainly due to topological reason.
3) Including septage facilities. Construction cost of lagoon and aerated lagoon are calculated by bill of quantity method; oxidation ditch is calculated using cost function of $C=1.5\times912\times Q^{0.79}=1.368\ Q^{0.79}$ (C: mil FCFA, Q=1,000 m^3/day), by referring to the Study on Urban Drainage and Wastewater Systems in Dakar City and its Surroundings" in 1994, JICA, in consideration of price escalation.
4) Cost of branch sewer in the unsewered and expansion area under the assumption that the length of branch sewer is 260 m/ha.
5) O&M cost of sewer network includes that of trunk sewer and branch sewer.

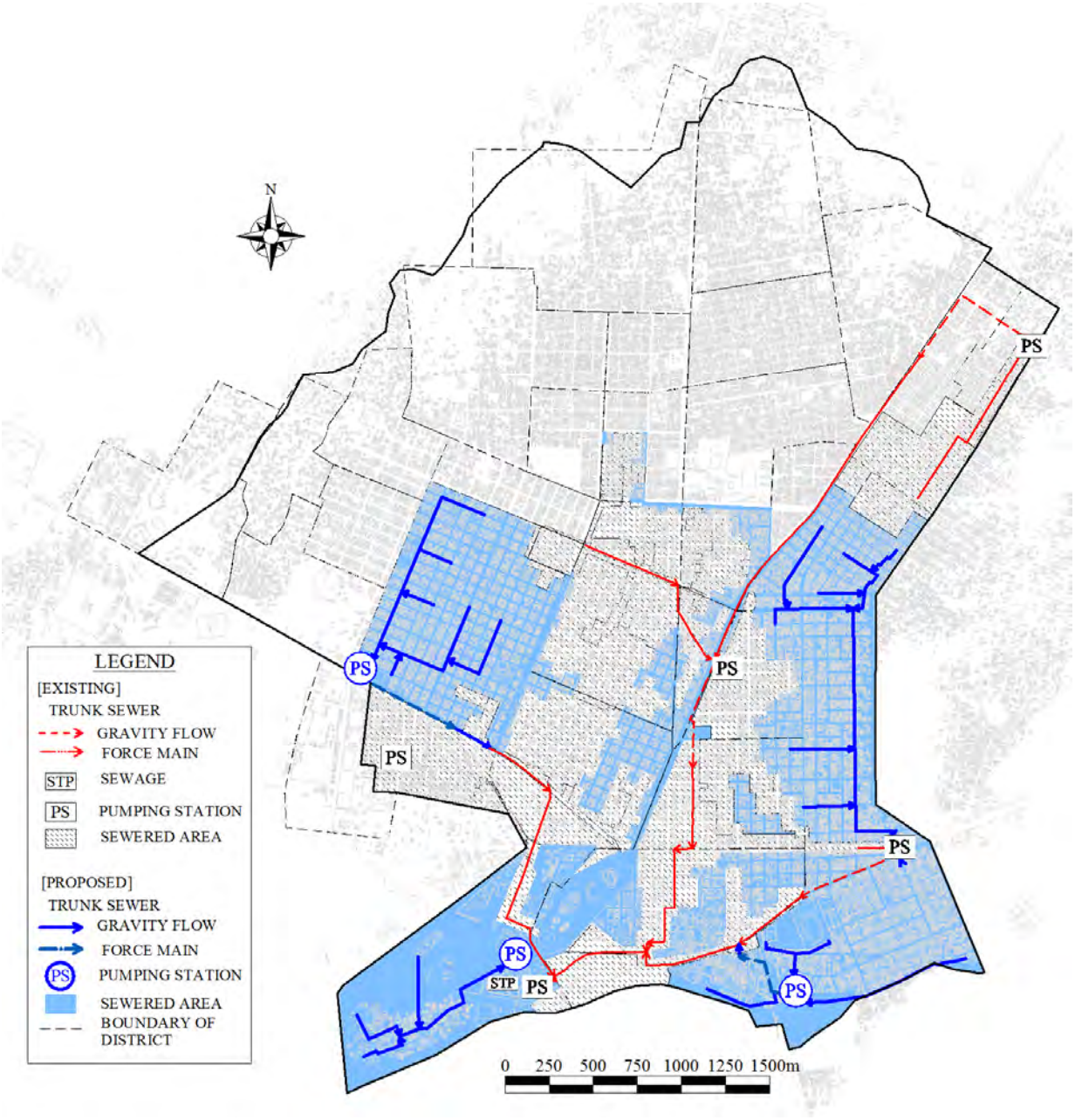


Fig. 4.3.2 Layout Plan of Alternative 1 (Sewer Network)

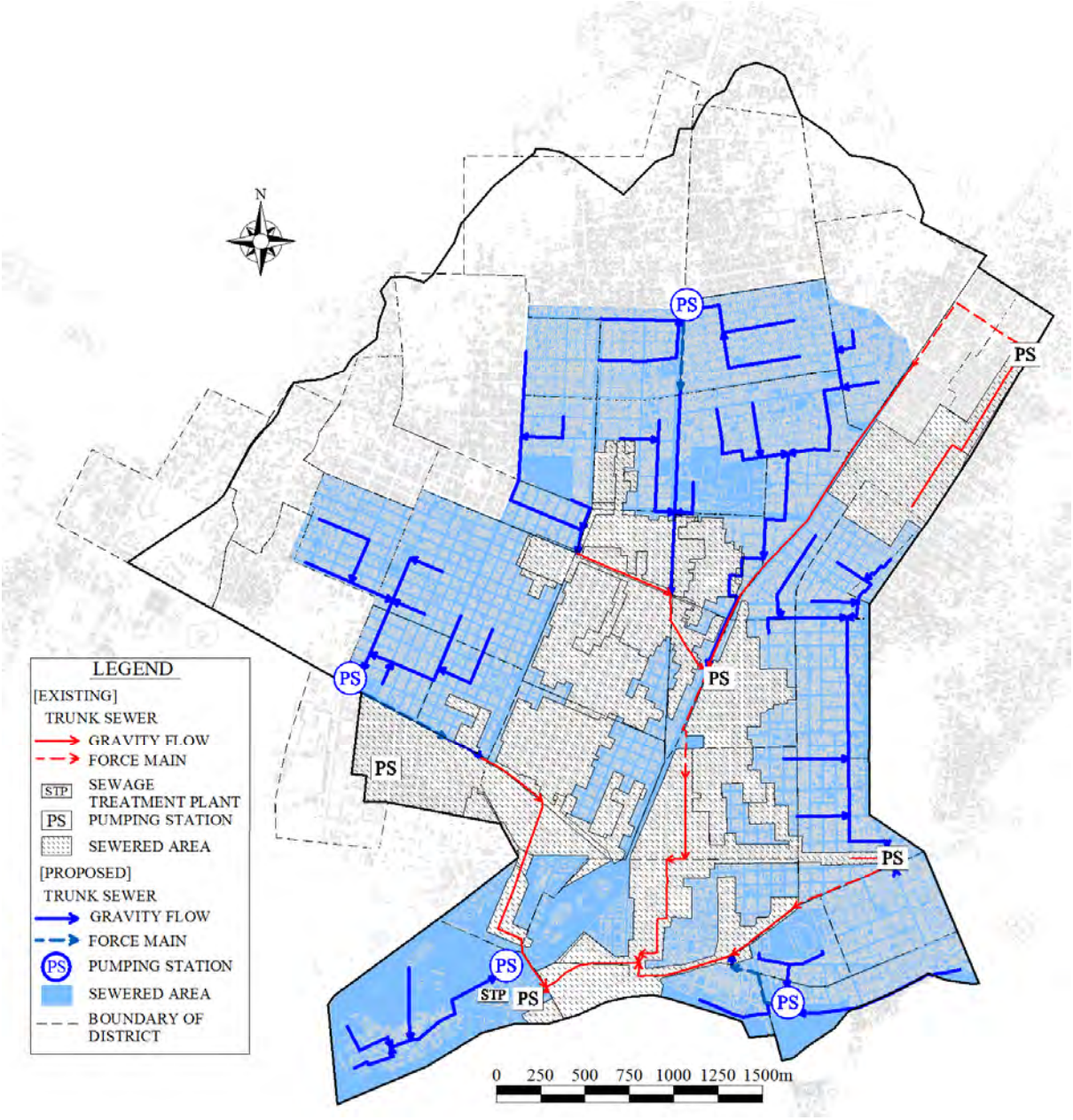


Fig. 4.3.3 Layout Plan of Alternative 2 (Sewer Network)

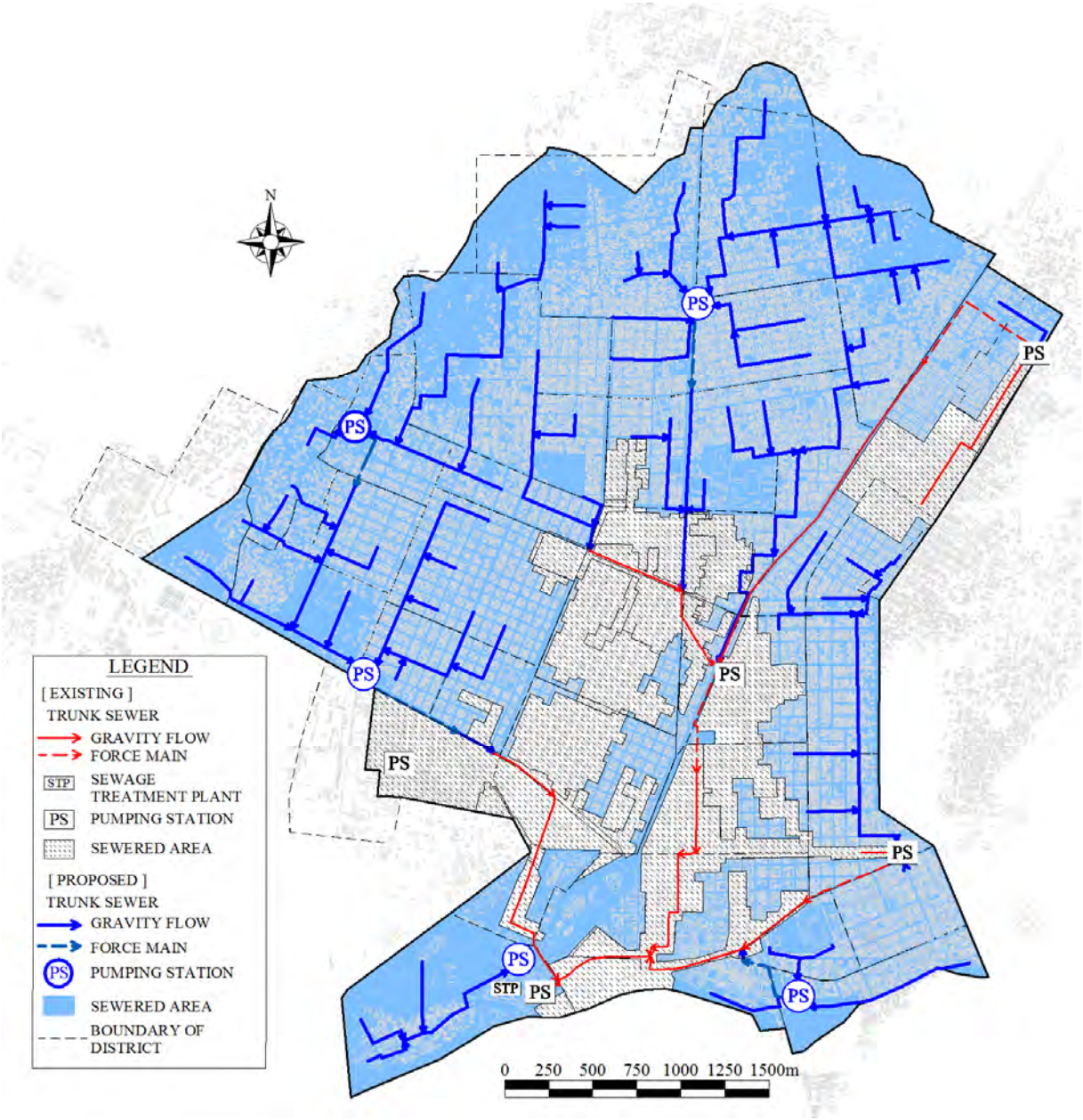


Fig. 4.3.4 Layout Plan of Alternative 3 (Sewer Network)

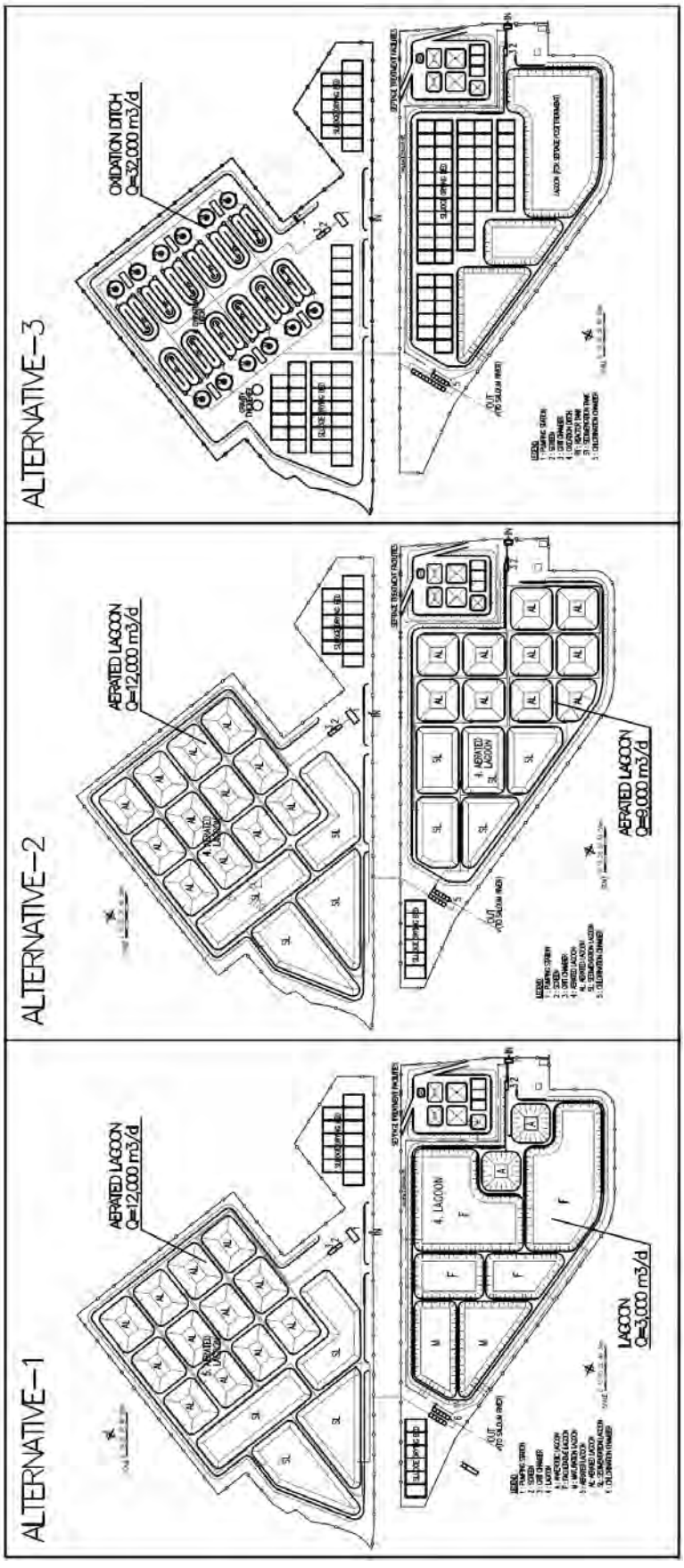


Fig. 4.3.5 Layout Plan of Alternatives (STP)

(6) Comparison of Alternatives

Comparison of the alternatives is discussed below.

(a) Evaluation Criteria

The criteria for the evaluation of alternative STPs are as follows:

- *Sewered Population* - Sewered population is the basic criterion in the evaluation.
- *Ease of Operation and Maintenance/Reliability* - Ease of operation and maintenance is essential to sustainable operation and maintenance. Reliability depends on the potential mechanical and electrical failures of the system, and it can be improved by reducing the number of pumping stations and selecting simplified treatment processes.
- *Operation and Maintenance Cost* - Lower operation and maintenance cost is favorable to minimize the financial burden to ONAS.
- *Environmental Impact* - negative impacts might be caused in the construction and operation of some facilities. On the other hand, positive impact may be expected by the installation of facilities (the evaluation is described in **Subsection 7.2.2** in detail).

(b) Evaluation of Alternatives

Based on the above criteria, a ranking of 1.0 to 3.0 is given to each criterion with 1.0 being the least favorable, as shown in the following table.

Alternative 1 is the most favorable in terms of ease of operation and maintenance/reliability, as well as operation and maintenance cost. However, sanitary improvement is limited due to the limited sewer expansion.

Alternative 3 is the most favorable in terms of sewered population. However, the alternative is less favorable in terms of ease of operation and maintenance/reliability because it requires the oxidation ditch process, which requires higher operational know-how than those of lagoon and aerated lagoon. Moreover, highest operation and maintenance cost will be a financial burden to ONAS. Further, large-scale and long-duration construction work covering the whole city center might cause more negative impacts compared with Alternative 2.

Alternative 2 is less favorable than Alternative 3 in terms of sewered population, but it could cover more than 66% of the city center. Considering actual septic tank installation ratio of about 50% in Kaolack City, sanitary improvement facilities (sewer network and septic tanks) could cover more than 80[12]% of city center in 2030. In terms of operation and maintenance cost, Alternative 2 is more favorable than Alternative 3.

Considering the above evaluation, Alternative 2 is selected as the optimal one. Thus, the sewerage improvement master plan has been formulated based on Alternative 2.

Table 4.3.4 Ranking of Alternatives STP's

	Alternative 1	Alternative 2	Alternative 3
Sewered population	1	2	3
Ease of O&M / Reliability	3	2	1
O&M cost	3	2	1
Environmental impact	1	3	2
Total	8	9	7
Overall ranking*)	**2nd**	**1st**	**3rd**

Note: * "1st" rank is most favorable.

[12] Sewered population (66%) + 50% of people in on-site sanitation area (34%) could reach more than 80%.

4.3.2 On-site Sanitation Treatment System

(1) Background

As of November 2011, 1,600 houses/buildings have been connected to the sewer network in Kaolack City. On the assumption of average number of ten residents in a household, the serviced population could be estimated at 16,000, which is equivalent to 6.4% of the total population of 249,000 of Kaolack City center in 2012. This fact means that the remaining 93.6% of residents in the city center are relying on some sort of on-site sanitation system at present. The city center is defined as a built-up area in the city excluding the four districts located in the outskirts of the city, namely; Kabatoki, Lyndiane, Sama Moussa and Sing Sing.

In the urban area of Kaolack, the major on-site sanitation facility is the septic tank with two compartments connecting to an infiltration pit with gravel base. Soak pit latrine and pit latrine are not popular in the urban areas due to poor infiltration capacity of soil. Furthermore, designing and installation of septic tanks should be basically approved by ONAS, but residents have been installing their own-sized tanks without approval according to ONAS Kaolack. On the other hand, the soak pit latrine and pit latrine are popular in the rural areas extending to the outskirts of Kaolack City.

It is required that not only human waste but wastewater from kitchen, laundry and bathroom should go together into the septic tank in private houses. It is, however, not always the case. Sludge accumulation occurs gradually at the bottom of the tank, and treatment efficiency will drop in parallel with the decrease of effective volume of the tank. Thus the sludge should be periodically removed once in every two to five years. Each household is responsible for desludging of septage, but it is not clear if they perform it properly. There is no regulation on desludging of septage accumulated in the septic tanks, and the desludging is made at the owner's decisions.

In these circumstances, septage desludged from the septic tanks are exposed to the environment without any treatment in Kaolack City. The desludging trucks have been disposing septage to the fields in the suburb of Sing Sing, Kaolack. Disposal of septage has been made, discharging it into a pond dug on the riverbed of the Saloum in the dry season, however, hauling trucks could not reach the pond and septage collected is disposed over the riverbed on the way to the pond in the rainy season due to inaccessibility. On the other hand, manual desludging by labors, called as "Baay Pelles," has been also popular in Kaolack due to cheaper cost. After manual desludging of septage, the removed sludge is disposed in the holes dug near the houses. According to interview results, residents pay 30,000 FCFA for desludging by tank truck, while they pay only 3,000 to 5,000 FCFA for manual desludging.

As the average sewerage charge paid by one household per month is estimated about 265 FCFA by JICA Expert Team. Thus, if desludging is conducted once in about 113 months by tank truck, or about 11 to 18 months by manual, its charge matches the sewerage one.

The present septage disposal system is regarded as a kind of land disposal and/or land spreading, of which methodology has been widely and commonly applied over the world where applicable wide land is available near the towns/cities. This kind of treatment, however, can be implemented on the premise that the residents and the related communities around the disposal site will accept this kind of simple technology from social and environmental aspects. In Kaolack City, the environmental degradation occurs in parallel with septage disposal, particularly, in the rainy season, and the residents also oppose the present disposal system. Thus the study on the suitable septage treatment system has been made as discussed below.

(2) Project Objectives

The specific objectives for the septage treatment plan are given below.

- To provide suitable overall wastewater management not only through sewerage network improvement but also through installation of septage treatment facilities for the remaining areas relying on on-site sanitation system, and

- To prevent the discharge of human wastes to the surrounding environment as well as ambient water bodies.

Prior to this study, a feasibility study on the septage treatment plant was made for three cities, Kaolack, Saint Louis and Louga by GKW Consult in 2005 with support from IDA (International Development Association). The F/S Report was named as the "Etude de Faisabilite et Etudes Techniques des Stations de Traitement des Boues de Vidange dans Les 3 Centres Regionaux de Saint-Louis, Kaolack et Louga" Rapport Definitif, Septembre 2005, GKW CONSULT (Credit IDA 3470 SE).

(3) Characteristics of Septage

Septage is generally defined as the liquid and solid material extracted from a septic tank during cleaning. Its high waste strength is due to accumulation of sludge and scum in the septic tank. Typically, a septic tank will retain 60 to 70% of suspended solids, oil and grease introduced from the dwelling served. The bulk of the suspended solids settle to the bottom of the tank, and the oil and grease and other floatable materials are retained between the inlet and outlet baffles. Over a period of time, the sludge and scum can build up to a point where it occupies from 20 to 50% of the total septic tank volume.

Septage generation rates reported in literatures vary widely. In the F/S Report, the design septage generation rate of 0.3 l/capita/day is used. Normally, between 200 to 300 l/capita/year is used in the developed countries. Thus 0.3 l/capita/day (= 110 l/capita/year) might be relatively small due to differences of water usage and living styles between the developed and the developing countries.

Regarding constituents in septage and municipal wastewater, septage is a waste similar in characteristics to domestic sewage, except that the former is more concentrated. However, there are also dissimilarities. Septage is anaerobic and odoriferous. It contains plastic materials, hair and grit that clog and wear pumps and conduits. Personal contact with septage for maintenance purposes is highly objectionable from aesthetic and healthy points of view. These aspects of septage characteristics must be considered in the design of septage handling and treatment facilities.

According to the F/S Report, the following septage parameters were used, so that this study refers to the same values as well.

- BOD_5: 3,540 mg/l
- COD_{Cr}: 1,700 mg/l
- TSS: 7,555 mg/l
- $N\text{-}NH_4$: 816 mg/l

(4) Selection of Suitable Septage Treatment Techniques

In general the basic methods of treating and disposing septage are three, namely; (a) land disposal; (b) co-treatment; and (c) independent treatment. Each method is briefly described below.

(a) Land Disposal

There are three techniques of land disposal of septage: land application; subsurface application; and burial practices.

Land application of septage is the most frequently used technique for septage disposal over the world. Septage treatment and disposal techniques include land spreading from septage hauler trucks/tank wagons, spray irrigation, ridge and fallow irrigation practices, and overland flow. In Senegal, direct agricultural application of septage is not acceptable due to religious and sociocultural reasons. Subsurface application techniques include plow furrow cover and subsurface incorporation alternatives. Placement in trenches, holding lagoons and sanitary landfills are classified as burial practices.

Properly managed land application is relatively simple, generally the most economical disposal technique, and can make beneficial utilization of the nutrient value of septage. However, pathogen control and environmental effects to the surrounding areas shall be carefully

examined and monitored for this kind of operation. Furthermore, social acceptance of the application is an indispensable prerequisite on the selection of application.

(b) Co-Treatment

The treatment of septage at municipal sewage treatment plants is also practiced in many countries. The constituents of septage, although highly concentrated and much stronger than domestic sewage, are generally similar to domestic sewage. Therefore, the same processes used to treat domestic sewage can also be used for co-treatment of septage and domestic sewage.

Septage is normally about 50 times as concentrated as domestic sewage in terms of organic and solid loading. Therefore, in order to prevent producing a shock load on the sewage treatment facilities, an appropriate pretreatment of septage is necessary before discharging the raw septage into the municipal sewage treatment system.

(c) Independent Treatment

Facilities have been constructed exclusively for handling septage. These systems vary from stabilization lagoons to sophisticated treatment plants. Such processes as lime stabilization, chlorine oxidation, aerobic digestion, composting, anaerobic digestion, and chemical treatment have been used to treat septage. Mechanical treatment systems, as opposed to simple lagoon systems, are generally more capital-intensive and usually cost more to operate. However, such systems have been found to be cost-effective in areas of significant septic system density, such as heavily congested urban areas. In low density urban areas and/or rural areas, simpler and less expensive alternatives are preferred. Lagoons are the most common and among the least expensive independent septage handling alternatives.

Referring to the F/S report, the primary criterion for selection of septage treatment process has been placed on simplicity of applied technology. Since the usual processes applied in developed countries use relatively sophisticated electromechanical devices, these installations need large investment, high operation and maintenance costs, and very strict standards for operation and maintenance works. Therefore, the F/S report proposed a simple type of septage treatment for Kaolack similar to Dakar but excluding land disposal techniques which has been applied in Kaolack in very primitive and unsafe practice.

The F/S report selected the co-treatment process of septage together with wastewater in the existing sewage treatment plant (STP), since the existing one has been functional since the 1980's. Pre-treatment process is proposed utilizing wastewater stabilization ponds technology, same as the existing STP in Kaolack, since this method is particularly suitable for tropical climate under strong sunlight and ambient high temperature.

(5) Planning Frames of Septage Treatment

Discussed in this item are the planning frames, particularly, the projected population, expansion of sewer planning area and sewer network, and increase of treatment capacity of the STP following one of the realistic improvement plan. Finally, the remaining urban population who rely on on-site sanitation could be calculated as the target population for desludging septage and its treatment.

Table 4.3.5 Planning Frames for Septage Treatment in Kaolack City

Planning Frame Parameters		unit	Year				
			2012	2015	2020	2025	2030
Population Projection							
	Whole City	Person	270,000	291,000	335,000	373,000	403,000
	City Center	Person	245,000	270,000	314,000	352,000	382,000
Capacity of STP							
	Capacity of Treatment	m^3/day	1,000	1,000	15,000	15,000	21,000
Sewer Network Area							
	Area	ha	303	395	576	848	1,337
	Population	Person	34,660	52,220	92,570	157,410	251,450

Sewer Connection							
	Connection Rate	%	50	56	69	85	100
	Population Connected	Person	17,330	29,020	63,970	133,050	251,450
Population Depending on On-site Sanitation							
	City Center	Person	227,670	240,980	250,030	218,950	130,550
	Whole City	Person	252,670	261,980	271,030	239,950	151,550

Table 4.3.5 presents the progress of sewer network coverage expressing the population in parallel with upgrading sewage treatment plant, based on the discussion in **Section 4.7** and **4.8**. On the other hand, residents who rely on any kind of on-site sanitation since they are not connected to the sewer network or live outside of the network will remain. The target population for estimation of septage volume has been set at 230,000 based on the following considerations:

- Almost 50 to 60% of the population in Kaolack City might be relying on improved sanitation facilities, while others might be depending on poor sanitation. The ratio to access the improved one will increase as time passes, as a major target of the MDGs and the succeeding goals to be established in near future.
- If a septage treatment system is established in the center of the city, desludging by vacuum truck will be much more popular in the city center area due to lower cost gained by the shorter distance to the disposal site. Thus in this study, manual desludging is not taken into account.
- As discussed in **Section 4.7** and **4.8**, the septage treatment facilities are to be constructed during 2015-2020. Therefore, the target population is set up in consideration of population trend in 2020-2025. The population of 230,000 is the average of: (i) population depending on on-site sanitation in the city center; and (ii) population of the whole city in 2025.
- After 2025, the septage treatment system could be functional also in the expanding urban areas out of the city center.

From the above considerations, the design population of 230,000 contains a substantial margin above the septage generation volume. For instance, 50 to 60% of the population relies on the improved sanitation such as septic tanks, VIP and so on. Furthermore, although the current detailed situation is not so clear, manual desludging is popular in the city. Thus the design population could contain the allowable margin of more than 100% at present. It means the septage treatment system could have sufficient capacity to treat collected septage as designed based on the population.

(6) Proposed Basic Parameters of Septage and Treatment Process

Basic parameters of septage, target of treatment level, septage that could be discharged into the STP, and necessary treatment process are discussed in this section. Basic parameters of septage and allowable capacity of STP are summarized in the following table.

Table 4.3.6 Planning Basic Parameters for Septage Treatment

Parameter	Planning Value	Source/Remarks
Septage Generation	0.3 l/capita day	Average figure in Senegal referring to F/S Report
Planning Population	230,000 people	Preceding section
Total Daily Septage Generation	70 m^3/day	0.3 l/capita day × 230,000 people
BOD_5 Concentration of Septage	3,540 mg/l	Laboratory of ONAS Camberene
BOD_5 Daily Load	250 kg/day	3,540 mg/l × 70 m^3/day

Regarding allowable capacity, the septage acceptable to the STP could be set by referring to the F/S report.

- As discussed in **Section 4.8**, the target year of the STP capacity is set at the year 2020 as a first step of improvement works in the STP. If the year is set at a later date, the capacity will increase so that the allowable capacity will also increase. As a result, the septage treatment system has to be designed into a very much simpler one. Thus, the target year 2020 might be appropriate.
- Existing lagoons and malfunctioning aerated lagoons will be upgraded into lagoons, which consists of anaerobic, facultative and maturation lagoons with capacity of 3,000 m^3/day in 2020.

- To be on safe side, the existing BOD_5 concentration of inflow of 240 mg/l on average, according to the laboratory of ONAS Camberene, is applied as the allowable BOD_5 load of septage treatment facilities in the STP.
- Based on the above conditions, BOD_5 load of septage inflow in 2020 could be estimated at 720 kg/day (= 240 mg/l × 3,000 m^3/day).
- Referring to the F/S report, necessary pretreatment level of septage is set at 10% of the STP capacity, so that minimum requirement for pretreatment is 72 kg/day in BOD_5 load.

(7) Septage Treatment Facility Plan

The septage treatment process as illustrated in **Fig. 4.3.6** is considered by referring to the F/S report. This process is the standard process of treatment using the wastewater stabilization pond system. Each treatment component plan is described below in line with the treatment process presented in **Fig. 4.3.6**. If the outflow of the anaerobic pond exceeds the minimum BOD_5 requirement of 72 kg/day load for pretreatment, additional treatment by facultative pond will be necessary after treatment by the anaerobic pond.

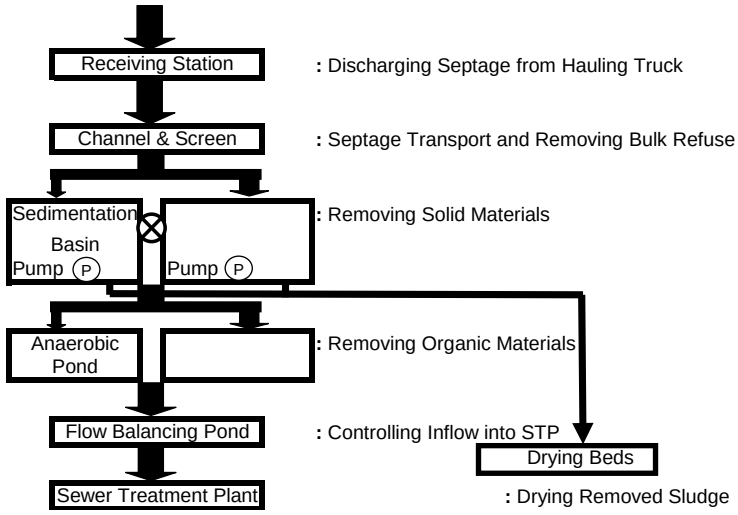


Fig. 4.3.6 Conceptual Septage Treatment Process

(a) Receiving Station, Channel and Screen

The functions of a receiving station are: (i) transfer of septage from hauler tracks, and (ii) storage and equalization of septage flow. Receiving station design should encourage simple and reliable operation, and have the flexibility to accommodate varying flow and loading conditions.

This station shall allow easy access for the trucks and shall be designed not to allow dumping sludge beside the structure including septage splash and to avoid long stagnation in the station and settling of septage. In order to keep such features, a closing device of sheet metal with opening shall be set up at the inlet of the station.

The structure of receiving station is a rectangular pond with a sloping bottom to make the septage flow toward the downstream screen. The structural dimensions in the preliminary design are summarized below, following the F/S report.

Table 4.3.7 Preliminary Setting of Receiving Station, Channel and Screen

Structure		Dimension	Remarks
Receiving Station			
	Width	2.6 m	
	Length	2.0 m	
	Depth	0.8 m	Entire Stretch
	Slope	5 ‰	Entire Stretch

Converging Section Connecting to Downstream Channel			
	Length	1.5 m	
	Width (Downstream End)	1.0 m	0.5 m×2 Nos.
Channel & Screen			
	Width	1.0 m	0.5 m×2 Nos.
	Length	1.7 m	
	Screen Space	25.0 mm	

(b) Sedimentation Basin

Sedimentation basin has the function to settle down the sludge of solid and suspended materials. Discharged raw septage through the screen arrives in a pond where it stagnates for hours, resulting in settling the suspended materials down and accumulating on the bottom of the pond.

Two parallel sedimentation basins system for septage treatment could be simple technique required for easy operation and maintenance. Typical two parallel ponds system is applied in Accra in Ghana. As illustrated in **Fig. 4.3.7**, the two basins function alternately.

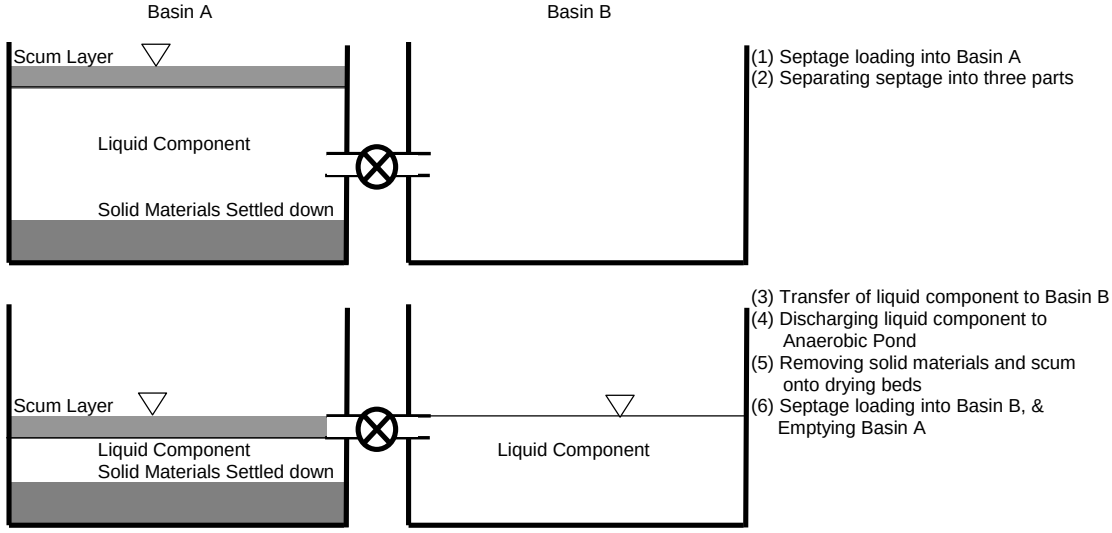


Fig. 4.3.7 Conceptual Usage of Two Parallel Basin System for Sedimentation

Thus the F/S report also recommends two parallel ponds system alternately working for two weeks. During 7 days, one pond is loaded, and solid materials settle down on the bottom. In the beginning of the next week the other pond is loaded. Since the first pond being out of service contains accumulated sediment, the sediment is removed into the drying beds.

Based on the total daily septage generation, necessary volume of sedimentation basins is calculated using various parameters as summarized in the following table.

Table 4.3.8 Preliminary Setting of Sedimentation Basin

Parameter	Symbol	Planning Value	Source/Remarks
Total Daily Septage Generation	Q_{ent}	70 m^3/day	
Solid Materials Concentration	M_s	15,000 mg/l	Measurement of septage in Accra, Ghana
Daily Load of Solid Materials	CM_s	1,050 kg/day	= $Q_{ent} \times M_s$
Specific Volume of Sludge Accumulation	VS_{acc}	7 l/kg	Measurement of septage in Accra, Ghana
Frequency of Removing Sludge	f_{sout}	7 days	Weekly removal of sludge
Sludge Disposal Time	t_{dech}	8 hours	Working time/day
Minimum Hydraulic Retention Time	t_{rhmin}	8 hours	Normally designed retention time: 2-4 hours
Volume of Sludge Storage	V_{stock}	52 m^3	= $CM_s \times VS_{acc} \times f_{sout}$
Volume of Sedimentation Basin	V_{sed}	122 m^3	= $Q_{ent} + V_{stock}$
Removal Efficiency of BOD_5		40 %	Measurement of Accra STP, Ghana
BOD_5 Load of Outflow		150 kg/day	more than 72 kg/day

Finally, the necessary volume of sedimentation basin is estimated at 122 m^3 so that two parallel ponds with an area of 61 m^2, depth of 2.0 m and 0.5 m of freeboard each, are necessary.

(c) Anaerobic Pond

Anaerobic ponds receive the effluent of sedimentation basin directly, since the treated wastewater contained by septage needs an additional treatment through anaerobic ponds before it is discharged into the STP to avoid overloading. It is important to note that the effluent from the sedimentation basin always contain lots of organic materials. Therefore, the installation of anaerobic ponds is indispensable to treat those heavy loads.

In tropical countries under 25°C or above of the mean temperature of the coldest month, BOD_5 removal efficiency of 70% could be expected through the anaerobic ponds with a relatively short retention time of about 2 days.

The removal of sludge is necessary in every 1 to 2 years, and the pond shall not be used for several days to several weeks after the removal. Thus two parallel ponds are planned to ensure continuous operation. In this plan, excess capacity rate to buffer the overload during maintenance period is set at 50%.

Based on the expected treatment results through sedimentation basins, necessary volume of anaerobic pond is calculated using various parameters as summarized in the following table. As calculated in the table, BOD_5 load in outflow of anaerobic ponds is far less than 10% of STP capacity so that the septage treatment process could terminate after treatment by anaerobic pond. Otherwise succeeding process of facultative pond and maturation pond shall be necessary.

Table 4.3.9 Preliminary Setting of Anaerobic Pond

Parameter	Symbol	Planning Value	Source/Remarks
Total Daily Septage Generation	Q_{ent}	70 m^3/day	
BOD_5 Load Entering Pond		150 kg/day	
BOD_5 Concentration Entering Pond	BOD_{in}	2,150 mg/l	= 150 kg/day / 70 m^3/day
Mean Temperature of the Coldest Month	T_{min}	25 °C	Kaolack Meteorological Station
Volumetric BOD_5 Loading	C_v	350 g/ m^3day	$=10T_{min}+100$
Excess Capacity Rate to Buffer the Overload during Maintenance	f_{surcap}	0.5 (50 %)	
Necessary Total Volume of Pond	V_a	645 m^3	$= Q_{ent} \times (BOD_{5in} / C_v) \times (1+ f_{surcap})$
Hydraulic Retention Time		9.2 days	
Removal Efficiency of BOD_5		70 %	under 25 °C or above
BOD_5 Load of Outflow		45 kg/day	Less than 72 kg/day (6.25 %)

Finally, the necessary volume of anaerobic pond could be estimated at 645 m^2 so that two parallel ponds with an area of 108 m^2, depth of 3.0 m and 0.5 m of freeboard each, are required.

(d) Flow Balancing Pond

Flow balancing pond has to be able to retain the entire volume of treated wastewater from anaerobic ponds within the day, and to control the effluent discharging into the STP. The necessary volume of the pond should correspond to 1.5 times the daily volume of septage entering the treatment system. Thus the necessary volume of flow balancing pond could be estimated at 105 m^3 (= 70 m^3/day × 1.5) so that one pond with flow control devices, pond area of 52.5 m^2, depth of 2.0 m and 0.5 m of freeboard is required.

(e) Drying Bed

Sludge shall be removed from the bottom of sedimentation basin and transferred to the drying bed surface once a week. Normally, sludge could be dried up under the strong tropical sunshine for one week in the dry season and for 2-3 weeks even in the rainy season. Thus design duration for sludge drying of 21 days is set to save on land area for the bed.

The wet sludge has to be laid flatly with less than 0.3 m in depth. If the layer is too thick, infiltration and evaporation process will not be optimum and drying period will be prolonged.

Liquid drained through the filter shall be returned to the treatment process, as the return-flow to the sedimentation basin.

The dried sludge shall be removed, taking care not to disturb the top sand layer on the drying beds. Afterwards the removed sludge shall be hauled to the suitable site for disposal, for instance, to the final disposal site of solid waste.

Table 4.3.10 Preliminary Setting of Drying Bed

Parameter	Planning Value	Source/Remarks
Volume of Sludge Generated Weekly in Sedimentation Basin	57.2 m^3	Refer to **Table 4.3.8**, and adding 10 % of rinsing water
Criteria of Drying Bed		
Thickness of the Filter	0.5 m	Different layers of sand, gravel and stone
Maximum Depth of Sludge on the Bed	0.3 m	
Maximum Duration of Sludge Drying	21 days	1 week in the dry season, 2-3 weeks in the rainy season
Number of Drying Beds	3	Using 1 lane/week for 21 days
Necessary Area/Lane	191 m^2	= 57.2 m^3 / 0.3 m
Necessary Area of Drying Bed	573 m^2	= 191 m^2 × 3 lanes

The final configuration of the proposed septage treatment system is shown in the following figure. Land requirement of the septage treatment facilities is about 0.8 ha, which includes treatment facilities, hauling road and embankment. The septage treatment facilities are operated and maintained by ONAS. Desludging vacuum trucks can enjoy the benefit of the facilities by lower cost gained by the shorter distance to the disposal site and thus the residents in Kaolack using septic tank can also enjoy the benefit of the facilities.

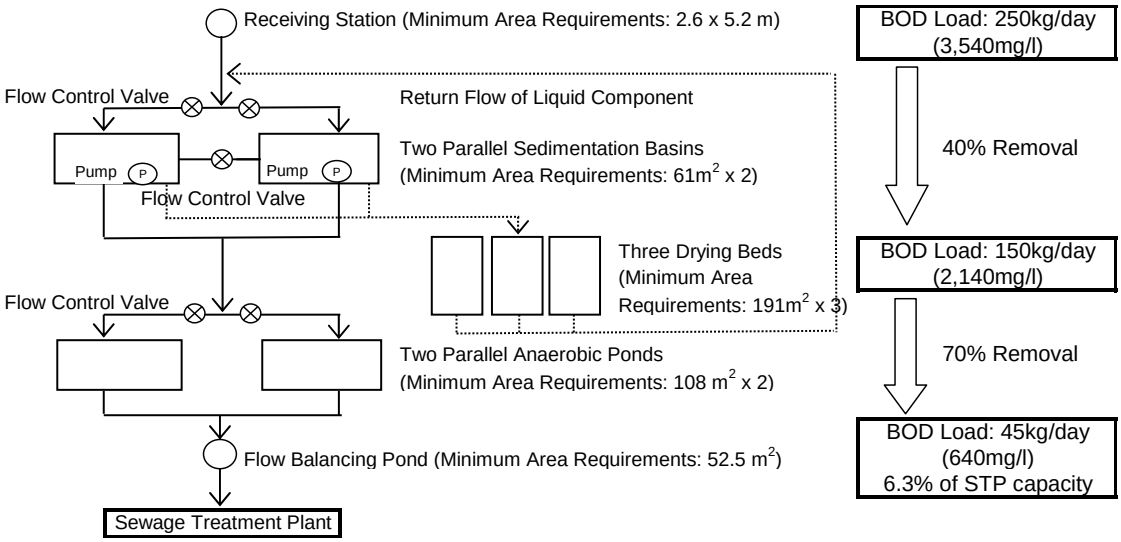


Fig. 4.3.8 Schematic Diagram of Proposed Septage Treatment System

4.4 Structural Sewerage System Improvement Plan

4.4.1 Sewer Network

(1) Installation of New Trunk Sewer

The total length of proposed new trunk sewers is 26.0 km, and the length of new force mains is 1.7 km, totally 27.7 km. The list of the proposed pipe length in each diameter is shown in **Table 4.4.1**.

Table 4.4.1 Length of Proposed New Trunk Sewer Pipes

Diameter of Pipe (mm)		Total Length of Pipe (km)	Covering Depth (m)
Trunk Sewer (by gravity)	200	12.8	1.00 – 2.82
	250	5.1	1.00 – 3.93
	300	1.8	1.00 – 3.19
	400	5.4	1.00 – 3.39
	500	0.9	1.00 – 3.54
	TOTAL	26.0	
Trunk Sewer (Force Main)	150	1.0	-
	200	0.7	-
	TOTAL	1.7	

(2) Replacement of Existing Trunk Sewer

Existing asbestos concrete sewer pipes should be replaced simultaneously with the expansion of sewer network, because some stretches of the pipes are significantly deteriorated due to aging and the other stretches suffer lack of carrying capacity for the wastewater generation in 2030. The stretches of asbestos concrete sewer pipe to be replaced are listed in **Table 4.4.2** and their locations are indicated in **Fig. 4.4.1**.

