



(RESEARCH ARTICLE)



COMPARATIVE ANALYSIS OF WATER SUPPLY PIPELINE INSTALLATION METHODS IN THE PERIPHERAL NEIGHBORHOODS OF BAMAKO: TECHNICAL CHALLENGES AND SUSTAINABLE SOLUTIONS

Seydou KOUNGOULBA GUINDO ^{1,*}, Sory DIALLO ², Mamoutou SAMAKE ³ and Alassane TOURE ⁴

¹ Doctoral School of Science and Technology of Mali (EDSTM).

² National School of Technical and Vocational Education (ENETP), Bamako, Mali.

³ University of Ségou / Faculty of Agronomy and Veterinary Medicine (FAMA).

⁴ National Engineering School (ENI-ABT)

* Corresponding Author; Email: seydouguinto342@gmail.com

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ABSTRACT

Safe drinking water is still a major challenge for fast-growing African cities. In Bamako, water networks regularly suffer from leaks, pipe breaks and joint failures that degrade service quality. This study looks at the pipe laying methods used in Lot 1 of the Kabala project, which involves building 12 km of new networks and commissioning 93 km of existing networks in Communes I and II. To do this, we analyzed the Tender Documents, the technical specifications and the network maps, and we completed this data with GPS surveys and field observations. The results show that open trenching with a 10 cm sand bed is the most commonly used method, both for PVC pipes (DN63 to DN160) and ductile iron pipes (DN100 to DN1000). We also found that the laying method was adapted depending on the area: concrete encasement in the alluvial soils of Missira and reinforced thrust blocks in the lateritic soils of Sikoro. On the social side, vibrations from heavy machinery affect nearby homes, and some workers refuse to lay pipes in hard rocky soils. The factors that ensure pipe durability are the quality of the sand bed, backfill compaction, joint quality, thrust blocks, pressure testing and disinfection. We therefore recommend carrying out geotechnical studies before any work, training workers, generalizing pressure testing and disinfection, and enriching AMANORMES standards. This study helps improve the sustainability of drinking water infrastructure in Mali, in line with Sustainable Development Goal 6.

Keywords: DWS, Laying methods, Pipes, Bamako, Network sustainability.

1 INTRODUCTION

Water is an indispensable resource for all human, animal, and plant life. Its availability and quality are central concerns for sustainable development. Discussions surrounding this resource are rich and diverse [1], reflecting its indispensability in most human activities.

The World Health Organization (WHO) estimates that 80% of diseases reported worldwide are waterborne [2]. This statistic highlights the crucial importance of access to quality drinking water for public health. In sub-Saharan Africa,

access to drinking water remains a major challenge. According to World Bank data, approximately 32% of the region's population does not have access to an improved source of drinking water [3].

In Mali, despite a significant number of exploitable water sources, the problems of drinking water supply and sanitation for the population are far from being resolved [4]. The city of Bamako, the country's capital, is particularly affected by difficulties in drinking water supply. Distribution networks experience recurrent failures (leaks, breaks, and joint failures), which compromise the quality of service [5].

Among the causes of these difficulties, pipeline installation methods appear to be a determining factor in the durability of infrastructure [6]. Indeed, the soils of Bamako (laterite, alluvial soils) impose specific constraints on pipeline installation [7]. Recurring problems of joint failures, pipeline defects, and differential settlements indicate that the installation methods used are not adequately adapted [5].

The Bamako Drinking Water Supply (DWS) project from the locality of Kabala, financed by the African Development Bank (AfDB), aims to meet the water needs of the capital by 2030 [8]. Lot 1 of this project, which is the subject of the present study, concerns the construction of 12 km of new networks and the commissioning of 93 km of existing networks in Communes I and II [8].

It is within this context that this study was initiated. It aims to analyze the pipeline installation methods used in Lot 1 of the Kabala project, based on contract data, and to formulate recommendations for improving practices.

2 MATERIALS AND METHODS

2.1 Description of the Study Area

The present study focuses on the city of Bamako, the capital of Mali. Bamako is located on the banks of the Niger River, between 12°39' north latitude and 8°00' west longitude. The city covers an area of approximately 267 km² and has a population of more than 2.7 million inhabitants.

