

Unit Price Study



Unit Cost and Reference Price Study

Revision: V0

November 2021

Name	Signature
Saidi Sibomana	
Pascal Ngendahimana	



Implemented by: **KFW**





DISCLAIMER

This report is subject to a disclaimer.

The contents of this publication are the sole responsibility of GOPA Consultants' Consultancy Team to conduct the Consulting Services for the Republic of Rwanda in the "Program for the Support to the Implementation of Decentralization / Local Administrative Entities Development Agency (LODA) IV (BMZ ID 2017 67 052)" and can in no way be taken to reflect the views of the German Development Cooperation, the Kingdom of the Netherlands and the national authorities.

The views expressed in this report have not been adopted or in any way approved by the German Development Cooperation and should not be relied upon as a statement of the German Development Cooperation's views. The German Cooperation does not guarantee the accuracy of the information given in this manual, nor does it accept responsibility for any use made thereof. The same applies for the Embassy of the Kingdom of the Netherlands.

This report was funded by the German Development Cooperation through Kreditanstalt für Wiederaufbau (KfW) and the Embassy of the Kingdom of The Netherlands.



TABLE OF CONTENTS

2	Executive Summary	1
3	Background Information	3
3.1	Decentralization Policy	3
3.2	Unit Price Reference Study Background	3
3.3	Relevance to Analyse Unit Prices	4
4	Objectives of the Unit Price Study	4
4.1	Unit Price Study in the Infrastructure Lifecycle	4
4.2	Objectives of the Unit Price Study Update	5
5	Methodology	6
5.1	Introduction	6
5.2	Standard Template	7
5.3	Inflation Rate	8
6	Reference Price	8
6.1	Aggregated Reference Prices for Road Infrastructure	8
6.1.1	Aggregate Reference Prices for Murrumbidgee Roads	9
6.1.2	Average Reference Cost of One Kilometre (km) of Chip Seal	13
6.1.3	Cost Drivers of Chip Seal Roads	15
6.1.4	Average Reference Price of one Km of Asphalt Road	17
6.1.5	Average Reference Price of one km of Street Lighting	23
6.2	Average Reference Price for one km of Water Supply System	24
6.2.1	Cost drivers of Water Supply Systems	26
6.3	Reference Unit Prices of one ha of Radical Terraces	33
6.3.1	Cost Drivers of one ha of Radical Terraces	35
6.4	Reference Unit Price of Buildings	36
6.4.1	Use of Reference Prices of Common BOQ Elements Along the Infrastructure Lifecycle of Buildings	43
7	Conclusion	46



7.1	General Recommendations	46
7.2	Recommendations for Roads Infrastructures	47
7.3	Recommendations for Water Supply Systems	48
7.4	Recommendations for Building Infrastructures planning	48

FIGURES

Figure 1:	Diagram of different stages of project life cycle	5
Figure 2:	Zaza-Sake murrum road	9
Figure 3:	RSB-Byimana Chip seal road /Kicukiro district	13
Figure 4:	Kagarama-Muyange asphalt road (Kicukiro)	17
Figure 5:	Street light on the access road to Musanze industrial zone	23
Figure 6:	Pumping station at Kanyonyomba water treatment In Bugesera District	25
Figure 7:	People fetching water at Gatoboro water kiosk	
Figure 8:	Presentation of a radical terraces (Source: WACAT - World Overview of Conservation Approaches and Technologies, 2014)	34
Figure 9 :	Selected pictures of maternity	36



TABLES

Table 1:	Summary of all aggregated average reference prices	1
Table 2:	Distribution of Local Government Development Budget for the FY2020/21	6
Table 3:	Average inflation rate for the last three years	8
Table 4:	The average unit price of one kilometre (km) of murrum roads	9
Table 5:	Cost drivers of a murrum road	10
Table 6:	Analysis of Karongi murrum road using the selected cost drivers	12
Table 7 :	Reference price of a chip seal (Chip seal road of more than 10km)	14
Table 8:	Reference price of a chip seal (Chip seal road of less than 5km)	15
Table 9:	Cost drivers of a chip seal road	16
Table 10:	Reference average price of Km of asphalt road	17
Table 11:	Reference price of asphalt road	18
Table 12:	Unit costs for street lightning	24
Table 13:	Reference aggregate unit price per km of water system.	25
Table 14:	Reference price of water pumps	26
Table 15:	Reference price of surge vessel	29
Table 16:	Reference price of pipes	29
Table 17 :	Reference price of one ha of radical terraces	34
Table 18:	Cost drivers of radical terraces and their unit prices	35
Table 19:	Reference price of common BOQ elements for building infrastructures	37
Table 20:	Application of building infrastructures reference prices	45

MODIFICATION HISTORY

Version	Date	Author(s)	Summary of Changes
V.0	20/01/2022	SID4 Consultants	Not applicable