Table 4.4.2 Stretches of Asbestos Concrete Pipes to be Replaced

Stretch	Length (m)	Reason to be Replacement
(1) Upstream of PS No.2	570	Malfunction due to sedimentation
(2) Upstream of PS No.3	280	Significant deterioration
(3) Upstream of STP	710	ditto
(4) Along National Road from Bongré to Kasnack District	500	ditto
(5) Upstream of stretch (1)	690	Lack of capacity for 2030
(6) From PS2 to upstream end of stretch (3)	2,140	ditto
(7) From PS3 to upstream end of stretch (3)	1,800	ditto
(8) From downstream end of stretch (4) to PS1 South	1,280	ditto
Total	7,970	

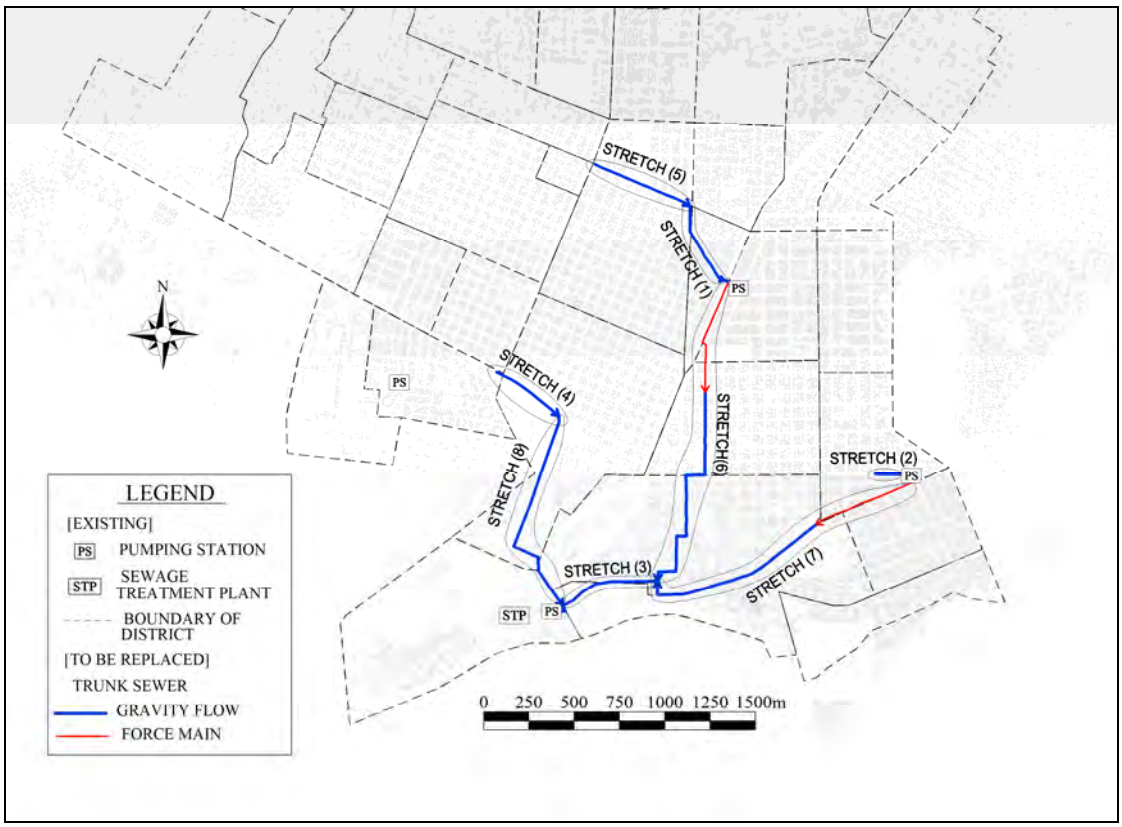


Fig. 4.4.1 Location of Sewers Pipe to be Replaced

(3) Branch Sewer

In the Master Plan, length of branch sewer in the expansion and existing unsewered area is estimated at 260 m/ha considering the length of road typical city blocks in the area.

4.4.2 Sewage Pumping Station

Pumping stations to be augmented or newly constructed are summarized in **Table 4.4.3**. All pumping stations shall have at least two pumps of equal capacity to avoid complete functional failure. Existing 5 pumping station are replaced or rehabilitated to discharge the wastewater generation in 2030. 4 pumping stations are to be newly constructed in vacant spaces to avoid resettlement.

Table 4.4.3 Specifications of Each Pumping Station

	Name of PS	Design inflow (m^3/min)	Pumps installed		Capacity (m^3/min)	Remarks
			m^3/min	unit		
Replacement/ rehabilitation	PS No.1 South	12.0	3.0	2	12.0	
			6.0	1		
			6.0	1	Stand-by pump	
	PS No.2	12.9	3.2	2	12.9	
			6.5	1		
			6.5	1	Stand-by pump	
	PS No.3	4.2	2.1	2	4.4	
			2.1	1	Stand-by pump	
	PS No.12	0.3	0.3	1	0.3	
			0.3	1	Stand-by pump	
	PS Médina Baye	1.3	1.3	1	1.3	
			1.3	1	Stand-by pump	
New construction	PS No.1 North[1)]	15.9	4.0	2	16.0	Land owner: public Land requirement: 100 m^2
			8.0	1		
			8.0	1	Stand-by pump	
	PS Touba	2.6	1.3	2	2.6	Land owner: public

	Name of PS	Design inflow (m^3/min)	Pumps installed		Capacity (m^3/min)	Remarks
			m^3/min	unit		
	Kaolack		1.3	1	Stand-by pump	Land requirement: 200 m^2
	PS Darou Salam Ndangane	1.8	0.9	2	1.8	Land owner: public
			0.9	1	Stand-by pump	Land requirement: 150 m^2
	PS Boustane	3.8	1.9	2	3.8	Land owner: private
			1.9	1	Stand-by pump	Land requirement: 200 m^2

Note: 1) Installed in the expansion area of STP

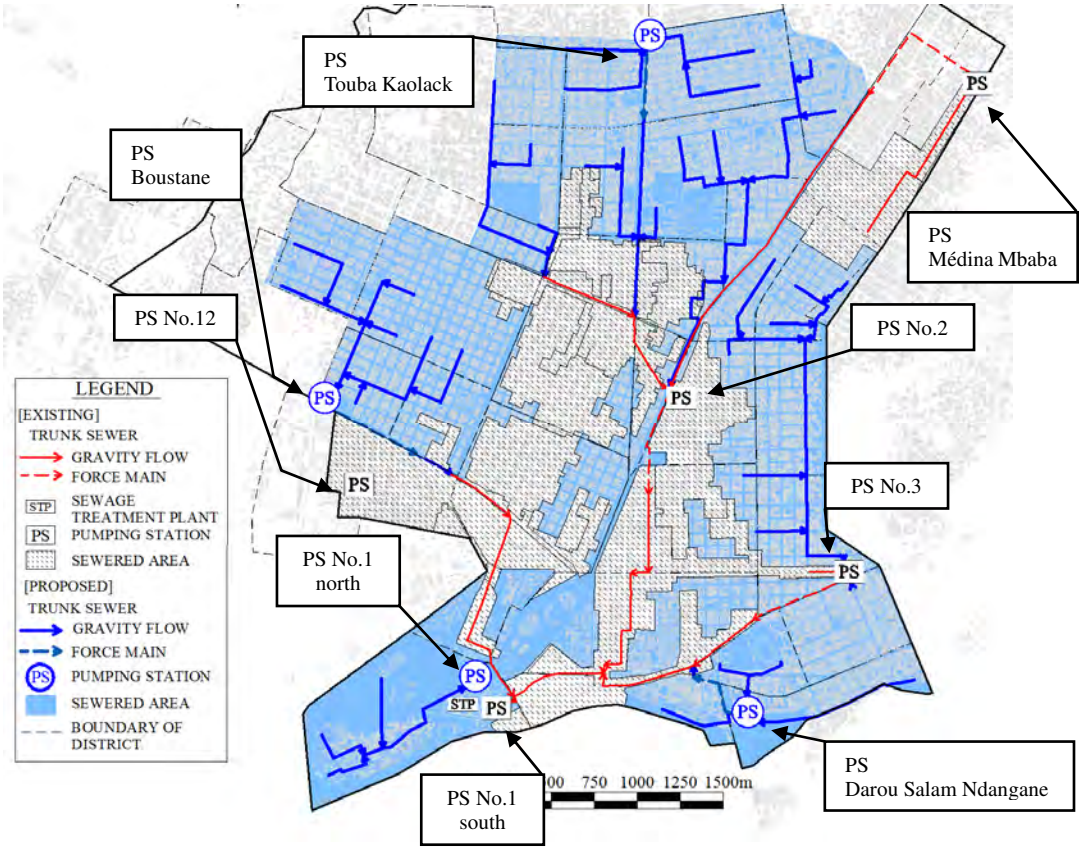


Fig. 4.4.2 Location of Pumping Stations

4.4.3 Sewage Treatment Plant and Septage Treatment Facilities

The structural improvement plan of sewage treatment plant and septage treatment facilities are summarized in the following table. Wastewater treatment facilities consist of aerated lagoons and sedimentation lagoons and chlorination chamber. Accumulated sludge and treated water are separated in sedimentation lagoons. Sludge accumulated in the aerated lagoon and sedimentation lagoons is desludged and dried up in the sludge drying beds. Septage treatment facilities are installed in the expansion area located north of the existing P1 pumping station. Effluent water from septage facilities is treated in the aerated lagoons.

Individual facilities for reuse/recycle of treated water and sludge are not proposed because no economically feasible demand for treated water and sludge is expected in the neighboring area of the STP. However, it is recommended that access points in the STP should be prepared for the inhabitants to reuse the treated water and/or sludge in response to their requests.

Table 4.4.4 Treatment Facilities in STP

		Specifications	Remarks
Septage treatment facilities			
Receiving Station, Channel & Screen		2.6 m (W) × 5.2 m (L) × 0.8 m (D) × 1 (Nos.)	New construction
Sedimentation basin		8.0 m (W) × 8.0 m (L) × 2.0 m (D) × 2 (Nos.)	ditto
Anaerobic pond		10.0 m (W) × 11.0 m (L) × 3.0 m (D) × 2 (Nos.)	ditto
Flow balancing pond		7.5 m (W) × 7.5 m (L) × 2.0 m (D) × 1 (Nos.)	ditto
Drying bed		191 m^2 × 3 (Nos.)	ditto
Sewage treatment plant			
Aerated lagoons	Expansion area	Area 970 m^2 × 4.0 m (D) × 12 (Nos.) Aerator 7.5 kw ×5 (Nos.) ×12 (lagoons)	New construction (Capacity: Q=12,000 m^3/day)
Sedimentation lagoons	Expansion area	Area 4,550 m^2 × 2.0 m (D) × 4 (Nos.) [1)]	
Chlorination chamber		5.0 m (W) × 25.6 m (L) × 2.0 m (D)	Rehabilitation
Aerated lagoons	Existing area	Area 875 m^2 × 4.0 m (D) × 10 (Nos.) Aerator 7.5 kw ×5 (Nos.) ×10 (lagoons)	New construction
Sedimentation lagoons	Existing area	Area 2,680 m^2 × 2.0 m (D) × 4 (Nos.) [1)]	(Capacity: Q=9,000 m^3/day)
Chlorination chamber		5.0 m (W) × 19.2 m (L) × 2.0 m (D)	New construction
Sludge drying beds		Area 270 m^2 × 0.3 m (D)×15 (Nos.) Area 360 m^2 × 0.3 m (D)× 6 (Nos.)	New construction

Note: Depth of 2.0 meter includes sludge allowance of 1.0 meter.
W: Width, L: Length, D: Depth

4.5 Operation and Maintenance Plan

4.5.1 Sewer Network

Based on the following purposes, maintenance work of sewer network shall be executed:

- To secure sewerage function, and
- To extend the expected lifetime of facilities (reduction of life-cycle cost).

Schematic flowchart of scheduled maintenance work is shown in **Fig. 4.5.1**.

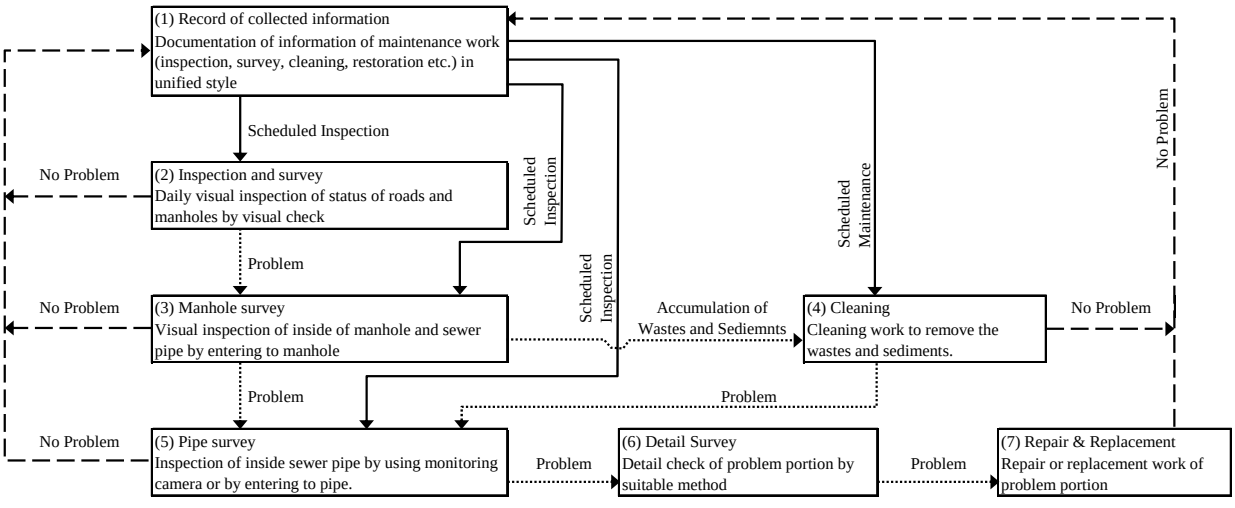


Fig. 4.5.1 Flowchart of Scheduled Maintenance Work

When the expansion of sewerage network is completed with 100% connection, sewered area will become 13.4 km^2, which is equivalent to 9 times of the present service area. Then, it is supposed that the total length of sewer pipes is about 460 km, which is 9 times of the existing length. Thus, planning of the scheduled work is required in order to avoid the malfunction of sewer network and to keep the good sanitary condition in Kaolack City.

(1) Present Methodology of Cleaning Work of Sewer Network

Present methodology of cleaning work of sewer network is as follows:

- The stretches of sewer network to be cleaned are designated by ONAS Kaolack with approval from ONAS Headquarters (for example, length of cleaned pipe in 2012 is about 10.7 km, which is equivalent to about 20% of existing);
- Cleaning teams and equipment are dispatched from ONAS Headquarters; and
- Cleaning of PVC pipes is executed by vacuum truck with water jet; on the other hand, the work on asbestos concrete pipes is by manual cleaning equipment

(2) Future Cleaning Work Volume of Sewer Network

Estimated cleaning work volume of sewer network in 2030 as well as cleaning work plan is shown in **Table 4.5.1**. The assumptions for the estimation are as follows:

- Length of sewer pipes to be cleaned annually is 20% of total in consideration of present cleaning work schedule,
- Vacuum truck with water jet is adopted as the standard cleaning method, and
- Specialized cleaning team with the cleaning vacuum truck is organized in Kaolack City.

Table 4.5.1 Estimation of Cleaning Work Volume in 2030

Items		Unit	Calculation	Remarks
(1)	Length of sewer pipe	km	350	Estimated from present total length of sewer pipes, including house connection
(2)	Average diameter of sewer pipe	mm	250	Considering that most sewer pipes are branch
(3)	Volume of sediment & waste	m^3	5,154	Volume of sediment & waste: 30% of sectional area of pipe
(4)	Volume of pressure water	m^3	2,577	Half of sediment & waste (1/2 × (3))
(5)	Volume of sludge to be cleaned	m^3	7,731	(3) + (4)
(6)	Frequency of sewer pipe cleaning	-	once in 5 years	
(7)	Daily cleaning volume by vacuum truck	m^3	6	Cleaning work: twice per day, tank volume of truck: $3m^3$
(8)	Number of days for cleaning work	days	240	Number of working day: 20 days / month
(9)	Annual volume to be dislodged by a team	m^3	1,440	(7) × (8)
(10)	Number of team required	-	1.07	(5) / [(6) × (9)]

Based on the above calculation, one specialized team is not enough to carry out the cleaning work on all sewer pipes in a five-year cycle. Thus additional cleaning work is necessary.

(3) Cleaning Work Plan after Expansion of Sewer Network

On the basis of aforementioned estimation results and predicted future status of sewer network, recommendable cleaning work plan of sewer network after expansion is described below:

- All sewer pipes shall be cleaned in every 5 years, at least, so as not to degrade the present service level of sewerage.
- Cleaning work shall be executed by vacuum truck with water jet for the following reasons:
  - PVC pipes are installed as trunk sewer, basically;
  - Deteriorated pipes are replaced simultaneously with the expansion work; and
  - Manual cleaning may damage the inside of PVC pipe by reciprocation of brush.
- At least one specialized cleaning team with cleaning vacuum truck shall be set in ONAS Kaolack to keep the cleaning schedule of sewer network in a five-year cycle.

4.5.2 Pumping Station

Maintenance work of the pumping stations is indispensable to keep the sound condition of sewer network. Maintenance works and inspection items are listed in **Table 4.5.2.**

Table 4.5.2 Maintenance Works and Inspection Items

		Items
Scheduled Inspection	Annual Inspection	- Detailed condition of mechanical and electrical equipment - Deterioration condition of concrete and architectural facilities - Comparison with past inspection data
	Monthly Inspection	- Condition while full load driving - Condition of various driving mode - Condition of driving by sub power supply
Daily Inspection		- Condition while stopping of pump driving - Condition while usual pump driving
Maintenance works of screen and grit chamber		- Removal of residues (Screen) - Desludging of accumulated sludge (Grit chamber)
Inspection after natural disaster		- Damage by disaster - Operability of equipment - Condition of concrete and architectural facilities

The results of inspection and maintenance works shall be documented to update the repair plan and to share the information between operators.

4.5.3 Sewage Treatment Plant and Septage Treatment Facilities

Inspections and maintenance works for sewage treatment plant and septage treatment facilities are summarized in the following table. ONAS is in charge of operation and maintenance of septage treatment facilities along with sewage treatment plant.

It is noted that protection works such as temporary embankment and placing steel plate should be carried out when the desludging using heavy equipment is conducted in aerated lagoon and sedimentation lagoon since the lining materials inside lagoons are easily damaged.

Table 4.5.3 Inspection Items and Maintenance Works in STP and Septage Treatment Facilities

	Items	Frequency
Septage treatment Facilities		
Screen	Removal of residues	Daily
Ponds and basins	Removal of scum and waterweed	Once in 2 weeks
Sludge drying beds	Check on thickness of sludge layer	Weekly
	Desludging	Once in 3 weeks
Sewage treatment plant		
Inlet channel	Recording of water flow	Daily
Aerated lagoons and sedimentation lagoons	Check on water level, odor and water temperature	Ditto
	Inspection of water leakage from embankment	On demand
	Removal of scum and waterweed	Once in 2 weeks
	Cleaning and greasing of aerators	2 time in a year
	Desludging	At least once a year
Chlorine chamber	Check on quantity of chlorine consumed	Daily
Water quality monitoring[1)]	pH, DO, BOD_5, TSS, COD_{Cr}, fecal coliform	At least 4 times in a year [2)]

Note: 1) Monitoring samples shall be sent and the water quality analysis shall be implemented in the laboratory in Camberene STP, as in the past.
2) 2 times in the dry season and 2 times in the rainy season.

4.5.4 Formulation of Ledger

At present, ONAS records operation and maintenance activities of sewerage facilities such as sewer pipe, pumping station and sewage treatment plant in the Monthly Report. On the other hand, ONAS has no well-organized ledger including information on the exact location of sewer pipe, manhole and house inlet, invert level of pipes and covering and so on. In parallel with the implementation of the project, well-organized ledger shall be formulated using the base map and design drawings prepared in the project.

4.6 Preliminary Project Cost Estimates

4.6.1 Construction Cost Estimates

(1) Basis and General Condition

The construction cost is calculated based on the various cost information obtained from ONAS Dakar, ONAS Kaolack, and "the Study on Urban Drainage and Wastewater Systems in Dakar City and its Surroundings" in 1994, JICA.

The following are the general conditions for construction cost estimation.

- The construction cost is estimated at 2012 price level.
- The annual price escalation rate of 3% up to 2012 is assumed in case of use of cost data on past project.
- All necessary costs other than direct construction cost, i.e., the cost for common temporary works such as preparation of temporary site office, access road, and also the costs for site expenses, contractor's overhead, profit, are included in construction cost.
- The unit rate for open cut method which is the most common method in Senegal is assumed for all necessary excavation works.
- The cost is classified into foreign and local currency portions based on the information on procurement obtained in Senegal.

(2) Particular Condition

The following are the particular conditions for the construction cost estimate.

[Trunk Sewers]

- Covering depth varies from 1 m to 4 m.(Average: 1.9 m)
- Manhole: 35 m interval, concrete volume 3.3 m^3/no

[Pumping Stations]

The following cost functions were used:

- New construction : $C=150.28Q^{0.6}$, where, C: Construction Cost (million FCFA), Q(m^3/min)
- Rehabilitation : $C=120.22Q^{0.6}$, where, C: Construction Cost (million FCFA), Q(m^3/min)

[Sewerage Treatment Plant (Aerated lagoon type)]

- Mechanical items such as aerator and chlorinator are assumed as imported materials from Europe.
- Mortar lining are considered for the protection of aerated lagoon.
- The construction of sewerage treatment plant (STP) in south side is considered in two stages, i.e., 1st stage: improvement of existing STP, 2nd stage: construction of new STP (aerated lagoon type).

[Branch Sewers]

- Average covering depth : 1m

(3) Construction Cost Estimates

Construction cost for the sewerage facilities is approximately 39,281 million FCFA as shown in **Table 4.6.2**.

4.6.2 Project Cost Estimates

(1) The Element of Project Cost

The element of project cost is as follows and the percentage other than the construction cost, i.e., Engineering Cost, Project Administration Cost, Physical Contingency, was assumed judging from the data obtained from the past project in Senegal or other countries. In addition, the price

escalation during the project from 2014 to 2030 was assumed based on the past 10-year data on the inflation rate by the World Bank.

- Construction cost
- Engineering cost : 10% of Construction Cost
- Project Administration Cost : 2% of Construction Cost
- Physical Contingency : 10% of Construction Cost and Engineering Cost
- Soft component (Support by the specialist): Contents of the soft component is summarized in **Table 4.8.7**.
- Price Escalation during the Project Period (2014 to 2030) : annual inflation rate 3% of local currency, 2% of foreign currency

In addition, VAT 18% of Project Cost is included.

(2) Percentage of Local and Foreign Currency

Project cost is divided into two currency portions, i.e. local and foreign currency portions as shown in the following table.

Table 4.6.1 Percentage of Local and Foreign Currency Portion

Cost Item	Work Item	L/C	F/C
Direct Construction Cost	Trunk Sewer	100%	0%
	Pumping Stations	40%	60%
	Sewage Treatment Plant	70%	30%
	Branch Sewer	100%	0%
Engineering Service		30%	70%
Government Administration		100%	0%
Physical Contingency		90%	10%
Soft Component		20%	80%

(3) Project Cost Estimates

Project Cost is estimated based on the abovementioned elements and the percentage of local and foreign currency.

The total project cost amounts to approximately 75,897 million FCFA at 2012 price level, in which 64,619 million FCFA is local currency portion and 11,278 million FCFA is foreign currency portion.

Table 4.6.2 Project Cost

Cost Item	Work Item		L/C (million FCFA)	F/C (million FCFA)	Total (million FCFA)
Direct Construction Cost	Trunk Sewer	New Construction	5,514	0	5,514
		Replacement	3,440	0	3,440
		Sub-Total	8,954	0	8,954
	Pumping Station		1,259	1,889	3,148
	Sewage Treatment Plant (including septage treatment facilities)		6,621	2,838	9,459
	Branch Sewer		17,720	0	17,720
	Sub-Total		34,554	4,727	39,281
Engineering Service			1,186	2,766	3,952
Government Administration			790	0	790
Physical Contingency			3,912	435	4,347
Soft Component			31	126	157
Price Escalation			14,253	1,504	15,757
VAT			9,893	1,720	11,613
Total (million FCFA)			64,619	11,278	75,897

4.6.3 Operation and Maintenance Cost

Annual operation and maintenance cost for sewer network facilities is approximately 1,245 million FCFA as shown in **Table 4.6.3**.

Table 4.6.3 Operation and Maintenance Cost

	Items	Cost (million FCFA/year)
Sewer pipe (Trunk sewer and branch sewer)	Cleaning and maintenance including personal expense and materials	259
Pumping station	Cleaning and maintenance including personal expense and materials	106
	Electricity	139
	Sub-total	245
STP	Personal expense	9
	Electricity	626
	Material and repair	42
	Chemicals	58
	Sludge disposal	6
	Sub-total	741
Total		1,245

4.7 Prioritization of Project Package

4.7.1 Introduction

Before entering into the formulation of implementation plan, the sewerage planning area (1,337 ha in total) is divided into 4 areas in consideration of their development histories and/or status of sewerage service (serviced or un-serviced), as enumerated below.

- Existing serviced area (303 ha),
- Existing unserviced area (154 ha)
- PRECOL area (92 ha),and
- Expansion area (788 ha).

Of the above 4 areas, the implementation plan is formulated, targeting the existing un-serviced area (154 ha) and expansion area (788 ha), totaling 942 ha. In order to determine their priorities for implementation, the target area of 942 ha is further divided into 9 zones, as shown in **Table 4.7.1** and **Fig. 4.7.1**.

Table 4.7.1 Outline of Nine Zones

Zone	Area (ha)			Population in 2030			Population density (person/ha)
	Total	Expansion	Existing unserviced	Total	Expansion	Existing unserviced	
Zone 1	129	129	0	34,900	34,900	0	270
Zone 2	147	99	48	24,750	19,250	5,500	170
Zone 3	82	82	0	20,740	20,740	0	250
Zone 4	47	47	0	8,840	8,840	0	190
Zone 5	98	92	6	16,280	15,360	920	170
Zone 6	142	110	32	29,790	26,960	2,830	210
Zone 7	131	107	24	36,640	31,400	5,240	280
Zone 8	34	34	0	6,740	6,740	0	200
Zone 9	132	88	44	9,540	6,510	3,030	70
Total	942	788	154	188,220	170,700	17,520	

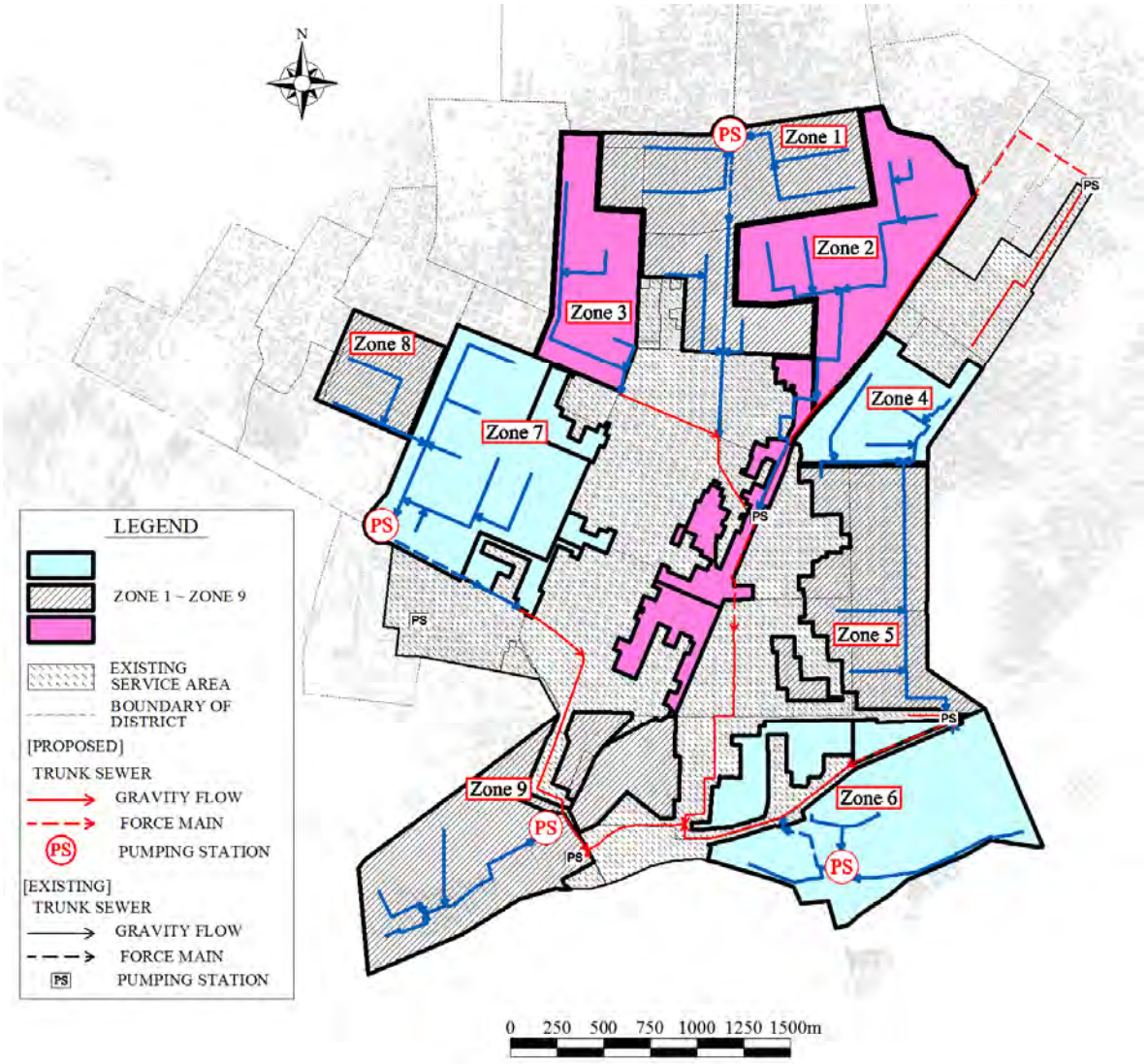


Fig. 4.7.1 Location of 9 Zones in Sewerage Planning

The following criteria are evaluated qualitatively to determine the priority of each zone.

- *Population /Population Density*– High priority is placed in large population and/or high population density area because the investment efficiency of the area is generally high.
- *Urgency* – There is an urgency of sewerage service especially in the areas in poor sanitary conditions and the areas where septic tanks are not effective due to such reason as high groundwater level.
- *Environmental Impact* - Negative impact might be caused especially in large-scale construction works such as pumping station. On the other hand, positive impact is to be expected by the installation of sewerage facilities, particularly in the areas in poor sanitary condition.

As shown in the following table, a ranking of "+" to "+++" is given to each criterion with "+" being the least favorable and some comments are given on the overall conditions of each zone including the results of interview survey conducted as a part of Basic Study. Then, the zones which have a score of more than +7 are evaluated as "1st priority" and the others are "2nd priority".

Table 4.7.2 Qualitative Evaluation of Zones

Zone	Population /Population density	Urgency	Environmental impact	Score	Comments	Evaluation
Zone 1	+++	+	++	+6	Population is large and density is high but existing septic tanks in the area are relatively effective and thus sanitary condition is not poor. Negative environmental impact might be caused by construction of trunk sewer along national road.	2nd priority
Zone 2	++	+	++	+5	Population density is relatively low compared to the other zones of expansion area and existing septic tanks in the area are relatively effective.	2nd priority
Zone 3	+++	+	+++	+7	Population density is high. This area can be serviced without new pumping station, which is favorable in terms of investment efficiency and environmental impact.	1st priority
Zone 4	+	+	+	+3	Population is not large and density is relatively low.	2nd priority
Zone 5	++	+++	+++	+8	Sanitary and environmental condition will be significantly improved since existing septic tanks in the area are ineffective as a whole.	1st priority
Zone 6	++	+++	+++	+8	Sanitary and environmental condition will be significantly improved considering present poor sanitary condition in the area. In addition, the interview survey shows high willingness to pay and highest demand of sewer connection in the area.	1st priority
Zone 7	+++	++	+++	+8	Population is large and density is highest in Zone 1 to 9. The interview survey shows high demand of sewer connection.	1st priority
Zone 8	+	+	+	+3	Population is not large and sanitary condition is not so poor.	2nd priority
Zone 9	+	+	+	+3	Population density is low and sanitary condition is not so poor.	2nd priority

Depending on the above qualitative evaluation in **Table 4.7.2**, the 9 zones are divided into two project areas, namely; (i) Project 1 area, which includes 1st priority zones, (ii) Project 2 area, which includes 2nd priority zones, as shown in the following table.

Table 4.7.3 Project Areas

	Zone	Area (ha)	Remarks
Project-1 area	Zone 3,5,6,7	453	
Project-2 area	Zone 1,2,4,8,9	489	
Total		942	

4.7.2 Project Package

(1) Introduction

Taking into consideration of the project areas in **Table 4.7.3**, two projects are formulated as shown in the following figure. Each project has two packages, namely, (i) major facilities construction (construction of trunk sewer, pumping stations and sewage treatment plant), (ii) branch sewer installation and soft component such as campaigns for sewer connection in the sewer planning area and septic tank installation in on-site sanitation area.

Project	Zone	Package	Items	Phase 1 (-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Project-1	Zone 3,5,6,7	Package P1-1	Major facilities[1)] construction			
		Package P1-2	Branch sewer installation and Soft component			
Project-2	Zone 1,2,4,8,9	Package P2-1	Major facilities[1)] construction			
		Package P2-2	Branch sewer installation and Soft component			

Note: 1) trunk sewer, pumping stations and sewage treatment plant

Fig. 4.7.2 Phased Projects and their Project Packages

4.8 Implementation Plan

4.8.1 Introduction

Based on the phased projects and project packages discussed in **Subsection 4.7**, implementation plan is formulated for three phases of phase 1 (-2020), phase 2 (2021-2025) and phase 3 (2026-2030).

4.8.2 Project Components

(1) Sewer Network and Pumping Stations

Locations of project components of sewer network and pumping stations are shown in **Fig. 4.8.1**, and the components of the sewer network (trunk sewer and branch sewer), as well as pumping stations are summarized in **Tables 4.8.1** and **4.8.2**. Branch sewer installation area for Phase 1 and Phase 2 is set at 181 ha and 272 ha, which corresponds to 40% and 60% of project 1 area (453 ha).

Table 4.8.1 Project Components (Sewer Network)

			Phase 1 (-2020)		Phase 2 (2021-2025)		Phase 3 (2026-2030)	
Trunk sewer								
		Pipe Diameter	New construction (m)	Replacement (m)	New construction (m)	Replacement (m)	New construction (m)	Replacement (m)
Project-1	Package P1-1	Trunk sewer (Gravity flow)						
		φ200	5,510	-	-	-	-	-
		φ250	1,780	-	-	-	-	-
		φ300	1,080	280	-	-	-	-
		φ400	2,270	1,460	-	-	-	-
		φ500	490	2,150	-	-	-	-
		φ600	-	570	-	-	-	-
		φ700	-	-	-	-	-	-
		φ700 x2	-	700	-	-	-	-
		φ900	-	10	-	-	-	-
		Sub-total	11,130	5,170				
		Trunk sewer (Force main)						
		φ150	480	660				
		φ200	720	-				
		Sub-total	1,200	660				
		Total	12,330	5,830	-	-	-	-
Project-2	Package P2-1	Trunk sewer (Gravity flow)						
		φ200	-	-	-	-	7,280	-
		φ250	-	-	-	-	3,320	-
		φ300	-	-	-	-	540	-
		φ400	-	-	-	-	3,220	-
		φ500	-	-	-	-	500	-
		φ600	-	-	-	-	-	-

			Phase 1 (-2020)		Phase 2 (2021-2025)		Phase 3 (2026-2030)	
		φ700	-	-	-	-	-	1,410
		φ700 x2	-	-	-	-	-	-
		φ900	-	-	-	-	-	-
		Sub-total	-	-	-	-	14,860	1,410
		Trunk sewer (Force main)						
		φ150	-	-	-	-	520	-
		φ200	-	-	-	-	-	-
		φ400	-	-	-	-	-	730
		Sub-total	-	-	-	-	520	730
		Total	-	-	-	-	15,380	2,140
Branch sewer installation (ha)								
Project-1	Package P1-2		181		272		0	
Project-2	Package P2-2		0		0		489	
Total			181		272		489	

Table 4.8.2 Project Components (Pumping Stations)

		Phase 1 (-2020)	Phase 2 (2021 -2025)	Phase 3 (2026-2030)
Project-1	Package P1-1	New construction	-	-
		PS No.1 north: 4.0 m^3/min × 2 8.0 m^3/min ×2(1)	-	-
		PS Darou Salam Ndangane : 0.9 m^3/min × 3(1)	-	-
		PS Boustane: 1.9 m^3/min × 3(1)	-	-
		Replacement/Rehabilitation	-	-
		PS No.1 south 3.0 m^3/min × 2 6.0 m^3/min ×1(1)		
		PS No.2: 3.2 m^3/min × 2 6.5 m^3/min × 1(1)	-	-
		PS No.3: 2.1 m^3/min × 3(1)	-	-
Project-2	Package P2-1	-	-	New construction
		-	-	PS Touba Kaolack: 1.3 m^3/min × 3(1)
				Replacement/Rehabilitation
		-	-	PS No.1 south: 6.0 m^3/min × 1
		-	-	PS No.2: 6.5 m^3/min × 1
		-	-	PS No.12: 0.3 m^3/min × 2(1)
		-	-	PS Médina Baye: 1.3 m^3/min × 2(1)

Note: Number in parenthesis is standby pump.

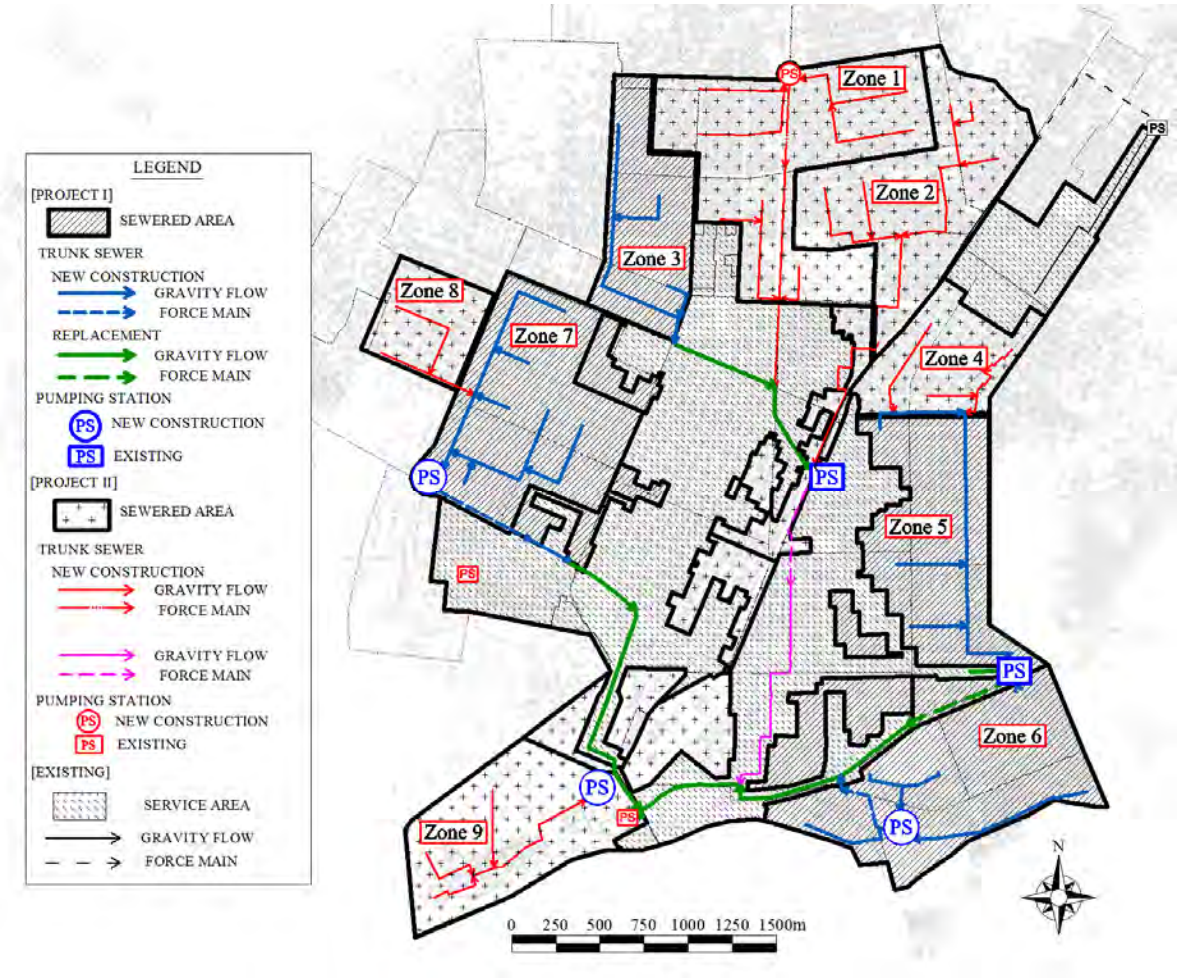


Fig. 4.8.1 Project Components (Trunk Sewer and Pumping Stations)

(2) Sewage Treatment Plant

(a) Sewered Population and Wastewater Generation

Based on the phased projects and their components in **Fig. 4.8.1**, stepwise sewered population of two project areas, as well as existing serviced area and PRECOL area, are projected. Then, stepwise wastewater generation is projected by multiplying the above stepwise sewered population by the connection ratio estimated under the following assumptions.

- Connection ratio of 100% is applied to all the planning area for the target year of 2030.
- Initial connection ratio of 50% is applied to existing serviced area and PRECOL area, considering actual connection ratio in Kaolack City. The connection ratio increases linearly and reaches to 100% in 2030.
- Initial connection ratio of 67% (2/3 of the total) is applied to Project-1 and Project-2 areas, considering advantageous effect of implementation of sewer connection campaign. The connection ratio increases linearly and reaches to 100% in 2030.

Table 4.8.3 Summary of Sewered Population and Wastewater Projection

Item	2012	2015	2020	2025	2030	Remarks
Total Population in planning area						
Existing serviced area	34,660	36,270	38,930	41,680	44,140	
PRECOL	15,400	15,950	16,920	17,970	19,090	
Project-1 area	80,640	84,590	91,790	97,760	103,450	
Project-2 area	59,950	63,630	70,860	77,950	84,770	

Item		2012	2015	2020	2025	2030	Remarks
	Total	190,650	200,440	218,500	235,360	251,450	
Sewered area (ha)							
	Existing serviced area	303	303	303	303	303	
	PRECOL	0	92	92	92	92	
	Project-1 area	0	0	181	453	453	
	Project-2 area	0	0	0	0	489	
	Total	303	395	576	848	1,337	
Population in the sewered area							
	Existing serviced area	34,660	36,270	38,930	41,680	44,140	
	PRECOL	0	15,950	16,920	17,970	19,090	
	Project-1 area	0	0	36,720	97,760	103,450	
	Project-2 area	0	0	0	0	84,770	
	Total	34,660	52,220	92,570	157,410	251,450	
Connection ratio (%)							
	Existing serviced area	50%	58%	72%	86%	100%	
	PRECOL	0%	50%	67%	84%	100%	
	Project-1 area	0%	0%	67%	84%	100%	
	Project-2 area	0%	0%	0%	0%	100%	
Population connected							
	Existing serviced area	17,330	21,040	28,030	35,840	44,140	
	PRECOL	0	7,980	11,340	15,090	19,090	
	Project-1 area	0	0	24,600	82,120	103,450	
	Project-2 area	0	0	0	0	84,770	
	Total	17,330	29,020	63,970	133,050	251,450	
Water consumption							
Wastewater generation (lpcd)		63	65	68	71	75	
Groundwater inflow (%)		10%	10%	10%	10%	10%	
Wastewater flow to the STP (m^3/day)							
	Plan	1,201	2,075	4,785	10,391	20,745	
	(Reference) 100% connection	2,402	3,734	6,924	12,294	20,745	

(b) Strategies for Phased Capacity of STP

(i) Phase 1 (up to 2020)

The strategies for Phase 1 are formulated considering the following:

- The handling of rapid increase of wastewater flow from 4,785 m^3/day in 2020 to 10,391 m^3/day in 2025
- Rehabilitation of existing lagoon and aerated lagoon that is not functioning

First of all, in order to assure the capacity of more than 10,391 m^3/day, construction of aerated lagoon in the expansion area (Capacity: 12,000 m^3/day) is indispensable. Therefore, two strategies for Phase 1, namely; (i) Case 1: With rehabilitation of the exiting lagoon and aerated lagoon and (ii) Case 2: Without rehabilitation of exiting lagoon and aerated lagoon, are selected and compared as shown in **Table 4.8.4**.

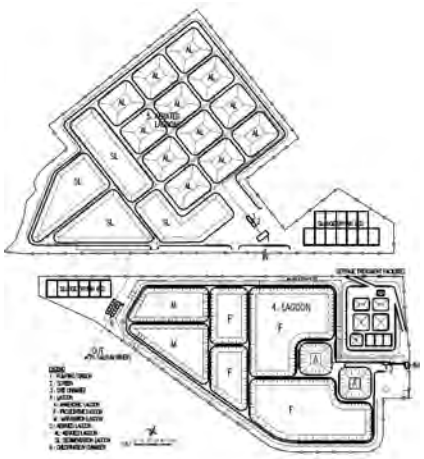
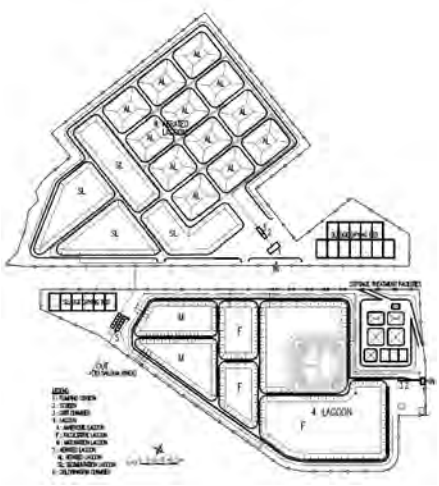
As shown in **Table 4.8.4**, both cases can assure the capacity to treat the inflow. Under the circumstances, Case 2 is better because no rehabilitation cost is required. However, the rehabilitation work is very urgent and indispensable even if rehabilitation cost and the additional renovation of the lagoon is required in Phase 3, because of the reasons that (i) lining material of all lagoons is so deteriorated, which will result in the drop of the existing capacity of 1,000 m^3/day due to the erosion of embankment and (ii) the concrete structures, mechanical aerators and embankment of the aerated lagoon, are seriously damaged, which will result in accidents.