Lot 1 of the Kabala project, which is the subject of this study, specifically concerns Communes I and II of the District of Bamako, located on the left bank of the Niger River [8]. The works concern, more specifically, the neighborhoods of Missira, Sikoro, and Dialakorodji.

The Missira neighborhood (Commune II) hosts the project's main pumping station, which is used to pump treated water to the Sikoro water tower. The Sikoro neighborhood (Commune I) is the site where 93 km of existing networks are commissioned and new distribution networks are installed. It also houses the 2,000 m³ water tower. The Dialakorodji neighborhood, located on the northwestern outskirts of Bamako, is concerned with the construction of 20 standpipes and the installation of pipelines [8].

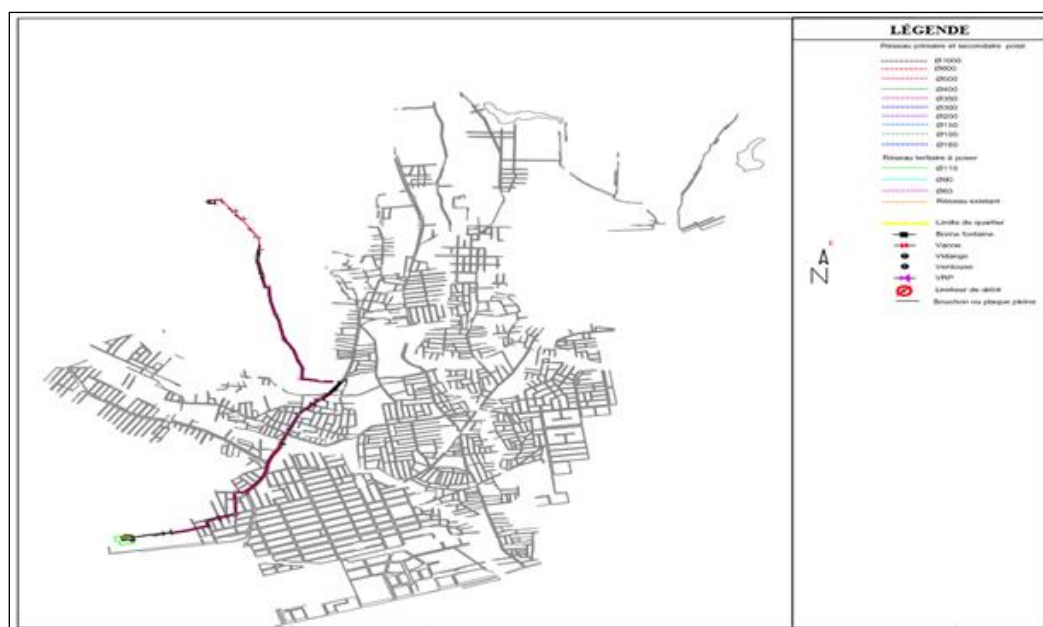


Figure 1: Missira Network Layout

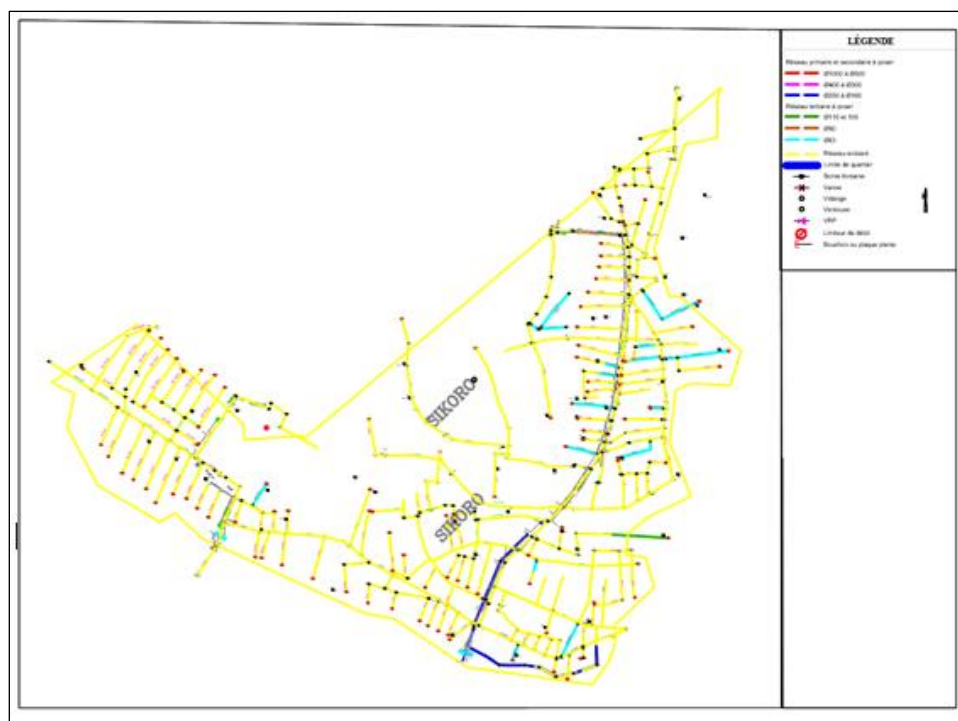


Figure 2: Sikoro Network Layout



Figure 3: Dialakorodji Network Layout

Table 1: Neighborhoods Covered by Lot 1 of the Kabala Project

Neighborhood	Commune	Type de travaux
Missira	Commune II	Pumping station
Sikoro	Commune I	Commissioning of 93 km of networks, installation of new networks
Dialakorodji	Outskirts (Kati)	20 standpipes, pipeline installation

From a geological perspective, the Bamako region is characterized by two main types of formations [7]:

- Lateritic plateaus: hard soils that are difficult to excavate but stable;
- Alluvial areas: loose soils along the Niger River, prone to differential settlement.

This geological diversity imposes specific constraints on the installation of drinking water pipelines. Du point de vue géologique, la région de Bamako est caractérisée par deux grands types de formations [7] :

2.2 Data Collection

The data used in this study were obtained from documentary sources and field surveys.

Table 2: Data Sources

Source	Type of Data