ABBREVIATIONS

Abbreviation	Description
#	Number
%	Percentage
€	Euro
AAP	Annual Action Plan
BCC (1+2)	Budget Call Circular
BMZ	German Federal Ministry for Economic Cooperation and Development
BoQ	Bill of Quantities
DI	Ductile Iron pipe
DN	Diameter Nominal
EUR	Euro
RWF	Rwandan Franc
FY	Financial year
GIS	Geographical Information System
GOPA	Gesellschaft für Organization, Planung und Ausbildung mbH (GOPA Consultants)
GS	Galvanized Steel Pipe
HDPE	High-density polyethylene
IFMIS	Integrated Financial Management Information System
KfW	Kreditanstalt für Wiederaufbau
LED	Local Economic Development
LG	Local Government
LM	Linear meter
LODA	Local Administrative Entities Development Agency
ml	Meter length
MTCD	Multistage Horizontal Centrifugal pump
NP	National Program
NST1	National Strategy for Transformation
PN	Nominal Pressure
PVC	Polyvinyl Chloride,
RTDA	Rwanda Transport Development Agency
SDGs	Sustainable Development Goals
SID4	Support to the Implementation of the Decentralization & Good Governance Consultancy
TDH	Total Dynamic Head
TVET	Environmental and Social Management Plan
TVET	Technical and Vocational Education and Training
WACAT	World Overview of Conservation Approaches and Technologies



1 Executive Summary

In the course of planning of development projects, it is important to have an idea of how much a given investment will probably cost and how that cost estimate was determined. Though the cost of each project reflects local circumstances and requirements, we developed a comprehensive database of unit prices of selected infrastructures and their cost drivers. We assume the proposed average unit price and cost drivers to be a reference for users when analysing the validity of the proposals and cost estimates of a given project.

During the study, we have collected 26 building infrastructure contracts, 19 gravity water system contracts, 14 water system contracts, 6 chip seal road contracts, 16 asphalt road contracts, 7 public light contracts, 31 murrum road contracts, and 3 radical terrace contracts. In total the unit cost estimates have been derived from 122 different contracts.

The contracts were analysed in order to derive reference prices for the different types of infrastructure. We elaborated unit reference average price for each infrastructure and its corresponding cost drivers, except on the building infrastructures where we elaborated only cost drivers because of differences in size and nature of building infrastructures. The study comes as a review of the 2017-unit price study elaborated by LODA and SID4 Consultants at the time.

For each infrastructure, we calculated the aggregated reference price, the minimum unit price, the maximum unit price, the standard deviation, and the coefficient of variation as statistical reference data during the updated unit price use. The statistical data helps to evaluate the deviation as far as the aggregate average reference price is concerned.

The main results of the study are provided below as table to provide a comprehensive overview. The detailed results and explanations are provided in the subsequent sections of this report.

Table 1: Summary of all aggregated average reference prices

Type of infrastructure	Aggregated Reference Price	Unit price estimate	Result assumptions
1. Murrum road	Aggregated reference price per Km in the Western Province	110,295,061	
	Aggregated reference price per Km in Northern Province	86,040,584	



Type of infrastructure	Aggregated Reference Price	Unit price estimate	Result assumptions
	Aggregated reference price per Km in Southern Province	97,334,055	Most of contracts were collected from Nyamagabe and Nyaruguru
	Aggregated reference price per Km in Eastern Province	58,066,062	
2. Chip seal road	Aggregate reference price for a road of more than 10km	151,494,666	Chip seal road in rural areas and without street lights with assumption of tendering of more than 10 km
	Aggregate reference price for a road of less than 5km	463,188,309	Chip seal road with street lights with the assumption of tendering less than 5 Km ¹
3. Asphalt road	Aggregate reference price	793,356,761	Urban asphalt road with street lights and non-motorized space
4. One Km of street light	Aggregate reference price	65,215,427	
5. Water Infrastructures	Aggregate reference price for gravity water system	19,268,350	
	Aggregate reference price for pumping water system	34,774,570	
6. Building infrastructures like office and health centers	Only reference price for cost drivers developed due to nature and size specificity of building infrastructures	NA	Reference price for cost drivers were developed due to infrastructure design difference
7. Radical Terraces	Aggregate reference price for one ha of radical terraces	2,294,295	

¹ Economies of scale¹ refers to reductions in unit cost as District's scale of output increases. Larger volume on offer will in most cases have some economy of scale benefit.



For each type of infrastructure, we aimed to establish a reference unit price and cost drivers that have a substantial influence on the overall unit price, which will guide the analysis of project costs. The detailed results are provided in the annexes attached to this report.

2 Background Information

2.1 Decentralization Policy

The initial Decentralization Policy for Rwanda was adopted and approved in May 2000, and since then was updated with the latest policy produced in June 2012. One of the strategic objectives of the policy is to strengthen accountability and transparency in Rwanda by making local leaders directly accountable to the communities they serve. Another key objective is to develop sustainable economic planning and management capacity at local levels.

2.2 Unit Price Reference Study Background

In line with the implementation of the decentralization policy in Rwanda, the Government of Rwanda has assigned LODA the mandate of financing development activities of Districts and supporting them in proper planning and monitoring of financed development activities. In order to respond to growing local government needs, it is crucial to LODA to know how much each investment will cost and how those costs are determined.