The main rehabilitation works consist of embankment, lining and demolition of aerated lagoon structures and so on. In parallel with the works, however, the capacity of the existing area of STP can be increased easily by introducing anaerobic lagoon using the area of aerated lagoon and a part of facultative lagoon, with the total rehabilitation cost of one billion FCFA. Consequently, the existing STP area is rehabilitated to be lagoon

system, which consists of anaerobic pond, facultative and maturation lagoons with a capacity of 3,000 m^3/day.

Based on the above discussion, Case 1 is selected as the best option and the aerated lagoon is constructed in the expansion area and the existing lagoon and aerated lagoon is rehabilitated in Phase 1. Thus a capacity of STP becomes 15,000 m^3/day in 2020.

Table 4.8.4 Comparison of Phased Capacity for the year 2020

	Case 1 (with rehabilitation)	Case 2 (without rehabilitation)
Layout Plan		
Concept	• Existing area is rehabilitated to have a capacity of 3,000 m^3/d by introducing the lagoon system, which consists of anaerobic, facultative and maturation lagoon. • New aerated lagoons with the capacity of 12,000 m^3/d, are constructed in the expansion area. • As a result, total capacity of the STP increase to 15,000 m^3/d.	• Deteriorated aerated lagoon portion is kept unchanged. Therefore, a capacity of 1,000 m^3/d, consisting of 5 lagoons (3 facultative and 2 maturation lagoons), is obtained in the existing area. • New aerated lagoons with the capacity of 12,000 m^3/d, are constructed in the expansion area. • As a result, total capacity of the STP increase to 13,000 m^3/d.
Advantages / disadvantages	[Advantages] • More than 11,000 m^3/day of total capacity is assured. • Deteriorated lagoon and aerated lagoon are improved and there will be no concern of decline in function and/or accidents due to damaged structures and embankment. • A total capacity of 15,000 m^3/d can be effectively used especially in the cases of inspection and malfunction of aerator. [Disadvantages] • Cost of rehabilitation is about 1 billion FCFA.	[Advantages] • More than 11,000 m^3/day of total capacity is assured. • No cost of rehabilitation is required. [Disadvantages] • Deteriorated lagoon and aerated lagoon is not improved for the time being, which results drop of existing capacity (1,000 m^3/day) and accidents due to damaged lining of lagoon and the concrete structures, mechanical aerators and embankment
Evaluation	Rehabilitation of existing lagoon and the aerated lagoon is very urgent because they are seriously damaged, even if rehabilitation cost is required. A total capacity of 15,000 m^3/d can be effectively used especially in the cases of inspection and malfunction of aerator.	To keep the deteriorated lagoon and aerated lagoon portion unchanged is a great risk in operation and safety control in the existing area.
	Best option	Second option

In Phase 1, septage treatment facilities are constructed along with the construction works of wastewater treatment facilities to properly treat septage generated in Kaolack City, and thereby to solve the septage management issues such as illegal septage dumping.

(ii) Phase 3 (2025 to 2030)

The 21,000 m^3/day capacity is assured by the year 2030 to handle the wastewater generation of 2030 with the connection ratio of 100% by installing aerated lagoons with the capacity of 9,000 m^3/day in the existing area.

(iii) Project Components (Sewage Treatment Plant)

Project components of sewage treatment plant are summarised in the following table.

Table 4.8.5 Project Components (Sewage Treatment Plant)

		Phase 1 (-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Project-1	Package P1-1	New construction		
		Aerated Lagoon (Expansion area): Q=12,000 m^3/day	-	-
		Septage Treatment Facilities : Q=70 m^3/day, BOD_5 load in 250 kg/day	-	-
		Rehabilitation	-	-
		Lagoon (Existing area): Q=3,000 m^3/day	-	-
Project-2	Package P2-1	-	-	Augmentation
		-	-	Aerated Lagoon (Existing area): Q=9,000 m^3/day

(c) Phased Capacity of STP

Based on the above strategies, the phased capacity of STP is summarized in **Table 4.8.6.** In addition, the relation between wastewater inflow and capacity of STP is depicted in **Fig. 4.8.2** and the schematic diagram of phased construction of STP is shown in **Fig. 4.8.3**.

Table 4.8.6 Phased Capacity of STP

Item	Unit	2012	2015	2020	2025	2030
Existing area	m^3/day	1,000	1,000	3,000	3,000	9,000
Expansion area	m^3/day	0	0	12,000	12,000	12,000
Total	m^3/day	1,000	1,000	15,000	15,000	21,000

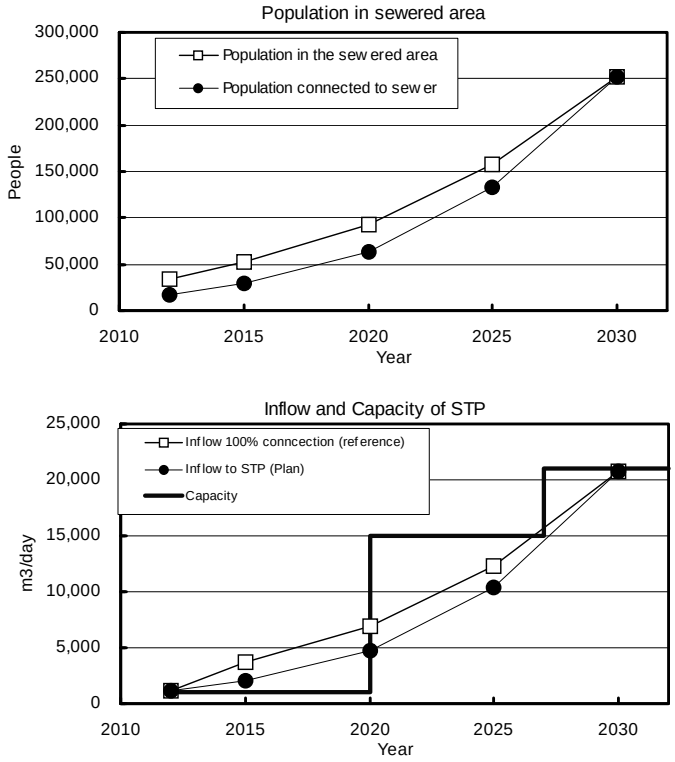


Fig. 4.8.2 Stepwise Sewered Population and Relations between Wastewater Projection and Capacity of STP

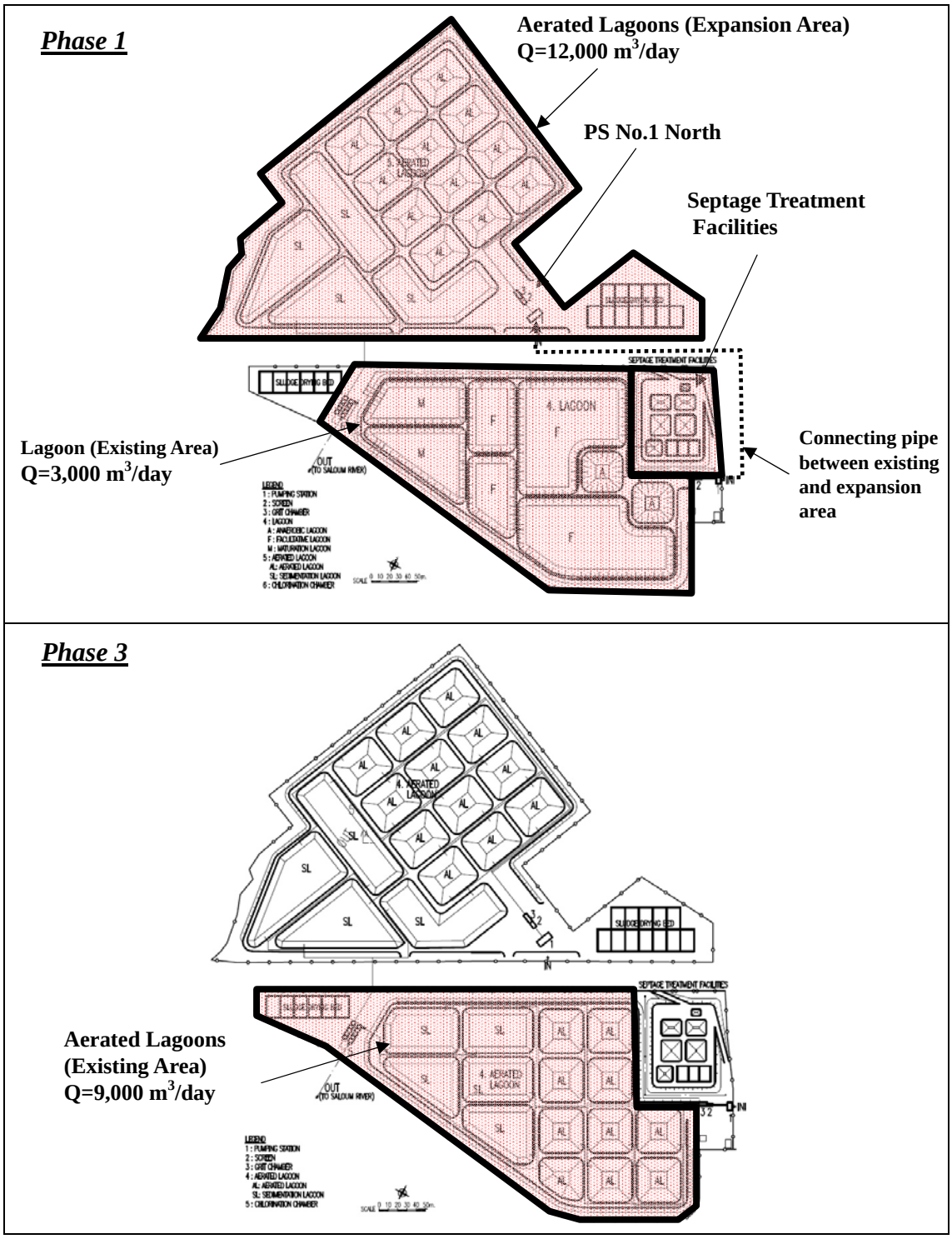


Fig. 4.8.3 Phased Construction of STP

(3) Soft Components

In order to optimize the sewerage facilities, especially the sewer network, house connections in the serviced area are indispensable. Besides, installation of septic tanks should be encouraged to improve sanitary conditions in the on-site sanitation area. Soft components are therefore proposed to promote sewer connections in the sewer serviced area and installation of septic tanks in on site sanitation area. The soft components consist of (i) campaign for sewer connection, and

(ii) campaign for septic tank installation and desludging of septage, as summarized with their activities in the following table.

Table 4.8.7 Outline of Soft Components

	Activities
Campaign for sewer connection	• Development of campaign materials including basic information on the mechanism of sewerage system, advantage of sewer connection and cost for sewer connection. • Assistance for holding briefing session on sewer connection implemented by ONAS in the sewer serviced area.
Campaign for septic tank installation and desludging of septage	• Survey on the status of septic tank installation in the on-site sanitation area. • Development of campaign material including advantage of septic tank installation, cost for septic tank installation, advantage of desludging, appropriate approach for desludging and cost reduction of desludging by the installation of septage treatment facilities in sewage treatment plant. • Assistance for holding briefing session on septic tank installation and appropriate desludging of septage, implemented by ONAS in the on-site sanitation area.

4.8.3 Implementation Schedule

Based on the implementation plan discussed in the preceding section, detailed implementation schedule is formulated as shown in **Fig. 4.8.4**. During the construction period of aerated lagoons in the existing area in 2026, all inflow of about 12,500 m^3/day is introduced and treated in the aerated lagoon in the expansion area. By applying this operation, the aerated lagoon will not be overloaded and the discharge criteria are complied.

4.8.4 Disbursement Schedule

Cost disbursement schedule is proposed as shown in **Table 4.8.8** (Construction Cost) and **Table 4.8.9** (Overall Project Cost). In **Table 4.8.8**, the total amount for STP which is 9,459 million FCFA includes the cost for the rehabilitation of existing lagoon and AL (923 Million FCFA) to be carried out during Phase 1.

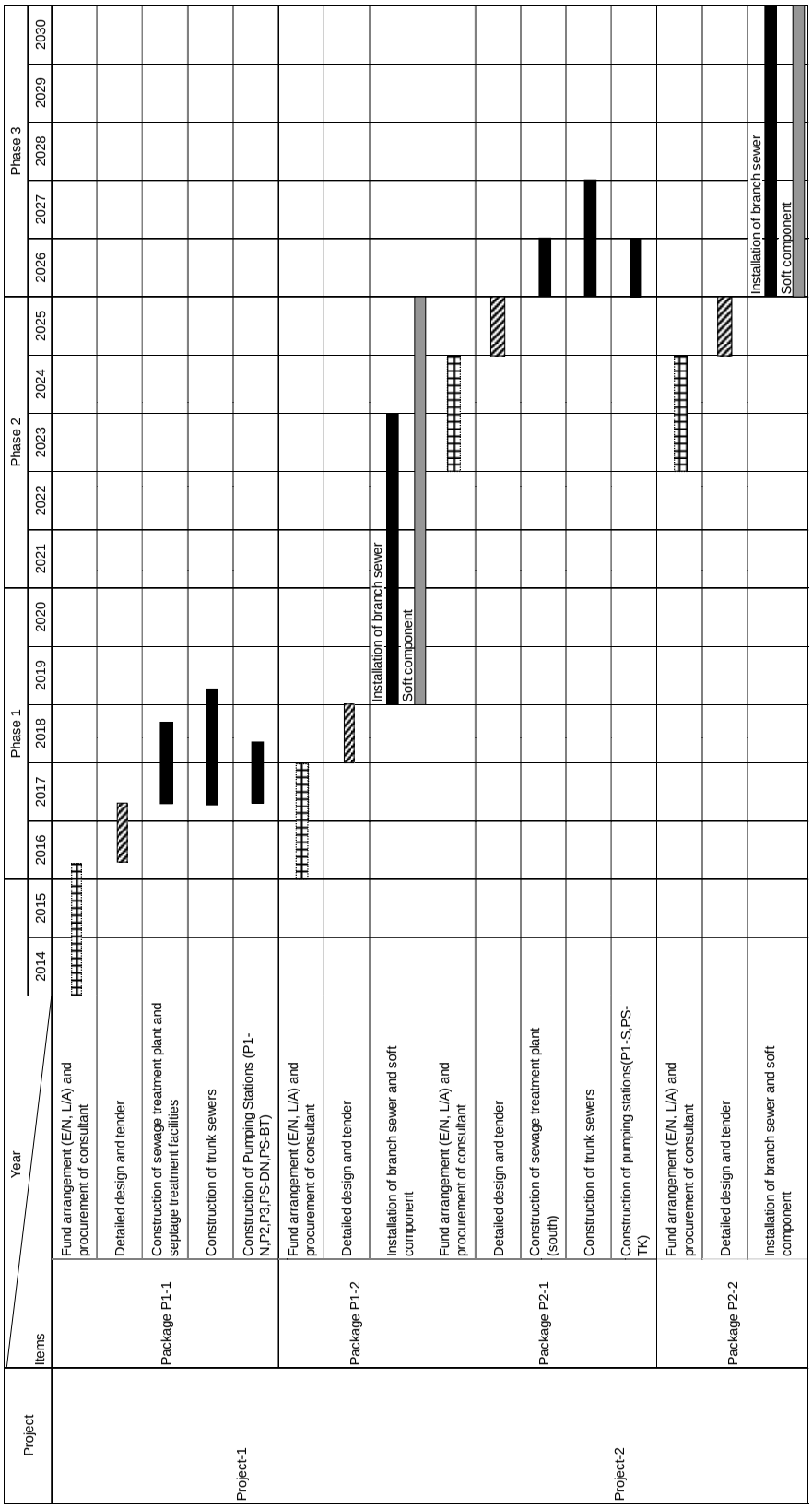


Fig. 4.8.4 Implementation Schedule of Master Plan (Sewerage/Sanitation Improvement)

Table 4.8.8 Cost Disbursement Schedule for Sewerage/Sanitation Improvement Facilities

(Unit: Million of FCFA)

Phase	year	Pumping Station			Trunk Sewer			STP			Branch Sewer			Construction Works		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2017	867	578	1,445	0	1,879	1,879	911	2,123	3,034	0	0	0	1,778	4,580	6,358
	2018	434	289	723	0	2,817	2,817	910	2,124	3,034	0	0	0	1,344	5,230	6,574
	2019	0	0	0	0	470	470	0	0	0	0	1,693	1,693	0	2,163	2,163
	2020	0	0	0	0	0	0	0	0	0	0	1,712	1,712	0	1,712	1,712
2	2021	0	0	0	0	0	0	0	0	0	0	1,693	1,693	0	1,693	1,693
	2022	0	0	0	0	0	0	0	0	0	0	1,712	1,712	0	1,712	1,712
	2023	0	0	0	0	0	0	0	0	0	0	1,712	1,712	0	1,712	1,712
	2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2026	588	392	980	0	1,895	1,895	1,017	2,374	3,391	0	1,826	1,826	1,605	6,487	8,092
	2027	0	0	0	0	1,895	1,895	0	0	0	0	1,843	1,843	0	3,738	3,738
	2028	0	0	0	0	0	0	0	0	0	0	1,843	1,843	0	1,843	1,843
	2029	0	0	0	0	0	0	0	0	0	0	1,843	1,843	0	1,843	1,843
	2030	0	0	0	0	0	0	0	0	0	0	1,843	1,843	0	1,843	1,843
Total		1,889	1,259	3,148	0	8,956	8,956	2,838	6,621	9,459	0	17,720	17,720	4,727	34,556	**39,283**

Table 4.8.9 Cost Disbursement Schedule for Sewerage/Sanitation Improvement Facilities (Project Cost)

(Unit: Million of FCFA)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Administration Cost			Soft Component			Price Escalation			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	184	80	264	29	259	288	0	52	52	0	0	0	13	37	50	41	77	118	267	505	772
	2017	1,778	4,580	6,358	184	79	263	29	259	288	0	52	52	0	0	0	164	624	788	388	1,007	1,395	2,543	6,601	9,144
	2018	1,344	5,230	6,574	184	79	263	29	259	288	0	52	52	0	0	0	162	895	1,057	309	1,173	1,482	2,028	7,688	9,716
	2019	0	2,163	2,163	184	79	263	29	259	288	0	52	52	71	74	145	28	496	524	45	549	594	357	3,672	4,029
	2020	0	1,712	1,712	184	79	263	29	259	288	0	52	52	54	71	125	33	484	517	46	466	512	346	3,123	3,469
2	2021	0	1,693	1,693	184	79	263	29	259	288	0	52	52	54	71	125	38	557	595	47	476	523	352	3,187	3,539
	2022	0	1,712	1,712	183	79	262	29	259	288	0	52	52	54	71	125	44	642	686	48	494	542	358	3,309	3,667
	2023	0	1,712	1,712	183	79	262	29	259	288	0	52	52	54	71	125	49	724	773	49	509	558	364	3,406	3,770
	2024	0	0	0	183	79	262	29	259	288	0	52	52	54	71	125	54	151	205	50	98	148	370	710	1,080
	2025	0	0	0	183	79	262	29	259	288	0	52	52	54	71	125	60	167	227	51	101	152	377	729	1,106
2	2026	1,605	6,487	8,092	183	79	262	29	259	288	0	51	51	71	74	145	536	3,223	3,759	425	1,818	2,243	2,849	11,991	14,840
	2027	0	3,738	3,738	183	79	262	29	259	288	0	51	51	54	71	125	71	2,117	2,188	53	1,125	1,178	390	7,440	7,830
	2028	0	1,843	1,843	183	79	262	29	258	287	0	51	51	54	71	125	76	1,247	1,323	54	627	681	396	4,176	4,572
	2029	0	1,843	1,843	183	79	262	29	258	287	0	51	51	54	71	125	82	1,352	1,434	55	646	701	403	4,300	4,703
	2030	0	1,843	1,843	183	79	262	29	258	287	0	51	51	54	71	125	88	1,459	1,547	56	664	720	410	4,425	4,835
Total Cost		4,727	34,556	39,283	2,751	1,186	3,937	435	3,882	4,317	0	775	775	682	858	1,540	1,498	14,175	15,673	1,717	9,830	11,547	**11,810**	**65,262**	**77,072**

4.9 Economic Analysis

4.9.1 Methodology

(1) General

A main objective of the economic analysis here is to examine the investment efficiency of the components of the Master Plan from the viewpoint of national economy using cost-benefit analysis in cases where it can be applied. Market prices have been converted to economic ones where the influence of market distortion is removed (the so-called shadow prices). Opportunity costs are used for the costs of goods and services whose markets do not exist. Willingness-to-pay is used for benefits whose markets do not exist. Internal Rate of Return (IRR) is used here as the indicator of the efficiency of a project investment. IRR is defined as the discount rate which makes the present value of the flow of costs incurred in the project the same as that of benefit, or which makes the Net Present Value (NPV) 0 (zero), showing what percentage of profit the investment will be paid back. IRR used in economic evaluation is called Economic Internal Rate of Return (EIRR).

(2) Preconditions

The following preconditions are assumed in the economic evaluation. Additional preconditions will be clarified as necessary.

(a) With-Project and Without-Project

"Without-project" is the case where the wastewater is managed by the currently existing systems. "With-project" is the case where the project component is implemented into the currently existing systems. By comparing the with-project and the without-project situations, costs and benefits are estimated to calculate EIRR.

(b) Evaluation Period

The evaluation period is from 2014 to 2060 (30 years after the completion of construction).

(c) Standard Conversion Factor (SCF)

SCF is the ratio of the economic price value of all goods in an economy at their border price equivalent values to their domestic market price value. Prices of goods and services procured domestically are converted to economic ones by the SCF. This study employs an SCF of 0.84, which is the value employed in *Project Appraisal Document on Stormwater Management and Climate Change Adaptation Project, April 12, 2012, the World Bank.*

(d) Other Preconditions

Price Level	:	Year 2012
Shadow Exchange Rate	:	1 (in accordance with the above-mentioned document of the World Bank)
Shadow Wage Rate	:	1 (*ditto*)
Social Discount Rate	:	12% (*ditto*)

(3) Costs

Additional costs are included in the evaluation by comparing the with-project and the without-project situations. The additional costs are calculated in the form of cash flow of each year during the evaluation period. The following cost items are calculated:

(a) Investment Cost

Investment cost includes costs of construction of the facility, equipment, and consulting services. Economic evaluation excludes price escalation but includes physical contingencies.

(b) Operation and Maintenance Costs

Operation and maintenance costs for each year are included. Price escalation is not included.

(c) Depreciation

Since the money allocated and subject to depreciation is not actually spent at that time, it is not included in the cost items.

(4) Benefits

Additional benefits are included in the evaluation by comparing with-project and without-project. The benefits are calculated in the form of cash flow of each year during the evaluation period. As each project component has different effects, their benefits should be identified for each project component. Project contents, expected effects and their benefits are summarized in the following table.

Table 4.9.1 Project Contents, Expected Effect, and Benefit

Project Contents	Expected Effect	Benefit
Augmentation of capacity of sewage treatment plant	Improvement of sanitary condition in the area	Living environment of the residents in the area improves.
Rehabilitation of existing sewer network and expansion of the network	Improvement of sanitary condition in the area	Living environment of the residents in the area improves.
Installation of septage treatment plant	Improvement of sanitary condition in the area	Living environment of the residents in the area improves.
Capacity development (Soft component)	Improvement of management of sewerage and sanitation facilities	Since this content helps other contents realize their effects effectively, it has no additional benefit by itself.

4.9.2 Cost-Benefit Analysis

Since the benefit of the component (improvement of living environment) cannot be attributed separately to each of three contents, namely; (i) Augmentation of capacity of sewage treatment plant; (ii) Rehabilitation of existing sewer network and expansion of the network; and (iii) Installation of septage treatment plant, such three contents are treated in an integrated manner. Since the capacity development helps other contents realize their effects efficiently and since it has no additional benefit, the economic evaluation of this content is not conducted separately.

(1) Project Cost

The following items are included in the cost calculation:

- Construction
- Engineering services
- Physical contingencies
- Administration cost
- Capacity development cost (Soft component)
- O&M

The land acquisition cost is not included here since the land to be used is presently owned by the government and not being used for any economic activity. These cost items are converted to economic ones as mentioned above. Calculation results are shown in **Tables 4.9.3** to **4.9.5**.

(2) Project Benefit

This project has positive effects on improvement of living environment in the target area, whose benefit can be calculated by their willingness-to-pay.

Willingness-To-Pay (WTP)

According to the results of Socio-economic Survey conducted by the JICA Expert Team, 23.8% of the interviewees answered the WTP for the improvement of sanitary conditions is 500 FCFA per month or 6,000 FCFA per year in 2012 and 8.3% answered 1,000 FCFA per month or 12,000 FCFA

per year. The weighted average is 202 FCFA per month or 2,429 FCFA per year. It is assumed that the WTP increases in accordance with the GDP per capita growth rate. The targeted population includes those who connect to the sewerage system and the septic tank users. The total WTP in the target area is shown in the following table.

Table 4.9.2 Total WTP for the Improvement of Living Environment in Target Area

	2012	2015	2020	2025	2030
Targeted Population (thousand)	–	169	259	339	403
WTP of 500 FCFA case (FCFA/pers/year)	6,000	6,196	6,522	6,849	7,175
Total WTP for 500 FCFA case (million FCFA/year)	–	0	1,690	2,324	2,892
WTP of 1,000 FCFA case (FCFA/pers/year)	12,000	12,392	13,044	13,697	14,350
Total WTP for 1,000 FCFA (million FCFA/year)	–	0	3,380	4,649	5,783
WTP of Weighted Average case (FCFA/pers/year)	2,429	2,508	2,640	2,772	2,904
Total WTP for Weighted Average case (million FCFA/year)	–	0	684	941	1,170

The benefit of the project accrues in accordance with the progress of the construction before 2031. Thus, Full of Total WTP in **Table 4.9.2** accrues after the completion of construction in 2030.

(3) Calculation Results

EIRR is calculated at 2.2% for WTP of 500 FCFA, 9.1% for WTP of 1,000 FCFA, and -9.3% for WTP of weighted average since its benefit is too low. WTP of 1,000 FCFA is of the same level as the solid waste collection fee which is presently paid by users, so that this amount can be realized by education and dissemination campaigns to the people. Detailed calculations are shown in **Tables 4.9.3** to **4.9.5**.

Table 4.9.3 EIRR Calculation (WTP of 500 FCFA)

Unit: Million FCFA

Year	Cost							Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	251.2	246.6	43.7	0.0	0.0	541.4	0.0	-541.4
2017	5,625.2	250.4	246.6	43.7	0.0	0.0	6,165.8	0.0	-6,165.8
2018	5,737.2	250.4	246.6	43.7	0.0	174.3	6,452.1	237.5	-6,214.6
2019	1,816.9	250.4	246.6	43.7	133.2	352.0	2,842.7	523.9	-2,318.8
2020	1,438.1	250.4	246.6	43.7	113.6	408.3	2,500.7	659.8	-1,840.8
2021	1,422.1	250.4	246.6	43.7	113.6	452.9	2,529.3	785.0	-1,744.3
2022	1,438.1	249.4	246.6	43.7	113.6	497.0	2,588.3	920.7	-1,667.6
2023	1,438.1	249.4	246.6	43.7	113.6	541.5	2,632.8	1,068.9	-1,563.9
2024	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	1,229.2	-10.1
2025	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	1,302.6	63.3
2026	7,054.1	249.4	246.6	42.8	133.2	586.1	8,312.1	1,364.3	-6,947.7
2027	3,139.9	249.4	246.6	42.8	113.6	804.6	4,596.9	1,959.1	-2,637.9
2028	1,548.1	249.4	245.7	42.8	113.6	901.9	3,101.6	2,293.7	-807.8
2029	1,548.1	249.4	245.7	42.8	113.6	949.9	3,149.5	2,520.2	-629.3
2030	1,548.1	249.4	245.7	42.8	113.6	997.8	3,197.5	2,758.9	-438.6
2031						1,045.8	1,045.8	2,891.5	1,845.7
2032						1,045.8	1,045.8	2,891.5	1,845.7
2033						1,045.8	1,045.8	2,891.5	1,845.7
2034						1,045.8	1,045.8	2,891.5	1,845.7
2035						1,045.8	1,045.8	2,891.5	1,845.7
2036						1,045.8	1,045.8	2,891.5	1,845.7
2037						1,045.8	1,045.8	2,891.5	1,845.7
2038						1,045.8	1,045.8	2,891.5	1,845.7
2039						1,045.8	1,045.8	2,891.5	1,845.7
2040						1,045.8	1,045.8	2,891.5	1,845.7
2041						1,045.8	1,045.8	2,891.5	1,845.7
2042						1,045.8	1,045.8	2,891.5	1,845.7
2043						1,045.8	1,045.8	2,891.5	1,845.7
2044						1,045.8	1,045.8	2,891.5	1,845.7
2045						1,045.8	1,045.8	2,891.5	1,845.7
2046						1,045.8	1,045.8	2,891.5	1,845.7
2047						1,045.8	1,045.8	2,891.5	1,845.7
2048						1,045.8	1,045.8	2,891.5	1,845.7
2049						1,045.8	1,045.8	2,891.5	1,845.7
2050						1,045.8	1,045.8	2,891.5	1,845.7
2051						1,045.8	1,045.8	2,891.5	1,845.7
2052						1,045.8	1,045.8	2,891.5	1,845.7
2053						1,045.8	1,045.8	2,891.5	1,845.7
2054						1,045.8	1,045.8	2,891.5	1,845.7
2055						1,045.8	1,045.8	2,891.5	1,845.7
2056						1,045.8	1,045.8	2,891.5	1,845.7
2057						1,045.8	1,045.8	2,891.5	1,845.7
2058						1,045.8	1,045.8	2,891.5	1,845.7
2059						1,045.8	1,045.8	2,891.5	1,845.7
2060						1,045.8	1,045.8	2,891.5	1,845.7
Total	33,754.0	3,747.2	3,695.9	651.0	1,402.7				
								EIRR	2.2%

Table 4.9.4 EIRR Calculation (WTP of 1,000 FCFA)

Unit: Million FCFA

Year	Cost							Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	251.2	246.6	43.7	0.0	0.0	541.4	0.0	-541.4
2017	5,625.2	250.4	246.6	43.7	0.0	0.0	6,165.8	0.0	-6,165.8
2018	5,737.2	250.4	246.6	43.7	0.0	174.3	6,452.1	475.0	-5,977.1
2019	1,816.9	250.4	246.6	43.7	133.2	352.0	2,842.7	1,047.8	-1,794.9
2020	1,438.1	250.4	246.6	43.7	113.6	408.3	2,500.7	1,319.7	-1,181.0
2021	1,422.1	250.4	246.6	43.7	113.6	452.9	2,529.3	1,570.0	-959.3
2022	1,438.1	249.4	246.6	43.7	113.6	497.0	2,588.3	1,841.3	-746.9
2023	1,438.1	249.4	246.6	43.7	113.6	541.5	2,632.8	2,137.8	-495.0
2024	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	2,458.3	1,219.0
2025	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	2,605.3	1,365.9
2026	7,054.1	249.4	246.6	42.8	133.2	586.1	8,312.1	2,728.6	-5,583.4
2027	3,139.9	249.4	246.6	42.8	113.6	804.6	4,596.9	3,918.1	-678.8
2028	1,548.1	249.4	245.7	42.8	113.6	901.9	3,101.6	4,587.5	1,485.9
2029	1,548.1	249.4	245.7	42.8	113.6	949.9	3,149.5	5,040.5	1,890.9
2030	1,548.1	249.4	245.7	42.8	113.6	997.8	3,197.5	5,517.7	2,320.2
2031						1,045.8	1,045.8	5,783.0	4,737.2
2032						1,045.8	1,045.8	5,783.0	4,737.2
2033						1,045.8	1,045.8	5,783.0	4,737.2
2034						1,045.8	1,045.8	5,783.0	4,737.2
2035						1,045.8	1,045.8	5,783.0	4,737.2
2036						1,045.8	1,045.8	5,783.0	4,737.2
2037						1,045.8	1,045.8	5,783.0	4,737.2
2038						1,045.8	1,045.8	5,783.0	4,737.2
2039						1,045.8	1,045.8	5,783.0	4,737.2
2040						1,045.8	1,045.8	5,783.0	4,737.2
2041						1,045.8	1,045.8	5,783.0	4,737.2
2042						1,045.8	1,045.8	5,783.0	4,737.2
2043						1,045.8	1,045.8	5,783.0	4,737.2
2044						1,045.8	1,045.8	5,783.0	4,737.2
2045						1,045.8	1,045.8	5,783.0	4,737.2
2046						1,045.8	1,045.8	5,783.0	4,737.2
2047						1,045.8	1,045.8	5,783.0	4,737.2
2048						1,045.8	1,045.8	5,783.0	4,737.2
2049						1,045.8	1,045.8	5,783.0	4,737.2
2050						1,045.8	1,045.8	5,783.0	4,737.2
2051						1,045.8	1,045.8	5,783.0	4,737.2
2052						1,045.8	1,045.8	5,783.0	4,737.2
2053						1,045.8	1,045.8	5,783.0	4,737.2
2054						1,045.8	1,045.8	5,783.0	4,737.2
2055						1,045.8	1,045.8	5,783.0	4,737.2
2056						1,045.8	1,045.8	5,783.0	4,737.2
2057						1,045.8	1,045.8	5,783.0	4,737.2
2058						1,045.8	1,045.8	5,783.0	4,737.2
2059						1,045.8	1,045.8	5,783.0	4,737.2
2060						1,045.8	1,045.8	5,783.0	4,737.2
Total	33,754.0	3,747.2	3,695.9	651.0	1,402.7				
								EIRR	9.1%

Table 4.9.5 EIRR Calculation (WTP of Weighted Average)

Unit: Million FCFA

Year	Cost							Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	251.2	246.6	43.7	0.0	0.0	541.4	0.0	-541.4
2017	5,625.2	250.4	246.6	43.7	0.0	0.0	6,165.8	0.0	-6,165.8
2018	5,737.2	250.4	246.6	43.7	0.0	174.3	6,452.1	96.1	-6,355.9
2019	1,816.9	250.4	246.6	43.7	133.2	352.0	2,842.7	212.1	-2,630.7
2020	1,438.1	250.4	246.6	43.7	113.6	408.3	2,500.7	267.1	-2,233.6
2021	1,422.1	250.4	246.6	43.7	113.6	452.9	2,529.3	317.7	-2,211.5
2022	1,438.1	249.4	246.6	43.7	113.6	497.0	2,588.3	372.7	-2,215.6
2023	1,438.1	249.4	246.6	43.7	113.6	541.5	2,632.8	432.7	-2,200.2
2024	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	497.5	-741.8
2025	0.0	249.4	246.6	43.7	113.6	586.1	1,239.3	527.3	-712.1
2026	7,054.1	249.4	246.6	42.8	133.2	586.1	8,312.1	552.2	-7,759.8
2027	3,139.9	249.4	246.6	42.8	113.6	804.6	4,596.9	793.0	-3,804.0
2028	1,548.1	249.4	245.7	42.8	113.6	901.9	3,101.6	928.4	-2,173.2
2029	1,548.1	249.4	245.7	42.8	113.6	949.9	3,149.5	1,020.1	-2,129.5
2030	1,548.1	249.4	245.7	42.8	113.6	997.8	3,197.5	1,116.7	-2,080.8
2031						1,045.8	1,045.8	1,170.4	124.6
2032						1,045.8	1,045.8	1,170.4	124.6
2033						1,045.8	1,045.8	1,170.4	124.6
2034						1,045.8	1,045.8	1,170.4	124.6
2035						1,045.8	1,045.8	1,170.4	124.6
2036						1,045.8	1,045.8	1,170.4	124.6
2037						1,045.8	1,045.8	1,170.4	124.6
2038						1,045.8	1,045.8	1,170.4	124.6
2039						1,045.8	1,045.8	1,170.4	124.6
2040						1,045.8	1,045.8	1,170.4	124.6
2041						1,045.8	1,045.8	1,170.4	124.6
2042						1,045.8	1,045.8	1,170.4	124.6
2043						1,045.8	1,045.8	1,170.4	124.6
2044						1,045.8	1,045.8	1,170.4	124.6
2045						1,045.8	1,045.8	1,170.4	124.6
2046						1,045.8	1,045.8	1,170.4	124.6
2047						1,045.8	1,045.8	1,170.4	124.6
2048						1,045.8	1,045.8	1,170.4	124.6
2049						1,045.8	1,045.8	1,170.4	124.6
2050						1,045.8	1,045.8	1,170.4	124.6
2051						1,045.8	1,045.8	1,170.4	124.6
2052						1,045.8	1,045.8	1,170.4	124.6
2053						1,045.8	1,045.8	1,170.4	124.6
2054						1,045.8	1,045.8	1,170.4	124.6
2055						1,045.8	1,045.8	1,170.4	124.6
2056						1,045.8	1,045.8	1,170.4	124.6
2057						1,045.8	1,045.8	1,170.4	124.6
2058						1,045.8	1,045.8	1,170.4	124.6
2059						1,045.8	1,045.8	1,170.4	124.6
2060						1,045.8	1,045.8	1,170.4	124.6
Total	33,754.0	3,747.2	3,695.9	651.0	1,402.7				
								EIRR	-9.3%

4.10 Financial Analysis

4.10.1 Methodology

(1) General

A main objective of the financial analysis here is to examine the investment efficiency of the component of Master Plan from the viewpoint of the project implementation body using cost-benefit analysis in the case where it can be applied. Market prices are used here. An Internal

Rate of Return (IRR) is used here as the indicator of efficiency of project investment. IRR used in financial evaluation is called the Financial Internal Rate of Return (FIRR).

(2) Preconditions

The following preconditions are assumed in the financial evaluation. Additional preconditions are clarified as necessary.

(a) With-Project and Without-Project

"Without-project" is the case where the wastewater is managed by the currently existing systems. "With-project" is the case where the project component is implemented in addition to the currently existing systems. By comparing the "with-project" and the "Without-project", costs and benefits accruing are estimated to calculate FIRR.

(b) Evaluation Period

The Evaluation period is from 2014 to 2060 (30 years after the completion of construction).

(c) Other Preconditions

Price Level	:	Year 2012
Exchange Rate	:	FCFA 1.00 =JPY 0.1487
Social Discount Rate	:	12% (employed in *Project Appraisal Document on Stormwater Management and Climate Change Adaptation Project, April 12, 2012, the World Bank.*)

(3) Costs

Costs include any money value in market prices actually spent for the project. The additional costs are calculated in the form of cash flow in each year during the evaluation period. The following cost items were calculated:

(a) Investment Cost

Investment cost includes costs incurred in the construction of the facility, equipment, and for consulting services. Financial evaluation excludes price escalation but includes physical contingencies.

(b) Operation and Maintenance Cost

Operation and maintenance cost for each year is included. However, price escalations are not included.

(c) Depreciation

Since the money allocated is subject to depreciation but is not actually spent at that time, it is not included in the cost estimates.

(4) Benefits

Benefits are any money value in market price actually gained by the project. Necessary additional benefits are estimated in the evaluation by calculating FIRR. The benefits are presented in the form of cash flow in each year during the evaluation period.

4.10.2 Cost-Benefit Analysis

Since the capacity development (soft component) helps other contents realize their effects efficiently and since it has no additional benefit, the economic evaluation of this content is not conducted separately.

(1) Project Cost

The following items are included in the cost calculation:

- Construction

- Physical contingencies
- Consulting services
- Administration cost
- Capacity development cost (soft component)
- VAT
- O&M

The land acquisition cost is not included here since the land to be used is presently owned by the government and not being used for any economic activity. All of the cost items are indicated in market prices as mentioned above. Calculation results are shown in **Tables 4.10.2** to **4.10.4**.

(2) Project Benefits

Project benefits are the revenues from (i) sewerage charges, that is, 8% of water supply charge which is collected with water supply charge for the people in sewerage area; and (ii) septage treatment charge outside sewerage area. However, since sewerage charge is presently collected also from those who have no connection to the sewerage system, sewerage charge is applied to all the people for the purpose of the benefit calculation.

Presently, sewerage charge for each concession is 10 FCFA per CM of water consumption of up to 20 CM and 45.65 FCFA per CM of water consumption from 21 CM to 40 CM. Average charge per CM is calculated with average number of people in one concession, 9.54 in 2012 by Kaolack City. It is regarded as the base case to estimate how many times the charge should be increased with calculating FIRR.

Sewerage charge collection is very effective since the non-revenue rate is presently around 20%, which is very low, compared with other developing countries, for example 40% in Pakistan whose per capita GDP is the similar level to Senegal's.

It is stipulated that sewerage charge is levied on water charge in Presidential Decree No. 96-662 (issued in 1996), which is the decree on establishment of ONAS. The Board of Directors, whose members consist of related Ministers, has the responsibility for the management of ONAS. However, the change in percentage levied on the water charge requires the agreement of SDE, which is the private operator of water production and distribution for urban area and in charge of billing and collection of water charge. Although ONAS has been asking SDE to increase the percentage because its charge revenue is very low, SDE has been rejecting so far.

Concerning the charge of the Septage Treatment, although it is usual that the charge should be levied on desludging service suppliers to such amount as operation and maintenance cost for public utility service, it should be considered that the charge be free for the time being with the following reasons: (1) it is highly concerned that the desludging service suppliers would dump the sludge illegally; (2) sewerage charge is levied on those households that are not connected to the sewerage system.

Table 4.10.1 Total Revenue from Sewerage Charge

	2012	2015	2020	2025	2030
Targeted Population (thousand)	–	169	259	339	403
Water Consumption (lpcd)	74.0	76.0	80.0	84.0	88.0
Average Charge (FCFA/CM)	11.98	12.87	14.51	15.99	17.34
Total Water Consumption (thousand CM/yr)	–	4,682	7,566	10,406	12,944
Total Revenue (million FCFA)	–	0	111	166	225

The benefit of the project accrues in accordance with the progress of construction before 2031. Thus, Full of Total Revenue in **Table 4.10.1** accrues after the completion of construction in 2030.

(3) Calculation Results

FIRR cannot be calculated with the base case because the benefit is too low, which means sewerage

charge is set at a very low level. FIRR will be 0.0% if the sewerage charge is increased to 13.6 times and 12.0% (equal to Social Discount Rate) if 49.0 times. Detailed calculations are shown in **Tables 4.10.2** to **4.10.4**.

Table 4.10.2 FIRR Calculation (Base Case)

Unit: Million FCFA

Year	Cost								Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	VAT	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	264.0	288.0	52.0	0.0	118.0	0.0	722.0	0.0	-722.0
2017	6,358.0	263.0	288.0	52.0	0.0	1,395.0	0.0	8,356.0	0.0	-8,356.0
2018	6,574.0	263.0	288.0	52.0	0.0	1,482.0	201.5	8,860.5	12.7	-8,847.8
2019	2,163.0	263.0	288.0	52.0	145.0	594.0	409.9	3,914.9	29.1	-3,885.7
2020	1,712.0	263.0	288.0	52.0	125.0	512.0	478.4	3,430.4	38.0	-3,392.4
2021	1,693.0	263.0	288.0	52.0	125.0	523.0	532.7	3,476.7	47.0	-3,429.7
2022	1,712.0	262.0	288.0	52.0	125.0	542.0	586.3	3,567.3	56.6	-3,510.7
2023	1,712.0	262.0	288.0	52.0	125.0	558.0	640.6	3,637.6	67.5	-3,570.1
2024	0.0	262.0	288.0	52.0	125.0	148.0	694.8	1,569.8	79.5	-1,490.3
2025	0.0	262.0	288.0	52.0	125.0	152.0	694.8	1,573.8	86.1	-1,487.8
2026	8,092.0	262.0	288.0	51.0	145.0	2,243.0	694.8	11,775.8	92.9	-11,683.0
2027	3,738.0	262.0	288.0	51.0	125.0	1,178.0	951.3	6,593.3	135.5	-6,457.8
2028	1,843.0	262.0	287.0	51.0	125.0	681.0	1,069.8	4,318.8	162.1	-4,156.7
2029	1,843.0	262.0	287.0	51.0	125.0	701.0	1,128.2	4,397.2	181.4	-4,215.7
2030	1,843.0	262.0	287.0	51.0	125.0	720.0	1,186.6	4,474.6	202.2	-4,272.4
2031							1,245.0	1,245.0	224.5	-1,020.5
2032							1,245.0	1,245.0	224.5	-1,020.5
2033							1,245.0	1,245.0	224.5	-1,020.5
2034							1,245.0	1,245.0	224.5	-1,020.5
2035							1,245.0	1,245.0	224.5	-1,020.5
2036							1,245.0	1,245.0	224.5	-1,020.5
2037							1,245.0	1,245.0	224.5	-1,020.5
2038							1,245.0	1,245.0	224.5	-1,020.5
2039							1,245.0	1,245.0	224.5	-1,020.5
2040							1,245.0	1,245.0	224.5	-1,020.5
2041							1,245.0	1,245.0	224.5	-1,020.5
2042							1,245.0	1,245.0	224.5	-1,020.5
2043							1,245.0	1,245.0	224.5	-1,020.5
2044							1,245.0	1,245.0	224.5	-1,020.5
2045							1,245.0	1,245.0	224.5	-1,020.5
2046							1,245.0	1,245.0	224.5	-1,020.5
2047							1,245.0	1,245.0	224.5	-1,020.5
2048							1,245.0	1,245.0	224.5	-1,020.5
2049							1,245.0	1,245.0	224.5	-1,020.5
2050							1,245.0	1,245.0	224.5	-1,020.5
2051							1,245.0	1,245.0	224.5	-1,020.5
2052							1,245.0	1,245.0	224.5	-1,020.5
2053							1,245.0	1,245.0	224.5	-1,020.5
2054							1,245.0	1,245.0	224.5	-1,020.5
2055							1,245.0	1,245.0	224.5	-1,020.5
2056							1,245.0	1,245.0	224.5	-1,020.5
2057							1,245.0	1,245.0	224.5	-1,020.5
2058							1,245.0	1,245.0	224.5	-1,020.5
2059							1,245.0	1,245.0	224.5	-1,020.5
2060							1,245.0	1,245.0	224.5	-1,020.5
Total	39,283.0	3,937.0	4,317.0	775.0	1,540.0	11,547.0				
									FIRR	#DIV/0!