Tender Documents and CCAP	Technical specification, installation requirements
Technical Specifications	Excavation, installation, backfilling, and testing requirements
Bill of Quantities	Diameters, materials
GPS Surveys	Coordinates of pipeline sections and structures
Network Plans	Pipeline layout

Table 3: Data Collection Tools

Tool	Use
GPS	Location of pipeline sections and structures
GIS	Network mapping
Camera	Site documentation

The data collected relate to the pipelines (materials, diameters, lengths), installation requirements (sand bedding, backfilling, compaction), and testing procedures (pressure testing, disinfection).

2.3 Variables Studied

The variables studied in this research are grouped into four complementary categories: geotechnical and topographical constraints, pipeline type, comparison criteria, and observed results.

2.3.1 Geotechnical and Topographical Constraints

Geotechnical and topographical constraints are a determining factor in the selection of installation methods. They are directly related to the areas crossed by the pipeline route. Within the framework of this project, three areas are concerned: Missira, Sikoro, and Dialakorodji.

Table 4: Geotechnical and Topographical Constraints by Area

Area	Soil Type	Main Constraint	Topography
Missira	Alluvial soils (riverbank)	Differential settlement, shallow groundwater table	Riverbank
Sikoro	Laterite (plateau)	Difficult excavation (lateritic crust)	Plateau, uneven terrain
Dialakorodji	Laterite and alluvial soils	Variation in soil characteristics	Flat to slightly undulating terrain



Figure 4: View of the Rocky Nature of the Soil at Dialakorodji (Source: Dr. A. TOURE; 2025) (a) Rocky outcrops and laterite blocks; (b) Overview of the rugged terrain

2.3.2 Types of Pipelines

For the purpose of analyzing this study, we selected two types of pipelines: PVC and ductile iron.