With the current era where COVID-19 has caused job loss and disruption to businesses, LODA itself is facing many competing priorities, which requires a delicate balance and prioritization strategy based on proper understanding of cost drivers of each and every investment. This necessitates a defined unit price database which gives explanations on different costs of financed projects.

In 2017, LODA commissioned the first Unit price study to define aggregated reference prices for roads, schools, health centers and market infrastructures under the support of German cooperation in framework of the Programme for the “Support to the Implementation of Decentralization / SID3”. The first unit price study has informed the planning for development projects on various occasions.



Due to changes over time with market prices, it was necessary to update the 2017-unit price study. This report presents the detailed updated study to reflect the current economic conditions. The updated report is an important tool to inform procurement officers, planners, and others who are involved in project cycle.

2.3 Relevance to Analyse Unit Prices

The leadership of LODA and Districts rely on quality information to make informed decisions. The need of information on which to base resource allocation is particularly important to LODA and Districts. Information on the unit prices can serve various purposes, including performing feasibility study analysis, bid analysis, contract negotiation, cost benefit analysis, and financial audits.

The unit price study serves also as a reference to analyse the bid submissions of different infrastructure projects and shed light on the reasonable cost to drive the contract negotiation. The unit prices help to ensure the value of money principle is observed at different stages of the infrastructure project.

3 Objectives of the Unit Price Study

3.1 Unit Price Study in the Infrastructure Lifecycle

Decision makers and technical teams, like procurement officers and planners, normally have unit cost estimates prepared by consultants in the course of project design. They also have bid submission cost estimates during the procurement process. Therefore, the unit cost prices for infrastructure projects serve as reference to compare both estimates at different stages of the project in order to determine a reasonable price.

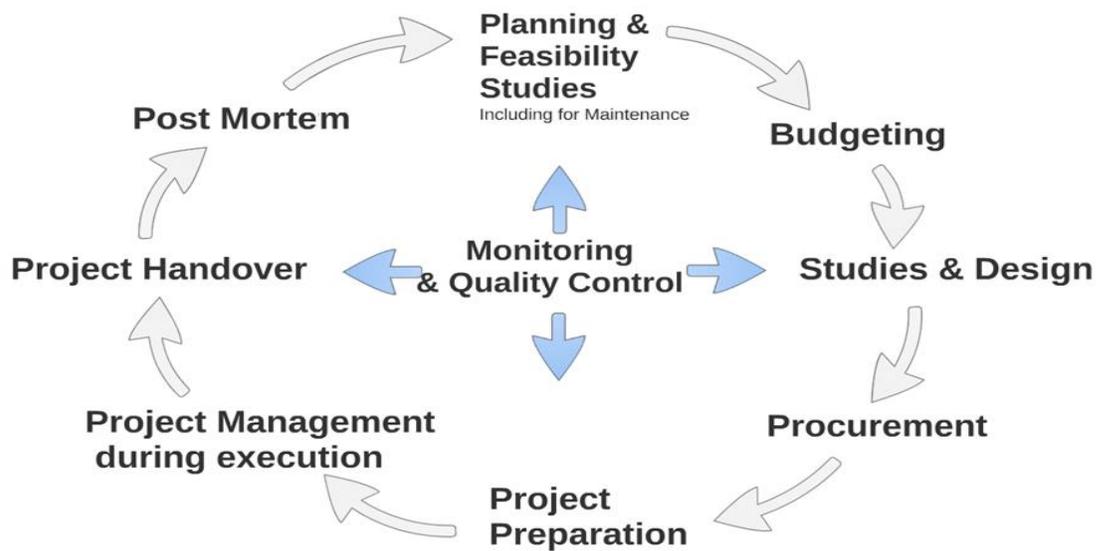


Figure 1: Diagram of different stages of project life cycle

The unit cost prices for infrastructure projects are particularly useful at the planning and feasibility study stage. Unit cost price estimates serve as reference costs that can be used to develop or verify the cost estimates while preparing the Project Profile Documents, the Feasibility Studies, or Simplified Feasibility Assessments. This will contribute to improving the accuracy of the planning and budgeting process.

3.2 Objectives of the Unit Price Study Update

The objectives of this Unit cost study are the following:

- a) To design, generate, and analyse an excel database of the unit reference prices of selected infrastructure projects that will inform the planning, budgeting and analysis of infrastructures projects. This follows the approach laid out in 2017 and requiring an update due to changed framework conditions and price developments faced in the period since then.
- b) To list the most important unit cost (cost drivers) by project type and recommend them as reference prices to ease verification of costs in contracts and cost estimates.



4 Methodology

4.1 Introduction

The present study covers road, water, building, and terrace infrastructures, which are the majority of projects financed by LODA. The selection of the different infrastructure types was made in consideration of their share in the development budget.