Table 4.10.3 FIRR Calculation (13.6 Times)

Unit: Million FCFA

Year	Cost								Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	VAT	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	264.0	288.0	52.0	0.0	118.0	0.0	722.0	0.0	-722.0
2017	6,358.0	263.0	288.0	52.0	0.0	1,395.0	0.0	8,356.0	0.0	-8,356.0
2018	6,574.0	263.0	288.0	52.0	0.0	1,482.0	201.5	8,860.5	173.5	-8,687.0
2019	2,163.0	263.0	288.0	52.0	145.0	594.0	409.9	3,914.9	397.3	-3,517.6
2020	1,712.0	263.0	288.0	52.0	125.0	512.0	478.4	3,430.4	518.1	-2,912.3
2021	1,693.0	263.0	288.0	52.0	125.0	523.0	532.7	3,476.7	640.2	-2,836.4
2022	1,712.0	262.0	288.0	52.0	125.0	542.0	586.3	3,567.3	771.9	-2,795.4
2023	1,712.0	262.0	288.0	52.0	125.0	558.0	640.6	3,637.6	919.8	-2,717.8
2024	0.0	262.0	288.0	52.0	125.0	148.0	694.8	1,569.8	1,083.9	-485.9
2025	0.0	262.0	288.0	52.0	125.0	152.0	694.8	1,573.8	1,173.4	-400.5
2026	8,092.0	262.0	288.0	51.0	145.0	2,243.0	694.8	11,775.8	1,266.1	-10,509.8
2027	3,738.0	262.0	288.0	51.0	125.0	1,178.0	951.3	6,593.3	1,847.2	-4,746.1
2028	1,843.0	262.0	287.0	51.0	125.0	681.0	1,069.8	4,318.8	2,209.2	-2,109.6
2029	1,843.0	262.0	287.0	51.0	125.0	701.0	1,128.2	4,397.2	2,473.2	-1,924.0
2030	1,843.0	262.0	287.0	51.0	125.0	720.0	1,186.6	4,474.6	2,756.5	-1,718.1
2031							1,245.0	1,245.0	3,059.6	1,814.6
2032							1,245.0	1,245.0	3,059.6	1,814.6
2033							1,245.0	1,245.0	3,059.6	1,814.6
2034							1,245.0	1,245.0	3,059.6	1,814.6
2035							1,245.0	1,245.0	3,059.6	1,814.6
2036							1,245.0	1,245.0	3,059.6	1,814.6
2037							1,245.0	1,245.0	3,059.6	1,814.6
2038							1,245.0	1,245.0	3,059.6	1,814.6
2039							1,245.0	1,245.0	3,059.6	1,814.6
2040							1,245.0	1,245.0	3,059.6	1,814.6
2041							1,245.0	1,245.0	3,059.6	1,814.6
2042							1,245.0	1,245.0	3,059.6	1,814.6
2043							1,245.0	1,245.0	3,059.6	1,814.6
2044							1,245.0	1,245.0	3,059.6	1,814.6
2045							1,245.0	1,245.0	3,059.6	1,814.6
2046							1,245.0	1,245.0	3,059.6	1,814.6
2047							1,245.0	1,245.0	3,059.6	1,814.6
2048							1,245.0	1,245.0	3,059.6	1,814.6
2049							1,245.0	1,245.0	3,059.6	1,814.6
2050							1,245.0	1,245.0	3,059.6	1,814.6
2051							1,245.0	1,245.0	3,059.6	1,814.6
2052							1,245.0	1,245.0	3,059.6	1,814.6
2053							1,245.0	1,245.0	3,059.6	1,814.6
2054							1,245.0	1,245.0	3,059.6	1,814.6
2055							1,245.0	1,245.0	3,059.6	1,814.6
2056							1,245.0	1,245.0	3,059.6	1,814.6
2057							1,245.0	1,245.0	3,059.6	1,814.6
2058							1,245.0	1,245.0	3,059.6	1,814.6
2059							1,245.0	1,245.0	3,059.6	1,814.6
2060							1,245.0	1,245.0	3,059.6	1,814.6
Total	39,283.0	3,937.0	4,317.0	775.0	1,540.0	11,547.0				
									FIRR	0.0%

Table 4.10.4 FIRR Calculation (49.0 Times)

Unit: Million FCFA

Year	Cost								Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	Soft Component	VAT	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	264.0	288.0	52.0	0.0	118.0	0.0	722.0	0.0	-722.0
2017	6,358.0	263.0	288.0	52.0	0.0	1,395.0	0.0	8,356.0	0.0	-8,356.0
2018	6,574.0	263.0	288.0	52.0	0.0	1,482.0	201.5	8,860.5	623.6	-8,236.9
2019	2,163.0	263.0	288.0	52.0	145.0	594.0	409.9	3,914.9	1,428.2	-2,486.6
2020	1,712.0	263.0	288.0	52.0	125.0	512.0	478.4	3,430.4	1,862.7	-1,567.7
2021	1,693.0	263.0	288.0	52.0	125.0	523.0	532.7	3,476.7	2,301.8	-1,174.9
2022	1,712.0	262.0	288.0	52.0	125.0	542.0	586.3	3,567.3	2,775.3	-792.0
2023	1,712.0	262.0	288.0	52.0	125.0	558.0	640.6	3,637.6	3,307.0	-330.6
2024	0.0	262.0	288.0	52.0	125.0	148.0	694.8	1,569.8	3,897.0	2,327.1
2025	0.0	262.0	288.0	52.0	125.0	152.0	694.8	1,573.8	4,218.5	2,644.7
2026	8,092.0	262.0	288.0	51.0	145.0	2,243.0	694.8	11,775.8	4,551.8	-7,224.0
2027	3,738.0	262.0	288.0	51.0	125.0	1,178.0	951.3	6,593.3	6,641.1	47.8
2028	1,843.0	262.0	287.0	51.0	125.0	681.0	1,069.8	4,318.8	7,942.7	3,623.9
2029	1,843.0	262.0	287.0	51.0	125.0	701.0	1,128.2	4,397.2	8,891.9	4,494.7
2030	1,843.0	262.0	287.0	51.0	125.0	720.0	1,186.6	4,474.6	9,910.3	5,435.7
2031							1,245.0	1,245.0	11,000.2	9,755.2
2032							1,245.0	1,245.0	11,000.2	9,755.2
2033							1,245.0	1,245.0	11,000.2	9,755.2
2034							1,245.0	1,245.0	11,000.2	9,755.2
2035							1,245.0	1,245.0	11,000.2	9,755.2
2036							1,245.0	1,245.0	11,000.2	9,755.2
2037							1,245.0	1,245.0	11,000.2	9,755.2
2038							1,245.0	1,245.0	11,000.2	9,755.2
2039							1,245.0	1,245.0	11,000.2	9,755.2
2040							1,245.0	1,245.0	11,000.2	9,755.2
2041							1,245.0	1,245.0	11,000.2	9,755.2
2042							1,245.0	1,245.0	11,000.2	9,755.2
2043							1,245.0	1,245.0	11,000.2	9,755.2
2044							1,245.0	1,245.0	11,000.2	9,755.2
2045							1,245.0	1,245.0	11,000.2	9,755.2
2046							1,245.0	1,245.0	11,000.2	9,755.2
2047							1,245.0	1,245.0	11,000.2	9,755.2
2048							1,245.0	1,245.0	11,000.2	9,755.2
2049							1,245.0	1,245.0	11,000.2	9,755.2
2050							1,245.0	1,245.0	11,000.2	9,755.2
2051							1,245.0	1,245.0	11,000.2	9,755.2
2052							1,245.0	1,245.0	11,000.2	9,755.2
2053							1,245.0	1,245.0	11,000.2	9,755.2
2054							1,245.0	1,245.0	11,000.2	9,755.2
2055							1,245.0	1,245.0	11,000.2	9,755.2
2056							1,245.0	1,245.0	11,000.2	9,755.2
2057							1,245.0	1,245.0	11,000.2	9,755.2
2058							1,245.0	1,245.0	11,000.2	9,755.2
2059							1,245.0	1,245.0	11,000.2	9,755.2
2060							1,245.0	1,245.0	11,000.2	9,755.2
Total	39,283.0	3,937.0	4,317.0	775.0	1,540.0	11,547.0				
									FIRR	12.0%

4.11 Selection of Priority Project for Feasibility Study

(1) Introduction

In the M/P, the priority projects are formulated focusing on the major facilities in the 1st priority area, namely; "Package P1-1 of Project-1". Outlines of the priority projects are described below. Feasibility study is conducted for the priority projects.

(2) Priority Projects (Sewer Network and Pumping Stations)

Based on the above introduction, "Package P1-1 of Project-1" is selected as the priority project, which consist of the construction of new trunk sewer (12,330 km) and replacement of trunk sewer (5,830 km); and new construction or replacement/rehabilitation of six pumping stations (new construction of three pumping stations and replacement/rehabilitation of three pumping stations), as listed in **Table 4.11.1** and **Table 4.11.2**. The locations of the priority projects are as indicated in **Fig. 4.11.1**.

Table 4.11.1 Priority Projects (Sewer Network)

Diameter (mm)	Length (m)		Total (m)
	New construction	Replacement	
Trunk sewer (Gravity flow)			
φ200	5,510	-	5,510
φ250	1,780	-	1,780
φ300	1,080	280	1,360
φ400	2,270	1,460	3,730
φ500	490	2,150	2,640
φ600	-	570	570
φ700	-	-	0
φ700 × 2	-	700	700
φ900	-	10	10
Sub-Total	11,130	5,170	16,300
Trunk Sewer (Force Main)			
φ150	480	660	1,140
φ200	720	-	720
Sub-total	1,200	660	1,860
Total	12,330	5,830	18,160

Table 4.11.2 Priority Projects (Pumping Stations)

	Capacity of each pump (m^3/min) and, number of pump	Total capacity (m^3/min)	Remarks
New construction			
PS No.1 north:	4.0 m^3/min × 2 8.0 m^3/min × 2(1)	16.0	Installed in the North Area of STP
PS Darou Salam Ndangane	0.9 m^3/min × 3(1)	1.8	-
PS Boustane:	1.9 m^3/min × 3(1)	3.8	-
Replacement/Rehabilitation			-
PS No.1 south	3.0 m^3/min × 2 6.0 m^3/min × 1(1)	6.0	Replacement and/or augmentation of pumping equipment and pumping well
PS No.2:	3.2 m^3/min × 2 6.5 m^3/min × 1(1)	6.4	
PS No.3:	2.1 m^3/min × 3(1)	4.2	

Note: Number in parenthesis is standby pump.

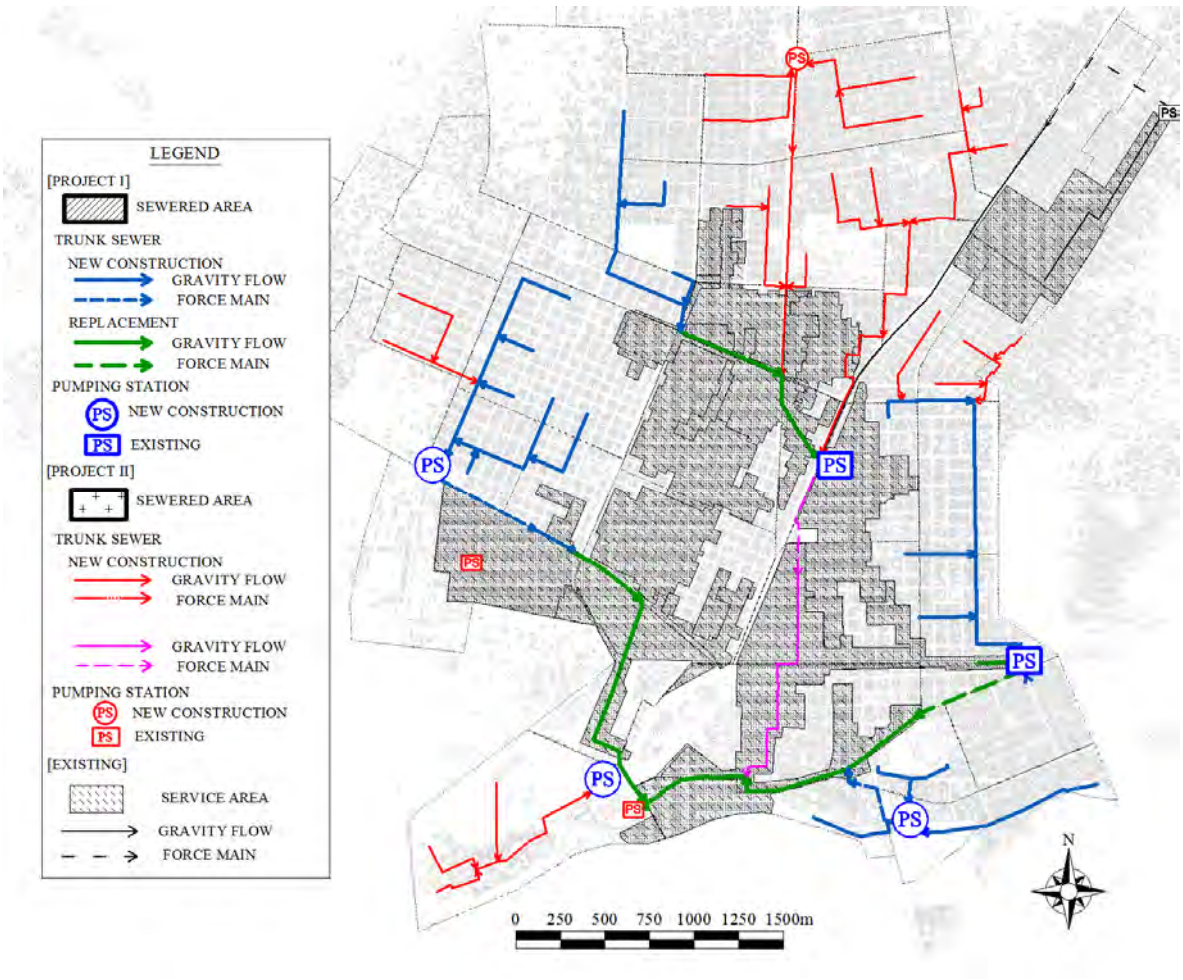


Fig. 4.11.1 Location of Priority Projects (Sewer Network and Pumping Stations)

(3) Priority Projects (Sewage Treatment Plant)

As with the priority projects of sewer network and pumping stations, "Package P1-1 of Project-1" is selected as the priority project. The priority projects includes rehabilitation of existing area to the lagoon (capacity: Q=3,000 m^3/day) with the configuration of anaerobic, facultative and maturation lagoons; construction of aerated lagoon (capacity: Q=12,000 m^3/day) and construction of septage treatment facilities, as summarized in the following table.

Table 4.11.3 Priority Projects (Sewage Treatment Plant)

	Name	Capacity	Remarks
New construction	Aerated lagoon	12,000 m^3/day	Including chlorination chamber
	Septage treatment facilities	70 m^3/day	BOD_5 load in : 250 kg/day
	Connection pipe	380 m	
Rehabilitation	Lagoon	3,000 m^3/day	

(4) Recommendation for Branch Sewer Installation

Branch sewer installation is not included in the priority projects. However, the branch sewer installation is indispensable to optimize the major facilities such as trunk sewer, pumping stations and sewage treatment plant. Based on the discussions in "**Subsection 4.8** Implementation Plan", the branch sewer installation plan is as summarized in the following table.

Table 4.11.4 Stepwise Branch Sewer Installation Plan

	Year	Area (ha)	Construction cost (mil FCFA)
Phase 1	2019	90	1,693
	2020	91	1,712
Phase 2	2021	90	1,693
	2022	91	1,712
	2023	91	1,712
	2024	0	0
	2025	0	0
Phase 3	2026	98	1,826
	2027	98	1,843
	2028	98	1,843
	2029	98	1,843
	2030	97	1,843
Total		942	17,720

ONAS is responsible for branch sewer installation and it should look for a financial source for the implementation. So far, financial support is envisaged from donors such as the WB and/or the Government of Senegal through ADM, which are involved in related sewerage projects in Kaolack.

The schedule for branch sewer installation is very challenging to ONAS, comparing the construction volume of every year (about 100 ha) and the latest historical achievement of the branch sewer installation, for example, about 90 ha by the WB and 92 ha in PRECOL area by ADM, implemented from 2003 up to the present. Under the circumstances, ONAS requires an extraordinary effort and involvement to secure funds from donors and/or the Government of Senegal for smooth installation of branch sewer network, more than ever.

CHAPTER 5. STORMWATER DRAINAGE MANAGEMENT PLAN

5.1 Planning Concept

5.1.1 Issues on Stormwater Drainage Management

A stormwater drainage network has been installed in the central part of Kaolack City. The stormwater drainage management has the following issues to be addressed.

- Kaolack City is vulnerable to floods and stormwater because of its low-lying topography and hydrological conditions. There are some habitual flooding areas. The flood and inundation affected residents, causing traffic and disturbing commercial activities in Kaolack City. Habitual flooding occurs in the depressed topography so that its lowest elevation without stormwater drainage system causes further difficulty to drain out flooded stormwater.
- The existing stormwater drainage facilities are composed of open drains, covered drains and manholes. Most of the drains could not meet their discharge capacities because of heavy deposits caused by illegal dumping of solid waste. Therefore, in the rainy season, stormwater cannot be conveyed through the drainage network due to the clogging situation.
- A large number of sewer pipes coming from houses along the drains are connected into the existing drains. Therefore, in the dry season, water mainly composed of domestic wastewater is stagnant and deteriorated, resulting in worsening the urban environment providing the offensive odor and bad scenery.
- Most of the existing open drains are simply excavated earth canals in unsustainable condition. Therefore, they get easily damaged and collapse. These open drains have large flow capacities so that they are considered as key facilities of the stormwater drainage system and should be sustained by proper rehabilitation, because they have been working effectively in improving the stormwater drainage.
- Proper O&M organizations and activities should be required to sustain the discharge capacities and protect the drainage against illegal activities such as dumping of solid waste and connecting sewer pipes to drainage from houses. To attain these objectives, the strengthening of O&M organization and O&M plan for the drainage system are considered.
- Public participation should be promoted by enhancement of public awareness for stormwater drainage management in order to improve and maintain the drainage facilities including various community-involved activities.

5.1.2 Planning Objectives

Based on the issues mentioned above, stormwater drainage management of this study has the following objectives:

- To minimize the inundation and damage caused by local rainfall by providing the new drainage system;
- To recover and maintain the original and potential functions of existing drainage systems; and
- To improve the hygienic condition of the urban environment for the residents

5.1.3 Target Area and Target Year

(1) Target Area

The target area of the Master Plan is about 24 km^2 in the city center of Kaolack City as agreed with Kaolack City through the Technical Committee (T/C) and the Steering Committee (S/C). The area covers the stormwater drainage basin of the city center of Kaolack City.

The delineation of drainage boundary was based on the concept of a ridgeline. The ridgeline is an

imaginary line from which surface runoff would separate and flow in either direction away from this imaginary line. The target area of the Master Plan is shown in **Fig. 5.1.1**.

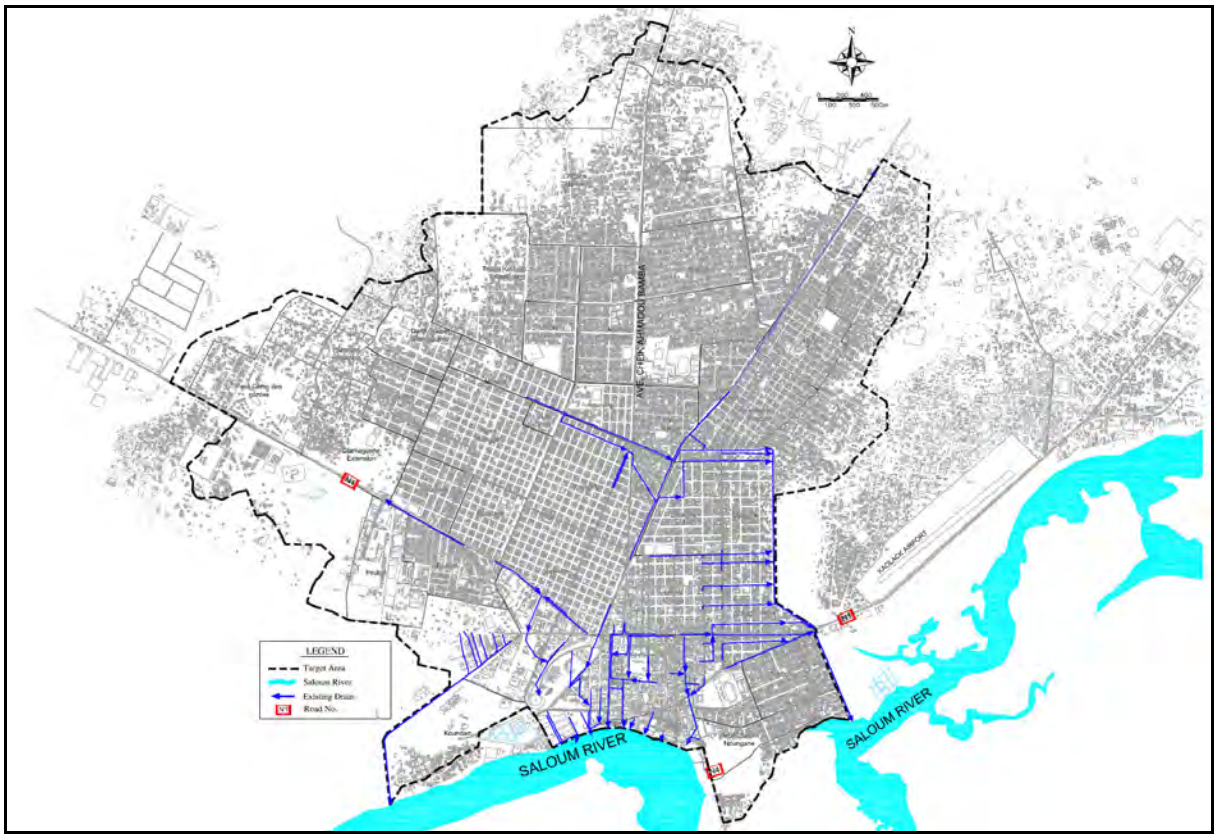


Fig. 5.1.1 Target Area for Stormwater Drainage Planning

(2) Target Year

Target year of the Master Plan is 2030, and the Master Plan is to be implemented in three terms as follows:

- Short-term for Phase 1 projects by end of 2020
- Mid-term for Phase 2 projects from 2021 to 2025
- Long-term for Phase 3 projects from 2026 to 2030

Priority projects are selected from the Phase 1 projects from the viewpoints of degree of urgency, number of project beneficiaries, and technical, financial and environmental considerations.

5.1.4 Planning Conditions

(1) Design Scale

The design scale means the safety level under which stormwater can be safely conveyed through structural countermeasures, such as drainage network system, pumping station and retention ponds. As described in the proceeding section, 10-years design storm could be adopted for Kaolack City for drainage planning.

(2) Design Discharge

Three generally accepted methods of determining runoff discharge were considered, namely; the Unit Graph Method is usually adopted for drainage areas greater than 20 sq. km while the Rational Method is used for drainage areas of 20 sq. km or less. Greater accuracy is achieved from the latter for drainage areas appreciably less than 20 sq. km. The Regional Frequency Method is usually used as a countercheck on the first two methods or where only discharge data are available on a wide scale within the region. Based on simplicity and applicability, as well as considering that most of

the tributaries are less than 20 sq. km., the Rational Formula was deemed most appropriate and was therefore adopted in the calculation of discharge.

In its simplest form, the Rational Formula is expressed as,

$$Q = \frac{1}{3.6} \times F \times I \times A$$

where;

Q = design discharge, m^3/sec
F = runoff coefficient
I = rainfall intensity, mm/hr
A = drainage area, km^2

(a) Rainfall Intensity

The value of I is calculated by using the following Tablet Formula:

$$I = \frac{b}{Tc + a}$$

where;

I = rainfall intensity, mm/hr
Tc = time of concentration, minutes
a, b = numerical constants

Probability analysis of daily rainfall and producing rainfall intensity curve describe in **Subsection 2.1.4**. The result of calculation for 10 years return period is as follows:

$$I = \frac{5{,}427.8}{Tc + 36.9}$$

(b) Runoff Coefficient

Values of F for different land use types are shown in **Table 5.1.1**.

Table 5.1.1 Runoff Coefficient, F, for Land Use Types

Land Use Category	Value of F
Central commercial Area	0.90
Industrial Area	0.80
Residential Area	
High density	0.40
Medium density	0.30
Low density	0.20
Agricultural Area	0.10
Park, Cemetery Area	0.20

Source: The Study on Urban Drainage and Wastewater Systems in Dakar City and Its Surroundings (JICA)
Stormwater Drainage and Land Reclamation for Urban Development (United Nations Center)

(c) Time of Concentration

The rainfall intensity, as shown above, is dependent on the time of concentration (Tc). This parameter is measured as the total time for a water particle to traverse its course from remotest part of the drainage divide to the point of interest. Two components of Tc have been considered, namely; the inlet time (Ti) and drain flow time (Td).

$$Tc = Ti + Td$$

The inlet time is controlled by many factors such as form and area of basin, slope of ground surface, etc. Generally, 20 to 30 minutes is used as the inlet time for flat residential area. The report of the Study on Urban Drainage and Wastewater System in Dakar City mentioned 20 minutes was applied for the inlet time in Dakar City. Kaolack City is more flat area than

Dakar City; however, with the consideration of safety of drainage facilities, 20 minutes is applied for the inlet time in this study. Drain flow time can be closely estimated from the hydraulic properties of the drains. In practice, expected average flowing-full velocity is used for calculation of the design flow. Actual flowing velocity could be obtained from calculation flow. If there are big discrepancies between the average velocity and the actual velocity, the design flow calculation will be based on the re-evaluated average velocity and must be calculated again.

(3) Design of Storm Drain

The Manning's formula shall be used for designing the storm drain. The formula is as stated below:

$$Q = \frac{1}{n} \times A \times R^{2/3} \times S^{1/2}$$

where;

Q = design discharge, m^3/sec
n = roughness coefficient
A = drain section area, m^2
R = hydraulic average depth, m
S = flow gradient

Coefficient of roughness for different materials, as shown in **Table 5.1.2**, shall be applied.

Table 5.1.2 Roughness Coefficient

Type	Roughness Coefficient
RC pipe	0.013
In-situ concrete	0.015
Excavated earth canal	0.030

Source: Guideline for Planning and Design of Sewerage Facility (Japan Sewage Works Associations)
Stormwater Drainage and Land Reclamation for Urban Development (United Nations Center)

(4) Pumping Station and Retention Pond

The design rainfall for pumping station and retention pond is determined by using 3 hours' rainfall amount and intensity-duration equation for the 10 years return period of storm.

5.1.5 Evaluation of Existing Drainage Network

As described in the **Subsection 2.3.2**, the installed drains reached a total length of 19.96 km, which consist of 12.38 km long open drain and 7.58 km long covered drain. The existing drainage system of 19.96 km long covered 7.8 km^2 of the territory of Kaolack City as shown in **Fig. 2.3.2**.

The Manning's formula is used for evaluation of the existing drainage system for 10 years return period of storm water. The existing drains have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to concrete drains. As a result, the existing drains have sufficient capacity for peak discharge of 10-year return period.

5.1.6 Necessary Measure of Stormwater Drainage Management

In order to achieve drainage improvement in Kaolack City, it is necessary to carry out integrated measures that include structural and supporting measures.

(1) Structural Measures

The structural measures aim to mitigate the inundation by installation of stormwater drainage network, construction of pumping station and retention pond, improvement of existing stormwater drainage, etc.

(2) Supporting Measures

The supporting measures aim to support and sustain the structural measures by improving and

developing organizational aspects of the operation and maintenance system, preparing the cleaning plan for drainage facilities, and enhancement of public awareness.

5.1.7 Organizational and Institutional Improvement

Financial sustainability as well as institutional improvement of related agencies and actors is important for the success of the project. The municipalities are closely related to the urban flooding issue and storm water management but lack resources and capacity. Improvement of institutional and financial capability should be started during project preparation. This improvement should be implemented over the project implementation period addressing issues on institutional development, financial sustainability as well as strengthening capacities of the related agencies and actors, in particular. Since the World Bank has presented an example of an implementation support plan in *Project Appraisal Document on Stormwater Management and Climate Change Adaptation Project, April 12, 2012*, it should be referred to make a detailed implementation plan.

Table 5.1.3 Example of Implementation Support Plan (World Bank)

Time	Focus	Skill Needed
First Twelve Months	• Establishment of Special Account. • Quality of Terms of Reference (TOR) and bidding documents • Procurement of key contracts • Execution of contracts (first priority investments) • Implementation of the Environmental and Social Impact Assessment (ESIA), Environmental and Social Management Framework (ESMF) and Resettlement Policy Framework (RPF). • Community investments preparation • Impact evaluation baseline survey	• Drainage • Disaster Risk Management • Institutional specialist (water and sanitation) • Urban climate change adaptation • Procurement • Financial management • Environment and social safeguards • Monitoring & Evaluation
12 to 48 Months	• Quality of TORs, studies and bidding documents • Procurement and execution of key contracts • Application of the Environmental and Social Management Plan (ESMP) and Resettlement Action Plans (RAPs). • Institutional reforms of the sector • Community investments monitoring	• Core team skills • Disaster Risk Management • Institutional specialist (water and sanitation) • Urban climate change adaptation • Financial management • Urban climate change adaptation

Source: World Bank

The Ministry of Restructuring and Spatial Flood Zone (Ministère de la Restructuration et de l'Aménagement des zones d'inondations) was established in October 2012. Kaolack City has to cooperate and coordinate with the Ministry on drainage issues. At this time of report preparation, detailed organization and responsibilities are not necessarily clear. Further study is required for incorporating this setup in the Master Plan in the next phase.

5.1.8 Financial Considerations

The budget for the drainage canal cleaning is shown below.

Table 5.1.4 Budget for Drainage Canal Cleaning of Kaolack City

Unit: FCFA

Year	Final Forecast (FCFA)	Realization (FCFA)	%
2005	19,122,950	19,080,000	99.78
2006	14,659,280	14,640,000	99.87
2007	10,000,000	0	0.00
2008	19,999,976	19,998,564	99.99
2009	10,000,000	9,917,699	99.18
2010	10,000,000	5,031,048	50.31

Year	Final Forecast (FCFA)	Realization (FCFA)	%
2011	15,000,000	4,548,192	30.32
2012*	23,000,000	7,085,000	30.80

Note: (*) as of October 2012
Source: Ministry of Economic and Finance and Kaolack City

It should be noted that the canal cleaning contractor was not paid in 2007 because the revenue of the city was not enough. The budget in 2007 was carried over to 2008 and the contractor was paid in 2008. Hence, the budget seems double in 2008 but the actual cleaning budget was almost the same. The realization rate has been low since 2010 because the tax revenue has been low due to the economic recession. If the Senegal's economy gets well, the budget of around ten million FCFA might be secured, but it will still be short to fully maintain the drainage canals. Thus, support or subsidy from the national government is strongly required.

5.2 Alternative Study for Structural Stormwater Drainage Improvement

5.2.1 Description of Alternative Layout

Three alternative layouts (**Fig. 5.2.1** to **Fig. 5.2.3)**, have been evaluated in order to arrive at the most appropriate system design.

(1) No Action

If all of the sectors concerning stormwater drainage do not take any action to improve stormwater drainage problems, the flooding conditions will worsen in the target year 2030. In other words, the future flooding conditions without improvement are considered in this case.

(2) Alternative 1

Alternative 1 is presented schematically in **Fig. 5.2.1**. This alternative consists of installation of drains, construction of pumping stations and improvement of existing drains. The target area is divided into 5 sub-catchment areas such as North, Northwest and West, etc. For North and West areas, those areas have new drainage network and pumping station. Drainage network of Northwest Area will connect to the existing drain of Central Area through pumping station; therefore, existing drains will require improvement works involving the dimension and type of structure. There are two new main drains in the Southeast Area and new drains will connect to the existing drain. This alternative does not include rainwater storage facilities.

(3) Alternative 2

Alternative 2 is presented schematically in **Fig. 5.2.2**. The number of sub-catchment areas, alignment of proposed drains and number of pumping station and location of pumping station of this alternative are the same as Alternative 1. However, this alternative includes the retention pond as rainwater storage facility; therefore, it will be able to reduce the dimension of drains and required pump capacity.

(4) Alternative 3

Alternative 3 is presented schematically in **Fig. 5.2.3**. This alternative consists of installation of drains, construction of pumping stations and retention ponds, and rehabilitation of existing drains. For this alternative, the target area is divided into 4 sub-catchment areas. The proposed drain of the West Area will not connect to the existing drain in the Center Area; therefore, a relay pumping station is not necessary. Most of runoff from the West Area will be conveyed to the retention pond. This alternative requires a lesser number of pumping stations than the other alternatives.

The outline of proposed facilities for each alternative is tabulated in **Table 5.2.1**.

Table 5.2.1 Proposed Facilities and Cost for Each Alternative

Item		Alternative 1	Alternative 2	Alternative 3
Drain	Dimension (m) (width × height)	1.3 × 1.3 ~ 8.0 × 2.0	1.3 × 1.3 ~ 8.0 × 2.0	1.3 × 1.3 ~ 3.2 × 3.2
	Total length (km)	28.38	28.38	28.31
Pumping Station	Number of station	3	3	2
	Total required capacity (m^3/s)	41.93	28.67	21.85
Retenrion Pond	Number of pond	0	2	2
	Total required volume (m^3)	0	70,300	112,300
Construction Cost	(Billion FCFA)	52.53	47.56	42.96
O&M Cost	(Million FCFA/Year)	33	35	35

Based on the preliminary cost estimation, construction cost and operation and maintenance cost for each alternative are estimated as shown in **Table 5.2.1**. Construction cost includes cost for construction works of proposed facilities and, improvement and rehabilitation works for existing drains. Operation and Maintenance cost includes cleaning work cost, electricity bill, personal expense and miscellaneous expense.

Kaolack City is responsible for the maintenance of drainage networks. STC (Service Technique Communal) of Kaolack City is in charge of operation and maintenance works. STC does not have the budget of the department. Basically, STC has a budget for each item in charge such as road repair, public light and building maintenance, however, they don't have item for cleaning of drainage networks. According to STC, cleaning costs are expenditures from miscellaneous.

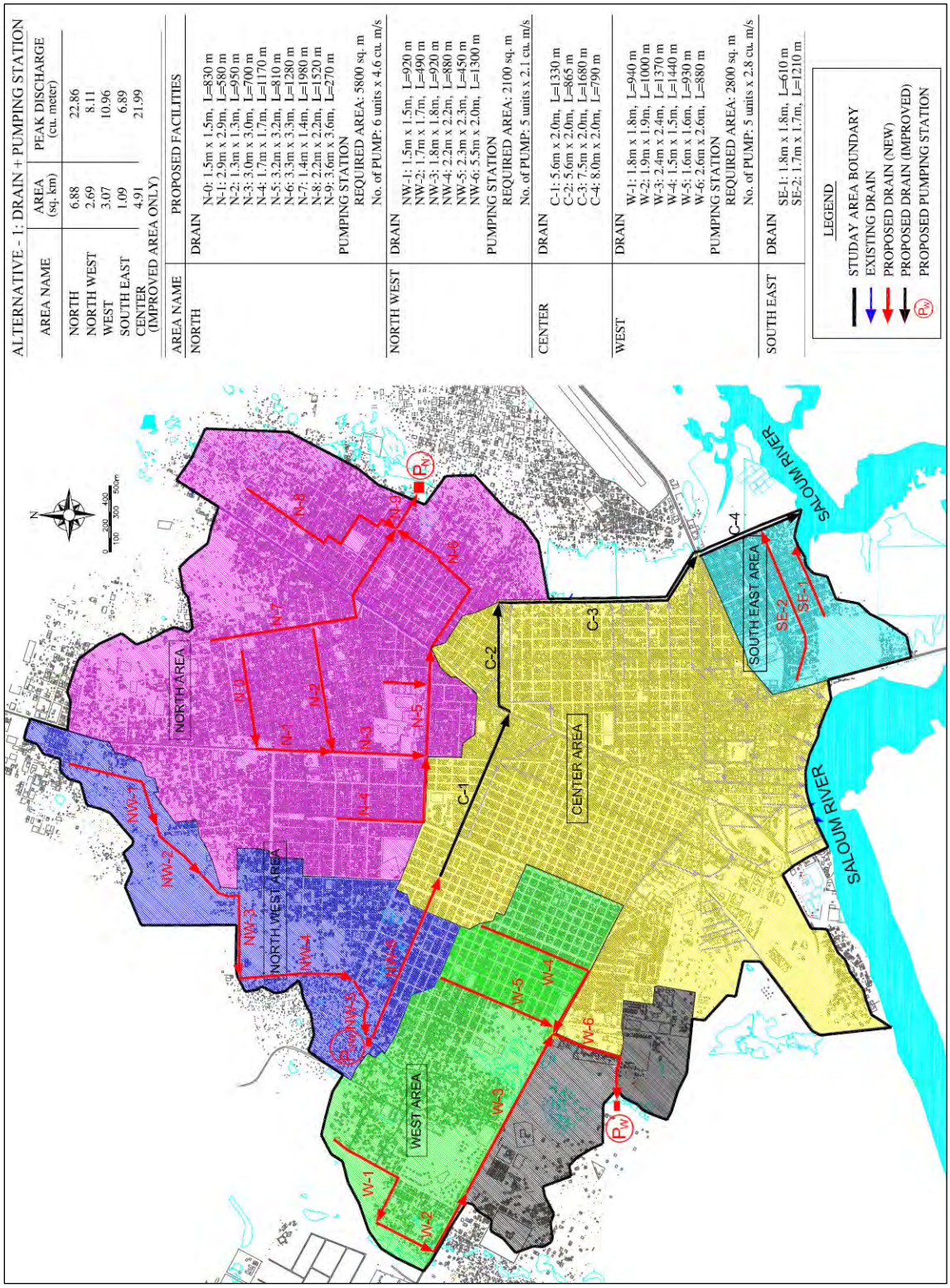


Fig. 5.2.1 Alternative 1

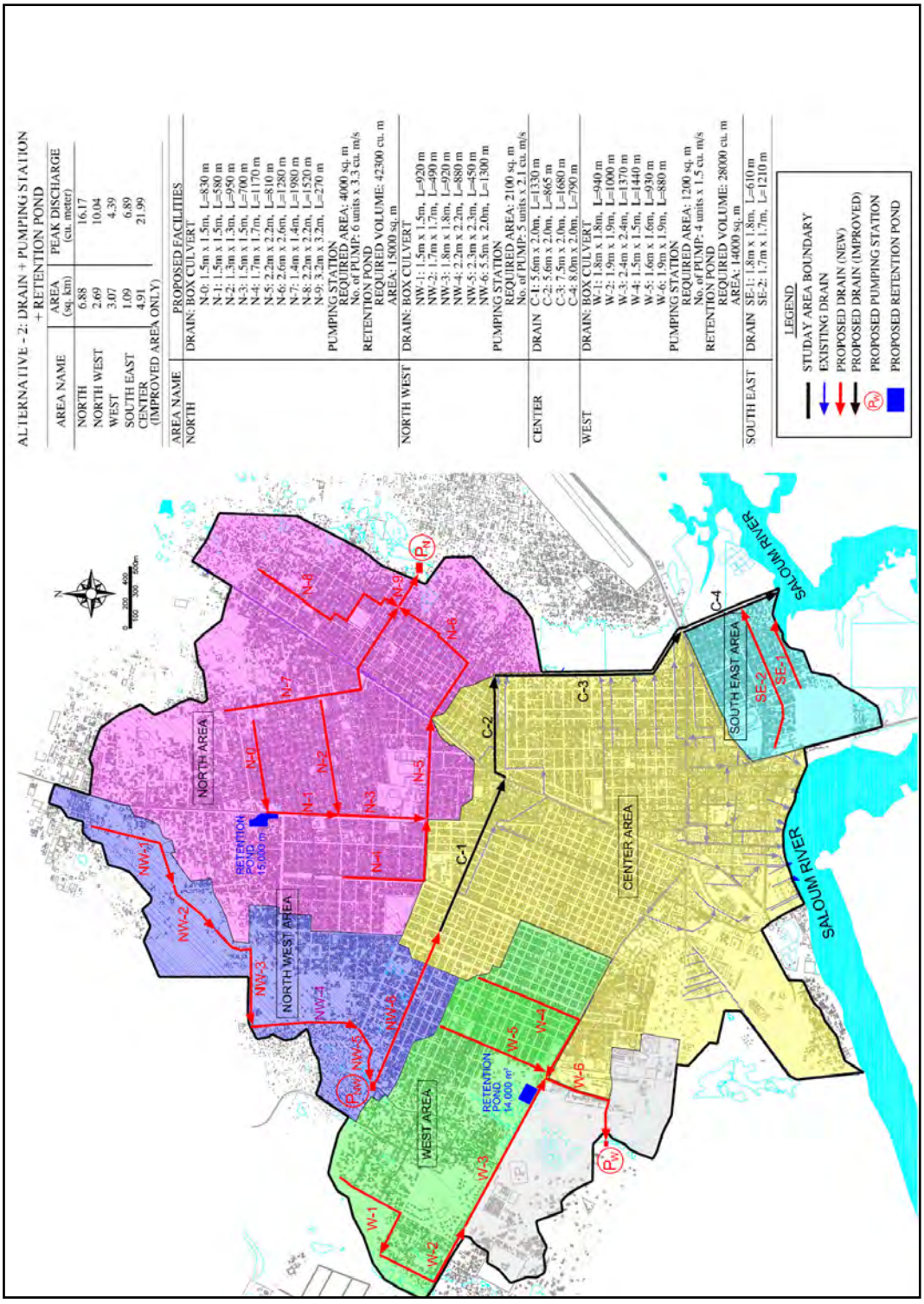


Fig. 5.2.2 Alternative 2

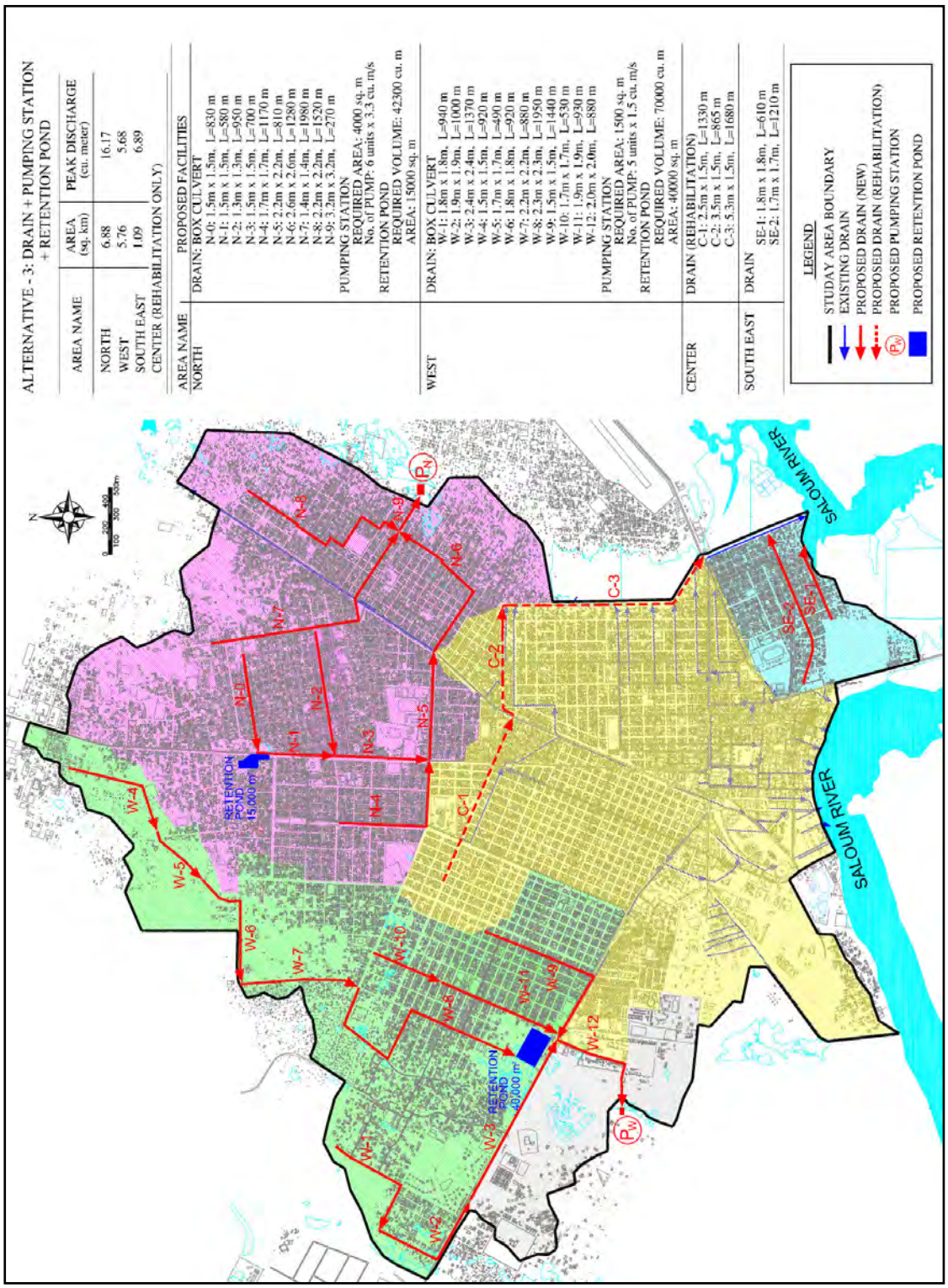


Fig. 5.2.3 Alternative 3

5.2.2 Qualitative Comparison of Alternative

Discussed hereunder is the qualitative evaluation of plan alternatives considering the relative merits of each alternative plans.