Table 5: Types of piplenes studied

Pipeline Type	Material	Use
PVC	Polyvinyl chloride	Distribution
Ductile iron	Cast iron	Distribution and pumping

2.3.3 Comparison Criteria

2.3.3.1 Diameters Used

In accordance with the table below, our analysis focuses on the following diameters, depending on the areas:

Table 6: Diameters Used by Area

Zone	PVC	Ductile Iron
Missira	DN90	DN150 and DN1000
Sikoro	DN110 and DN63	DN200 and DN1000
Dialakorodji	DN160 and DN90	DN200 and DN1000

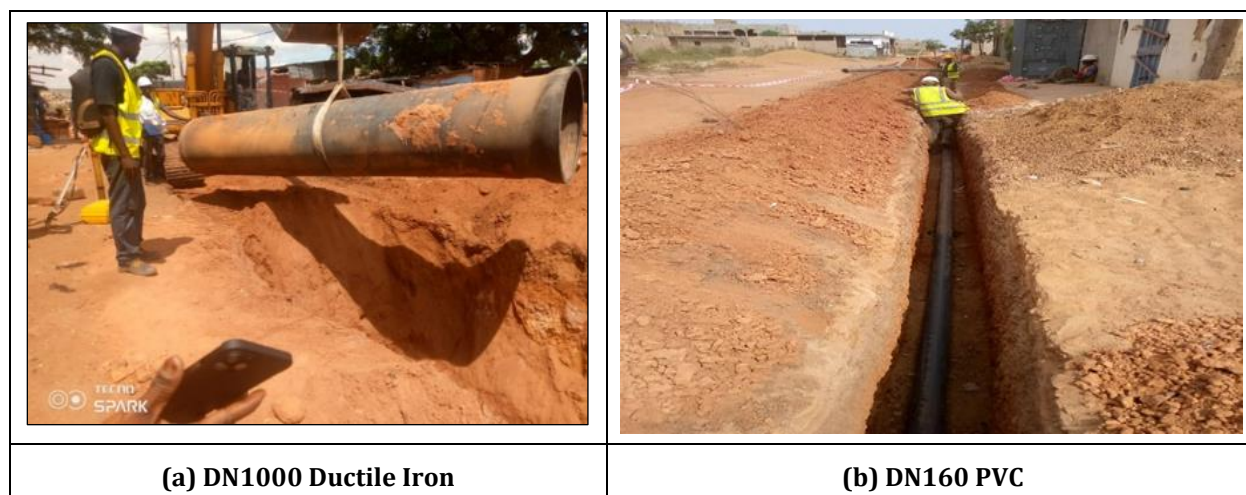


Figure 5: Views of the Types of Pipelines Used (Source: S. GUINDO)

2.3.3.2 Comparison Criteria Used

Based on the variables studied, five comparison criteria were selected:

- Overall cost;
- Durability;
- Quality;
- Ease of execution;
- Ease of maintenance.

3 RESULTS

3.1 Modifications to the Network Characteristics and Installation

During our study, we observed that the installation was modified in some areas: concrete encasement or reinforced thrust blocks were used due to the nature of the soil.

Table 7: Observed Modifications to Pipeline Installation

Zone	Méthode prévue	Méthode modifiée	Raison
Missira	Open trench	Concrete encasement	Unstable alluvial soil
Sikoro	Open trench	Reinforced thrust blocks	Hard rocky soil
Dialakorodji	Open trench	Concrete encasement + thrust block	Mixed soil

These adaptations reflect consideration of geotechnical constraints [5]. Similar observations have been made in Zinder, Niger, where the nature of the soil (exposed crystalline basement) required technical adaptations for pipeline installation [9].

3.2 Technical Impact

Mechanical installation was used for two reasons: the large pipe diameter (DN > 300 mm) and geotechnical conditions (hard soils) [8]. The use of machinery makes it possible to excavate deep trenches and penetrate hard soil layers (lateritic crust) [7].

Ces adaptations traduisent une prise en compte des contraintes géotechniques [5]. Des observations similaires ont été faites à Zinder au Niger, où la nature du sol (socle cristallin affleurant) a imposé des adaptations techniques pour la pose des conduites [9].