The methodology used to perform the study includes several steps:

- The first step was to gather actual unit costs from recently completed projects contracts. The data collected for each project was a copy of the contract with the approved Bill of Quantities (BoQ). We have collected 26 building infrastructure contracts, 19 gravity water system contracts, 14 water system contracts, six chip seal road contracts, 16 asphalt road contracts, 7 public lighting contracts, 31 murrum road contracts, and 3 radical terraces contracts totalling 122 projects executed in the last 3 years.
- The second step was to identify possible cost drivers and units of measurement for each infrastructure type and package it into the customized excel template. For each contract, we captured the contract total price and price of selected cost drivers or components that have a major impact on the overall costs of construction.
- Finally, we analysed collected data to generate the average reference unit price, the minimum price, the maximum price, the standard deviation, and the coefficient of variation for each infrastructure type. We noted buildings could not have the contract average unit price calculated due to uniqueness of each building infrastructure project.

The following table shows the distribution of Local Government Development Budget for the Financial Year (FY) 2020/21 by national programme.

Table 2: Distribution of Local Government Development Budget for the FY2020/21

Local Government Development Budget for the planned FY2020/21 per programme			
Name of NP	Number of projects	Budget per National Programme in RWF	Programme budget percentage
Transport	324	83,535,134,291	22%
Water & Sanitation	128	12,730,948,442	3%



Local Government Development Budget for the planned FY2020/21 per programme			
Social Protection	355	57,532,579,150	15%
Decentralisation	52	3,906,984,856	1%
Education	138	134,659,151,326	35%
Health	84	7,842,770,801	2%
Sports & Culture	20	3,516,293,258	1%
Private Sector Development	69	8,447,463,025	2%
Agriculture	331	33,142,672,281	9%
Environment and Natural Resources	145	13,466,514,126	4%
Energy	57	3,513,748,805	1%
Urbanisation & Rural Settlements	93	20,961,973,276	5%
<i>Total</i>		<i>383,256,233,637</i>	<i>100%</i>

The table demonstrates that transport is the most important in terms of the budget. Therefore, roads were selected due to its budget share while water and building infrastructures were also selected due to their importance as far as the NST1 is concerned.

4.2 Standard Template

For each infrastructure type, a standard template was developed in order to properly enter the information and then consequently ease the data processing and analysis. Each standard template is composed of four parts collecting different types of information:

- The first column provides the list of all *selected cost drivers* or major construction components for a given infrastructure type.
- The second column provides the information about the *unit of measurement* of selected cost drivers for a given type of infrastructure.
- The third column provides the information about the estimated *unit price* as per selected contract appearing in the row one.



- d) The fourth row provides the information about the *total costs* of the contracts for selected infrastructures.

4.3 Inflation Rate

The inflation will always cause the project cost overrun as projects materials prices, labour wages, and machinery hire rates are changing annually. As per the table below, we calculated the average inflation for the last three years which is equal to 6.0%.

Table 3: Average inflation rate for the last three years

Period	Annual average inflation
December 2021 and December 2020	8%
December 2020 and December 2019	7.7%
December 2019 and December 2018	2.4%
Average for the last three years	6.0%

Source: Consumer Price Index by Rwanda National Institute of statistics

We recommend users of this unit price study to consider the aggregated reference price of the concerned infrastructure and then adjust the price with the average annual Rwandan inflation rate of 6%.

5 Reference Price

5.1 Aggregated Reference Prices for Road Infrastructure

Under the National Strategy for Transformation (NST1), road infrastructures are considered to be among the key drivers of the economy through transport cost reduction, investment attraction, and economic opportunity access facilitation. With this in mind, LODA has been supporting districts to improve the road network through extension, rehabilitation, and upgrading different



categories of roads. In this unit price study, we will analyse the unit price of murrum, chip seal and asphalt roads.

5.1.1 Aggregate Reference Prices for Murrum Roads

The study sampled 11 road projects totalling a length of 89 km in the Western Province, 4 roads with 39 km in the Southern Province, 5 roads with 42 km in the Northern Province and 11 roads with 134 km in the Eastern Province. An example for a murrum road in Ngoma District is presented in the following figure.



Figure 2: Zaza-Sake murrum road

The average unit price was calculated per province due to the consideration of different geographical characteristics of each province. The average unit prices of murrum roads by province are presented in the table below.

Table 4: The average unit price of one kilometre (km) of murrum roads

Statistical data	Eastern Province	Western Province	Northern Province	Southern Province
Average Unit Price per Km	58,066,062	110,295,061	86,040,584	97,334,055



Minimum unit Price per Km	18,705,342	50,048,020	51,666,675	75,509,953
Maximum Unit price	111,098,832	201,552,831	110,553,813	144,410,091
Standard deviation	27,060,423	50,648,915	20,639,825	27,774,534
Coefficient of deviation (%)	47	46	24	29

The table above shows that the murrum road average cost per kilometre is approximately 110.2 million RWF in the Western Province, 97.3 million RWF in the Southern Province, 86 million RWF in the Northern Province, and 58 million RWF in the Eastern Province. The identified price differences relate mainly to the different relief and related challenges in road construction or rehabilitation.

The coefficient of variation is higher in the Western Province due to its mountainous geographical characteristics. Please note that the construction of a bridge to any given road influences the cost of the road. Therefore, it is always important to examine the selected cost drivers during the analysis of road projects.