(1) Evaluation Criteria

Several factors are considered in the evaluation of alternative as discussed hereunder.

- Reliability – the potential for mechanical and electrical failure of the system must be minimized by reducing the number of pumping stations and total required pump capacity.
- Viability – the plan must minimize construction cost. This allows for ease of construction and reduces the overall financial burden.
- Environmental impact – the possible adverse impacts that might be caused by the proposed project area such as dust generation, noise, vibration, water pollution and resettlement, etc. This matter is described in **Subsection 7.2.2**.
- Flexibility – the plan should consider the ability to expand for future increased areas and flows.

(2) Evaluation of Alternatives

Each plan alternative is ranked using the qualitative criteria discussed above. A ranking of 1 to 3 is given with 1 being the most favorable. Qualitative ranking of alternatives is shown in **Table 5.2.2**.

Table 5.2.2 Qualitative Ranking of Alternatives

Item	Alternative 1	Alternative 2	Alternative 3
Reliability	1	2	3
Viability	1	2	3
Environmental impact	1	2	3
Flexibility	3	2	1
Total	6	8	10
Overall ranking*)	**3rd**	**2nd**	**1st**

Note: * 1st rank is most favorable.

5.3 Structural Stormwater Drainage Improvement Plan

Kaolack City is located in the wide sandy floodplains of the Saloum River and is a comparatively flat area. Target area is divided into 4 sub-catchment areas as shown in **Fig. 5.2.3**. Drainage sub-catchment boundaries have been determined primarily on the basis of topographical features, existing drain network and site investigations.

5.3.1 Structural Improvement Plan for North Area

The catchment area of the North Area is 6.88 km^2. At present, there is no drainage system and there are some low land areas in District Ngane Saar, Ngane Alassane, Gawane, Touba Kaolack, Sam and Ndorong Sadaga. Therefore, serious damage is caused by inundation during rainy season.

The tentative alignment of proposed drains and proposed location of pumping station and retention pond are shown in **Fig. 5.3.1**.

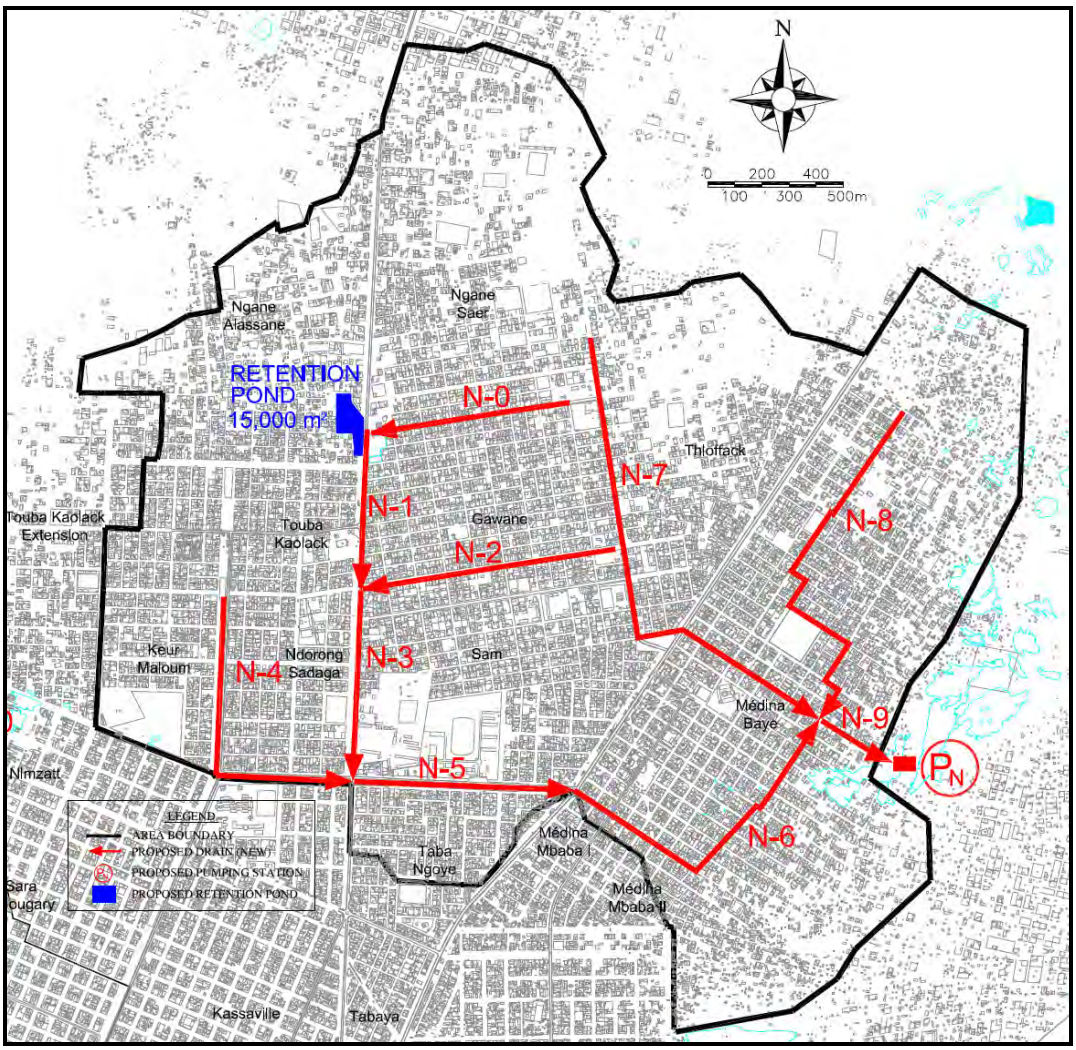


Fig. 5.3.1 Location of Proposed Drainage Facilities for North Area

At the beginning point of N-1 Drain, new retention pond is proposed to minimize the size of new drains. This proposed location of retention pond is called 'Khakhoune' and it is a lowland area; therefore, during rainy season, this area becomes a natural pond. A new pumping station proposed to collect storm water from the North Area is to be located in lower elevations at the eastern side of District Medina Baya. Stormwater is to be discharged into the natural pond. Discharge capacity of proposed drains has been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to in-situ concrete box culverts. The design rainfall for pumping station and retention pond are determined by using 3 hours' rainfall amount and intensity-duration equation for the 10 years return period of storm. The pump capacity is decided in relation to the effective storage volume of the pond. Land for the pond is proposed taking account of the site condition to avoid compensation problem. Details of proposed drainage facilities are given in **Table. 5.3.1**.

Table 5.3.1 Proposed Drainage Facilities for North Area

Component	Specification
Box Culvert	
N-0	1.5m × 1.5m, L= 830 m
N-1	1.5m × 1.5m, L= 580 m
N-2	1.3m × 1.3m, L= 950 m
N-3	1.5m × 1.5m, L= 700 m
N-4	1.7m × 1.7m, L=1,170 m
N-5	2.2m × 2.2m, L= 810 m
N-6	2.6m × 2.6m, L=1,280 m
N-7	2.2m × 2.2m, L=1,980 m

Component	Specification
N-8 N-9	3.2m × 3.2m, L=1,520 m 1.4m × 1.4m, L= 270 m
Pumping Station (P_N)	No. of Pump: 6 units × 3.3 m^3/s Required area: 4,000 m^2 Pump Total Head: 3.2 m
Retention Pond	Required volume: 42,300 m^3 Required area: 15,000 m^2

5.3.2 Structural Improvement Plan for West Area

The West Area includes 11 districts and the catchment area is 5.76 km^2 with a gentle slope towards southwest. In this area, there is no drainage system and there are frequent inundation areas in District Parcelles Assainies, Nimzatt, Diamaguene and Boustane I.

The tentative alignment of proposed drains and proposed location of pumping station and retention pond are shown in **Fig. 5.3.2**.

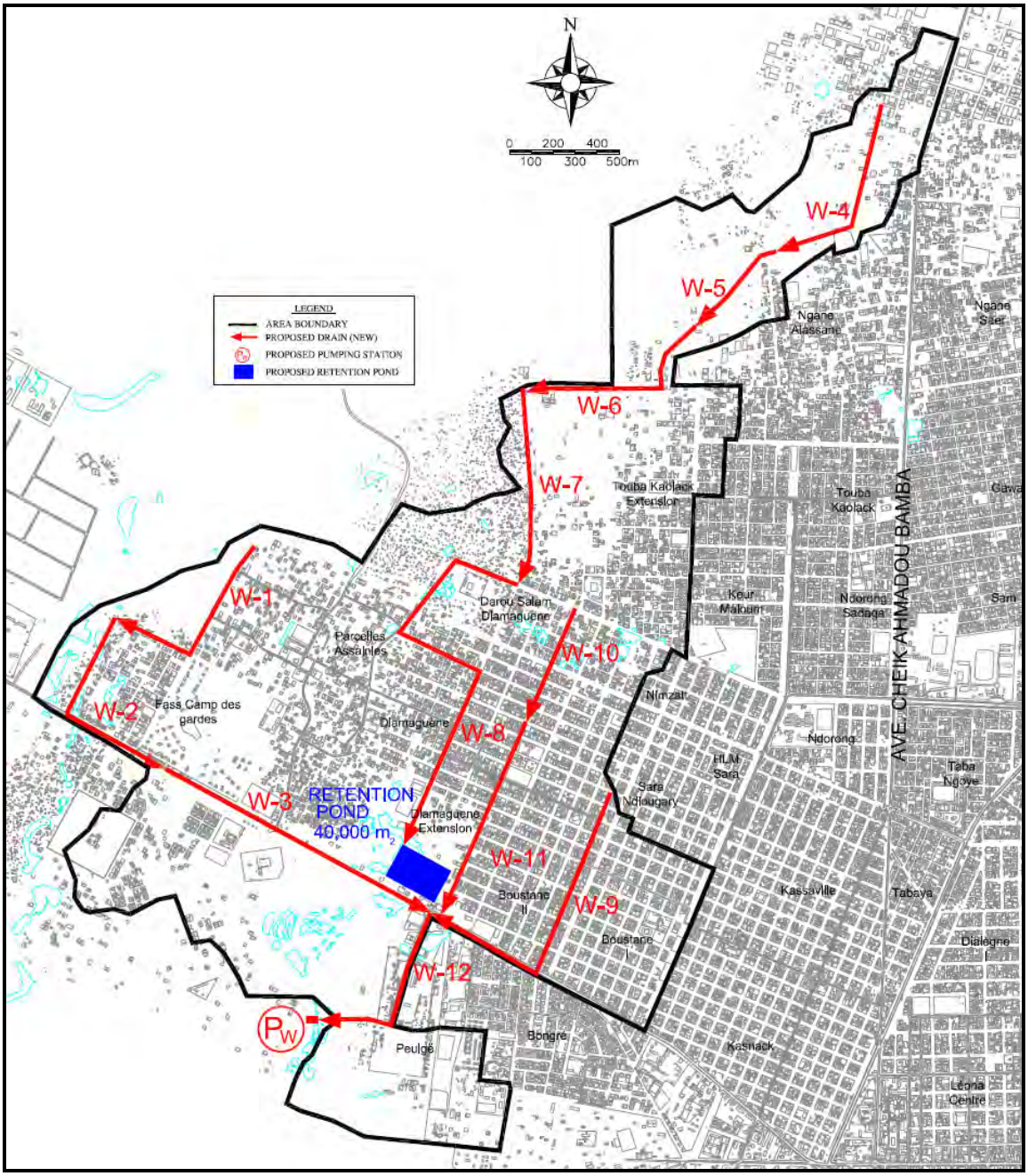


Fig. 5.3.2 Location of Proposed Drainage Facilities for West Area

New retention pond is proposed to minimize the size of new drains at Diamaguene Extension. This proposed area is lowland area; therefore, during rainy season, this area becomes a natural pond. A new pumping station proposed to collect stormwater from the North Area is to be located in lower elevations and vacant area at the western side of District Peulge. Collected storm water is to be discharged to the natural pond. Discharge capacity of proposed drains has been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to in-situ concrete box culverts. The design rainfall for pumping station and retention pond are determined by using 3 hours' rainfall amount and intensity-duration equation for the 10 years return period of storm. The pump capacity is decided in relation to the effective storage volume of the pond. Land area of the pond is to be proposed taking account of the site condition to avoid compensation problem. Details of proposed drainage facilities are tabulated in **Table. 5.3.2**.

Table 5.3.2 Proposed Drainage Facilities for West Area

Component	Specification
Box Culvert	
W-1	1.8m × 1.8m, L= 940 m
W-2	1.9m × 1.9m, L=1,000 m
W-3	2.4m × 2.4m, L=1.370 m
W-4	1.5m × 1.5m, L= 920 m
W-5	1.7m × 1.7m, L= 490 m
W-6	1.8m × 1.8m, L= 920 m
W-7	2.2m × 2.2m, L= 880 m
W-8	2.3m × 2.3m, L=1,950 m
W-9	1.5m × 1.5m, L=1,440 m
W-10	1.7m × 1.7m, L= 530 m
W-11	1.9m × 1.9m, L= 930 m
W-12	2.0m × 2.0m, L= 880 m
Pumping Station (P_W)	No. of Pump: 5 units × 1.5 m^3/s Required area: 1,500 m^2 Pump Total Head: 4.0 m
Retention Pond	Required volume: 70,000 m^3 Required area: 40,000 m^2

5.3.3 Structural Improvement Plan for South East Area

This area is located along the Saloum River and the catchment area is 1.09 km^2. At present, there is no drainage system and there are frequent inundation areas in District Abattoirs and Darou Salam.

The tentative alignment of proposed drains is shown in **Fig. 5.3.3**. The proposed drain will be connected to the existing open drains.

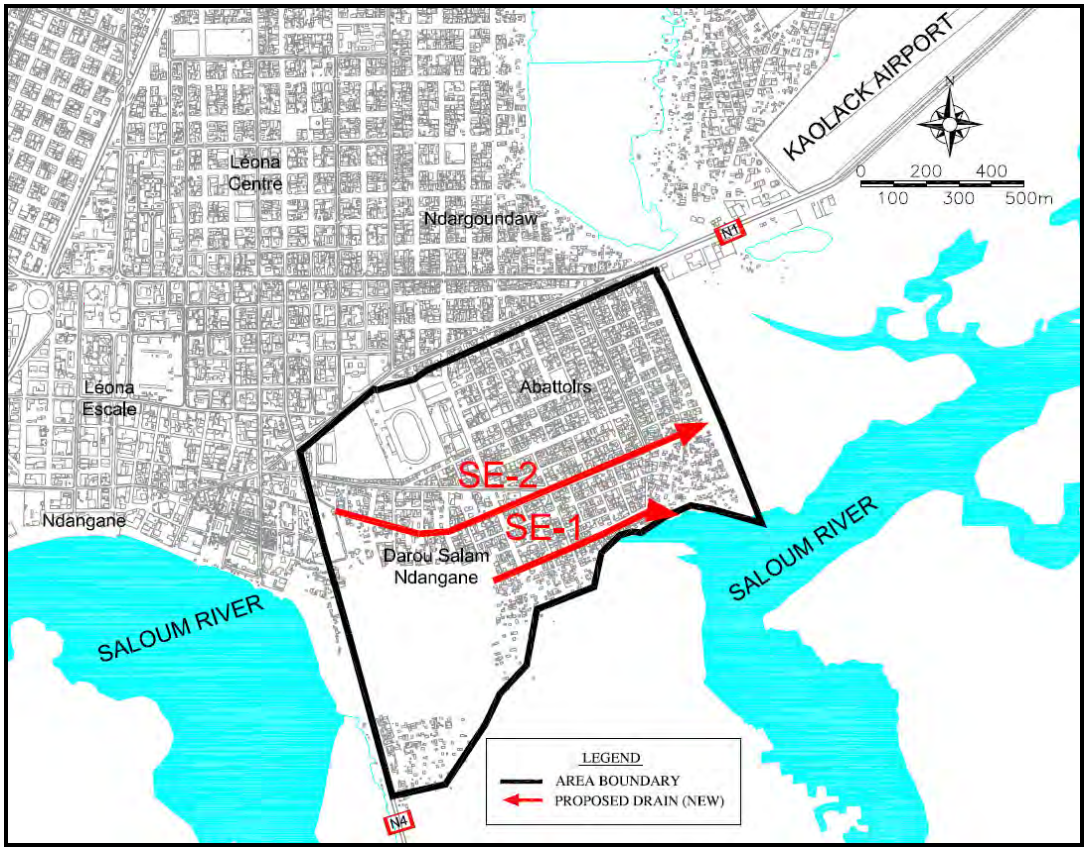


Fig. 5.3.3 Location of Proposed Drainage Facilities for South East Area

Discharge capacity of proposed drains has been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to in-situ concrete box culverts. Detail of proposed drainage facilities are tabulated in **Table. 5.3.3**

Table 5.3.3 Proposed Drainage Facilities for South East Area

Component	Specification
Box Culvert	
SE-1	1.8m × 1.8m, L= 610 m
SE-2	1.7m × 1.7m, L=1,210 m

5.3.4 Structural Improvement Plan for Center Area

This area is core area and Kaolack City has provided drainage system for Center Area since the 1980's. The installed drains reached to total length of 19.96 km, consisting of 12.38 km long open drain and 7.58 km long covered drain. As shown in **Fig. 2.3.2**, the existing drainage system of 19.96 km long covers 7.8 km^2 of territory of Kaolack City. As described in **Subsection 5.1.5**, the existing drains have sufficient capacity for peak discharge of 10-year return period. Parts of the existing open drains are excavated earth canals of unsustainable structure and the original section has been reduced due to encroachment. The excavated earth canals should be reconstructed into reinforced concrete structures for sustainability and keeping the original cross-section area. The rehabilitation works is simple construction work and, Kaolack City will be able to conduct it. However, Kaolack City had strongly requested to include this rehabilitation work in the Master Plan. Therefore, Kaolack City and JET discussed the request deeply and selected the biggest main open drains as the target of rehabilitation work. The target drainage channels are as indicated in **Fig. 5.3.4**.

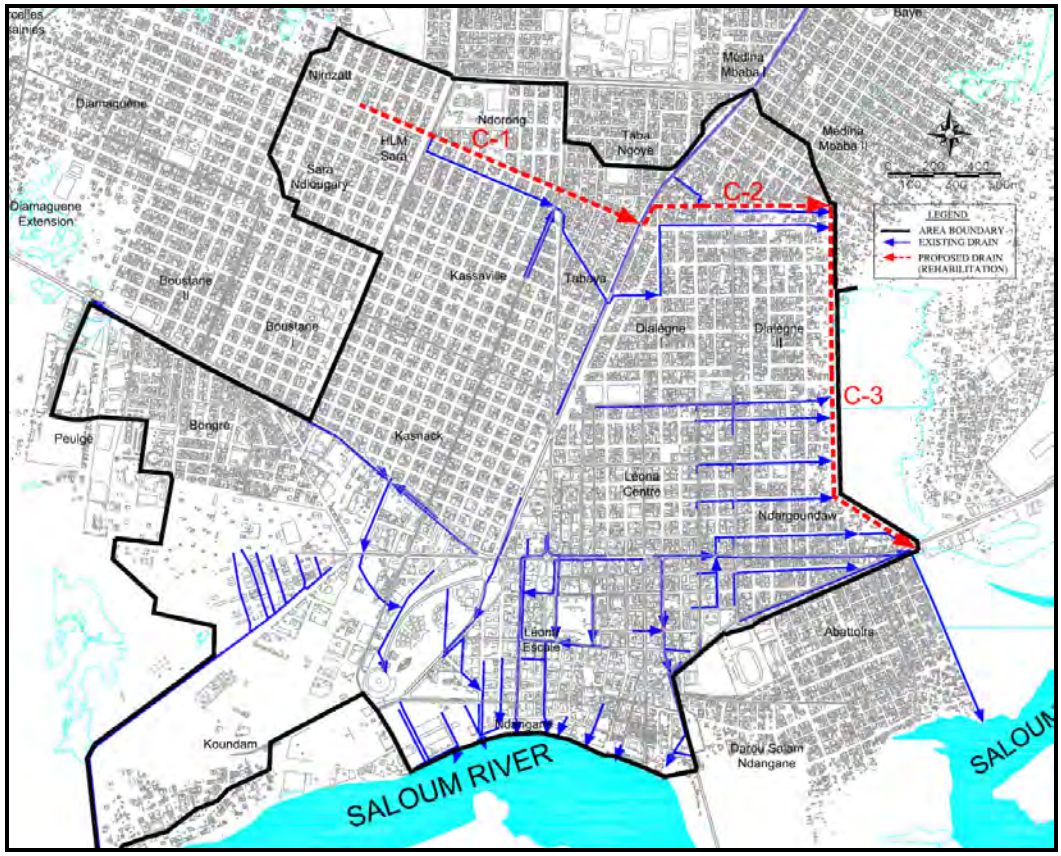


Fig. 5.3.4 Location of Rehabilitation Drainage Channels for Center Area

Details of rehabilitation drainage channels are tabulated in **Table. 5.3.4**

Table 5.3.4 Rehabilitation Drainage Channels for Center Area

Component	Specification
C-1	2.5m × 1.5m, L=1,330 m
C-2	3.5m × 1.5m, L= 865 m
C-3	5.3m × 1.5m, L=1,680 m

5.4 Supporting Measures

With the implementation of only structural measures, mitigation of flooding and inundation damage will be limited. In order to sustain the structural aspects in effective condition, a supporting system is indispensable. Therefore, the following supporting measures are recommended to support and sustain the structural measures in the Master Plan.

5.4.1 Public Awareness Campaign

The Kaolack City Hall shall take the initiative of promoting the public awareness campaign with its own budget. The campaign will help enhance public interest in sanitary environment and may call attention to the problems of clogged drainage channels. In addition, the roles and activities of the Kaolack City Hall will be informed to the public through various media.

Table 5.4.1 Example Tools of Public Awareness Campaign

Activities	Description	Remarks
Newspaper Advertisement		Fortnightly
Message on Radio Channels	15 seconds	6 days/week, 2 times/day
Message on Television	15 seconds	4 times/month
Message on Local Cable	15 seconds	2 times/day
Project Video Documentary	10 minutes in DVD	
Website/Internet	Development and Updating	
Radio Program	Interview with project personnel	
Printing	10,000 Handbills, 2,000 Posters	
Banners and Signboards	25 Banners and 20 Signboards	To be placed at main roads, school etc.
Others	Feedback Survey, Workshop	

5.4.2 Education against Solid Waste Dumping into Drains

The educational campaign aims to minimize influence on drainage system and ensure the existing functions by influencing people in a positive manner. In order to improve the existing situation, the educational campaign is addressed to promote proper knowledge, as well as changes in lifestyle and behavior. It is difficult to change attitudes and behavior of grown-up persons. It is therefore necessary to start educating the youth early about proper solid waste disposal.

This plan covers primary schools and high schools in Kaolack City. The school curriculum should cover the following aspects:

- Daily activities on solid waste
- Problems of solid waste management
- System and process of solid waste management
- Recycling and environmental conservation

Effective environmental education should be developed. Education kit shall include textbook and video program that support environmental education effectively. Video/DVD material is good teaching tool that can help students understand the importance of solid waste management. An example of video/DVD program is given below.

Table 5.4.2 Development of Training Kit for School Students

Proposed Title	Daily Activities and Solid Waste Problems
Target Audience	School students
Message	Daily activities generate refuse. A cycle is started thus: Man throws refuse into drains, road sides, vacant spaces along drains and other areas, and these casual activities give rise to deterioration of natural environment and living and health environment. Then, Environment retaliates by increasing risk of flood, generating

Proposed Title	Daily Activities and Solid Waste Problems
	flies and mosquitoes. Going about the business of daily living in an appropriate manner is important to secure man's health and safety.
Playing Time	About 20 minutes

Some of teachers do not have a clear understanding of solid waste problems. Therefore, Kaolack City should support the provision of lectures to school teachers. Contents of teacher's training are shown in **Table. 5.4.3**.

Table 5.4.3 Contents of Teacher's Training

Aims	Contents
• To understand the current situations of solid waste management in Kaolack City • To understand improper solid waste management impacting living environment and people's health • To recognize people's responsibility and the need for them to cooperate	■ Existing solid waste management and its facilities ■ Current status and solid waste management problems in Kaolack City ■ Solid waste and people's safety ■ Community-based solid waste management including collection and recycling ■ Roles of stakeholders in solid waste management

5.4.3 Improvement of Operation and Maintenance Organization and Activities

Improvement of operation and maintenance organization in the Kaolack City Hall is proposed. Insufficient budget results in low rate accomplishment of daily activities on operation and maintenance. Setting up the responsibility and roles required for operation and maintenance activities is recommended to be able to draw up the required budget. The issue is described in **Subsection 5.1.7**.

5.5 Operation and Maintenance Plan

5.5.1 Responsible Organization for Operation and Maintenance

As described in **Subsection 2.3.3**, the Service Technique Communal (STC) of Kaolack City Hall is the organization in charge of operation and maintenance work of drainage facilities, such as pumping stations, retention pond and drains.

5.5.2 Base Map and Database for Drainage Facilities

At present, the annual maintenance work plan of the STC includes only drainage length to be cleaned. The STC doesn't have existing drainage map and specific data of drainage lines. In order to conduct the proper operation and maintenance work, the cleaning plan will be needed and base map and database will be necessary to prepare the cleaning plan. Therefore, it is recommended to prepare the base map and database for drainage facilities.

The base map will show the location of drainage facilities include the some specific data such as length, size and flow direction. The database corresponds with the base map and will be included more detailed data for each drainage facilities. In this study, the inventory survey for main existing drainage was conducted. The result of inventory survey can be used as base map and database for existing drainage facilities. For future special drainage facilities such as pumping station and the retention pond, As-built drawings and design report will be utilized as base map and database, respectively.

5.5.3 Operation and Maintenance Method

(1) Drainage Network

Since drainage pipes are laid underground, it is difficult to predict and detect any troubles and abnormalities. On the other hand, if these abnormalities/troubles occur within the installed drainage box culverts, accidents would be caused directly affecting city activities and civil life, such as leakage, road collapse, etc. Positive promotion of operation and maintenance works of drainage box culverts would reduce accidents, maintain performance of drainage box culverts and extend the practical service life of box culverts. Taking these effects into account, carrying out operation and

maintenance works for the drainage box culverts has economical advantages.

Adequate operation and maintenance work of drainage pipes shall involve following procedures:

a) Maintenance and inspection;
b) Cleaning and dredging; and
c) Renewal and repair.

(a) Maintenance and Inspection

In the "Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries (issued by the Infrastructure Development Institute, Japan, October 2001)", the inspection frequency is about once in every five years for pipes without any particular problem. According to the record, the inspection frequency in urban area in Japan is once in every three to seven years.

It has been confirmed in the site investigations that the existing drainage system in many parts are clogged with debris and sediment. With consideration of this situation, it is preferable to execute the inspection work at the frequency of about one in every three to five years for the drainage box culverts constructed under the Project.

(i) Inspection Items

Principal inspection items shall be as follows:

[Drainage Box Culvert]

- Flow condition and sediment build-up condition
- Settlement of the ground surface: cracking in pavement due to differential settlement of the ground, etc.
- Damage situation: damage, crack, penetration of root of tree
- Groundwater infiltration condition
- Illegal connection

[Manhole]

- Manhole cover and internal condition

(ii) Inspection Method for Box Culvert and Manhole

In addition to visual inspection inside the manhole with the cover removed, the inspection shall be made by viewing the inside part of manhole through box culverts. Most abnormalities can be detected through visual manhole inspection.

(iii) Record of Inspection Result

Inspection results shall be recorded in proper recording sheets, which shall be documented for future use in the elaboration of cleaning plans.

(b) Cleaning and Dredging

Garbage and sludge deposits in box culverts reduce flow capacity. Therefore, it is essential to carry out regular inspections and remove deposits when observed.

(i) Guidelines for Cleaning and Dredging

Generally, the clogging ratio required for cleaning, which is calculated by [(clogged sectional area) / (interior cross sectional area) × 100(%)], is approximately 20% for drainage mains. Basically, cleaning does not need to be more frequent than the inspections.

(ii) Cleaning and Dredging Method

In this project, large size of box culvert will be installed, therefore, the workers can go inside the box culverts to break and remove the deposits and garbage manually using shovels. The manual removal work will be continued basically for the cleaning work in large size of box culverts. On the other hand, in case that the high water-jet machine will be able to be procured by the Kaolack City Hall, it shall be used to break and remove the deposits and garbage more easily. The deposits/garbage removed from box culverts are to be accumulated inside the manholes and sucked out using the sludge sucker, as illustrated in **Fig. 5.5.1**.

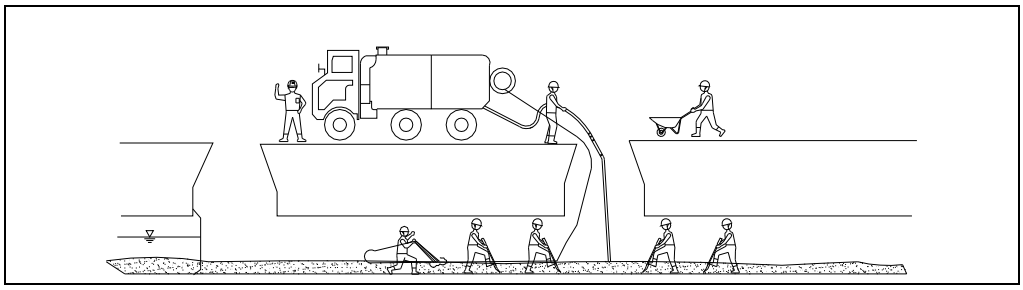


Fig. 5.5.1 Cleaning and Dredging Method

(c) Renewal and Repair of Drainage Pipes

Deterioration of pipes proceeds over the surface as a whole, and renewal and repair will take a considerable time. Therefore, it is necessary to implement renewal and repair according to the plan established on the basis of the results of inspections and surveys to prevent accidents beforehand.

(2) Pumping Station and Retention Pond

Pumping station is a significant facility for drainage system. In case that pumping station does not function, it will cause serious damage to the city by flooding. Therefore, it is necessary to understand the specifications and characteristics of pumps for operation and maintenance.

The operation and maintenance work for new pumping stations require the assignment of 3 to 4 personnel. For new pumping stations, spare pumps shall be provided as emergency pumps and should be operated alternately to ensure that each pump is operated at least once a week, and regular inspection also should be conducted. Basic inspection items for pump are shown in **Table. 5.5.1**.

Table 5.5.1 Inspection Items for Pump

Item	Frequency
Electric current and Voltage	Daily
Sound and vibration	Daily
Leakage	Monthly
Float switch	Monthly
Body of pump	Every 3 months
Lubrication oil	Check: Every 3 month Change: Yearly
Overhaul	Every 2 years

There is no drainage pumping station in Kaolack City; therefore, it is necessary to attempt technology transfer to pump operating personnel through the initial operation guidance carried out by the supplier/manufacturer of equipment and machineries newly introduced.

The retention pond has the function to store stormwater temporarily. It is preferable to execute the cleaning work on retention pond once a year before rainy season. STC has to designate a cleaning work team composed of about 10 members. The retention pond is an open space; therefore, the workers can go inside to clean and remove the deposits and garbage manually using shovels. Alternatively, the work for retention pond cleaning can be subcontracted to a private contractor based on inspection results.

5.6 Preliminary Project Cost Estimate

5.6.1 Construction Cost Estimates

(1) Basis and General Conditions

The construction cost is calculated based on the various cost information obtained from ONAS Dakar, ONAS Kaolack, and "the Study on Urban Drainage and Wastewater Systems in Dakar City and its Surroundings" in 1994, JICA.

The following are the general conditions for the construction cost estimate.

- The construction cost is estimated at 2012 price level.
- The annual price escalation rate of 3% up to 2012 is assumed in case of the use of cost data on past project.
- All necessary costs other than direct construction cost, i.e. the cost for common temporary works such as preparation of temporary site office, access road, and also the costs for site expenses, contractor's overhead, profit, are included in construction cost.
- The unit rate for open cut method which is the most common method in Senegal is assumed for all necessary excavation works.
- The cost is classified into foreign and local currency portions based on the information on procurement obtained in Senegal.

(2) Particular Conditions

The following are the particular conditions for the construction cost estimate.

[Drain: Box Culvert or Open Ditch]

- Average covering depth for box culvert: 2 m
- Thickness of wall, top slab: 300mm, base slab: 400 mm
- Reinforcement: 100kg/m^3(concrete volume)
- Inclusive of 100mm thickness of concrete cover for Open Ditch

[Pumping Station]

The following cost function shall be used.

- C=232,625,000Q+244,912,500, where, C: Construction Cost (FCFA), Q(m^3/s)

[Retention Pond]

- The cost for mortal lining and the installation of fence for the safety purpose are included.

(3) Construction Cost Estimates

The Construction Cost for stormwater drainage facilities is approximately 42,955 million FCFA as shown in **Table 5.2.1**.

5.6.2 Project Cost Estimate

(1) The Element of Project Cost

The element of project cost is as follows and the percentage other than the construction cost, i.e., Engineering Cost, Project Administration Cost, Physical Contingency, is assumed judging from the data obtained from the past project in Senegal or other countries. In addition, the price escalation during the project from 2014 to 2030 is assumed based on the past 10 years data on the inflation rate by the World Bank.

- Construction cost
- Engineering cost : 10% of Construction Cost
- Project Administration Cost : 2% of Construction Cost
- Physical Contingency : 10% of Construction Cost and Engineering Cost

- Price Escalation during the project (2014 to 2030): Annual inflation rate of 3% of local currency, 2% of foreign currency

In addition, VAT of 18% of Project Cost is included.

(2) Percentage of Local and Foreign Currency

Project cost is divided into two currency portions, i.e., local and foreign currency portions as shown in the following table.

Table 5.6.1 Percentage of Local and Foreign Currency Portions of Project Cost

Cost Item	Work Item	L/C	F/C
Direct Construction Cost	Drain(Box Culvert)	100%	0%
	Pumping Station	40%	60%
	Retention Pond	100%	0%
Engineering Service		30%	70%
Government Administration		100%	0%
Physical Contingency		90%	10%

(3) Project Cost Estimates

Project Cost is estimated based on the abovementioned elements and the percentage of local and foreign currency.

The total project cost amounts to approximately 84,002 million FCFA at 2012 price level, in which 73,516 million FCFA is local currency portion and 10,486 million FCFA is foreign currency portion.

Table 5.6.2 Project Cost

Cost Item	Work Item	L/C (million FCFA)	F/C (million FCFA)	Total (million FCFA)
Direct Construction Cost	Drain(Box Culvert)	35,153	0	35,153
	Pumping Station	2,736	4,104	6,840
	Retention Pond	962	0	962
	Sub-Total	38,851	4,104	42,955
Engineering Service		1,289	3,007	4,296
Government Administration		859	0	859
Physical Contingency		4,253	472	4,725
Price Escalation		17,050	1,303	18,353
VAT		11,214	1,600	12,814
Total (million FCFA)		73,516	10,486	84,002

5.6.3 Operation and Maintenance Cost

It is estimated that the annual operation and maintenance cost for drainage facilities become 34,657,000 FCFA after completion of the Project. The breakdown of operation and maintenance cost after the completion of the project is described below.

(1) Operation and Maintenance Cost of Pumping Station

Electric fee occupies the majority of operation cost of the new pumping stations. Annual pump operation time is calculated based on record of rainfall in the last 13 years (from 1998 to 2011). Annual pump operation day and hour are estimated at about 60 days and 110 hours, respectively. The annual operation cost of new pumping station is about 9,552,000 FCFA.

Maintenance cost consists of personal and miscellaneous expenses. One chief engineer and three workers are assigned at the pumping station in the North Area and one chief engineer and two workers are assigned at the pumping station in the West Area. Personal expense is assumed to be about 4,500,000 FCFA. Miscellaneous expense is 10% of the electric fee and personal expense. It is assumed to be about 1,405,000 FCFA.

The annual operation and maintenance cost of pumping station is estimated to be 15,457,000 FCFA

in total.

(2) Maintenance Cost of Box Culvert

Based on the proposed operation and maintenance plan in this study, new box culverts shall be cleaned in every 4 years. In this project, about 28 km in total of box culvert will be constructed. Therefore, 7 km of box culverts will be cleaned every year. The unit cost of box culvert cleaning is assumed to be 600 FCFA/m. Annual maintenance cost for box culverts is estimated to be 4,200,000 FCFA.

(3) Maintenance Cost for Retention Pond

The cleaning work for the retention pond mainly consists of the removal of garbages, weeds and mud, similar to the cleaning works for open drains. Therefore, Kaolack City and JET discussed and set up the unit cost of cleaning work for retention pond based on the unit cost for open drains. For open drains, 200 FCFA/m is applied for the unit cost of cleaning works, based on this, the cleaning unit cost for retention pond is set at 300 FCFA/m^2. Total cleaning area of retention pond is about 50,000 m^2, annual maintenance cost is estimated to be 15,000,000 FCFA.

5.7 Prioritization of the Project Packages

The target area is subdivided into 4 drainage sub-catchment areas, namely; North, Center, West and Southeast. Each area has drainage improvement project and some projects consist of several packages. For dividing the project into packages, scale of construction work, situation of target area and social impact are taken into consideration. For each project package, it is necessary to decide their priority ranking. The priority ranking is determined on a point system based on the following criteria. The composition of project and project package is shown in **Table 5.7.1** and **Fig. 5.7.1**, respectively.

Table 5.7.1 The Composition of Project

Area	Project	Package
North Area	Project-1	Package P1-1, Package P1-2
Center Area	Project-2	Package P2
West Area	Project-3	Package P3-1, Package P3-2, Package P3-3
South East Area	Project-4	Package P4

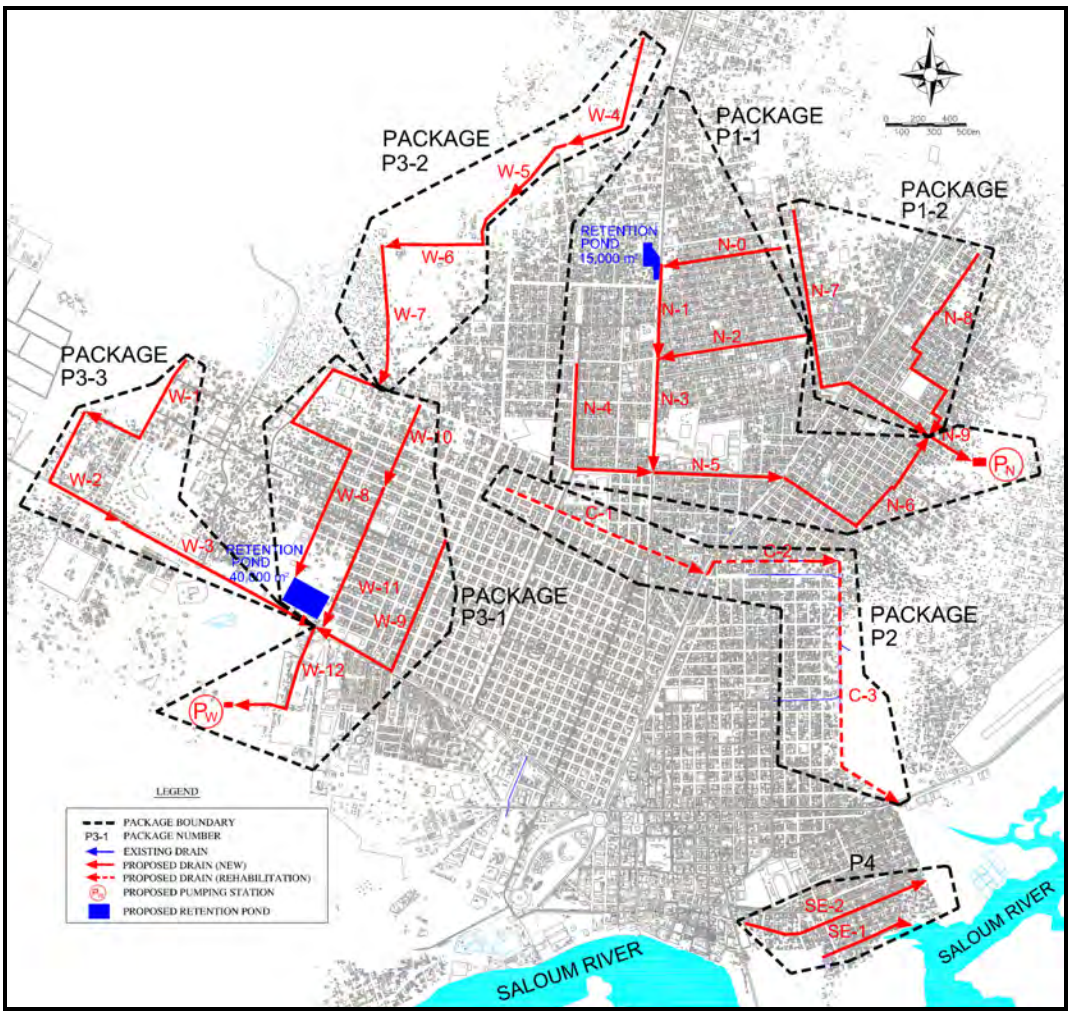


Fig. 5.7.1 Project Packages

(a) Number of Population

The highest population is given 5 points. For other areas, points are calculated by obtaining the ratio of the highest population number to the other area's population numbers and by multiplying the calculated ratio by 5.

(b) Inundation Area

The largest total area undergoing inundation is given 5 points. For other areas, points are calculated by obtaining the ratio of largest total area inundated to other area's total area of inundation and multiplying the calculated ratio by 5.

(c) Requested by the Kaolack City Hall

The priority ranking is determined based on the discussion with the Kaolack City Hall.

(d) Environmental Impact

Evaluation of project packages for project prioritization is described in **Section 7.2**. The highest evaluation point of environmental impact is given 5 points. For other package projects, points are scored as follows: (i) Score 5 for the project whose point is the highest; (ii) Give 1 to 5 for the other projects in proportion to the highest points and (iii) Round off to the nearest integer number.

Criterion (a) is an important factor in prioritizing the components from the viewpoint of number of project beneficiaries. The project will be more effective if there are many beneficiaries involved.

The main purpose of the drainage improvement project is to mitigate flood damage. Therefore, criterion (b) is the most important factor in any attempt to improve the current situation. The present inundation area shown in **Fig. 2.3.6** was surveyed in this study. At present, most of the roads are no pavement and there are still many open spaces in Kaolack City. However, urbanization has been in progress. Open space are being converted into commercial and residential complexes. Due to the urbanization, stormwater retention capacity in the catchment area is decreasing. Also, infiltration capacity to underground is decreasing because of asphalting of ground surface. As a result, runoff coefficient of storm water is expected to increase remarkably in the future. In consideration of the above, the inundation area in 2030 was roughly estimated based on the discussion with Kaolack City, field survey and contour map. The estimated inundation area is shown in **Fig. 5.7.2**.

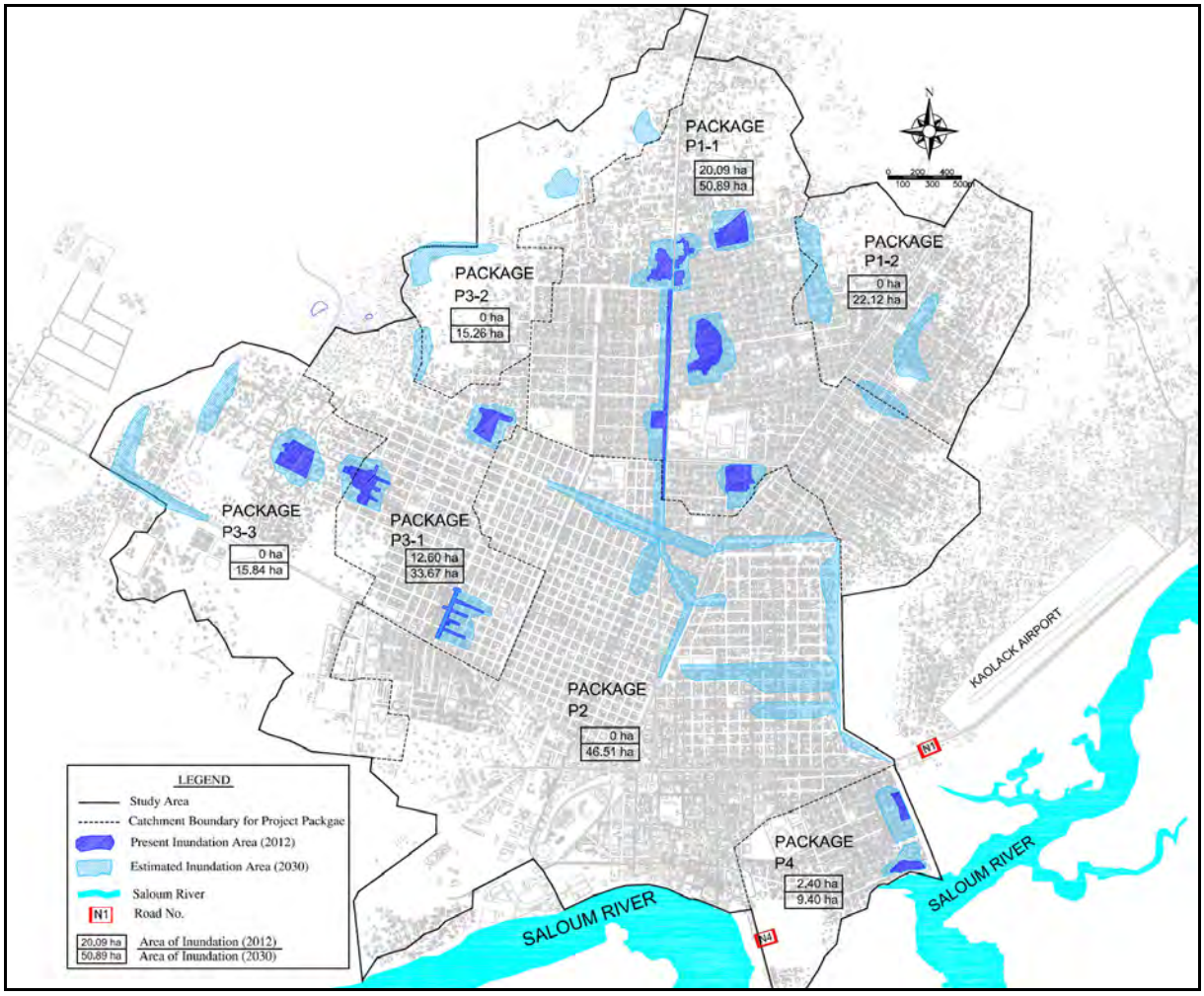


Fig. 5.7.2 Estimated Inundation Area in 2030

Criterion (c) is also a significant factor to guide the project forward. The improvement of the hygienic condition of the urban environment for the residents is one of the purposes in this study. Therefore, criterion (d) needs to be considered. The criteria considered and the priorities assigned to the 7 project packages are shown in **Table 5.7.2**. From this it is evident that Package P1-1 of Project-1 has the top priority in the Phase 1.