Table 8: Reasons for the Use of Machinery

Reason	Area Concerned
Large diameter (DN > 300 mm)	Missira, Sikoro, Dialakorodji (DN1000)
Geotechnical conditions	Sikoro, Dialakorodji

These results confirm the observations of Mamadou et al. (2016) [9], who showed that in Sahelian cities, geological constraints (crystalline basement, laterite) require technical adaptations in pipeline installation.

3.3 Social Impact

Two social impacts were observed: vibrations affecting nearby buildings and workers' refusal to carry out installation work in rocky soils [6].

Table 9: Observed Social Impacts

Impact	Cause	Consequence
Vibrations	Engins de terrassement	Cracks in buildings
Workers' refusal	Hard rocky soil	Delays in the works

Mamadou et al. (2016) [9] also showed that difficulties in accessing water can generate social tensions, sometimes escalating to water riots, as occurred in Zinder in 2014.

4 DISCUSSION

4.1 Interpretation of the Results

The results show that the installation methods were adapted to local constraints. In alluvial areas (Missira), concrete encasement protects the pipeline against differential settlement [5]. In lateritic areas (Sikoro), reinforced thrust blocks withstand thrust forces at changes in direction [7].

The use of machinery is justified by the large pipe diameter and geotechnical conditions [8]. It offers advantages (deep excavation) but also disadvantages (vibrations, nuisances) [6]. These findings are consistent with those of Mamadou et al. (2016) [9], who showed that in Sahelian cities, topographical and geological constraints directly affect the quality of pipeline installation and the durability of networks.

The social impacts observed (vibrations, workers' refusal) are consistent with the observations of Kriga et al. (2016) [6], who emphasized the importance of taking into account the nuisances caused to local residents in infrastructure projects.

4.2 Key Sustainability Factors

The key sustainability factors identified during our study are compiled in Table 9.

Table 10: Key Sustainability Factors

Factor	Impact	Reference
Quality of the sand bedding	Prevents settlement	[5, 6]
Backfill compaction	Ensures stability	[5, 6]
Joint quality	Prevents leaks	[5, 6]
Thrust blocks	Withstand thrust forces	[7]
Pressure testing	Detects leaks	[5]
Disinfection	Ensures potability	[6]

Kriga et al. (2016) [6] showed that water quality also depends on the quality of infrastructure. Touré et al. (2022) [5] emphasized the importance of compliance with technical specifications and the quality of the workforce. Mamadou et al. (2016) [9] showed that in Zinder, low network pressure and limited distribution expansion are major factors contributing to inequalities in access to water.

4.3 Practical Implications

For project owners: systematically carry out pressure and disinfection tests and require prior geotechnical studies [5, 7].

For contractors: train workers, provide protective equipment, and plan the works while taking social impacts into account [6].

For AMANORMES: strengthen standards by incorporating the specific characteristics of Bamako's soils [5, 7], in line with what has been done in other Sahelian countries [9].

4.4 Limitations of the Study

- Study based on contract data, without direct observation of the construction site [8].
- Variables limited to pipelines and installation methods [5].
- Study covering only one lot of the Kabala project [8].

5 CONCLUSION

This study analyzed the installation methods for drinking water supply pipelines in Lot 1 of the Kabala project in Bamako. The objective was to understand how pipelines are installed in the field and to propose recommendations for improving practices.

The results show that open-trench installation with a 10 cm sand bedding remains the reference method, both for PVC pipelines (DN63 to DN160) and for ductile iron pipelines (DN100 to DN1000). We also found that the installation was adapted according to local constraints: concrete encasement in the alluvial areas of Missira and reinforced thrust blocks in the lateritic areas of Sikoro.

However, our study also highlighted social impacts that should not be overlooked. Machinery vibrations affect nearby buildings, and some workers refuse to install pipelines in excessively hard rocky soils.

In view of these results, we make four recommendations: conduct geotechnical studies before any construction work, train workers in proper installation practices, systematically carry out pressure and disinfection tests, and strengthen AMANORMES standards by incorporating the specific characteristics of Bamako's soils.

This study contributes to improving the sustainability of drinking water infrastructure in Mali. It falls within the framework of Sustainable Development Goal 6, which aims to ensure access to drinking water and sanitation for all.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Documents and Calculation Notes for the Bamako Drinking Water Supply Project from Kabala.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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