4.1.1.1 Cost drivers of Murrum Roads

The bill of quantities of murrum roads construction has a number of main BOQs items or building components that impact cost more than others, including the embarkment from unclassified excavation (cuts of any nature), re-levelling, compaction & finishing of the formation, wearing course of 20 cm thick after compaction of lateritic gravel (murrum), stone masonry for head walls, and supply & laying of concrete culverts 100 cm. The listed cost drivers comprise up to 80% of the murrum project costs. The table below summarizes the cost drivers and their respective price estimates for a murrum road.

Table 5: Cost drivers of a murrum road

No	Cost drivers	UoM	Average Unit price	Minimum unit price	Maximum Unit price	Standard deviation	Coefficient of variation
----	--------------	-----	--------------------	--------------------	--------------------	--------------------	--------------------------



1	Embarkment from Unclassified Excavation (Cuts of Any Nature)	m3	2,749	1,000	5,912	1,393	51
2	Re-levelling, Compaction & Finishing of the Formation(Platform)	m2	734	400	1,500	373	51
3	Wearing course of 20cm thick after compaction of lateritic gravel(murram surface layer))	m3	13,114	9,500	21,240	3,158	24
4	Stone Masonry for Head Walls	m3	49,468	22,000	108,150	21,380	43
5	Supply & Laying of Concrete pipe Culverts 100cm	ml	177,620	110,000	250,000	42,915	24

The table above demonstrates the average unit price of selected cost drivers in the Western Province. The cost drivers play an important role in the analysis of project cost as the project may have a low price compared to other similar projects, but the project itself may have higher or overestimated prices of inputs. Therefore, we recommend the analysis to always consider the price of cost drivers. The table below summarizes the analysis done on one of the projects in Karongi .



Table 6: Analysis of Karongi murrum road using the selected cost drivers

No	Cost drivers	Unit	Contract Rate (RWF)	Average unit price	Estimated Quantities	Contract Amount	Contract amount using average unit price	cost effect	Percentage cost effect
1	Excavation (Cuts of Any Nature)	m3	4,200	2,749	27,700	116,340,000.00	76,147,300.00	40,192,700.00	35%
2	Re-levelling, Compaction & Finishing of the Formation	m2	650	734	120,300	78,195,000.00	88,300,200.00	- 10,105,200.00	-13%
3	Supply & Laying of Concrete pipe Culverts 100cm	ml	165,000	177,620	570	94,050,000.00	101,243,400.00	-7,193,400.00	-8%
4	Stone Masonry for Head Walls	m3	52,000	49,468	770	40,040,000.00	38,090,360.00	1,949,640.00	5%

The table above shows that the cost of excavation would be reduced by 35% and the cost of stone masonry by 5% if the reference unit prices are considered as a benchmark. This table does not mean that the contract would reduce of the same amount. However, the table clarifies the benefits in terms of value of value that lies in the contract negotiation. We encourage District staff to consider the price of inputs for each contract and verify if there is no room for savings on the side of institution through contract negotiation



5.1.2 Average Reference Cost of One Kilometre (km) of Chip Seal

The Government of Rwanda has been investing in the connection of farmers to markets through the construction of feeder roads using the selected laterite materials. However, it was found that constructed roads with gravel deteriorate rapidly and require constant maintenance, which is costly in terms of spending. Therefore, the Government of Rwanda took the initiative of introducing low volume sealed technology to mitigate the murrum road deterioration. In this study, we will look at the average reference price of one kilometre of chip seal road.

The chip seal road is constructed by distributing a thin base of hot bitumen (a by-product of crude oil) onto existing pavement or prepared road base area, and then embedding finely graded aggregate into it. The aggregate is evenly distributed over the hot seal spray, then rolled into the bitumen using heavy rubber-tired rollers, creating a paved surface. Road engineers advise to reapply the bitumen every five to eight years, depending on the area used. The picture below represents one of the chip seal roads in Kicukiro District



Figure 3: RSB-Byimana Chip seal road /Kicukiro district

In this study, we referenced contracts of 214 Km that were financed by the World Bank under the feeder roads programs. All those roads are to be constructed using the chip seal technology and were tendered under the design and build contracting mechanism. The below table summarizes



the reference prices established after analysing contracts that were awarded by Rwanda Transport Development Agency (RTDA).

Table 7 : Reference price of a chip seal (Chip seal road of more than 10km)

Chip seal statistical data (more than 10 Km)	Reference Price in RWF
Average reference price per Km	151,494,666
Minimum unit Price per Km	103,427,357
Maximum Unit price	193,353,474
Standard deviation	31,792,309

After the analysis of 214 km that were tendered under the chip seal program within six districts, we realized that the unit reference price per kilometre is closer to the reference unit price of a murrum road. In order to shed light on why the reference price seems to be smaller comparatively to other roads, we discussed with the team of road engineers and come out with the below observations.

- a) The above reference price confirms the principle of *economies of scale*: The more kilometres are planned to be constructed, the more interested competitive contractors will bid and offer a reasonable price
- b) The *equipment mobilization* for one kilometre of chip seal road is the same as the one of many kilometres
- c) The reference price is mostly influenced by the *cost of relocating utilities and street lights*: Readers of this unit price study need to note that the above listed average cost does not include the cost of street lights
- d) The above average unit price of chip seal roads is to be considered with the assumption of *having a road length of more than 10 to 20 km to be constructed*. Apart of the economies of scale principle, the larger the project, the more it attracts a significant number of both local and international companies which at the end reduces the project costs.