Table 5.7.2 Priority of Project Packages

Area	NORTH				CENTER		WEST						SOUTH EAST	
Project	Project-1				Project-2		Project-3						Project-4	
Package	P1-1	points	P1-2	points	P2	points	P3-1	points	P3-2	points	P3-3	points	P4	points
Population (2030)[1)]	104,970	5	56,970	3	59,200	3	57,500	3	45,260	2	37,510	2	25,390	2
Estimated Inundation Area (2030) (ha)[2)]	50.89	5	22.12	2	46.51	5	33.67	4	15.26	1	15.84	2	9.40	1
Inundation Area (2012) (ha)[2)]	20.09	5	0	0	0	0	12.60	4	0	0	0	0	2.4	3
Requested by Cityhall	-	5	-	4	-	5	-	5	-	4	-	4	-	5
Environmental Impact	-	5	-	4	-	5	-	5	-	4	-	3	-	4
Phasing the Implementation[3)]	**Phase 1**	25	Phase 3	13	Phase 2	18	Phase 2	21	Phase 3	11	Phase 3	11	Phase 2	15

Note; 1) Source: JICA Expert Team Estimates; all the population in Drainage Areas 2) Source: Interview Survey by JICA Expert Team 2012, 3) Phase 1 : -2020, Phase 2: 2021-2025, Phase 3: 2025-2030

5.8 Implementation Plan

5.8.1 General

The phased implementation program of the project is based on the following:

(1) All proposed drainage improvement measures are divided into three phases to be completed by the target year 2030.

(2) For phasing the implementation schedule of proposed measures, economic efficiency and social impact are taken into consideration.

5.8.2 Project Components

The drainage improvement projects are composed of the following components:

Table 5.8.1 Drainage Improvement Project Components

Project	Package	Component	Specification	Remark
Project-1 (North Area)	P1-1	Box Culvert		
		N-0	1.5m × 1.5m, L= 830 m	New Construction
		N-1	1.5m × 1.5m, L= 580 m	
		N-2	1.3m × 1.3m, L= 950 m	
		N-3	1.5m × 1.5m, L= 700 m	
		N-4	1.7m × 1.7m, L=1,170 m	
		N-5	2.2m × 2.2m, L= 810 m	
		N-6	2.6m × 2.6m, L=1,280 m	
		N-9	1.4m × 1.4m, L= 270 m	
		Pumping Station (P_N)	No. of Pump: 6 units × 3.3 m^3/s Required area: 4,000 m^2 Pump Total Head: 3.2 m	New Construction
		Retention Pond	Required volume: 42,300 m^3 Required area: 15,000 m^2	New Construction
	P1-2	Box Culvert		New Construction
		N-7	2.2m × 2.2m, L=1,980m	
		N-8	3.2m × 3.2m, L=1,520m	
Project-2 (Center Area)	P2	Open Channel		
		C-1	2.5m × 1.5m, L=1,330 m	Rehabilitation
		C-2	3.5m × 1.5m, L=8,65 m	
		C-3	5.3m × 1.5m, L=1,680 m	
Project-3 (West Area)	P3-1	Box Culvert		
		W-8	2.3m × 2.3m, L=1,950 m	New Construction
		W-9	1.5m × 1.5m, L=1,440 m	

Project	Package	Component	Specification	Remark
		W-10 W-11 W-12	1.7m × 1.7m, L= 530 m 1.9m × 1.9m, L= 930 m 2.0m × 2.0m, L= 880 m	
		Pumping Station (P_W)	No. of Pump: 5 units × 1.5 m^3/s Required area: 1500 m^2 Pump Total Head: 4.0 m	New Construction
		Retention Pond	Required volume: 70,000 m^3 Required area: 40000 m^2	New Construction
	P3-2	Box Culvert W-4 W-5 W-6 W-7	 1.5m × 1.5m, L= 920 m 1.7m × 1.7m, L= 490 m 1.8m × 1.8m, L= 920 m 2.2m × 2.2m, L= 880 m	New Construction
	P3-3	Box Culvert W-1 W-2 W-3	 1.8m × 1.8m, L= 940 m 1.9m × 1.9m, L=1,000 m 2.4m × 2.4m, L=1,370 m	New Construction
Project-4 (South East)	P4	Box Culvert SE-1 SE-2	 1.8m × 1.8m, L= 610 m 1.7m × 1.7m, L=1,210 m	New Construction

5.8.3 Implementation Schedule

The Implementation Schedule of the Master Plan is shown in **Fig. 5.8.1**.

5.8.4 Disbursement Schedule

Based on the Implementation Schedule shown in **Fig. 5.8.1**, the cost disbursement schedule is proposed as shown in **Table 5.8.2** (Construction Cost only) and **Table 5.8.3** (Overall Project Cost).

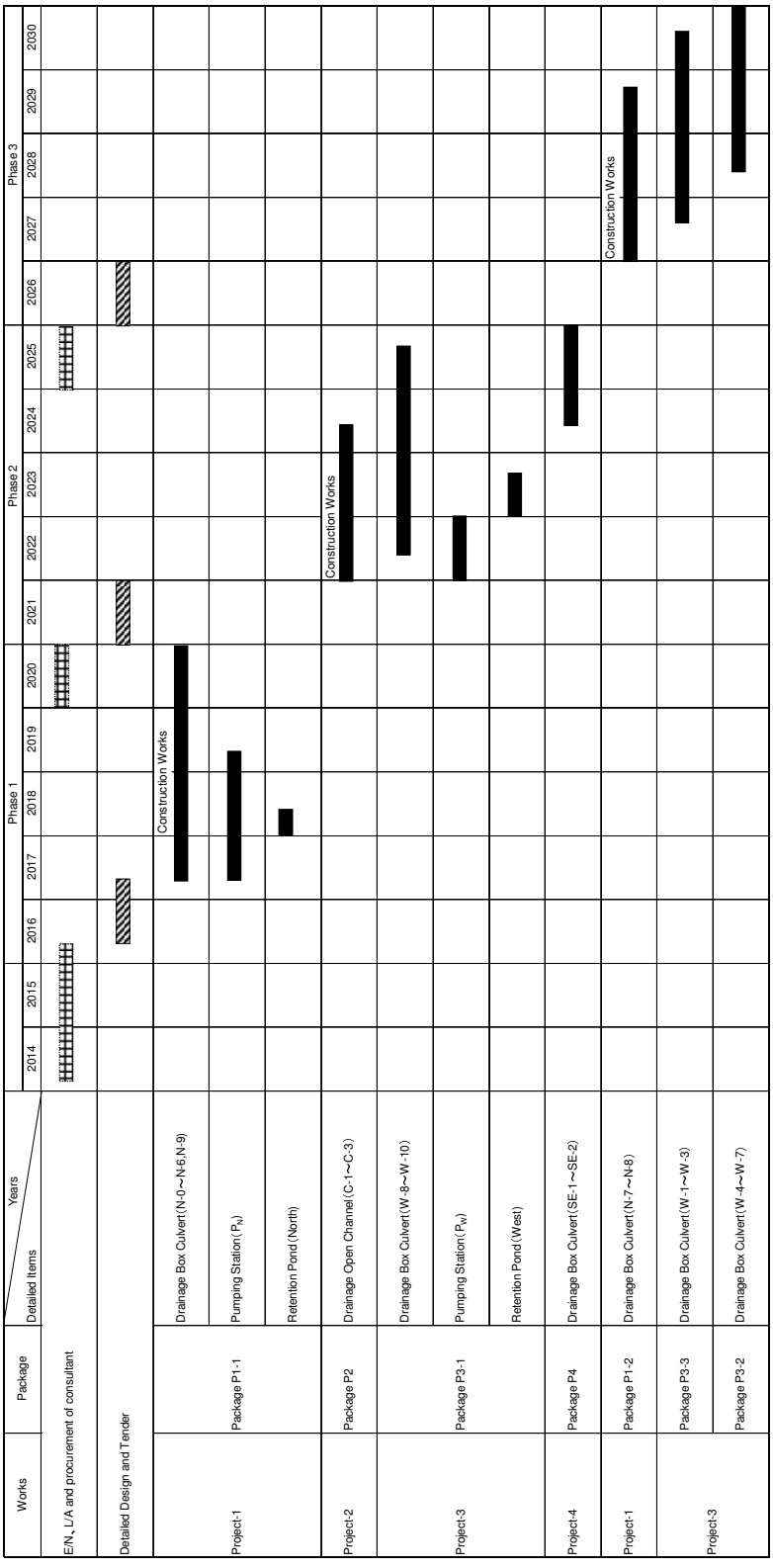


Fig. 5.8.1 Implementation Schedule of Master Plan (Drainage Facilities)

Table 5.8.2 Cost Disbursement Schedule for Drainage Facilities（Construction Cost）

(Unit: Million of FCFA)

Phase	year	Drainage			Pumping Station			Retention Pond			Construction Works		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2014	0	0	0	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0	0	0	0	0	0
	2017	0	1,569	1,569	970	647	1,617	0	0	0	970	2,216	3,186
	2018	0	2,352	2,352	1,455	970	2,425	0	319	319	1,455	3,641	5,096
	2019	0	2,352	2,352	485	323	808	0	0	0	485	2,675	3,160
	2020	0	2,352	2,352	0	0	0	0	0	0	0	2,352	2,352
2	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	0	3,502	3,502	1,194	796	1,990	0	0	0	1,194	4,298	5,492
	2023	0	3,502	3,502	0	0	0	0	643	643	0	4,145	4,145
	2024	0	3,502	3,502	0	0	0	0	0	0	0	3,502	3,502
	2025	0	3,502	3,502	0	0	0	0	0	0	0	3,502	3,502
3	2026	0	0	0	0	0	0	0	0	0	0	0	0
	2027	0	3,130	3,130	0	0	0	0	0	0	0	3,130	3,130
	2028	0	3,130	3,130	0	0	0	0	0	0	0	3,130	3,130
	2029	0	3,130	3,130	0	0	0	0	0	0	0	3,130	3,130
	2030	0	3,130	3,130	0	0	0	0	0	0	0	3,130	3,130
Total		0	35,153	35,153	4,104	2,736	6,840	0	962	962	4,104	38,851	**42,955**

Table 5.8.3 Cost Disbursement Schedule for Drainage Facilities（Project Cost）

(Unit: Million of FCFA)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Administration Cost			Price Escalation			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	0	0	0	201	86	287	31	283	314	0	58	58	15	41	56	45	84	129	292	552	844
	2017	970	2,216	3,186	201	86	287	31	283	314	0	58	58	100	331	431	234	535	769	1,536	3,509	5,045
	2018	1,455	3,641	5,096	201	86	287	31	283	314	0	58	58	177	648	825	335	849	1,184	2,199	5,565	7,764
	2019	485	2,675	3,160	201	86	287	31	283	314	0	58	58	90	602	692	145	667	812	952	4,371	5,323
	2020	0	2,352	2,352	201	86	287	31	283	314	0	57	57	34	639	673	48	615	663	314	4,032	4,346
2	2021	0	0	0	201	86	287	31	283	314	0	57	57	40	114	154	49	97	146	321	637	958
	2022	1,194	4,298	5,492	201	86	287	31	283	314	0	57	57	277	1,440	1,717	308	1,110	1,418	2,011	7,274	9,285
	2023	0	4,145	4,145	200	86	286	31	284	315	0	57	57	51	1,572	1,623	51	1,106	1,157	333	7,250	7,583
	2024	0	3,502	3,502	200	86	286	32	284	316	0	57	57	56	1,510	1,566	52	979	1,031	340	6,418	6,758
	2025	0	3,502	3,502	200	86	286	32	284	316	0	57	57	62	1,673	1,735	53	1,008	1,061	347	6,610	6,957
2	2026	0	0	0	200	86	286	32	284	316	0	57	57	68	200	268	54	113	167	354	740	1,094
	2027	0	3,130	3,130	200	86	286	32	284	316	0	57	57	74	1,823	1,897	55	968	1,023	361	6,348	6,709
	2028	0	3,130	3,130	200	86	286	32	284	316	0	57	57	80	1,985	2,065	56	998	1,054	368	6,540	6,908
	2029	0	3,130	3,130	200	86	286	32	284	316	0	57	57	86	2,151	2,237	57	1,027	1,084	375	6,735	7,110
	2030	0	3,130	3,130	200	85	285	32	284	316	0	57	57	93	2,321	2,414	58	1,058	1,116	383	6,935	7,318
Total Cost		4,104	38,851	42,955	3,007	1,289	4,296	472	4,253	4,725	0	859	859	1,303	17,050	18,353	1,600	11,214	12,814	**10,486**	**73,516**	**84,002**

5.9 Economic Analysis

5.9.1 Methodology

The methodology is basically the same as that of the Sewerage/Sanitation System Improvement Plan in **Subsection 4.9.1 Methodology, Chapter 4** except the sources of benefits. Project contents, expected effects and their benefits are as summarized below:

Table 5.9.1 Project Contents, Expected Effect, and Benefit (Drainage Improvement)

Project Content	Expected Effect	Benefit
• Improvement of drainage capacity of existing drainage canals	To reduce inundation	Production activities which have been halted by inundation can be reduced.
• Installation of drainage facilities in the habitual inundation areas	To reduce inundation	Production activities which have been halted by inundation can be reduced.

5.9.2 Cost-Benefit Analysis

Since the benefit of the component called as "improvement of living environment" cannot be attributed separately to each of the contents, namely; (i) Improvement of drainage capacity of existing drainage canals; and (ii) Installation of drainage facilities in the habitual inundation areas, such two contents are treated in an integrated manner.

(1) Project Cost

The following items are included in the cost calculation:

- Construction
- Engineering services
- Physical contingencies
- Administration cost
- O&M

Land acquisition cost is not included here since the land to be used is presently owned by the government and not being used for any economic activity. The cost items are converted to economic costs as mentioned in **Subsection 4.9.1, Methodology, Chapter 4**. Calculation results are shown in **Table 5.9.4**.

(2) Project Benefit

The benefit of the drainage component is to reduce the down time of economic activities due to inundation. Economic down time is estimated by the estimated inundation depth. It is assumed that the severest inundation (70 cm) lasts for about 1 to 2 weeks and others last pro rata. This down time is converted to an economic value with per capita GDP projection. Finally, the total benefit is calculated including multiplier effect.

Table 5.9.2 Estimated Inundation Depth and Duration

Drainage Area	District Name	Affected Population (persons)		Estimated Inundation Depth (median, cm)		Estimated Duration (median, Days)	
		2012	2030	2012	2030	2012	2030
Khakhoune	Ngane Alassane	92	847	30	45	4.29	6.43
	Ngane Saer	40	298	30	45	4.29	6.43
	Gawane	85	404	30	45	4.29	6.43
	Touba Kaolack	483	1,553	30	45	4.29	6.43
	Ndorong Sadaga	600	2,115	30	45	4.29	6.43
	Ndorong	216	1,025	30	45	4.29	6.43
Ngane Saer	Ngane Saer	161	675	20	30	2.86	4.29
Sam	Gawane	411	1,592	25	30	3.57	4.29
	Sam	270	720	25	30	3.57	4.29
Tobangoye	Tabangoye	516	984	15	20	2.14	2.86
	Médina Mbaba I	106	503	15	20	2.14	2.86
Nimzatt	Nimzatt	282	939	20	30	2.86	4.29
	Touba Kaolack Extension	114	597	20	30	2.86	4.29
Parcelles	Parcelles Assainies	1,146	5,047	30	45	4.29	6.43
	Diamaguene Extension	0	207	30	45	4.29	6.43
Diamaguène	Diamaguène	557	1,831	20	30	2.86	4.29
Boustane I	Boustane I	678	2,232	15	20	2.14	2.86
Abattoirs	Abattoirs	228	1,680	15	20	2.14	2.86
Ndangane	Darou Salam Ndangane	230	740	15	20	2.14	2.86
Center	HLM Sara	0	97	0	20	0.00	2.86
	Nimzatt	0	102	0	20	0.00	2.86
	Ndorong	0	700	0	20	0.00	2.86
	Kassaville	0	857	0	20	0.00	2.86
	Taba Ngoye	0	404	0	20	0.00	2.86
	Tabaya	0	821	0	20	0.00	2.86
	Dialègne I	0	663	0	20	0.00	2.86
	Dialègne II	0	2,143	0	20	0.00	2.86
	Médina Mbaba I	0	564	0	20	0.00	2.86
	Médina Mbaba II	0	331	0	20	0.00	2.86
	Léona Centre	0	1,073	0	20	0.00	2.86
	Ndargoundaw	0	1,507	0	20	0.00	2.86
P1-2 Area	Thioffack	0	2,978	0	20	0.00	2.86
	Médina Baye	0	3,377	0	20	0.00	2.86
P3-2 Area	Ngane Alassane	0	766	0	20	0.00	2.86
	Touba Kaolack Extension	0	3,052	0	20	0.00	2.86
P3-3 Area	Fass Camp des gardes	0	4,577	0	20	0.00	2.86
TOTAL		6,216	48,001	—	—	63.57	125.71

Table 5.9.3 Value of Down Time in Economic Activities

	2012	2015	2020	2025	2030
Total Affected Population*	6,216	13,180	24,787	36,394	48,001
Per Capita GDP Projection (USD)	1,166	1,204	1,267	1,330	1,394
Total Down Duration	20,795	34,159	68,781	118,897	187,274

	2012	2015	2020	2025	2030
(days × persons)					
Total Time Value (USD)	66,410	112,646	238,768	433,392	715,167
Total Time Value with Multiplier Effect (USD)	716,628	1,215,559	2,576,545	4,676,734	7,717,369
Total Time Value with Multiplier Effect (million FCFA)	371	629	1,333	2,419	3,992

Note * Total Population actually affected by stormwater in all the population of Drainage Areas shown in **Table 5.7.2**.
Source: JET and the World Bank

Multiplier Effect

An increase in GDP triggers an additional increase in GDP. According to a macro-economic theory, GDP consists of consumption and saving, and an increase in consumption as the result of increase in GDP causes an increase in GDP finally by a factor of,

$$\frac{1}{1-c}$$

where,

c : Consumption share of GDP (%)

Senegal's average consumption share of GDP in the last 10 years is 90.7% based on the data of the World Bank. Thus, the multiplier is 10.75. The total benefit is increased by 10.75 times.

[Note on Multiplier Effect]

National income (Y) consists of consumption (C) and saving (S).

$$Y = C + S$$

Increase in Y causes increase in C, which in turn causes Y as follows:

$$\Delta C_1 = \Delta Y_2 = c\Delta Y_1$$
$$\Delta C_2 = \Delta Y_3 = c\Delta Y_2 = c(c\Delta Y_1) = c^2\Delta Y_1$$
$$\Delta C_3 = \Delta Y_4 = c\Delta Y_3 = c(c\Delta Y_2) = c\{c(c\Delta Y_1)\} = c^3\Delta Y_1$$
$$\cdots$$
$$\Delta C_n = \Delta Y_{n+1} = c\Delta Y_n = c(c\Delta Y_{n-1}) = c\{c(c\Delta Y_{n-2})\} = \cdots = c^n\Delta Y_1$$
$$\cdots$$

Thus, the total increase is

$$\Delta Y = \Delta Y_1 + c\Delta Y_1 + c^2\Delta Y_1 + \cdots + c^n\Delta Y_1 + \cdots = (1 + c + c^2 + \cdots + c^n + \cdots)\Delta Y_1$$

Finally, the formula of infinite geometric series is applied.

$$\Delta Y = \frac{1}{1-c}\Delta Y_1$$

(3) Calculation Result

EIRR is calculated as 6.7%. Although this figure is less than the 12.0% of Social Discount Rate, the project seems fully reasonable, considering it is an infrastructure development. Detailed calculation is shown in **Table 5.9.4**.

Table 5.9.4 EIRR Calculation

Unit: Million FCFA

Year	Cost						Benefit	Net Benefit
	Construction	Engineering	Physical Contingency	Administration	O&M	Total		
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	273.2	268.7	48.7	0.0	590.7	0.0	-590.7
2017	2,831.4	273.2	268.7	48.7	0.0	3,422.1	0.0	-3,422.1
2018	4,513.4	273.2	268.7	48.7	2.3	5,106.4	78.5	-5,027.8
2019	2,732.0	273.2	268.7	48.7	5.9	3,328.6	230.2	-3,098.4
2020	1,975.7	273.2	268.7	47.9	8.1	2,573.6	365.5	-2,208.0
2021	0.0	273.2	268.7	47.9	9.6	599.5	508.1	-91.4
2022	4,804.3	273.2	268.7	47.9	9.6	5,403.8	571.5	-4,832.3
2023	3,481.8	272.2	269.6	47.9	13.5	4,085.0	906.2	-3,178.8
2024	2,941.7	272.2	270.6	47.9	16.3	3,548.6	1,216.9	-2,331.7
2025	2,941.7	272.2	270.6	47.9	18.6	3,551.0	1,532.9	-2,018.1
2026	0.0	272.2	270.6	47.9	21.0	611.7	1,906.0	1,294.3
2027	2,629.2	272.2	270.6	47.9	21.0	3,240.9	2,119.5	-1,121.4
2028	2,629.2	272.2	270.6	47.9	23.1	3,243.0	2,554.8	-688.2
2029	2,629.2	272.2	270.6	47.9	25.2	3,245.1	3,054.3	-190.8
2030	2,629.2	271.4	270.6	47.9	27.3	3,246.3	3,706.1	459.7
2031					29.4	29.4	3,991.7	3,962.3
2032					29.4	29.4	3,991.7	3,962.3
2033					29.4	29.4	3,991.7	3,962.3
2034					29.4	29.4	3,991.7	3,962.3
2035					29.4	29.4	3,991.7	3,962.3
2036					29.4	29.4	3,991.7	3,962.3
2037					29.4	29.4	3,991.7	3,962.3
2038					29.4	29.4	3,991.7	3,962.3
2039					29.4	29.4	3,991.7	3,962.3
2040					29.4	29.4	3,991.7	3,962.3
2041					29.4	29.4	3,991.7	3,962.3
2042					29.4	29.4	3,991.7	3,962.3
2043					29.4	29.4	3,991.7	3,962.3
2044					29.4	29.4	3,991.7	3,962.3
2045					29.4	29.4	3,991.7	3,962.3
2046					29.4	29.4	3,991.7	3,962.3
2047					29.4	29.4	3,991.7	3,962.3
2048					29.4	29.4	3,991.7	3,962.3
2049					29.4	29.4	3,991.7	3,962.3
2050					29.4	29.4	3,991.7	3,962.3
2051					29.4	29.4	3,991.7	3,962.3
2052					29.4	29.4	3,991.7	3,962.3
2053					29.4	29.4	3,991.7	3,962.3
2054					29.4	29.4	3,991.7	3,962.3
2055					29.4	29.4	3,991.7	3,962.3
2056					29.4	29.4	3,991.7	3,962.3
2057					29.4	29.4	3,991.7	3,962.3
2058					29.4	29.4	3,991.7	3,962.3
2059					29.4	29.4	3,991.7	3,962.3
2060					29.4	29.4	3,991.7	3,962.3
							EIRR	6.7%

5.10 Financial Analysis

5.10.1 Methodology

The methodology is basically the same as that for the Sewerage/Sanitation System Improvement. (See **Subsection 4.10.1 Methodology, Chapter 4**.)

5.10.2 Cost-Benefit Analysis

Solution or mitigation of storm water drainage is one of the tasks of the municipal or national government, which should be implemented as infrastructure development. Thus, all the cost should be managed by governmental budget and it is inappropriate to collect charges from residents. It means that it is inappropriate to calculate the benefit for the purpose of the financial analysis. For example, the World Bank's document (Report No. 66451-SN), *Project Appraisal Document for a Stormwater Management and Climate Change Adaptation Project*, April 12, 2012 describes, "There is no financial analysis to be done in this context (Financial Analysis of the proposed flood prevention component) as the drainage system is considered as a public good that will need to be funded and maintained by national and/or municipal budgets directly through force account or indirectly through the contracting out of private services to perform the drainage management."

5.11 Selection of Priority Project for Feasibility Study

The projects proposed for Phase 1 in the Master Plan are selected as the priority projects. As discussed in **Section 5.7**, Package P1-1 of Project-1 has the top priority in the Master Plan. Therefore, Package P1- 1 of Project-1 is selected as the priority project for the Feasibility Study. The project components for the Feasibility Study are shown in **Table 5.11.1**

Table 5.11.1 Project Components for Feasibility Study (Drainage Improvement)

Project	Package	Component	Specification	Remark
Project-1 (North Area)	P1-1	Box Culvert		
		N-0	1.5m × 1.5m, L= 830 m	New Construction
		N-1	2.9m × 2.9m, L= 580 m	
		N-2	1.3m × 1.3m, L= 950 m	
		N-3	1.5m × 1.5m, L= 700 m	
		N-4	1.7m × 1.7m, L=1,170 m	
		N-5	2.2m × 2.2m, L= 810 m	
		N-6	2.6m × 2.6m, L=1,280 m	
		N-9	1.4m × 1.4m, L= 270 m	
		Pumping Station (P_N)	No. of Pump: 6 units × 3.3 m^3 Required area: 4,000 m^2 Pump Total Head: 3.2 m	New Construction
		Retention Pond	Required volume: 42,300 m^3 Required area: 15,000 m^2	New Construction

CHAPTER 6. SOLID WASTE MANAGEMENT PLAN

6.1 Review of Kaolack SWM Master Plan by APROSEN

6.1.1 General

Kaolack City formulated the Master Plan of Solid Waste Management (SWM) in 2008 with the technical assistance from APROSEN, and prepared the report called as the "Study for the Operational Implementation System of Solid Waste sustainable Management in Kaolack City, Volume I & Volume II, 2007 & 2008" as summarized in the following table. According to the Technical Services, it is being used as the comprehensive plan of SWM for the City.

Table 6.1.1 Objective of the 2008-Master Plan for Kaolack City by APROSEN

Overall Objective	To realize a sustainable, technically possible and financially feasible SWM for the city.
Road/Street Cleaning	To keep city roads and streets clean.
Collection	To ensure the application of selectable collection means and ensure to use the waste transportation means to a final disposal site.
Final Disposal	To ensure that a technically possible and environmentally feasible final disposal site is constructed in accordance with the related laws and ordinances.

Source: Kaolack City

6.1.2 Outline of Kaolack SWM Master Plan

The major issues on the 2008 Master Plan are as summarized in the following table.

Table 6.1.2 Outline of Kaolack SWM Master Plan by APROSEN

Name of study	SWM Master Plan by APROSEN/ Kaolack City
Study year	2007/2008 (1.5 years)
Estimated Project Cost	818,125,000 FCFA
Legislation	Environment Code (law N°2001-01 of 15 Jan.2001) & other related decrees
Target year	Year 2010 (4 years: 2007 to 2010)
Target collection rate	100 % (2010)
Estimated waste amount generated	125 t/day (2007), 129 t/day (2008), 132 t/day (2009), 136 t/day(2010)
Zoning	Zone 1 to Zone 6
Solid waste management Pre-collection Collection:	 ROC system would be replaced gradually by tricycles in over 3 years. House-to-house collection: by ROC trucks to transfer stations, and motorized tricycles (59 units) Transfer stations: 4 (Zones 1, 3, 4, 5), containers: 16 Refuse box structures (10m × 9m size): 11 Communal collection: Containers ($15m^3$): 34 Public containers ($12m^3$, markets & bus-stations):22
Transportation:	Skip trucks (polybenne trucks): 6 Container tractors: 2 Dump truck: 1
Landfill Site:	Landfill site has not been decided at the time of the master plan; Mbadakhoune was included only as an alternative landfill site. Sanitary landfill site: 2 landfill-cells of 170m × 150m × 5m high each, Cell construction by alternation of clay layer and waste layer Buldozer:1, wheel loader: 1, Dump truck: 1
Remarks:	This Mater Plan was not implemented by the authorities concerned due to financial problems.

6.1.3 Conclusions

- Unfortunately, the master plan by APROSEN was not implemented by the authorities concerned like Kaolack City due to financial constraints. However, IDB included the results of the Master Plan for Kaolack City among the four major urban solid waste management projects which formed the IDB SWM Project.

- There was no study on the drainage system to Saloum River from the disposal area at Mbadakhoune. If the drainage system is expected to affect the disposal area and expand the inundation area due to excess of rainwater above the maximum water level at the site (e.g., Elev. 0 m), further implementation of a study on the drainage system for the sanitary landfill site is required.
- Although the Master Plan assumes that the ROC system in Kaolack City would be replaced by tricycles in 3 years, it is expected that the economy should be more active and the infrastructure system including road pavement works for the bare sandy road is needed progressively. The ROC system operation and maintenance in Kaolack City should, therefore, be carefully monitored.

6.2 Recommendations on IDB Project

6.2.1 Outline of the Project

There is an IDB project for SWM in the four major cities of Dakar, Kaolack, Tivaouane, and Touba, based on the Master Plan study results on urban solid waste management endorsed by APROSEN and completed in December 2010. The APROSEN's SWM project for Kaolack was approved by IDB in May 2011 and the IDB project for the 4 urban SWMs was officially signed between IDB and Senegal in June 2011. The project cost is estimated at about USD35 million (or 17.51 billion FCFA), covering the five components as discussed below.

The overall project objective is to contribute to the improvement of health and environmental conditions in the targeted cities of Dakar, Kaolack, Tivaouane and Touba, which have more than 4.5 million inhabitants, in the western and central parts of Senegal. Specifically, the project will support the Government's efforts to establish an effective and sustainable system for municipal SWM, through:

- Construction of 3 municipal solid waste landfills and transfer stations, and 90 controlled waste collection points to meet the cities' disposal needs;
- Provision and roll out of about 300 units of collection equipment, and services;
- Institutional support to assist the beneficiaries (APROSEN and municipalities) in managing solid waste systems in an effective, efficient, sustainable and environmental way; and
- Launching a communication campaign to help in changing the population's behavior.

6.2.2 SWM Project Cost for Kaolack City

There are mainly five components of the IDB SWM Project, namely; (i) infrastructure development; (ii) waste collection and transportation equipment; (iii) institutional support and capacity building; (iv) engineering and consulting services; and (v) project management.

The IDB had estimated the Kaolack SWM Project to be about USD 9 million (or 4.5 billion FCFA), which include USD 5.4 million (or 2.7 billion FCFA) for infrastructure development (1 sanitary landfill, 1 transfer station, 20 collection points), USD 1.45 million (or 0.73 billion FCFA) for waste collection and transportation equipment (refer to **Table 6.2.1**), USD 0.14 million (or 0.07 billion FCFA) for institutional and consulting services; USD 0.38 million (or 0.19 billion FCFA) for engineering and consulting services, USD 0.44 million (0.22 billion FCFA) for project management, and USD 1.17 million (or 0.59 billion FCFA) for contingencies, based on the exchange rate of 1 USD = 500 FCFA.

Table 6.2.1 Project Cost of the IDB's SWM Project for Kaolack City

Item	Component	Local Currency (Million USD)	Foreign Currency (Million USD)	Total (Million USD)	Total (Billion FCFA)
A	**Infrastructure development**				
	A1- Construction of sanitary landfill	1.60	2.40	4.00	2.00
	A2- Construction of transfer station	0.48	0.72	1.20	0.60
	A3- Construction of collection points	0.10	0.10	0.20	0.10
	Sub-total A	**2.18**	**3.22**	**5.40**	**2.70**
B	**Waste collection & transport equipment**				
	B1- Kaolack	0.03	1.42	1.45	0.73

	Sub-total B	**0.03**	**1.42**	**1.45**	**0.73**
C	**Institutional & consulting services**				
	C1- Study for municipal tax/budget reform	0.03	0.00	0.03	0.02
	C2- Municipal technical departments (MTD)	0.04	0.00	0.04	0.02
	C3- Training for APROSEN & MTD	0.02	0.00	0.02	0.01
	C4- public awareness campaigns & outreach	0.05	0.00	0.05	0.02
	Sub-total C	**0.14**	**0.00**	**0.14**	**0.07**
D	**Engineering & consulting services**	**0.15**	**0.23**	**0.38**	**0.19**
E	**Project management**				
	E1- Implementation support (AGETIP)	0.32	0.00	0.32	0.16
	E2- Support to project management unit	0.09	0.00	0.09	0.04
	E3- Audit	0.02	0.00	0.02	0.01
	E4- Startup workshop	0.01	0.00	0.01	0.00
	E5- Familiarization visit & study tours	0.01	0.00	0.01	0.01
	Sub-total E	**0.44**	**0.00**	**0.44**	**0.22**
Base cost (A+B+C+D+E)		**2.94**	**4.87**	**7.81**	**3.39**
Contingencies					
	Physical contingencies (10%)	0.29	0.49	0.78	0.39
	Price contingencies (5%)	0.15	0.24	0.39	0.20
Grand total		**3.38**	**5.60**	**8.98**	**4.49**

Source: IDB, Dakar

Table 6.2.2 shows the list of heavy collection and ancillary equipment prepared by IDB for the SWM in Kaolack City. However, the number of equipment in the table seems to be for the short-term period only and does not include the mid-term and long-term plan phases of SWM for the city. It seems that the number of heavy equipment is good for about five years only. Furthermore, it is anticipated that the city, presently, does not have enough number of skilled mechanics with adequate tools and mechanical equipment as well as technical knowledge at the City's workshop.

Table 6.2.2 List of Heavy Equipment and Ancillary Equipment for SWM in Kaolack City

	Heavy Collection Equipment	Number of Equipment	Ancillary Equipment	Number of Equipment
1	Dumpster Trucks	2	Wheelbarrows	**150**
2	Poly Bucket Trucks	3	Round shovels	150
3	Ordinary Trucks	1	Broom sweepers	300
4	Tractors	2	Rakes	300
5	Tractor's Trucks	6	Forks	150
6	Tricycles	30	Uniforms	200
7	Excavators	1	Boots	200
8	Poly Bucket Containers	30	Protective gloves	200
9	Containers	40	Masks	200
Total		115		**1,850**

Source: IDB Dakar

6.2.3 Recommendations

The following are the recommendations for the IDB Project for SWM in Kaolack City:

- It is expected that since the Kaolack project has been approved and signed by both the IDB and the Senegal Government in June 2011, the new administration will make a good decision on the early implementation of the project. (As of November 2012, the Bank has been waiting for a response on its proposal for the Project from the new administration. It is said that at the end of this JICA Study in November 2013, the Bank is still waiting for the response on its proposal for the Project.)

- It is recommended that during the implementation of the Kaolack SWM Project supported by IDB, the progress should be monitored carefully and all necessary actions should be taken immediately to realize the Project's completion and objectives.
- The number of equipment required for SWM as listed by IDB seems to be for an urgent SWM work of short-term duration only and does not cover the mid-term and long-term plan/phases of the SWM in Kaolack City. It also seems that the number of heavy equipment is good for about five years only. Therefore, it is recommended that a more comprehensive SWM plan study shall be made for a more precise estimation of number of equipment required for an integrated SWM plan including the mid- and long-term plan phases for Kaolack City.
- Since there seems to be no skilled mechanic at the workshop of the city, it is essential that mechanics at the workshop shall be provided with a more comprehensive training, with tools and mechanical equipment, in order to acquire more skill and knowledge on SWM.
- For the completion and sustainability of the Project implementation, all stakeholders concerned such as central and local government agencies, state companies, CDQ, NGO, and so on, should be involved and take the necessary actions immediately.

6.3 Proposal of Preliminary Kaolack SWM Plan by 2030

6.3.1 Issues on Solid Waste Management in Kaolack City

(1) Issues on SWM

In order to reflect the present condition of SWM and the results of the revision of the SWM Master Plan by APROSEN and the IDB SWM project for Kaolack City, major issues to be addressed are summarized below.

a) Low rate of waste collection: Collections decreased from 25% in 2007 to 12% in 2010, 6% in 2011 and less than 6% in 2012. Combination of the measures of hard, soft and administrative support against SWM issues shall be appropriately structured.

b) Utilization of the current collection system: Donkey-truck (ROC system), monocycle and wheelbarrow are more suitable for Kaolack City because of the unpaved and sandy roads which get inundated in the rainy season. Motorized tricycles are not also technically reliable for solid waste collection in Kaolack due to mechanical problems as experienced in 2007 (ASDES).

c) Composition of solid waste by weight shows more than 50% of sand & stone. Collection equipment like compactor would easily be damaged by fine sandy materials. Therefore, more careful operation and maintenance are indispensable (ASDES).

d) Existing illegal disposal sites should be controlled. Suitable transfer sites should be selected.

e) A solid waste transportation system should be established between transfer sites and the final disposal site. A combination of suitable transportation system from the generation sources to the final disposal site is required.

f) The final disposal site should be designed to have the capacity to dump all the collected solid wastes towards 2030.

g) SWM sector wide capacities should be enhanced through IEC campaign among the City Government, APROSEN, related agencies, residents, NGOs, and private sectors.

h) Institutional strengthening is required to support smooth management of the total system of SWM.

Limitations and constraints of the City and the ROC system are summarized in **Table 6.3.1**.

Table 6.3.1 Limitations and Constraints of Municipality Kaolack and ROC System for SWM

Limitations	Constraints
Municipality	
- Insufficient and dilapidated logistics. - Lack of financial resources mobilized for service. - Insufficient human resources and lack of training at all levels. - No sweeping in the city center in particular. - Low coverage of SWM. - Bad choice of technical equipment. - Informal management/lack of organizational scheme.	- Lack of Disposal Site: Disposal sites are not subject to planning and daily management. - Urbanization: Most of the districts are built on tannes/ inundation areas which people occupy after many years of backfilling with waste. - Lack of stabilized roads that does not foster a good traffic for collection vehicles and increases the frequency of breakdowns. - The central districts no longer have land reserves that can accommodate transfer sites.
ROC system	
• Waste collected by cart is disposed in any available space in the town or even the districts. • Waste is sold to people as backfill material. • Unhygienic areas exist in all districts. • Veterinary care for donkeys is lacking in all CDQ except Taba-Ngoye, Parcelles Assainies., and Ndorong 1 and Koundam. • Insufficient number of GIE for complete coverage of districts. • Unavailability of a large population of donkeys to make more efficient collection and better work organization.	• Lack of carts, low number of customers. • Weakness of financial balance of activity and its unreliability. • CDQ offers free service to some poor households, which affects the balance of operating account. • Inaccessibility of transfer sites and lack of containers. • Non-involvement of city/municipal authorities to organize the system: The field of intervention of GIE in districts is not defined (area divided into sectors assigned to GIE).

Source: APROSEN master plan report, 2007/2008
(Note)
CDQ: Committee for District Development, the official core unit
GIE: Economic Interest Group

(2) JICA Interview Survey with City Residents

The interview survey on SWM in Kaolack City was conducted by JET for selected 100 households in January 2012. Major results of the survey are summarized as follows.

- ROC system by private associations (about 89%) is used for pre-collection, and by the municipality (1%), and 6% for dumping into canals or open-spaces;
- A least two times per week of waste collection services are supported by 67% of households;
- About 90% of households can afford waste collection services (willingness-to-pay);
- 1,000 FCFA (54%) per month is affordable for the charge of solid waste collection services (the affordability-to-pay). 1,000 FCFA corresponds to 0.8% of monthly average income of 120,000 FCFA per household obtained through the Socio-economic Survey conducted by JET);
- 77% of households are satisfied with the present collection services;
- 94% of households remain unconcerned about the environmental impacts caused by waste dumping into channels or open-air spaces; and
- 98% of households put trust in the private association and not the municipality for solid waste collection services.

6.3.2 Planning Concept

(1) SWM Planning Concept

Formulation of the preliminary SWM plan for Kaolack City is based on the following:

a) Projected collection rate of solid waste is set at more than 60% in 2020 and 100% in 2030.

b) All the City areas are to be served with waste collection, transportation and disposal system by Kaolack City, except for a self-disposal area (Zone 6).

c) New collection and transportation system will be introduced:

- Pre-collection system: ROC carts (90% in 2012) are supposed to be maintained as long as possible until the accessible roads to the transfer stations will be paved. Motorized tricycles and three-wheel vehicles will gradually increase towards 2030.
- Collection system to a final landfill site.
- New transfer stations: Transfer stations will be increased from the existing 3 stations to 10 stations including one transfer station center for composting and recycling, which is proposed in APROSEN's Master Plan and the IDB Project.

d) Improvement of the transportation system from transfer stations to the final disposal site.

e) Kaolack City states that the final sanitary landfill site for the City is to be constructed in Mbadakhoune Rural Community and is now under the signing process of the two parties, Kaolack City and Mbadakhoune Rural Community. The detailed information of the landfill site is not available but the following items are roughly identified or estimated.

- Starting year of operation: 2010
- Land owner: Mbadakhouene Rural Community
- Design capacity estimated: about 400,000 m^3
- Filled up space of landfill estimated: about 10,000 m^3
- Remaining space of landfill estimated: about 390,000 m^3

Construction of the final sanitary landfill site is recommended to follow the "Fukuoka Method" developed by Fukuoka University and Fukuoka City in Japan, which is a type of sanitary landfill based on semi-aerobic landfill structure and technology offering improved landfill site simply and at low cost utilizing materials readily available in developing countries, and environmentally friendly.

f) For solid waste generation, the city area of Kaolack is divided into two SWM system areas, namely; (i) Population in collection service area (Zones 1 to 5, population of 253,300/386,000 in 2013/2030); and (ii) Population in self-disposal area (Zone 6, population of 16,700 in 2013/2030) (refer to **Fig. 6.3.1**). The self-disposal area of Zone 6 is located at a remote area of about 16 km from the final disposal site at Mbadakhoune and the projected population of Zone 6 is almost constant 4 to 6% from 2013 to 2030. Therefore, Zone 6 is selected as a self-disposal area.

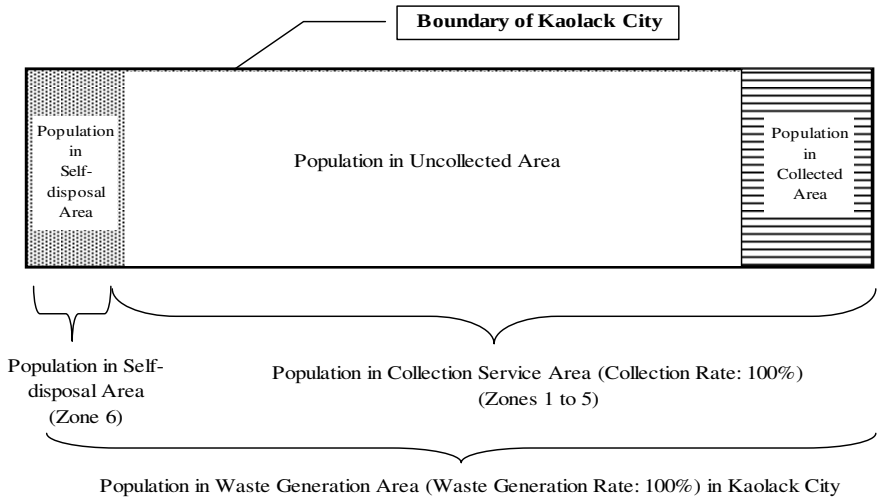


Fig. 6.3.1 Schematic Diagram of Collected, Uncollected and Self-disposal Areas in Kaolack City

(2) Related Laws and Regulations

The National Environmental Code (Law No. 200-01 of January 15, 2001) of Senegal, Chapter I defines "Waste" and "Waste Management," and Chapter III describes the mandates of "Waste Management" from Article 30 to Article 43. "Waste" is defined as all solid, liquid, gaseous matter, or residue from production, transformation process or from utilization of every other substances eliminated, intended to be eliminated or that must be eliminated in accordance with the laws and regulations in force. Then, "Waste Management" defines the collection, transportation, storage, recycling and wastes elimination including the surveillance of elimination sites. In Chapter III, all the categories of wastes including biomedicine wastes are mandated.

On the other hand, there is the Local Government Code (Law No. 96-06 and Law No. 96-07, both of 22 March 1996) on the transfer of authority to Regions, Communes, and Rural Communities. Decree No. 96-1134 of 27 December 1996 confirmed the application of the law on the transfer of authority regarding environmental and natural resources management. The authority of solid waste management had been handed down also to the local governments.

The responsibility, duty, authority, regulations, etc., of the local government such as Kaolack City mandated by legislation will be the key elements to formulate the solid waste management (SWM) plan. To set the policy on SWM, the responsibilities of each party concerned have to be clarified. Such responsibilities may be as follows:

(i) The central government shall be responsible for the provision of financial sources, technology development and legislative set up;

(ii) The local authority shall be responsible for the provision of sufficient facilities and regulations of SWM services; and,

(iii) The beneficiaries shall be responsible for co-operating with the local authority on the discharge of waste and on bearing the charges.

The responsibility of the local authority is the most important to establish an efficient municipal solid waste management system for Kaolack City. It shall be defined in the following statement:

"Kaolack City Government has the primary duty of care for SWM in the City through regulation and services."

As described in the National Environmental Code of Senegal, Chapter III, "Waste Management," Kaolack City should hold the power and responsibility for organizing solid waste management. As shown below, there are other organizations involved in solid waste management.

- Central Government
- Kaolack City
- Industrial and Commercial Waste Generators including Medical facility
- Residents

The proposed principal responsibilities of respective organizations are given in the following table.

Table 6.3.2 Parties Involved in Solid Waste Management and their Responsibilities

Parties Involved	Responsibilities
1. Central Government	1) To formulate a national policy with respect to waste reduction, recycling and solid waste management. 2) To formulate and pass a national SWM law. 3) To set technical standards. 4) To research on solid waste management. 5) To ensure that the laws and regulations are applied. 6) To provide guidance to local governments.

Parties Involved	Responsibilities
2. City Council of Kaolack	1) To formulate a local policy and prepare local strategies and plans (short and long term). 2) To finance SWM. 3) To levy a waste tax. 4) To formulate regulations. 5) To formulate guidelines with respect to: a) methods of discharging waste (types of containers to be used); b) the waste reporting requirements of business waste generators; and, c) recycling (types of waste to be recycled). 6) To provide waste collection, haulage and street sweeping services under contractual arrangements
3. Industrial and Commercial Waste Generators including Medical facility	1) To manage (collection, treatment and disposal) their waste except those accepted by the local government as municipal waste 2) To submit reports on their waste (types, quantity, pre-treatment and other information) as required by the municipal regulations.
4. Residents	1) To reduce generation of waste. 2) To recycle. 3) To comply with the local government's waste collection procedure. 4) Not to litter waste. 5) To dispose of discarded vehicles by using commercial enterprises.

(3) Planning Objectives

The primary objectives of the solid waste management are proposed to be applied commonly by the City of Kaolack to achieve the goals of better living environment such as the following three items:

(a) Improvement of Public Cleanliness;
(b) Improvement of Public Health and Hygiene; and
(c) Protection of the Environment.

The IDB project document in December 2010 also states that the primary objective of the SWM is to promote public health and environmental protection through the improvement of conditions of hygiene and cleansing in urban environment, by a healthy and durable management of the urban solid waste by setting up systems viable in the environmental plan, technically feasible, socially acceptable, suitable for elimination of risks from infections and to guarantee a healthy and clean environment.

(4) Planning Strategy

To achieve the primary objectives, the strategic approach to formulate the Preliminary SWM Plan for Kaolack City are proposed with the following eight approaches of solving the implicated constraints of the city towards improvement of technical and institutional deficiencies:

Technical Approach

- Collection Plan including Pre-collection and Transportation Plans
- 3R and Intermediate Treatment Plan
- Final Landfill Plan

Institutional and Financial Approach

- Institutional capacity building includes financial strengthening of SWM
- Human resource development in SWM
- Improvement of SWM operational capacity
- Private sector involvement in SWM
- Public awareness and participation of communities and NGOs (IEC)

The three measures, namely "Engineering Measures (Engineering and consulting services)," "Soft Measures (Peoples' Understanding and Help)" and "Administrative Support Measures (Kaolack City)" should be integrated to solve the solid waste issues in Kaolack City.

6.3.3 Proposed Solid Waste Management Plan

(1) Solid Waste Collection and Treatment Systems for their Respective Zone Areas

According to the former Master Plan (2007-2010) of the Kaolack solid waste management prepared by APROSEN and endorsed by the City Government in 2008, the whole city area is zoned for the communal territories of SWM system, namely, 6 zones as shown below.

Table 6.3.3 Zoning of the Communal Territory in Kaolack City

Zone	District	Remarks
Zone 1	1.Leona Center, 2.Leona Escale, 3.Ndangane, 4.Darou Salam Ndangane, 5.Abattoirs, 6.Ndargoundaw, 7.Dialegne I, 8.Dialegne II	8 districts
Zone 2	1.Medina Mbaba I, 2.Medina Mbaba II, 3.Medina Bave, 4.Taba Ngove, 5.Sam	5 districts
Zone 3	1.Thioffack, 2.Gawane, 3.Ngane Saer, 4.Ngane Alassane	4 districts
Zone 4	1.Touba kaolack, 2.Touba kaolack Extension, 3.Ndorong Sadaga, 4.Keur Maloum, 5.Ndorong, 6.Tabaya, 7.Kassaville, 8.Nimzatt, 9.HLM Sara, 10.Sara Ndiougary, 11.Diamaguene Extension, 12.Diamaguene, 13.Darou Slam Diamaguene, 14.Fass Camp des Gardes, 15.Parcelles Assainies	15 distircts
Zone 5	1.Kasnack, 2.Boustane I, 3.Boustane II, 4.Bongre, 5.Peulge, 6.Koundam, 7.Sama Moussa	7 districts
Zone 6	1.Sing-Sing, 2.Lyndiane, 3.Kabatoki, 4.Ngade	4 districts, Self-Disposal Zone
Total		43 districts

Source : APROSEN Report 2008, Kaolack City and JET
Note: Number of Districts increased to 43 in 2012.

(2) Projection of Future Solid Waste Generation Amount

(a) General

Future solid waste generation amount by the year 2030 is projected based on the population projection in Kaolack City. The following considerations were taken in the updating of future waste amounts.

- Population;
- Area; and
- Per capita GDP.

(b) Population Projection in Kaolack City

The most direct influence on waste generation is the change in population. The population projection of Kaolack City for the planning period until 2030 is as described in **Chapter 3** and shown in **Table 6.3.4**.

Table 6.3.4 Forecast of Future Population of Kaolack City

(Unit: person)

Zone	Year				
	2012	2015	2020	2025	2030
Zone 1	52,248	54,490	58,500	62,881	67,669
Zone 2	37,335	38,381	40,221	42,193	44,306
Zone 3	26,886	31,375	40,686	52,930	65,973
Zone 4	98,780	110,189	135,737	151,292	158,123
Zone 5	38,097	39,985	43,473	47,101	50,006
Zone 6	16,654	16,654	16,654	16,654	16,654
City Center (Zone 1-Zone 5)	253,346	274,419	318,618	356,397	386,076

Zone	Year				
	2012	2015	2020	2025	2030
Total (Whole City)	270,000	291,000	335,000	373,000	403,000

Source: Kaolack City

(c) Relationship between Gross Domestic Product (GDP) and Solid Waste Discharge

GDP is one of the important indicators which may represent levels of social welfare, industrial technology and import of goods. The growth rate in GDP is thus expected to have a larger impact on the solid waste amount per capita of developing countries and it will also remarkably result in charges in the composition of waste at a certain welfare level. The annual growth rate in per capita GDP has been projected at 1.09% in 2012 and 0.92% in 2030. Then, the annual waste generation amount per capita from the period of 2012 towards 2030 has been computed, namely, at 0.52 kg/capita/day in 2012 and 0.6 kg/capita/day in 2030, based on the waste unit amount of 0.49 kg/capita/day in 2007 in the master plan of APROSEN, 2007/2008.

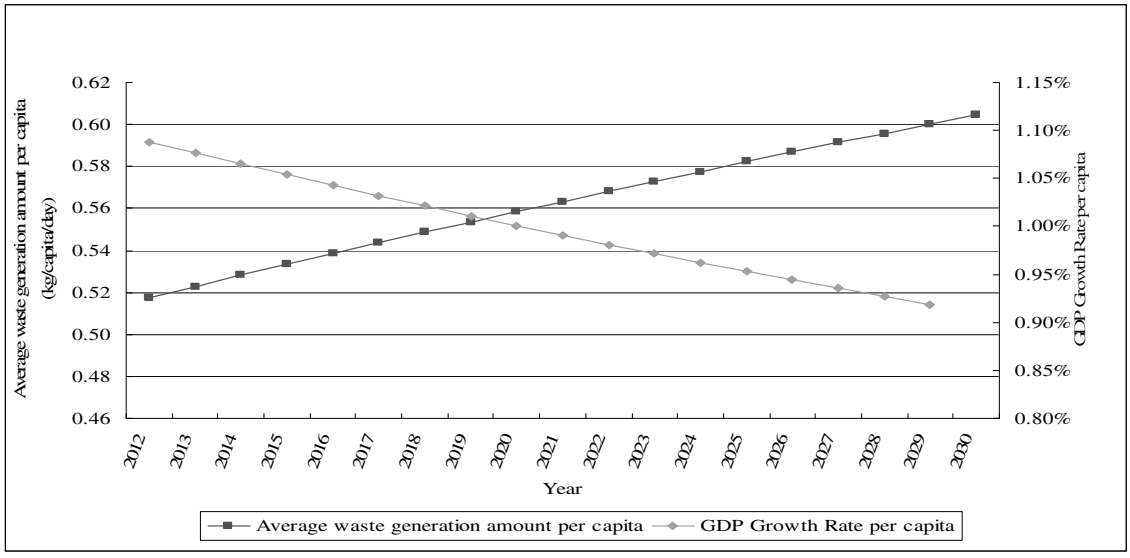


Fig. 6.3.2 Projected Average Waste Generation Amount per Capita

(d) Projection of Future Solid Waste Generation Amount

The solid waste generation in 2030 has been estimated for each zone in Kaolack City as shown in **Table 6.3.5**.

Table 6.3.5 Projection of Solid Waste Amount Generation (2012-2030) in Kaolack City

(Unit: ton/day)

Zone	2012	2015	2020	2025	2030
Zone 1	27.0	29.1	32.7	36.6	40.9
Zone 2	19.3	20.5	22.5	24.6	26.8
Zone 3	13.9	16.7	22.7	30.8	39.9
Zone 4	51.1	58.8	75.8	88.1	95.6
Zone 5	19.7	21.3	24.3	27.4	30.2
Zone 6	8.6	8.9	9.3	9.7	10.1
Total	139.7	155.2	187.2	217.2	243.5

(Notes)
Domestic waste: (Projected population) × (Projected average daily solid waste generation) × (Projected growth rate of per capita GDP).
Commercial waste: considered as part of domestic waste.
Market waste: 0.01 kg/capita/day/market used in the APROSEN Report 2008
Road waste: considered as already included in the domestic wastes

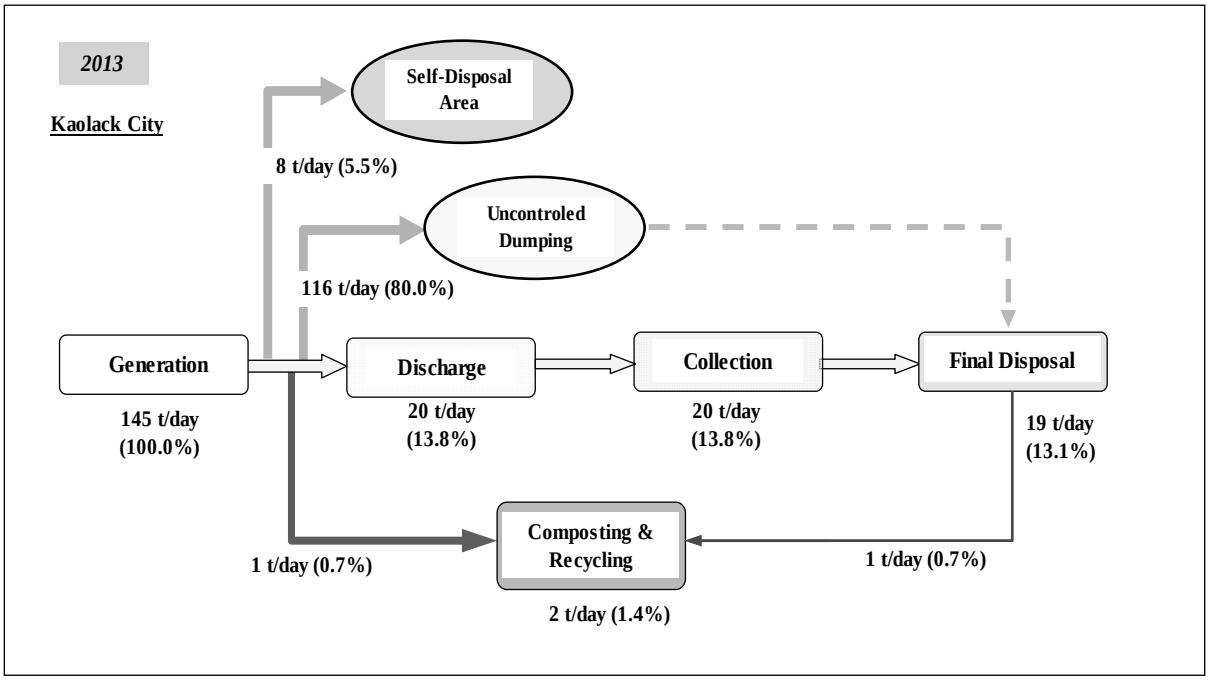
The projected waste generation in the above table (2012–2030) for the entire City shows smooth succession to the estimated solid waste production (2007 2010) in the APROSEN Report of 2008.

The waste stream projected in Kaolack City for the years 2013 and 2030 are shown in **Fig. 6.3.3**. From the projected waste streams in the figure, the waste to be conveyed to the final sanitary landfill at Mbadakhoune Rural Community are estimated with a stepwise increase in waste collection rate, based on the target collection rate of 100% in 2030. The collection rate of 100% is ideal. The collection rates of more than 60% in 2020 and 100% in 2030 in the preliminary SWM plan were set up to realize the current SWM situation of the very low collection rate of 13% in Kaolack City to the visible improvement progressively of the environmental and sanitary condition at the target years of 2020 and 2030.

The target collection rate and waste amount estimated in the whole Kaolack City are summarized in **Table 6.3.6**.

Table 6.3.6 Target Collection Rate and Waste Amount of Kaolack City

Year	2013	2015	2020	2025	2030
Collection Rate (%)	20	40	65	90	100
Waste Amount (t/day)	28	45	95	150	211



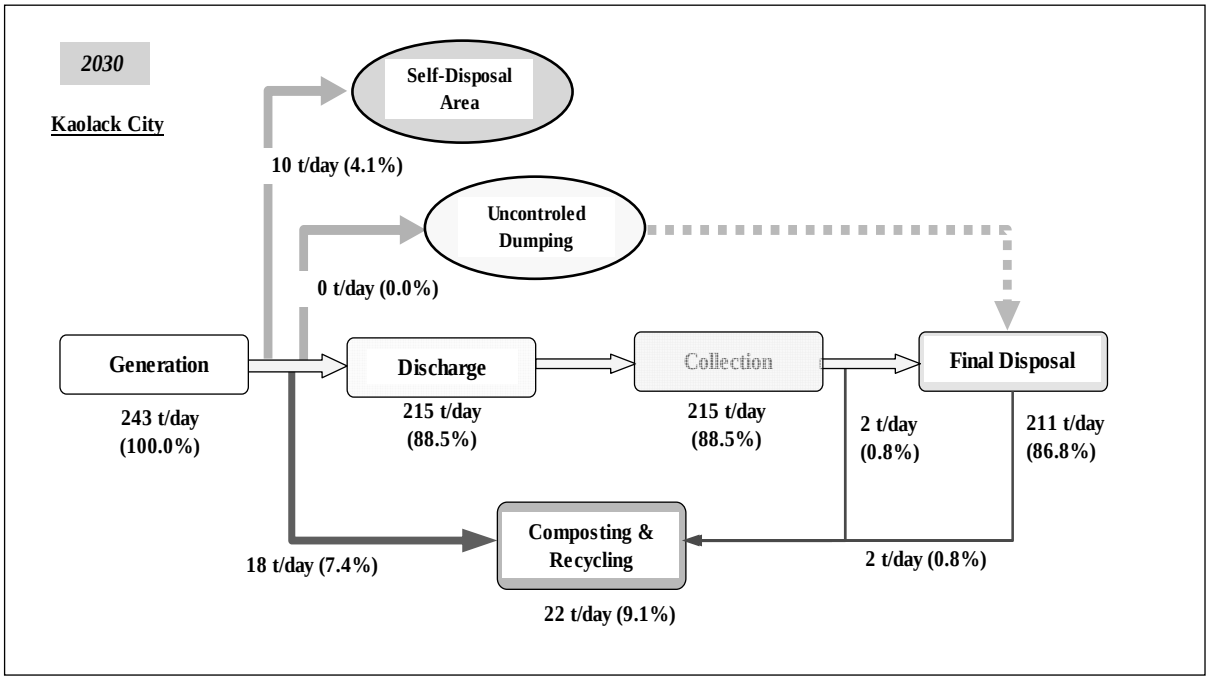


Fig. 6.3.3 Solid Waste Stream in Kaolack City (2013 and 2030)

The number of required collection vehicles is approximately shown in **Table 6.3.7**.

Table 6.3.7 Required Number of Proposed Equipment for Kaolack City

Zone	2015						2020						2025						2030					
	Compactor	Skip Container Truck	Dump Truck	Bola Taxi	Wheel Loader	Sub-total	Compactor	Skip Container Truck	Dump Truck	Bola Taxi	Wheel Loader	Sub-total	Compactor	Skip Container Truck	Dump Truck	Bola Taxi	Wheel Loader	Sub-total	Compactor	Skip Container Truck	Dump Truck	Bola Taxi	Wheel Loader	Sub-total
Zone 1	1	2	1	1	1	6	1	3	1	2	1	8	1	3	2	3	1	10	1	3	2	3	1	10
Zone 2		1	1	1	1	4		1	1	2	1	5		1	1	3	1	6		1	1	3	1	6
Zone 3		1	1	1	1	4		1	1	2	1	5		1	2	3	1	7		2	1	3	1	7
Zone 4	1	1	2	3	1	8	1	1	3	6	2	13	1	1	4	9	2	17	1	1	5	11	2	20
Zone 5	1	2	1	1	1	6	2	3	2	1	1	9	2	3	2	1	1	9	4	3	3	1	2	13
Total	3	7	6	7	5	28	4	9	8	13	6	40	4	9	11	19	6	49	6	10	12	21	7	56

(3) Improvement Concept for SWM System

(a) Collection Service Plan

(i) Existing Collection and Transportation System

The current waste collection system including pre-collection system in Kaolack City is mainly carried out by the ROC system (about 90%) and mostly disposed illegally at dumping sites in the city, and partly wastes generated at the markets and bus stations are collected by the City (about 10%) and transported to the temporary final disposal site at Mbadakhoune. The City is now engaged in waste collection work at the markets and bus stations with only poor equipment [one mechanical wheel loader (granted by NGO to the City) and one rented truck of 16 m^3 capacity].

In organizing, operating and implementing the newly proposed collection and transportation system, pre-collection system, transfer stations, collection points, etc., should be mutually discussed among the stakeholders concerned such as the City Government, the District Council at each District, representatives of CDQ, GIE, private parties, associations, residents, etc. The proposed collection and transportation system for waste in Kaolack City is described below.

(ii) Pre-Collection System

For waste pre-collection, the ROC system with the donkey-cart for solid waste pre-collection has been utilized around Kaolack City for a long time. The ROC system for waste pre-collection is described in detail in the report of APROSEN 2007/2008 and being activated because of the bare sandy grounds and inundation spots during rainy season in the districts.

According to CARITAS (NGO), there are currently 110 ROC-carters system recorded in the City by CDQ, GIE, private parties and associations as shown in **Table 6.3.8**, and the number of ROCs had slightly increased year by year, covering about 39 Districts out of the 43 Districts in all the City Area. In Kaolack City, it is significant that since the City Government engages only in waste collection in city markets and bus stations, the ROC cart system has a very important role in pre-collection of SWM system and covers most of the districts in the City. Therefore, the City Government should recognize the importance of the ROC system for the SWM system and support and maintain the private association's power in the collection and transportation system for SWM as much as possible. It is noted that the number of ROC trucks increased from 109 in 2009 to 123 in 2012 (ASDES/ CARITAS).

The ROC system (donkey-truck) for waste pre-collection is managed by various stakeholders such as CODEKA (Committee for Development of Kaolack City for coordination of state and non-state office activities), APROSEN, CDQ (Committee for District Development, the official core unit), GIE (Economic Interest Group), NGO (CARITAS, ASDES), etc.

(b) Transfer Station (T/S)

There are three existing transfer stations: at the districts of Ndargoundaw, Ngane Saer and Diamaguene. However, two transfer stations (Ndargoundaw and Diamaguene) are already abandoned and the other (Ngane Saer) is not maintained well. It is therefore proposed that improvement/renovation of the three existing transfer stations shall be made and more transfer stations shall be established at several districts to improve the new waste collection system for Kaolack City.

There are ten transfer stations consisting of three existing transfer stations and six potential transfer stations, and one transfer station center with composting & recycling plant, for the new waste management system for the City. **Table 6.3.9** shows the nine potential transfer stations consisting of three existing transfer stations and new six potential transfer stations, as well as the reasons for selection and the distance from the station. Basically, the potential transfer stations primarily selected by JET are the illegal disposal sites already investigated by APROSEN and JET, which provide conveniently situated uncontrolled refuse disposal sites. Compared with Zones 1 to 4, Zone 5 has only six tones per one transfer station, which is the smallest waste amount generation of each zone (There will be about 13 to 25 tons/transfer station in Zones 1 to 4, while about 6 tons per transfer station in Zone 5). Because Zone 5 will be divided into three sub-zones of: (i) Peulge, Bongre, northern part of Kasnack and Boustane I & II, (ii) Koundam and southern part of Kasnack and (iii) Sama Moussa, and thus totally three transfer stations are required for Zone 5. Among the 10 transfer stations, the location of No. 10 transfer station is not proposed yet (and hence the location of this station is not shown in **Fig. 6.3.4**). It is a transfer station center which was proposed in the Master Plan of the APROSEN 2007/2008. The Transfer Station Center is a center plant/ facility of composting and recycling activities. This T/S center will require large land areas for its activities of not only temporary storage of solid wastes but also as center of composting and recycling for the City. The idea was already introduced and discussed during the Technical Committee meetings held on 29 May 2012 and 22 November of 2012 in Kaolack. It is needed that the final selection of the proposed transfer stations should be carefully discussed and finally decided together with all the concerned parties such as Kaolack City, district residents, landowners, etc., so that necessary actions on land acquisition can be carried out by the parties in advance.

Table 6.3.8 Records of ROC Carters and ROC User Rate in Kaolack City

No.	Zones	Districts	CDQ	GIE	Privates	Asso-ciations	Total	Total Population (2012)	Number of ROC Sub-scriber
1.	Zone 1	Ndangane			1	3	4	6,857	
2.		Darou Salam Ndangane						7,837	
3.		Leona Center		1	6	2	9	6,531	
4.		Leona Escale						4,898	
5.		Abattoirs			2	3	5	8,164	
6.		Dialegne I		11			11	7,075	
7.		Dialegne II						6,531	
8.		Ndargondaw						4,354	
9.	Zone 2	Medina Mbaba I	1	1	2		4	7,293	1,666
10.		Medina Mbaba II						4,463	
11.		Medina Baya		1	4		5	13,062	
12.		Taba Ngoye	1		1	1	3	5,769	1,740
13.		Sam		1	2		3	6,749	1,188
14.	Zone 3	Gawane	1	2	2		5	7,075	1,247
15.		Ngane Saer	1				1	3,810	1,612
16.		Ngane Alassane	1	1	1		3	5,660	1,536
17.		Thioffack	1	1	1		3	10,341	3,485
18.	Zone 4	Kassaville	1		6		7	5,987	201
19.		Tabaya						1,959	
20.		Ndorong	1	1		6	8	5,442	1,796
21.		Ndorong Sadaga	1	1	4		6	7,619	1,245
22.		Keur Maloum						4,354	
23.		Sara Ndiougary		4		7	11	16,327	
24.		HLM Sara						1,034	
25.		Nimzatt	1		2		3	4,136	1,452
26.		Touba Kaolack	1		4		5	9,796	
27.		Touba Kaolack Extension						16,327	2,040
28.		Diamaguene Extension		1	2		3	3,265	
29.		Diamaguene						4,898	
30.		Darou Salam Diamaguene						2,721	
31		Fass Camp des Gardes						4,572	101
32.		Parcelles Assainies	1				1	10,341	1,293
33.	Zone 5	Koundam	1				1	3,048	3,000
34.		Kasnack			2	1	3	7,619	
35.		Bongre	1				1	7,293	
36.		Peulge						1,306	
37.		Boustane I	1		2	1	4	8,164	
38.		Boustane II						6,313	
39.	Zone 6	Kabatoki				1	1	5,007	
Total			**15**	**26**	**44**	**25**	**110**	**253,997**	**23,602**

Source: CARITAS, ASDES, 2009, JET

Table 6.3.9 Existing and Proposed Transfer Stations (T/S)

No.	Zones	Transfer Station (T/S)		District	Reasons for selection	Remarks
		Existing	Proposed			
1	Zone 1	Ndargoundaw (Down Dialegne)		Ndargoundaw	Needs improvement work	All districts within 1 km distance to T/S, [Land requirement] about 300 m^2 [Land owner] public
2		-	Ndangane	Ndangane	Existing illegal disposal site to new T/S	All districts within 1 km distance to T/S, [Land requirement] several hundred m^2 [Land owner] public
3	Zone 2	-	Medina Baya market	Medina Baya	Not well-operating disposal site to new T/S	All districts within 1 km distance to T/S Partly direct disposal to final disposal area (at Mbadakhoune village), [Land requirement] several hundred m^2 [Land owner] public
4	Zone 3	Ngane Saer	-	Ngane Saer	Needs improvement work	All districts within 1.5 km distance to T/S, [Land requirement] about 1,500 m^2 [Land owner] public
5	Zone 4	Diamaguene	-	Diamaguene	Needs improvement work	All districts within 1.5 km distance to T/S, [Land requirement] about 2,000 m^2 [Land owner] public
6		-	Touba Kaolack Extension	Touba Kaolack Extension	Existing illegal disposal site to new T/S	All districts within 1.5 km distance to T/S, [Land requirement] several hundred m^2 [Land owner] private
7	Zone 5	-	Peulge	Peulge	Existing illegal disposal site to new T/S	All districts within 2 km distance to T/S, [Land requirement] several hundred m^2 [Land owner] public
8		-	Koundam	Koundam	Existing illegal disposal site to new T/S	All districts within 1.5 km distance to T/S, [Land requirement] several hundred m^2 [Land owner] public
9		-	Sama Moussa	Sama Moussa	Existing illegal disposal site to new T/S	All districts within 1.5 km distance to T/S, [Land requirement] several hundred m^2 [Land owner] public
10	Not yet	Not yet	Kaolack Composting & Recycling Plant	Not yet fixed	Available large area at remote location from city center	Large land area is needed at remote location from City Center, [Land requirement] several ha [Land owner] not yet fixed

Source: Kaolack City, APROSEN, JET

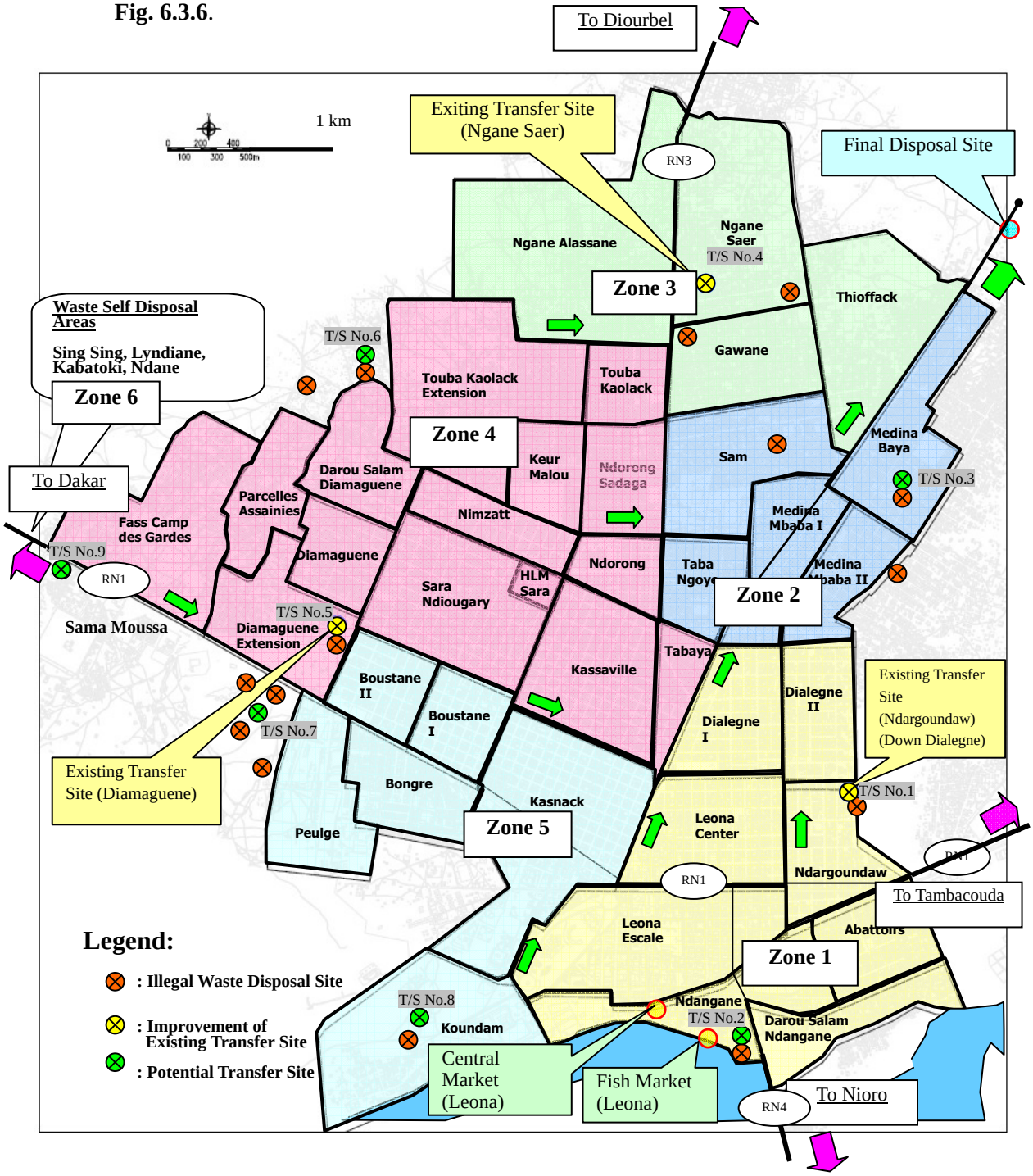
(c) Collection Points

In the new collection system for wastes, Kaolack City shall plan to fix a waste collection point at each district where residents carry wastes on their heads/wheelbarrow and dispose them into a container manually. The collection point should be located within a walking distance from a dwelling. Kaolack City is supposed to decide the suitable location of the collection points at districts in collaboration with district residents before the new collection system is applied. To determine the location of collection points, consensus-building is very crucial among the stakeholders such as owners of the collection point (Kaolack City or private owner) and residents around the collection points.

Due to the unpaved or sandy grounds, large capacity collection vehicles such as the 8-ton or 10-ton class are not recommended in the City to avoid getting stuck or slipping during the rainy day. It is also recommended that the residents' turn system for doing cleaning duty be applied for cleaning collection points and communal stations at each district.

The waste collection zoning in Kaolack City and the new collection and transportation system are schematically shown in **Fig. 6.3.4**. **Fig. 6.3.5** shows the present collection, transportation

and disposal system. Wastes from public markets and bus stations are collected by only one truck (rental) and directly transported to the final disposal site in Mbadakhoune. The collection service area covers quite insufficiently. The conceptual figure of the new systems of waste collection, transportation and final sanitary landfill site for Kaolack City is also shown in **Fig. 6.3.6**.



Source: New administrative district boundary of Kaolack City (2012), ADM, APROSEN.
Notes: Zoning system (Zone 1 to Zone 6) of new waste collection system with new transfer station system.
Locations of "Illegal Waste Disposal Sites", "Improvement of Existing Transfer Site" and "Potential Transfer Site", also represent those of present collection points.

Fig. 6.3.4 Waste Collection Zoning and New Collection, Transportation and Disposal System in Kaolack City

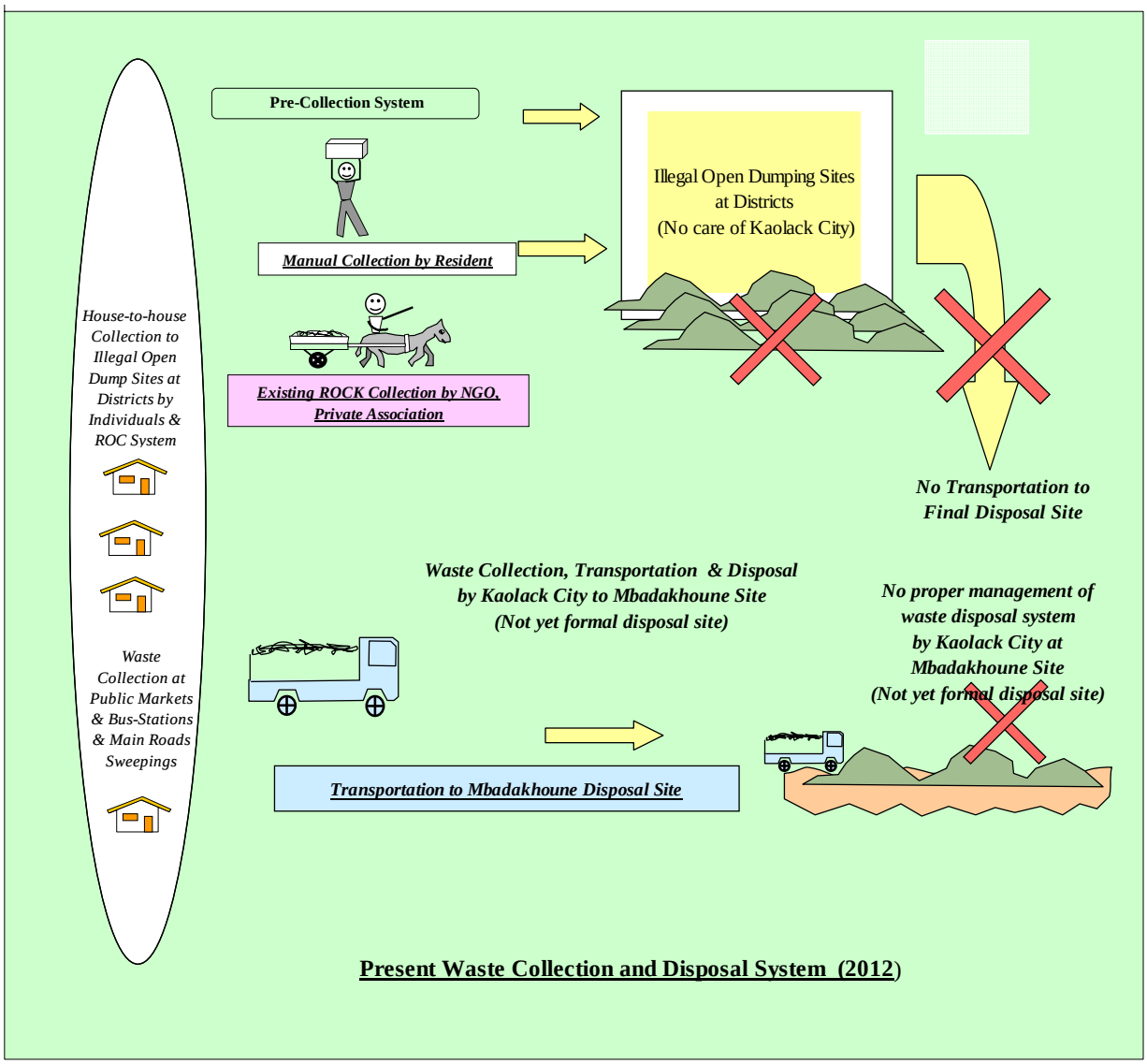


Fig. 6.3.5 **Diagram of Present Collection, Transportation, and Disposal System in Kaolack City**

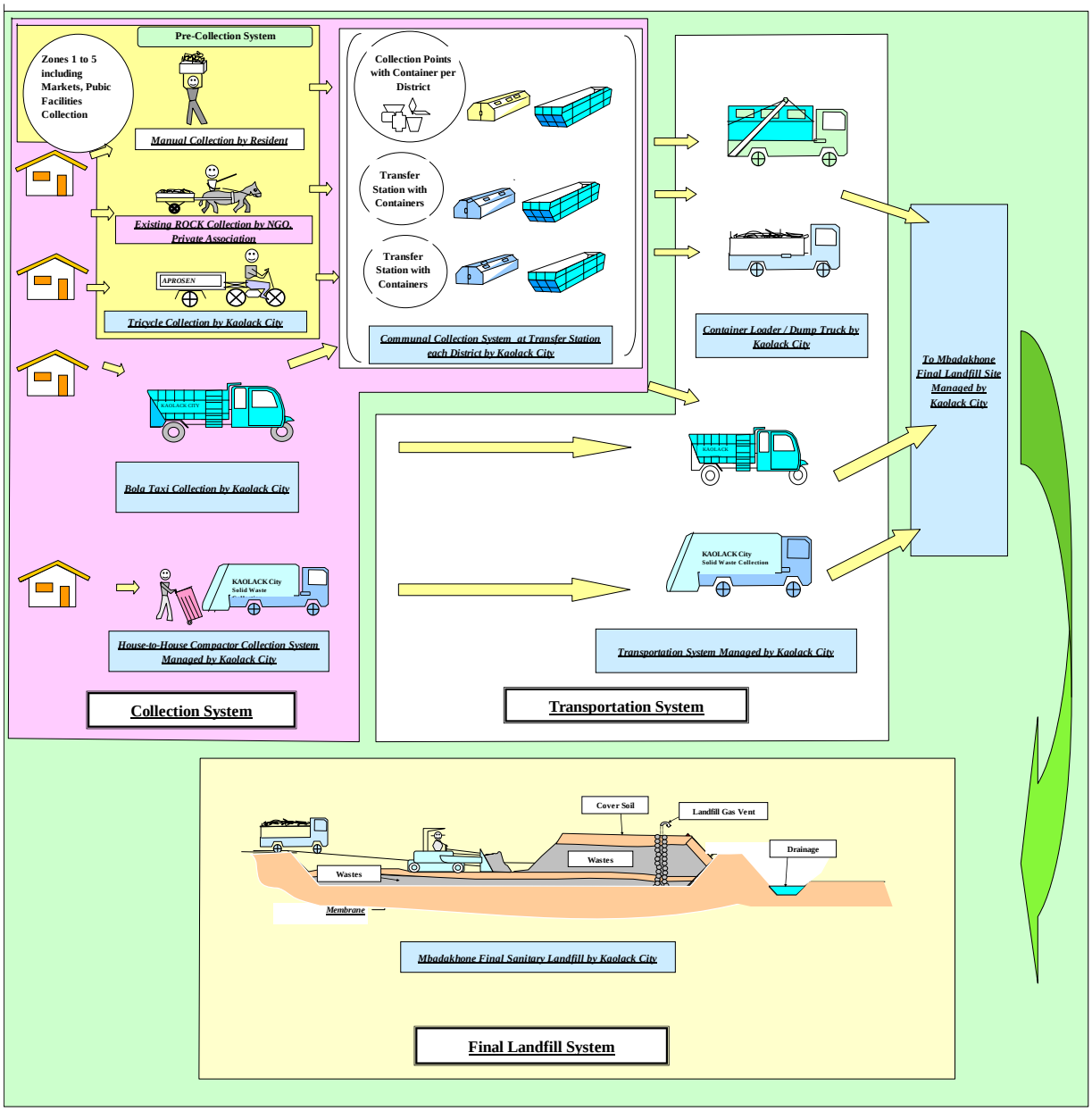


Fig. 6.3.6 Conceptual Diagram of New Collection, Transportation, and Landfill System in Kaolack City

(d) Final Landfill Plan

(i) Progress of Lease Agreement on Landfill Site

As of November 2013, there was no official agreement between Kaolack City and the Mbadakhoune Rural Community located in Kaolack Department of Kaolack Region on the lease of land for the final landfill. The Vice Governor stated in the Technical Committee meeting in Kaolack on 22 November 2012, the agreement may be signed by both parties in early 2013. It was finally confirmed that the official agreement between Kaolack City and the Mbadakhoune Rural Community was still under preparation as of November 2013.

The landfill site is located at about 6 km north of the city center of Kaolack. The existing landfill site is about 1 ha, as shown in **Photo 6.3.3**. The geographical feature before the use of the Mbadakhoune dumpsite area presents a former sand quarry. The land to be used for landfill is located at lower elevations of about 2 to 4 m high with a total area of dozens

of hectares including the impounding water ponds (based on Google Earth). The entire area of the proposed landfill site to be rented is not yet known as shown in **Photo 6.3.1**. The detailed features of the contract such as land area boundary, land area, rental period, etc., will be disclosed after the agreement is signed by the two parties but the estimated area is about 15 ha. It is not clear if the existing land fill area is included in the newly designated landfill site.

Existing final disposal site (Nov. 2012)
(Mbadakhoune Rural Community)

Proposed new final disposal site (Nov. 2012)
(Mbadakhoune Rural Community)

Photo 6.3.1 Conditions of Final Disposal Site (Nov. 2012)

(ii) Proposed Drain System from Landfill Site

A drainage system will be required at the landfill site in future. In November 2012, the inundation area reached the current open dumping site. It is therefore anticipated that excess water above a certain water level (e.g., Elev. 0 m) should be drained through an open channel to Saloum River so that the landfill facility will not be inundated. This matter should be considered before a proposed landfill facility is put to the implementation including the design stage.

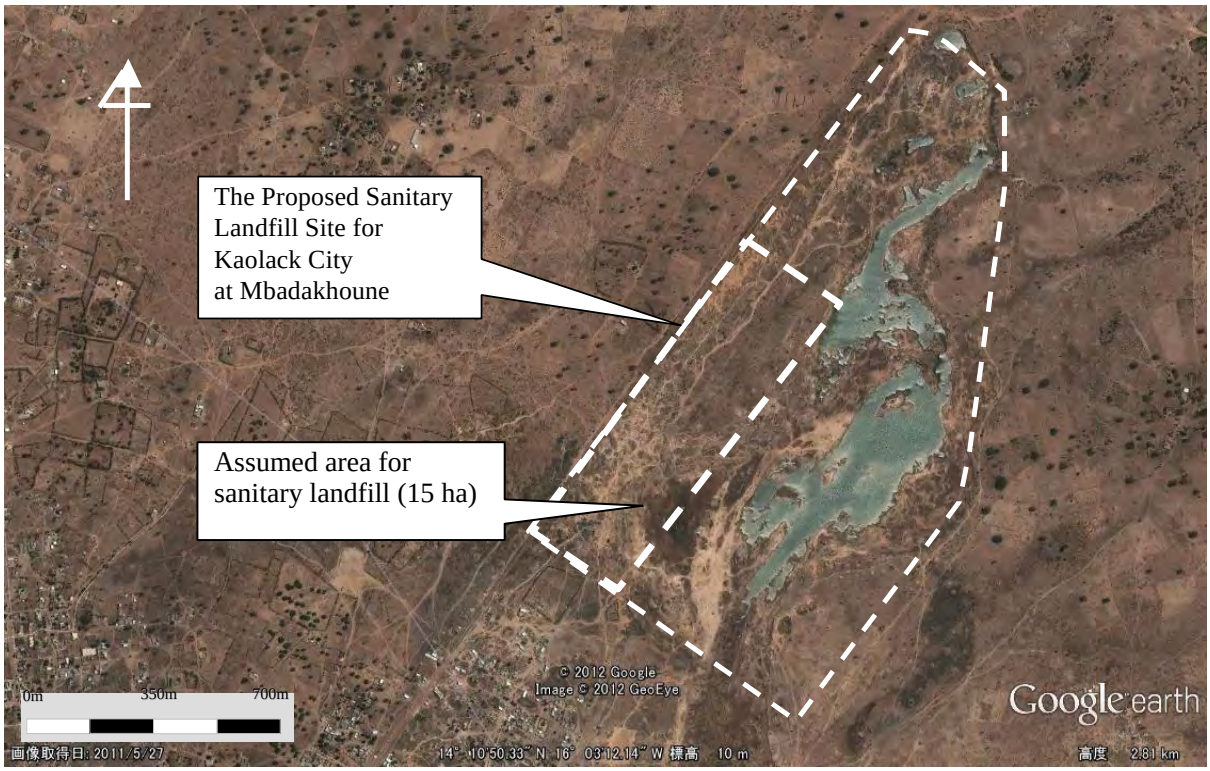


Photo 6.3.2 Location of Proposed Sanitary Landfill Site Area for Kaolack City at Mbadakhoune (Exact location of proposed landfill area within the dotted line is not delineated yet)

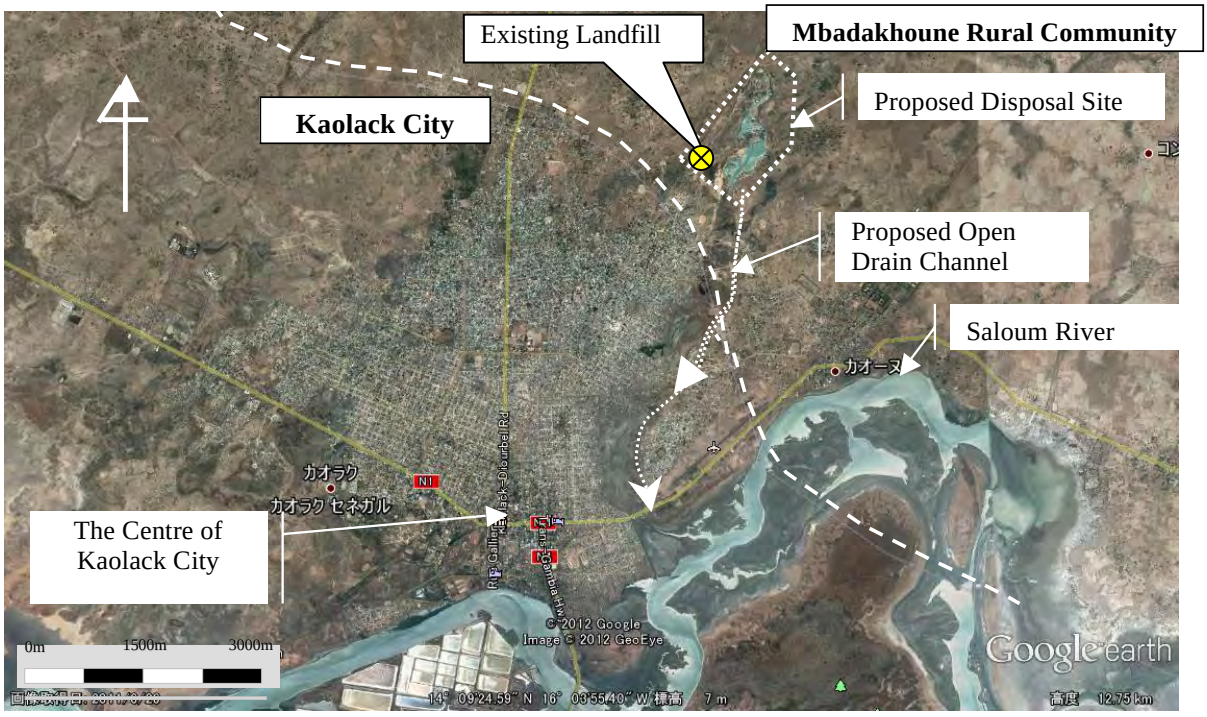


Photo 6.3.3 Location of Proposed Landfill Site at Mbadakhoune for Kaolack City and the Proposed Drain System

(e) 3R and Intermediate Treatment System

The term 3R as defined herein stands for Reduce, Reuse and Recycling. The current state of 3R in Kaolack City is not so active. In the proposed Collection and Transportation System, it is recommended that sorting of wastes is to be carried out at source, collection points, transfer

stations, and final landfill site. The 3R and intermediate treatment system are as discussed below.