The current study has also considered the case where a given institution is tendering the chip seal road of less than 5 km with the component of street lights. We observed that the cost is higher comparatively to the above case because most of those roads are constructed in most agglomerated sites where utilities relocation also influences the road price considerably. The table below gives the reference unit price for a chip seal road of less than 5 km.



Table 8: Reference price of a chip seal (Chip seal road of less than 5km)

Chip seal statistical data (less than 5Km)	Reference Price in RWF
Average reference price per Km	463,188,309
Minimum unit Price per Km	286,273,135
Maximum Unit price	644,423,365
Standard deviation	123,998,335
Coefficient of deviation	27

The table above demonstrates that the reference price for smaller projects is higher comparatively to where we have a road with more kilometres. This case is explained by the fixed cost of a road construction and other factors like expropriation and utilities relocation.

5.1.3 Cost Drivers of Chip Seal Roads

The bill of quantities of chip seal road construction has a number of main BOQs items that impact cost more than others including survey and site clearance, earthworks and formation of embankment/ subgrade, slope protection, earthen drains all-inclusive 6 m road; gravel wearing course min 200 mm; rough-cut cobblestones on road carriage way 15 cm depth, and pavement layer under bituminous wearing course as specified for low volume road design, including prime coat. The table below provides the reference price estimates of the main cost drivers of a chip seal road.



Table 9: Cost drivers of a chip seal road

Chip seal cost drivers	UoM	Average Unit price in RWF	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
Survey, Site clearance, Earthworks and Formation of Embankment/ Subgrade, slope protection, earthen drains all-inclusive 6 m road	lm	53,814	18,130	79,191	24,492	46
Gravel Wearing Course min 200 mm	m3	11,025	4,962	15,018	4,715	43
Rough-cut Cobble stones on road carriage way 15 cm depth	m3	138,461	108,192	199,000	52,428	38
Pavement layer under bituminous wearing course as specified for Low Volume Roads design including prime coat	m3	18,899	10,200	25,963	6,040	32
Provide bituminous DBST layers as specified including prime coat (minimum 6m width)	lm	37,323	22,260	59,850	13,254	36
Stone masonry	lm	42,617	11,855	101,206	37,620	88

The table above illustrates the reference price of the main cost drivers of a chip seal road.



5.1.4 Average Reference Price of one Km of Asphalt Road

Though the chip seal road cost is lower than the cost of asphalt road, road engineers advise to consider asphalt as the best option where there is high turning of vehicles, especially heavy vehicles. Asphalt is a hot product, consisting of bitumen, but is mixed at a batching plant together with aggregates (chips) of sand and dust at a high temperature. Asphalt comes out of the plant at 180 degrees Celsius and is laid by either hand or with a paving machine. Road engineers prove that surfaces provide an almost unlimited variety in form and flexibility and can last as long as 25 years.



Figure 4: Kagarama-Muyange asphalt road (Kicukiro)

In order to analyse the reference price of one kilometre of an asphalt road, 16 projects with 79 km costing up to 12 billion have been compiled and the table below summarizes the reference price.

Table 10: Reference average price of Km of asphalt road

Asphalt statistical data	Reference Price in RWF
Reference Unit Price per Km	793,356,761
Minimum unit Price per Km	286,273,135
Maximum Unit price	1,369,560,733
Standard deviation	176,289,602
Coefficient of deviation	22

The table above illustrates that the average reference price for one km of asphalt road is 793,356,761 RWF, with the maximum price of 1,369,560,733 RWF. Please note that the minimum price was captured on the asphalt road where works requirements were only the upgrade of the asphalt road.



5.1.4.1 Cost Drivers of Asphalt Roads

During this study, jointly with the team of engineers, we listed a number of BOQ elements that affect cost more than others and we then aggregated to get their unit reference prices.

Table 11: Reference price of asphalt road

Designation	UoM	Average Unit price in RFW	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
EARTHWORKS						
General excavations and disposal off	m3	4,251	2,677	14,085	2,624	62
Backfill with excavated materials	m3	4,544	1,654	9,085	2,424	53
Backfill with selected materials from borrow pit	m3	7,286	2,860	17,151	3,166	43
Preparation, levering and finishing of the platform	m2	954	376	3,430	884	93
Foundation layer of murrum gravel 27.5 cm thick	m3	7,219	3,081	12,764	2,144	30
0/31.5 stone base layer 20 cm thickness	m3	39,122	31,028	58,867	7,195	18
Priming	m2	3,266	1,079	13,209	3,935	120