(i) Reduce

Waste generation amount per capita is not so high in Kaolack and it maybe a challenging scheme to conduct the waste reduction plan. However, there are still some spaces to reduce waste generation through avoiding excessive use or saving consumable goods, repairing and reuse of commodities.

(ii) Reuse

Based on the results of the waste composition survey[13], the commingled ratio of reusable commodities is very small. People in Kaolack, especially the lower income group families, are practicing reuse as a natural daily activity. Secondhand clothes and shoes are commonly sold at the markets such as Leona Central Market, Medina Baya, and others. However, there still exist waste generation groups to promote reuse or use of items over and over again, even the repaired ones, for the reduction of waste discharge amount.

(iii) Recycling

The recycling of paper, glass and metals is not being practiced in Kaolack City so much. There is a plastic recycling unit in Koundam District which was constructed under Japanese grant aid in 2001 with technical cooperation from an Italian NGO (LVIA: Lay Volunteers International Association). After LVIA left the industry for Thies Region, an NGO (CARITAS) and GIE took over the operation of the plastic recycling factory. The plastic recycling industry uses only hard plastic recyclable materials but produces still small amount (around 10 kg/day). After chipping plastic materials to small size, the chipped plastic materials are sold to a private company (UTRALPAST) in Dakar through an NGO (LVIA). So far, there are only two plastic recycling factories in Theis and Kaolack in Senegal. Since 2002, UTRALPAST has been producing water reservoirs, septic tanks, and so on from collected plastic chip materials. The company purchased 12 tons of hard plastic chip materials from NGOs last year. Besides, the hard plastic materials (high density polyethylene), metals, scrap irons and grasses have a high potential market for recycling if an economic distribution system and recycling means are developed in Senegal in future.

(iv) Waste Recovery

According to the results of the waste composition survey in Kaolack City, it is noted that in terms of composition by weight, the combination of fine sand (46.3%) and stones (11.6%) exceeds more than 50% and it is the characteristic of solid wastes in Kaolack (APPROSEN Master Plan). This characteristic should be carefully considered for operation of compactors to avoid unnecessary mechanical troubles of compactor operation and other heavy equipment. Separation or sorting of sands and stones from other wastes at source are indispensable before collection of wastes. The major items of resource recovery without the sand and stone are paper, plastic, glass and metals. The waste composition survey shows 25% of the total amount of paper, plastics, glass and metals is recyclable.

(v) Composting

According to the City Government of Kaolack, it is noted that the residents of Kaolack City and its surrounding regional areas of Kaolack Region have never experienced

[13] Seyni Thiam, Domestic Solid Waste in the Commun de Kolack, Contribution for Rationalization of Management ESP 2000-2001 derived from 'Etude Pour la Mise En Oeuvre Operationnelle d'un Systeme de Gestion durable des dechets solides dans la ville de Kaolack TOME I, November 2007'.

composting activities. Even though organic waste composition shows the higher ratio of more than 50%[14] in Kaolack, it is potential that composting of biodegradable waste is considered as the most practical way for intermediate treatment. It is expected that Kaolack City will plan to study composting through the National Institute of Pedology (Institut national de pedologie) of Senegal and try to spread the composting knowledge to residents.

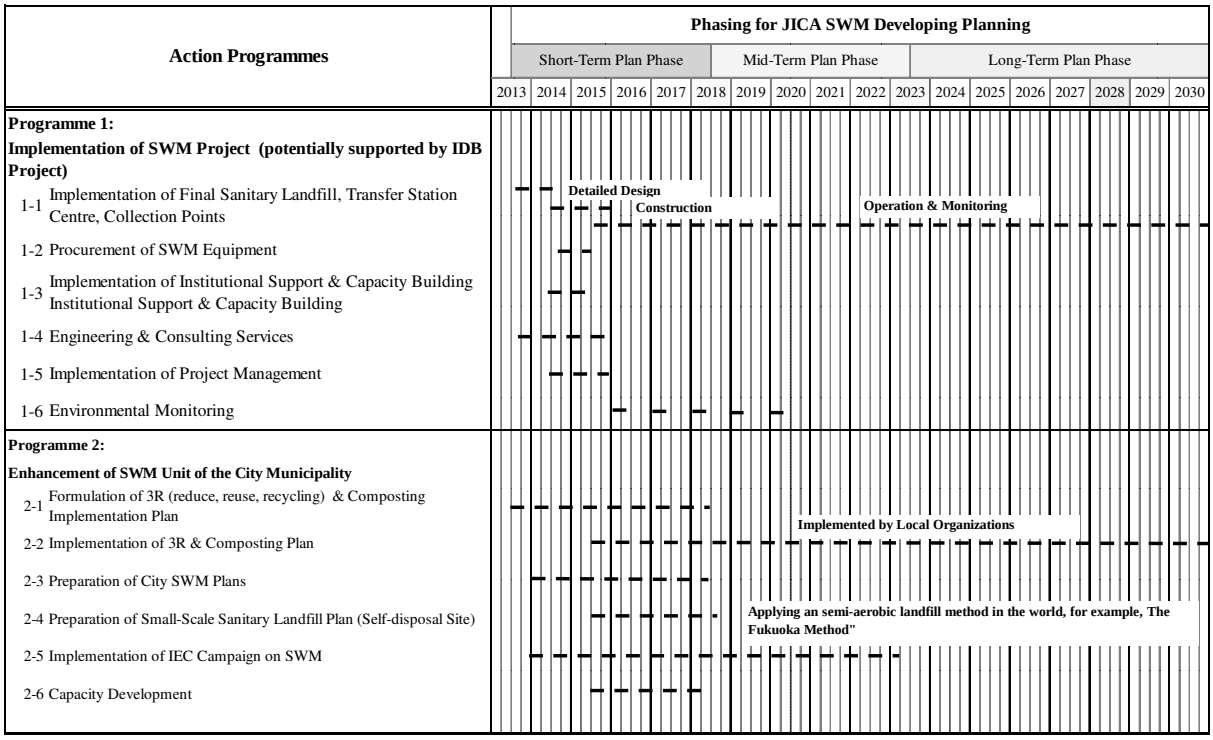
On the other hand, it is planned that a JICA project activates composting and has started spreading an ecological sanitation toilet (eco-san) project in rural areas in the regions of Kaolack and Fatick in November 2012. The project is "Projet de Renforcement des Capacites pour le Controle de la Degradation des Terres et la Promotion de leur Valorisation dans les Zones de Sols degrades" or "Project of Capacity Building for the Restoration and the Promotion of Effective Use of Degraded Soil in the Areas of Soil Degradation." Night-soil use for agriculture products has not been popular in Senegal yet and Eco-san toilets were used in Thies which was the first case in Senegal. Composting has a potential not only in Kaolack City but in the entire country of Senegal.

(f) Proposed Implementation Programme of SWM Sector for Kaolack City

The implementation plan for SWM in Kaolack City consists of the following two Programmes. Programme 1 shows the proposed implementation of the SWM Project which will be supported by IDB for the time schedule from the year 2013 to the year 2030, while Programme 2 will be an enhancement of SWM Unit of the City Municipality which is the weakest point of the executing agency of the City Municipality of Kaolack.

The implementation schedule of SWM sector for Kaolack City (2013-2030) is proposed in **Fig. 6.3.7**.

[14] More than 50% is the percentage of remaining waste composition excluding stone/sand materials, Seyni Thiam, Domestic solid waste in Kaolack, Contribution for rationalization of management ESP 2000-2001, "etude pour la mise en oeuvre operationnelle d'un systeme de gestion durable des dechets solides dans la ville de Kolack, 2007)



Sources: Based on the interview survey with Kaolack City

Fig. 6.3.7 Proposed Implementation Schedule of SWM Sector for Kaolack City

6.3.4 Hazardous Waste

According to Kaolack City, at present, there is no concrete national legislation to guide the City of Kaolack in the management of hazardous waste. The City of Kaolack recognizes that effective management of industrial and medical wastes is difficult under the present situation. Under the circumstances, JET conducted an interview survey on the current situation of waste treatment with the industrial factories and medical facilities in Kaolack City, in May 2012.

(1) Industrial Waste

According to the Technical Services of the City Government, industrial wastes shall be controlled and disposed adequately by the dischargers in accordance with the polluter-pays principle. The industrial factories are not very well developed. There is no reference on industrial waste management in Senegal (Sewage, Storm Water and Solid Waste Management Project in Kaolack, Strategic Environmental Assessment, October 2012 Final Report, JICA, IDEV-ic ex SENAGROSOL), and there has been no further information on the industrial wastes from Kaolack City. Therefore, JET conducted an interview survey with the following factories to obtain information on the industrial waste in May 2012.

- SUNEOR : Peanut cooking oil
- NOVASEN : Peanut cooking oil
- SALIN DU SALOUM : Salt
- USINE KOUDAME : Plastic products

It is noted that even though JET had not inspected all the conditions in the factory there seemed to be no hazardous waste at the factories and the waste amounts were collected on monthly basis and treated by respective factories under their responsibility. The storage was strictly secured, and no one could enter without the permission of the manager, and the visitor should be accompanied by the person-in-charge only.

(2) Medical Hazardous Waste

There is a Decree that aims at governing all activities related to biomedical waste management in

Senegal (Decree No. 2008-1007 of 18 July 2008). This applies to health facilities regardless of level (hospitals, health care centers, community health care, medical analysis laboratories, clinics, and consulting-rooms), veterinary facilities, industries and research facilities managing waste. All biomedical waste operators shall have a permit from the ministry in charge of health. There is one regional hospital and there are small several clinics and healthcare centers in Kaolack City. The interview survey with the medical facilities was conducted by JET.

There is only one incinerator located and being used in the hospital facility and there are two incinerators being used in healthcare centers in Kaolack City. In this hospital facility, the ashes taken out from the incinerator are buried at specific compound ground in the hospital facility. The assumed medical wastes are currently estimated at 1.5 t/day and projected to be about 2.3 t/day in 2030 in Kaolack City.

(3) Recommendations

The following are recommendations to be considered in the improvement and development of the hazardous waste management system in Kaolack City:

- To provide a separate cell at the proposed sanitary landfill for the ashes of incinerated hazardous wastes in future;
- The environmental management and coordination Act by the concerned ministries concerning hazardous waste should be properly implemented and enhanced with common standards;
- The related policies or guidelines for hazardous waste management system should be implemented by the Central Government through the city council of Kaolack; and
- Proper treatment system of hazardous wastes including biomedical waste management should be needed in conformity with the related legislation (the Environmental Code and decrees).

6.3.5 Peri-urban Self-disposal Plan

The Zone 6 self-disposal area consisting of the four districts of Lyndiane, Kabatoki, Sing-Sing and Ngade is supposed to manage its own solid waste collection, transportation and disposal system as the districts have been doing in the past and continue the SWM for their districts.

However, some improvement will be necessary for the waste collection, transportation and disposal system including the City and NGO's assistance, e.g., in sorting of wastes, collection/transport means/points, designated site of disposal, person in-charge for SWM, etc. IEC activities on SWM in self-disposal districts and the monitoring activities for residents are also required periodically.

The projected solid waste amounts for Zone 6 are about 8 t/day in 2013 and 10 t/day in 2030. More adequate self-treatment system of wastes should be considered such as a small-scale open landfill or a simple and easy way. The City is responsible for all the SWM in the districts. It is expected that the person-in-charge of SWM in the City should be more active and take care of not only the resident's public hygiene but also sanitation education in the districts.

6.3.6 Organization and Institutional Improvement

The present waste operation service by the City Government is collection and transportation and disposal of wastes at Mbadakhoune. The collection and transportation services are for the public facilities only such as the Central Market, Medina Market and other markets, and 2 bus stations. It is noted that the present capacity of the organization and institutional situations in the City Government does not cover and match the required responsibility of SWM for the City.

Systematic and enhanced institutional and legal reform plans for the technical service structure/system of the City Government with an adequate manpower & office equipment/supplies and capacity development.

It is, however, realistic that the current SWM services taken by the City continue to cover the public facilities like public markets and public bus stations. However, SWM in all the remaining areas (Zone 1 to Zone 5) should be served by the service providers on contract basis and the City supervises and evaluates the SWM services served by the contractors. It is expected that the SWM services should be

conducted in a professional manner for both the City Government and the Contractors' service providers.

6.3.7 Financial Considerations

(1) Basic Principles

The costs of SWM services for households are divided into two categories, namely, (1) **capital investments** including vehicles and facilities as a part of improvement in social capital, which produces services continuously for their lives or public service; and (2) **operating costs** for services of individual households which are produced from the capital investments or private service.

Considering the definitions mentioned above, following are the general principles for financing SWM services:

- In principle, public service (capital investments) should be financed by general taxation or subsidy from the national government;
- Operating costs should be covered wherever possible through a waste charge rather than through general taxation;
- Cost recovery should be improved by reforming the budget system and improving efficiency of SWM operations on step-by-step basis; and
- When operating costs cannot be fully recovered through a waste charge after improving cost efficiencies, deficits should be financed through general taxation or subsidies.

(2) Financial Reform for SWM

The SWM Division of Kaolack City needs to be financially "ring fenced" by establishing a special account to ensure that revenues are controlled and spent by the SWM services only and are not used to finance other services in the City. Additionally, funds for replacement of equipment and facilities should be accumulated as depreciation in the operation of the system in order to sustain the operation after the equipment and facilities initially introduced are finished.

Creating a new tax or charges for SWM should be avoided as much as possible before the SWM services become successful and confidence of the people on the City's SWM is developed. A new tariff system should be discussed by a committee where representatives of users, NGOs and service providers participate as members.

(3) Non-Governmental Sector Participation

It is possible for government to work with community groups, NGOs and cooperatives in the conduct of solid waste services. This possibility should be considered for low-income households and in the recycling of secondary materials.

In many developing countries, the non-governmental sector provides waste collection services to low-income households, especially in Latin America where government cannot provide appropriate solid waste collection service for those living in marginal zones since so many people have been migrating into the urban area. It is common to see these areas served by individuals with donkey carts or old dump trucks. Since such collectors could not travel far to the official dumping site with their equipment, they are prone to dump solid wastes illegally.

Kaolack City has been facing the same situation mentioned above with the ROC system. For this reason, it is worthwhile for the City to explore these collections into a cooperative and develop a franchise arrangement whereby the rights and responsibilities of the collectors are defined. It should also be noted that for developing countries, franchise can be successful in the areas where most of the households and establishments can be readily educated to be concerned in public cleanness.

6.3.8 Recommendations

(1) It is expected that, in order to replace the ROC system with tricycles, the economy should be more activated and infrastructure development including road pavement work for the unpaved and sandy roadway is needed progressively. The ROC system operation and maintenance should be carefully monitored by Kaolack City.

(2) It is expected that, since the Kaolack SWM Project approved and signed between IDB and Senegal government in June 2011, the new administration will make a good decision on early implementation of the Project (as of Nov. 2013, the Bank has been now waiting for a response regarding its proposal for the Project from the new administration).

(3) It is recommended that, during the implementation of the Kaolack SWM Project supported by IDB, the progress should be monitored carefully and all necessary actions should be taken immediately to realize the completion of the Project.

(4) The number of required equipment for SWM listed by IDB seems to be for an urgent SWM work for a short-term period only and not for a mid-term or long-term plan phase of SWM for Kaolack City. The number of heavy equipment might be good for about five years only. Therefore, it is recommended that an overall SWM plan study shall be carried out for the estimation of the number of required equipment needed for an integrated SWM plan of the mid-term plan phase for Kaolack City.

(5) Since there seems to be no skilled mechanic at the workshop in the City, some trainings at the workshop are required for mechanics, with sufficient number of tools and mechanical equipment, and knowledge.

(6) There has been no study on a drainage system to Saloum River from the disposal area at Mbadakhoune, i.e., if the system will induce an excess of rainwater above a certain maximum water level at site (e.g., Elevation 0 m), and if the inundation water area will expand and impact a sanitary landfill area. A study on the drainage system of the sanitary landfill facility is thus required for further implementation.

(7) The following are the technical issues to be addressed:

- Reinforcement and dissemination of preparation and development of technical standards and guidelines for SWM to the parties concerned.
- Considering the characteristic of solid waste composition by weight in Kaolack, sorting/separation of sand and stone wastes at source is indispensable and the operation of compactors should be done more carefully because of sandy wastes in Kaolack City.
- Preparation for the construction of new small-scaled sanitary landfill sites as a part of the new SWM system for the City.

(8) For the completion and sustainability of the Project implementation, all the necessary parties concerned should be involved and take necessary actions immediately, such as central and local government agencies, state companies, CDQ, NGO, and so on.

(9) In order to improve the current SWM system in the City, all the concerned government offices, related agencies, residents and NGOs, private sector involvement shall enhance their capabilities through the IEC campaign.

(10) A Transfer Station Center for Composting and Recycling for Kaolack City should be established in the suburb area of the City Center.

(11) Introduction of private service provider contracting system for the City SWM services is indispensable.

(12) IDB will support the structural solid waste management system in Kaolack City. According to recent information, the United Nations Industrial Development Organization (UNIDO) utilizing Global Environmental Facility (GEF) will provide assistance for the solid waste management in

Kaolack City which will include domestic, medical and industrial wastes. Issues on the SWM in Kaolack City should be solved through proper collaboration between both projects.

CHAPTER 7. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

7.1 Implementation of SEA at Master Plan Stage

In accordance with the Senegalese Environmental Law and the Regulation on Environmental Impact Assessments, the JICA Expert Team had conducted Strategic Environmental Assessment (SEA) from January 2012 with a consultant (iDEV) authorized by DEEC.

The first technical committee meeting on the SEA report was held on 25 July 2012 at Kaolack, and several comments and recommendations were proposed from the committee. DEEC summarized the results of the meeting and sent a letter to the consultant. The second technical committee meeting was held on 7 November, in order to confirm the revised SEA report in accordance with the letter from DEEC and to validate it. Twenty-five participants (except the JICA Expert Team and iDEV) attended the meeting and further reviewed the revised SEA report. Finally, the committee approved the SEA report with some conditions (requesting additional corrections). The draft final reports were distributed to the participants of the SEA validation meeting (the French version on 23/10/12) and JICA Expert Team (the English version on 17/10/12). Finally, the SEA report was approved by DEEC in January 2013. Therefore, comprehensive contents and recommendations of the SEA report shall be referenced and utilized for formulation of the Master Plan and preparation for Feasibility Studies.

Photo 7.1.1 SEA Validation Meeting (7 November 2012, Kaolack)

7.2 Environmental and Social Considerations for Alternative Projects

7.2.1 Evaluation of Alternative/Projects from the Viewpoint of Environmental and Social Considerations

Based on the environmental laws and regulations in Senegal (e.g., Ministerial Order No. 9471: 28 November 2001, which contains the terms of reference for impact studies), the SEA report (draft version), and the JICA Guidelines for Environmental and Social Considerations, the JICA Expert Team had selected the essential environmental and socio-economic impacts for the evaluation criteria. Then, the Expert Team prepared an evaluation table in order to compare impacts of alternatives/projects from the environmental and social considerations, and selected the most preferable alternative for Master Plan and some projects for Feasibility Study.

The JICA Expert Team proposed the evaluation table to DREEC, and through the discussion, DREEC accepted it for evaluating prospective natural and socio-economic impacts of alternatives/projects, because the table includes the main elements of impact study assessment, and the table is to be used for only the planning stage. In the Feasibility Study level, the detailed EIA or IEE shall be conducted in accordance with the categorization of environmental laws and regulations in Senegal.

Moreover, DREEC and the JICA Expert Team have agreed on alternatives/projects which are to be compared not only from environmental and social considerations, but also from financial, technical and other perspectives. DREEC recommended that the JICA Expert Team shall refer to “the EIA guidelines

Annex 4, 4.1A: Reminder of the mission objectives and the methodology of conducting studies," and it emphasized that explanation be needed for every step of the implementation of the Study.

The evaluation with environmental and social considerations has been conducted by not only reviewing several documents (e.g., the SEA report, JICA Guidelines' environmental checklist filled-out by ONAS, Kaolack Regional Environmental Action Plan 2011-2015 and so on), but also reflecting the results of field surveys in targeted areas (including interviews with local people) with technical experts of the JICA Expert Team.

7.2.2 Evaluation of Alternatives of the Master Plan

(1) Sewerage System Component of the Master Plan

Alternatives for the sewerage system component of the Master Plan have been evaluated as shown in the following table. The outline of alternatives is shown in **Table 4.3.3** and the evaluation results in the following table are reflected in **Table 4.3.4**.

Table 7.2.1 Evaluation of Alternatives for Sewerage System Component for Master Plan

	Likely Impacts	Evaluation Point	Alternatives		
			1	2	3
Natural Environment	Biology	Impact on biology (forest, farmland, aquatic life)	+	++	++
	Air pollution	Impacts on atmosphere(various gas , dust)	－	－	－－
	Climate change	Impact on climate change(emission of CO_2, methane)	－－	－	－
	Soil contamination	Impact on soil contamination in proposed areas by improvement of sewerage system	+	++	++
	Erosion/ salinization	Impact on erosion/salinization in proposed area	－	－	－
	Water pollution	Impact of drained water	+	++	++
	Offensive Odor	Impact on the local population	－－	－	－
	Noise/Vibration	Impact on the local population	－	－	－－
	Waste	Impact on the local population (soil, materials)	－	－	－－
Socio-economic Environment	Economy	Impact on economic loss from sanitation problem (health care cost, nuisance,)	+	++	++
	Health and hygiene	Impact on waterborne diseases (cholera, typhoid)	+	++	++
	Infection and risks	Impact on infection of HIV/AIDS and respiratory disorder	－	－	－－
	Land use	Impact on land use in the proposed sites (effective land use, land value)	+	++	++
	Accidents	Impact on the local communities	－	－	－－
	Conflicts	Impact on the local population (illegal discharge of septage)	+	++	++
	Traffic	Impact on traffic in proposed sites(traffic control)	－	－	－－
	Women /vulnerable people	Impact on women and vulnerable groups in proposed areas(high water table areas)	+	++	++
	Resettlement	Impact on the local communities	No	No	No
Total number of items of positive and negative impacts					
		++	0	8	8
		+	8	0	0
		－	7	9	3
		－－	2	0	6
		No	1	1	1
Total number of Plus (+) and Minus (－)					
		+	8	16	16
		－	11	9	15
Difference of Plus (+)and Minus(－)			－3	+7	+1

(Note)

＋＋	Expected significant positive impact
＋	Expected positive impact
－	Expected negative impact
－－	Expected significant negative impact
No	Expected no impact

With Alternative 2 or 3, eight significant positive impacts (e.g., biology, soil contamination, water pollution, economy, land, conflicts, and women/vulnerable groups) are expected, because the target area is wider than Alternative 1 and technology for treatment of wastewater might be more effective than Alternative 1. On the other hand, the scale of construction work of Alternative 3 is much larger than Alternative 1 or 2. Therefore, the number of prospective negative impacts (e.g., air pollution, noise/vibration) of Alternative 3 is expected to be larger than the other alternatives during the construction work as well.

The difference in total number of plus and minus in Alternative 2 is + 7, Alternative 3 is +1, and Alternative 1 is －3. Therefore, Alternative 2 can be selected for the Master Plan from the viewpoint of environment and social considerations.

(2) Drainage Management Component for Master Plan

Alternatives for the drainage management component of the Master Plan have been evaluated as shown in the following table. The outline of alternatives is shown in **Table 5.2.1** and the evaluation results in the following table are reflected in **Table 5.2.2**.

Table 7.2.2 Evaluation of Alternatives for Drainage Management Component for Master Plan

	Likely Impacts	Evaluation Points	Alternatives		
			1	2	3
Natural Environment	Biology	Impact on biology (forest, farmland, aquatic life)	No	+	++
	Air pollution	Impacts on atmosphere(various gas , dust)	－－	－－	－
	Climate change	Impact on climate change (effects from flood and drought)	+	+	++
	Soil contamination	Impact on soil contamination in proposed areas by construction work	+	+	+
	Erosion/ salinization	Impact on the erosion/ salinization in proposed area	－	－	－－
	Water pollution	Impact of drained water	+	+	+
	Offensive Odor	Impact on the local population	No	No	No
	Noise/Vibration	Impact on the local population	－－	－－	－
	Waste	Impact on the local population (soil, materials)	－	－	－－
Socio-economic Environment	Economy	Impact on the economic loss from floods	++	++	++
	Health and hygiene	Impact on waterborne diseases (malaria, diarrhea)	++	++	++
	Infection and risks	Impact on infection of HIV/ AIDS and respiratory disorder	－－	－	－
	Land use	Impact on land use in the proposed sites (utilization of land during dry and rainy seasons)	+	+	++
	Accidents	Impact on the local communities	－－	－	－
	Conflicts	Impact on the local population caused by floods(thief, dispute about embankment)	++	++	++
	Traffic	Impact on traffic in proposed sites(traffic control)	－－	－	－
	Women /children /vulnerable people	Impact on women, children and vulnerable groups in flood areas	+	+	+
	Resettlement	Impact on the local communities	No	No	No
Total number of items of positive and negative impacts					
		++	3	3	6
		+	5	6	3
		－	2	5	5
		－－	5	2	2
		No	3	2	2
Total number of Plus (+) and Minus (－)					
		+	11	12	15
		－	12	9	9
Difference of Plus (+)and Minus(－)			－1	+3	+6

(Note)

＋＋	Expected significant positive impact
＋	Expected positive impact
－	Expected negative impact
－－	Expected significant negative impact
No	Expected no impact

With Alternative 3, the highest number (6) of significant positive impacts (e.g. biology, climate change and land use) are expected from effective utilization of storm water due to the construction of retention ponds, and which is larger than Alternative 2. On the other hand, the highest number (i.e., 5) of significant negative impacts (e.g., air pollution, noise/vibration) is prospected from Alternative 1 due to the largest size of construction work.

The balance of total number of plus and minus in Alternative 3 is + 6, Alternative 2 is +3, and Alternative 1 is -1. Therefore, Alternative 3 might be selected from the Master Plan from the viewpoint of environment and social considerations.

7.2.3 Evaluation of Priority Projects

(1) Evaluation of Projects of Sewerage/Sanitation System Improvement

Evaluation for selection of priority projects of sewerage/sanitation system improvement, were in the following table. Two projects in the following table correspond to Project-1 and Project-2, which were detailed in **Section 4.7**.

Table 7.2.3 Evaluation for Selection of Priority Projects of Sewerage/Sanitation System Improvement

	Likely Impacts	Evaluation Point	Project	
			1	2
Natural Environment	Biology	Impact on biology (forest, farmland, aquatic life)	++	+
	Air pollution	Impacts on atmosphere(various gas , dust)	－	－
	Climate change	Impact on the climate change(emission of CO_2, methane)	－	－
	Soil contamination	Impact on soil contamination in proposed areas by improvement of sewerage system	++	++
	Erosion/ salinization	Impact on erosion/salinization in proposed area	－	－
	Water pollution	Impact of drained water	++	+
	Offensive Odor	Impact on the local population	－	－
	Noise/Vibration	Impact on the local population	－	－
	Waste	Impact on the local population(soil, materials)	－－	－
Socio-economic Environment	Economy	Impact on economic loss from sanitation problem (health care cost, nuisance,)	++	+
	Health and hygiene	Impact on waterborne diseases (cholera, typhoid)	++	+
	Infection and risks	Impact on infection of HIV/AIDS and respiratory disorder	－	－
	Land use	Impact on land use in the proposed sites (effective land use, land value)	++	+
	Accidents	Impact on the local communities	－	－
	Conflicts	Impact on the local population (illegal discharge of septage)	++	+
	Traffic	Impact on traffic in proposed sites(traffic control)	－－	－
	Women /vulnerable people	Impact on women and vulnerable groups in proposed areas(high water table areas)	++	+
	Resettlement	Impact on the local communities	No	No
Total number of items of positive and negative impacts				
		++	8	0
		+	0	8
		－	7	9
		－－	2	0
		No	1	1
Total number of Plus (+) and Minus (－)				
		+	16	8
		－	11	9
Difference of Plus (+)and Minus(－)			+5	－1

(Note)

＋＋	Expected significant positive impact
＋	Expected positive impact
－	Expected negative impact
－－	Expected significant negative impact
No	Expected no impact

Similar positive and negative impacts are expected with both Projects. The main difference between Project-1 and Project-2 is the number of significant positive impact, eight of significant positive impacts (e.g biology, water pollution, economy, and so on) are expected with Project-1 while there is no prospected significant positive impacts with Project 2. The reason is that Project-1 includes construction of septage treatment facilities which might contribute to effective land use, and also reduce the number of conflicts due to illegal discharge of septage. Moreover, Project-1 focuses on vulnerable areas caused by high water table such as Albatoir, Dialegne districts.

Consequently, the balance of total number of plus and minus, Project-1 is + 5, Project-2 is －1. Therefore, Project-1 might be selected as priority project from the viewpoints of environment and social considerations.

(2) Evaluation of Projects of Stormwater Drainage Management

Evaluation for selection of priority projects of stormwater drainage management, were in the following table. The priority projects in the following table correspond to the ‘project packages’, detailed in **Section 5.7**.

Table 7.2.4 Evaluation for Selection of Priority Projects of Stormwater Drainage Management

	Likely Impacts	Evaluation Point	Project Package						
			P1-1	P2	P3-1	P4	P1-2	P3-3	P3-2
Natural Environment	Biology	Impact on biology (forest, farmland, aquatic life)	+	No	++	No	No	No	No
	Air pollution	Impacts on atmosphere(various gas , dust)	－	－	－－	－	－	－－	－
	Climate change	Impact on climate change(effects from flood and drought)	++	+	++	+	+	+	+
	Soil contamination	Impact on the soil proposed areas by construction work	++	++	++	+	+	+	+
	Erosion/ salinization	Erosion/salinization in proposed areas	－－	－	－－	－－	－	－	－
	Water pollution	Impact of drained water	++	++	++	＋	＋	＋	＋
	Offensive Odor	Impact on the local population	No	No	No	No	No	No	No
	Noise/Vibration	Impact on the local population	－	－	－－	－	－	－－	－
	Waste	Impact on the local population （soil, materials）	－－	－	－－	－	－	－－	－
Socio-economic Environment	Economy	Impact on economic loss from floods	++	+	++	+	+	+	+
	Health and hygiene	Impact on waterborne diseases (malaria, diarrhea)	++	+	++	+	+	+	+
	Infection and risks	Impact on infection of HIV/AIDS and respiratory disorder	－	－	－－	－	－	－－	－
	Land use	Impact on land use in the proposed sites (utilization of land during dry and rainy seasons)	++	+	++	+	+	+	+
	Accidents	Impact on the local communities	－	－	－－	－	－	－－	－
	Conflicts	Impact on the local population caused by floods (thief, dispute about embankment)	++	+	++	+	+	+	+
	Traffic	Impact on traffic in proposed sites	－	－	－－	－	－	－－	－
	Women/children/ Vulnerable people	Impact on women, children and vulnerable groups in flood areas	++	++	++	++	+	+	+
	Resettlement	Impact on the local communities	No	No	No	No	No	No	No
Total number of items of positive and negative impacts									
		++	8	3	9	1	0	0	0
		+	1	5	0	7	8	8	8
		－	5	7	0	6	7	1	7
		－－	2	0	7	1	0	6	0
		No	2	5	2	3	3	3	3
Total number of Plus (+) and Minus (－)									
		+	17	11	18	9	8	8	8
		－	9	7	14	8	7	13	7
Difference of Plus (+)and Minus(－)			+8	+4	+4	+1	+1	-5	+1

(Note)

＋＋	Expected significant positive impact
＋	Expected positive impact
－	Expected negative impact
－－	Expected significant negative impact
No	Expected no impact

With Project P3-1, nine significant positive impacts (e.g. biology, climate change, water pollution and so on) are expected, while seven significant negative impacts (e.g. air pollution, noise/vibration and so on) are protected due to the size of construction work of retention pond, and also location of the Project package P3-1 includes the trunk road from Kaolack city to Dakar. Compared to Project package P3-1, eight significant positive impacts are expected with Project package P1-1, and the contents of significant positive impacts are similar to Project package P3-1. However, the number of prospected significant negative impacts is only two with Project package P1-1, which is less than one-third of Project package P3-1. The reasons are that the construction work size of Project package P1-1 is smaller than Project package P3-1, and also the project location of Project package P1-1 is northern periphery of Kaolack city as well.

Consequently, the balance of total number of plus and minus, Project package P1-1 is + 8, Project package P2 and P3-1 are +4, Project package P4, P1-2, and P3-2 are +1, and Project package P3-3 is －5. Therefore, Project package P1-1 might be selected as priority project from the viewpoints of environment and social considerations.

7.2.4 Environmental Impacts without Projects (Zero Option) and Environmental Projection

(1) Without-Project

The SEA report analyses that the current environment management in Kaolack city is facing serious difficulties. Storm water drainage systems are very deteriorated, and also being damaged by people through sewerage discharge, waste disposal and unauthorized connection to the sewer system. The following table summarizes the current situation in Kaolack city.

Table 7.2.5 Situation of Without-Project (Business as Usual)

Facilities	Sewerage	Stormwater drainage	Household waste management
Current situation	6% coverage	38.5% coverage	25% capacity
Problems	- Tipping out of solid household waste and sewage discharge into canals. - Unauthorized connections	- Low flow capacity. - Reduced flow due to sediments and various wastes.	- Lack of logistics. - Lack of workforce. - Lack of organization and competence. - NGOs lacking capacity to solve issues.

At the technical, socio-economic, and socio-sanitary level, this situation translates into mainly following consequences:

- Continuous and advanced deterioration of facilities and infrastructure.
- Very high prevalence of water and sanitation related –diseases, in addition to the persisting smell and other nuisance.
- Significant economic losses related to health care and absenteeism cost.

(2) Environmental Projection

It is concluded that the option 'without-project' is not viable; and considering the dynamics for the time horizons, 2015, 2020, 2025 and 2030, the following situation is expected:

- Increase in the pollution of the water table and the river that will no longer be able to provide safe drinking water,
- Increase in the prevalence of water-related diseases and degradation of the living environment,
- Increase in economic losses related to health care and absenteeism costs,
- Decrease in job opportunities due to lack of preferable infrastructure, and
- Increase in population protesting floods and the state of unhealthy living environment.

(3) Other Alternatives

The following table shows the summary of other alternatives for the projects. Besides, it is suggested that every alternative needs soft components such as capacity building. Without soft

components, the projects might not sustain, and also deteriorate the structural measures or facilities.

Table 7.2.6 Other Alternatives

Components	Other Alternatives	Prospected Impacts	
		Positive/ Advantage	Negative/Disadvantage
Sewage (individual sanitation)	- TMF (Toilet with Manual Flush)	- Less pollution of ground water when it is well installed	- Contamination of water during rainy season
	- VIP (Ventilated Improved Pit)	- Economize the cost	- Pollution of water
	- TMF with PVC-septic tank and underground infiltration system	- Plastic recycling - Job creation	- Clogging of the underground filtration system
Drainage	- Open clay canals	- Easy to clean	- Risk of accidents - Waste disposal - Nuisance - Water pollution
	- Closed canals	- Safety - Less waste	- Difficult to clean

Table 7.2.7 Required Soft Components

Soft Components	- Training of administrative authorities and public servants on their competence in the field of environment and sanitation. - Training and equipping technical services staffs for solid waste management and storm water drainage. - Awareness training of students and citizens on environment and sanitation. - Dissemination of information about environmental laws and regulations. - Preparation of training materials.

Regarding capacity building, for instance, ASDES has been implementing awareness training targeting six concerned schools (TOUBA NDORONG, NIMZATT, SAMBA DIACK, ISSA DIOUF, MOUSSA SOW and SECK FAYE). ASDES also prepares the training programs and materials collaborating with teachers. The training programs include two courses: (i) household waste management course; and (ii) wastewater management. The contents of training programs are the methods of basic cleaning (sweeping, swiping, collecting and sorting garbage and so on) of their own houses and schools. Financial and technical support for NGOs is recommended to improve the environment from the grass-roots level.

The Environmental Law in Senegal also emphasizes environmental education. For instance, Article 7 of Chapter II describes as follows:

The State guarantees all citizens the right to environmental education. In this context, the public and private institutions in charge of teaching, research or communication should participate in education, training, and sensitization of population to environmental problems:

> *The State guarantees all citizens the right to environmental education. In this context, the public and private institutions in charge of teaching, research or communication should participate in education, training, and sensitization of population to environmental problems:*

- By including in their programs to ensure better understanding of the environment;
- By promoting capacity building for environmental actors.

> *Local authorities, within the limits defined by the laws and regulations in force, and the associations of environmental protection contribute to action undertaken by government departments.*

7.3 Provisional Scooping for the Draft of Feasibility Study

Scoping for the draft of Feasibility Study was provisionally conducted in the Master Plan phase. Results are summarized as follows.

Table 7.3.1 Provisional Scoping of Sewerage System Improvement

	No.	Likely Impacts	Rating[*1]			Description
			D	C	O	
Anti-Pollution Measures						
	1	Air Pollution	N	C-	N	During the construction work, there will be some exhaust emission and suspended particles from trucks and machineries.
	2	Water Pollution	N	N	A+	Water pollution will be mitigated from treatment of wastewater and septage.
	3	Noise and Vibration	N	B-	N	During the construction work, noise and vibration from trucks and machineries will be concerned.
	4	Soil Contamination	N	N	A+	Soil contamination by septage will be reduced.
	5	Ground Subsidence	N	N	N	No impact
	6	Offensive Odor	N	N	C+-	Generally, offensive odor will be reduced in the whole Kaolack city, while some odor will be concerned around the septage treatment facilities.
	7	Waste	N	B-	N	During construction work, management of soil and old sewer pipes might be needed.
	8	Bottom Sediment	N	N	N	No impact
	9	Accident	N	C-	N	During the construction work, there might be some possibilities of accidents.
Natural Environment						
	10	Climate Change	N	N	C-	Emission of methane will be concerned from the expanded wastewater treatment station.
	11	Protected areas	N	N	N	No impact
	12	Biology	N	N	A+	Biology in farmland and river will be improved by reduction of untreated wastewater and septage.
	13	Ground Water	N	N	B+	Quality of ground water will be improved by reduction of untreated wastewater and septage.
	14	Soil Erosion	N	B-	N	During the construction work, there will be soil erosion.
	15	Costal Zone, Mangroves, Coal reefs, tidal flats, etc.	N	N	N	No impact
Social Environment						
	16	Local economy such as employment and livelihood	N	C+	A+	Some local people will be employed for the construction work. Livelihood will be improved due to reduction of nuisance.
	17	Land use and utilization of local resources	N	N	A+	Farmland utilization will be improved due to reduction of illegal discharge of septage.
	18	Existing social infrastructures and services	N	N	C+	The condition of existing social infrastructures and services will be improved due to reduction of nuisance.
	19	Vulnerable social groups such as poor and	N	N	A+	Vulnerable people living in high water table areas will be benefited from the sewerage network.
	20	Equality of benefits and losses and equality in the development process	N	C-	B-	Some claims are concerned from the people who live around the wastewater treatment station.
	21	Cultural heritage	N	N	N	No impact
	22	Local conflicts of interest	N	N	A+	The number of conflicts due to the illegal discharge of septage might be reduced.
	23	Traffic	N	B-	N	During the construction work, there will be traffic controls mainly along the trunk road.
	24	Health and hygiene	N	N	A+	Water borne diseases (cholera, typhoid) could be reduced by improvement of sanitation.
	25	Infection and risks	N	C-	N	During the construction work, infection of HIV/AIDS and respiratory disorder might depend on the size of construction.
	26	Involuntary Resettlement	N	N	N	No impact

	No.	Likely Impacts	Rating[*1]			Description
			D	C	O	
	27	Working conditions, occupational safety	N	N	C+	Working conditions will be improved due to the reduction of nuisance.

(Notes)
* D: Design Stage, C: Construction Stage, O: Operation Stage
** $A^{+}/^{-}$: Significant positive/negative impact is expected.
$B^{+}/^{-}$: Positive/negative impact is expected to some extent.
$C^{+}/^{-}$: Extent of positive/negative impact is unknown.
N: No impact is expected.

Table 7.3.2 Provisional Scoping of Improvement Works for Storm-water Management

	No.	Likely Impacts	Rating[*1]			Description
			D	C	O	
Anti-Pollution Measures						
	1	Air Pollution	N	C-	N	During the construction work, there will be some exhaust emission and suspended particles from trucks and machineries.
	2	Water Pollution	N	N	B+	Water pollution by floods could be mitigated.
	3	Noise and Vibration	N	B-	N	During the construction work, there will be noise and vibration from trucks and machineries.
	4	Soil Contamination	N	N	B+	Soil contamination by floods could be mitigated.
	5	Ground Subsidence	N	N	N	No impact
	6	Offensive Odor	N	N	N	No impact
	7	Waste	N	B-	N	During the construction work, soil and waste management might be needed.
	8	Bottom Sediment	N	N	C-	Some sediments will be accumulated at bottom of retention pond.
	9	Accident	N	C-	N	During the construction work, there might be some possibilities of accidents.
Natural Environment						
	10	Climate Change	N	N	A＋	Effects from flood and drought due to the climate change could be reduced by the construction of retention pond and drainage system.
	11	Protected areas	N	N	N	No impact.
	12	Biology	N	N	C+	Some aquatic life and plant species might be propagated in and around the retention pond.
	13	Ground Water	N	N	C+	Quality of ground water will be improved during the rainy season.
	14	Soil Erosion	N	C-	N	During the construction work, there will be some soil erosion.
	15	Costal Zone, Mangroves, Coal reefs, tidal flats, etc.	N	N	N	No impact.
Socio-economic Environment						
	16	Local economy such as employment and livelihood	N	C+	A＋	Some local people will be employed for the construction work. After construction work, the economic loss due to floods will be reduced.
	17	Land use and utilization of local resources	N	N	A＋	Opportunities of land use could be improved during dry and rainy season in flooded areas.
	18	Existing social infrastructures and services	N	N	A＋	Due to the reduction of floods, the conditions of existing social infrastructures and services will be improved.
	19	Women/ children and Vulnerable people	N	N	A＋	Due to the reduction of floods, commuting to school would be easier for school children.
	20	Equality of benefits and losses and equality in the development process	N	N	N	No impact.
	21	Cultural heritage	N	N	N	No impact

	No.	Likely Impacts	Rating*1			Description
			D	C	O	
	22	Local conflicts of interests	N	N	A+	The number of conflicts caused by floods might be reduced.
	23	Traffic	N	C-	C+	During the construction work, there will be some traffic control. After construction work, the traffic problems due to floods will be reduced.
	24	Health and hygiene	N	N	A+	Waterborne diseases (malaria, diarrhea) could be reduced by improved sanitation.
	25	Infection and risks	N	C-	N	During the construction work, infection by HIV/AIDS and respiratory disorders might depend on the size of construction.
	26	Involuntary resettlement	N	N	N	No impact
	27	Working conditions, occupational safety	N	N	B+	Working condition will be improved and, occupation will be safer during rainy season.

(Notes)
* D: Design Stage, C: Construction Stage, O: Operation Stage
** $A^+/^-$: Significant positive/negative impact is expected.
$B^+/^-$: Positive/negative impact is expected to some extent.
$C^+/^-$: Extent of positive/negative impact is unknown.
N: No impact is expected.

7.4 Greenhouse Gas Emission and Reduction Effects of Master Plan

According to the literatures, CO_2, CH_4 and N_2O are considered to be the major greenhouse gases discharged from the treatment process in sewage treatment plants or on-site sanitation facilities such as septic tanks. Greenhouse effect arising from CH_4 and N_2O corresponds to 21 times and 310 times of CO_2, respectively. Greenhouse gas emission from wastewater treatment by sewerage or on-site sanitation facilities, are generally evaluated focusing on CH_4 and N_2O because CO_2 which is discharged from wastewater treatment process originates not from fossil fuel but from organic substances associated with CO_2 in the atmosphere.

Wide range of greenhouse gas emission rates are reported because there is considerable variability in the testing samples. Examples of emission rates of CH_4 and N_2O from treatment plant as well as septic tank are shown in the following table. It is noted that the table shows the emission rate of sewage treatment which would be based on activated sludge process because the emission rate of aerated lagoon type, which is proposed in the Master Plan is unclear. However, emission rate of sewage treatment plant is much lower than those of septic tanks, so that considerable reduction in greenhouse gas emission would be expected in the course of sewer network expansion.

Table 7.4.1 Example of Greenhouse Gas Emission Rates

	Unit	CH_4 emission rate	N_2O emission rate	Remarks
Sewage treatment plant	g/m^3	0.88	0.16	1)
Septic tank	g/capita/day	10.7	0.20	2)

Source:1) Greenhouse Gases Emission Rate of Sewage and domestic wastewater treatment, Ministry of Environment, Japan
2) Evaluation of Greenhouse Gas Emissions from Septic Systems, The Water Environment Research Foundation, 2010

Reduction of greenhouse gas emission with and without implementation of M/P for the target year 2030 is estimated using the above emission rate. As a result, about 731 tons of CH_4 and 13 tons of N_2O reduction per year could be expected with the implementation of M/P, as shown in the following table.

Table 7.4.2 Estimation of Greenhouse Gas Emission (CH_4 and N_2O)

	Without implementation of M/P	With implementation of M/P	Reduction	Remark
Population in sewered area	63,230[1)]	251,450		
Others [2)]	339,770	151,550		
Wastewater generation (m^3/day)	4,742	18,859		75 lpcd
CH_4 emission per year (kg/year)				
Sewage treatment plant	1,523	6,057		

	Without implementation of M/P	With implementation of M/P	Reduction	Remark
Septic tank	1,326,972	591,879		
Total	1,328,495	597,936	730,559	
N_2O emission per year (kg/year)				
Sewage treatment plant	277	1,101		
Septic tank	24,803	11,063		
Total	25,080	12,164	12,916	

Note: 1) Population in existing serviced area and PRECOL area
2) Greenhouse gas emission is calculated under the assumption that "Others" use septic tanks.