Designation	UoM	Average Unit price in RFW	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
Tack coat	m2	2,350	1,055	13,420	3,096	132
Asphalt concrete bitumen layer 5 cm thick	m3	18,425	17,160	19,690	1,265	7
Bed course of sand	m2	1,200	1,200	1,200	-	-
Supply and implementation of cape seal	m2	6,125	5,308	6,941	817	13
Bituminous concrete -Wearing course of asphalted concrete (BBSG 0/10)	m 3	304,593	213,654	411,144	67,261	22
DRAINAGE						
Exit channels towards ravines in stone masonry Type R4: 0.80m x 0.95m (e = 0.20m)	ml	49,810	18,927	64,150	13,268	27
Rock filling 30/50 kg Protection head downstream	m3	63,562	61,412	63,562	2,150	3
Excavation works for crossing structures	m3	7,320	7,320	7,320	-	-



Designation	UoM	Average Unit price in RFW	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
Concrete mixed at 100kg /m 3	m3	104,065	104,065	104,065	-	-
Concrete mixed at 250kg /m 3	m3	158,349	118,114	192,092	30,548	19
Concrete mixed at 300kg /m 3	m3	289,277	146,860	696,646	208,136	72
Concrete mixed at 350 kg /m 3	m3	350,620	350,620	350,620	-	-
Concrete culverts - Diameter 80	ml	163,814	49,825	246,788	72,940	45
Concrete culverts - Diameter 60	ml	150,252	65,426	314,375	84,621	56
Concrete culverts - Diameter 100	ml	245,476	129,840	498,110	103,819	42
Headworks for reinforced concrete pipe culvert-1000mm dia pipe	Pcs	569,732	82,779	1,139,343	435,282	76
Headworks for reinforced concrete pipe culvert-800mm dia pipe	Pcs	490,794	61,656	911,474	346,988	71



Designation	UoM	Average Unit price in RFW	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
Headworks for reinforced concrete pipe culvert-600mm dia pipe	Pcs	442,217	55,662	759,562	291,503	66
Headworks for reinforced concrete pipe culvert-400mm dia pipes as utility duct	Pcs	124,238	84,539	158,767	30,523	25
Travaux de fouille de fossé en forme trapézoïdale sur les deux côtés de la route (140x110x90)	ml	2,954	2,677	3,230	277	9
Construction du fossé trapézoïdal en maçonnerie	m3	45,674	22,640	100,300	30,193	66
WALKWAYS						
Supply and Installation of road kerbs	ml	16,286	12,153	26,576	3,688	23
Supply and installation of the gutter kerbs	ml	16,114	10,709	26,576	4,524	28



Designation	UoM	Average Unit price in RFW	Minimum unit price	Maximum Unit price	standard deviation	Coefficient of variation
Supply and installation of interlocking pavers, thick 6cm	m2	17,146	13,183	23,124	4,058	24

The table above illustrates the reference price of BOQ elements that impact the asphalt project cost more than others.



5.1.5 Average Reference Price of one km of Street Lighting

The Government of Rwanda has adopted the policy of including street lighting among road requirements to improve the security of road users. It is recommended to include street lighting for all planned road projects. The street lighting promotes security and improves quality of life by extending the hours in which it is light so that activity can take place. Street lighting improves safety for drivers, riders, and pedestrians. An example is pictured below.



Figure 5: Street light on the access road to Musanze industrial zone

In order to identify the reference price for one kilometre (km) of street lighting, we collected seven contracts covering 263 km in different districts of Rwanda. The table below summarizes the statistical information related to the average unit reference price.



Table 12: Unit costs for street lightning

Street lightning	Reference Price in RWF
Average Unit Price per Km	65,215,427
Minimum unit Price per Km	41,995,434
Maximum Unit price per Km	87,770,984
Standard deviation	15,227,486
Coefficient of deviation (%)	23

The table above illustrates that the average reference price for one km of street light is 65,215,427 RWF with the maximum price of 87,770,984 RWF. Please note that the minimum price was captured on street roads contract of more than 50 Km, deferring the results due to the economies of scale.

5.2 Average Reference Price for one km of Water Supply System

Rwanda is committed to moving towards a ‘modern Rwandan household’ under its NST-1, and its broader Vision 2050. Under NST-1, the target is to reach 1,937 km pipe length of water supply systems for Kigali City and other towns, 1,851km for rural areas, and increase water production capacity from 182,120 m³ to 303,120 m³. These targets are intended to contribute specifically to the SDG targets of ensuring basic water and sanitation services by 2024 and safely managed services by 2030.

In order to understand the cost of one km of water network, contract data from 34 water system projects with a total length of 867 km were collected and analysed. Water systems cost drivers defined among them are pumps, pipes, and cost of construction of water reservoirs.

Technically, water supply systems are differentiated by their type of water distribution: We normally have gravity and pumping water systems. The region elevation difference determines a choice between gravity and pumping water systems. The gravity system is chosen where the water can flow from the input point (source) to the terminal point of the distribution system in required quantity and pressure. Pumping water systems are constructed where it is not feasible to channel the water by pure means of gravity and pumps are required to bridge heights between source and distribution tanks. While the pumping water system can be adopted in any type of



topography, the gravity system is only feasible where the input point is at higher elevation than all the withdraw points.



Figure 6: Pumping station at Kanyonyomba water treatment In Bugesera District

Figure 7: People fetching water at Gatoboro water kiosk

We collected contract data from 19 gravity water systems with a total length of 375 km and 14 water pumping systems with a total length of 452 km across the country. We calculated the average cost of kilometre per gravity water systems and average cost of kilometre per pumping water systems. The table below summarises the finding on the reference prices for both water systems.

Table 13: Reference aggregate unit price per km of water system.

Water system statistical data	Gravity water system reference unit price RWF	Pumping water system reference unit price RWF
Reference unit Price per Km	19,268,350	34,774,570
Minimum unit Price per Km	6,250,722	15,609,422
Maximum Unit price	39,350,951	90,060,632
Standard deviation	8,683,244	19,436,238
Coefficient of deviation	45	56

The table above demonstrates that the reference price of a water pumping system is higher than the water gravity systems and water experts consider gravity water distribution systems to be reliable and cost effective over pumping systems as no external power is required to maintain the



flow. The following table describes the cost drivers that may help unit price users to analyse inputs of a given water system.

5.2.1 Cost drivers of Water Supply Systems

Decisionmakers need to understand the cost drivers related to construction and maintenance of water systems over their life cycles. The proper definition of cost drivers helps to determine the fair value of the construction of water systems and help to make a choice related to maintenance and operationalization. Together with the team of engineers, we established a number of BOQ elements that influence cost more than others, including water pumps, electricity line, type of pipes and a number of reservoirs.

5.2.1.1 Reference Price of Water Pumps

During the analysis, we collected a number of pump types that have been used recently, along with their respective prices. The price includes the cost of supplying and applying the water pumps. The following table gives cost drivers for number of water pumps that have been procured by Districts on different occasions.

Table 14: Reference price of water pumps

Type of pumps	Reference Unit price in RWF
Pump KSB MTCD 65/8; Q=35m ³ /h, H _{tm} =220m, NPSH =15m - N=2945tr/MIN; Efficiency=0.9, Three phase Dynamo (Engine) asynchronous P=45W including all accessories	60,000,000
Two units of pumps (Q=15m ³ /hr, TDH = 475m, such head=3m) and their equivalent motors (with max power of 45 KW) with Electrical command Board and other accessories including installation of Automatic switch water tank float - Electric water level switch (Water pump float switch) and automatic water pump pressure controller Electronic switch control unit	41,300,000
A vertical multi-stage centrifugal pump with an electric motor and the following characteristics: Flow = 35 m ³ /h, H _{man} = 210 m	20,500,000



Type of pumps	Reference Unit price in RWF
Two units of Pumps (Q = 35 m ³ /hr, TDH = 460m) and their equivalent motors (with max power of 75kW) with Electrical Command Board and other accessories including installation Automatic Switch Water tank float-Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit	50,000,000
Two units of Pumps (Q = 25 m ³ /hr, TDH = 320 m) and their equivalent motors (with power less than 57 kW) with Electrical Command Board and other accessories including installation Automatic Switch Water tank float-Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit	45,000,000
Two units of Pumps(from KSB) (Q = 20m ³ /hr, TDH = 380m ,suction 3m) and their equivalent motors (with max power of 50kW) with Electrical Command Board and other accessories including installation Automatic Switch Water tank float- Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit	29,000,000
Une pompe de refoulement avec électromoteur et des caractéristiques suivantes: Q = 19,7 m ³ /h, H _{man} = 134 m	8,550,000
Une pompe de refoulement avec électromoteur et des caractéristiques suivantes: Q = 15,5 m ³ /h, H _{man} = 130 m	8,550,000
Submersible pump GRUNDFOS stainless steel with 11Kw,Qmin=12m ³ /hr-Qmax=22.5m ³ /hr, TDH=100m used for borehole water pumping including all accessories and fittings similar to pump including electric control panel ,automatic water flow controller, manometer,water meter, elbows, valves, et.	18,000,000
Two units of KSB Pumps (Q = 18 m ³ /hr, TDH = 170 m) and their equivalent motors (with power less than 37 kW) with Electrical control panel and other accessories including installation Automatic Switch Water tank float-Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit, Valves PN 25,Elbows PN 25,Flanges,Gaskets,manometers 30bars etc...	20,000,000



Type of pumps	Reference Unit price in RWF
An electrical Submersible electrical pump GRUNDFOS stainless steel with 11Kw, Qmin=6m ³ /hr-Qmax=12m ³ /hr,TDH=80m used for borehole water pumping including all accessories and fittings similar to the type of the pump including electric control panel ,automatic water flow controller and manometer, elbow, valves, gaskets, flanges ,water meter etc.	19,000,000
Deux moto- pompes électrique centrifuges type MULTITEC KSB d'une hauteur manométrique de 250m (Hmt : 250 m, Q : 25m ³ /H, P=37KW),Bride d'aspiration DN 125, et bride de refoulement DN 80.	39,970,326
Two units of Pumps (MTC C ; Q=18m ³ /H; HMT=325 m; P= 30kW; N=2900 rpm ; Horizontal position) with Electrical Command Board and other accessories including installation Automatic Switch Water tank float- Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit	25,000,000
An Electrical KSB Pump with Hm=400m, N=2950tr/mim, Q=30m ³ /hr, 3p-380V-50Hz, P=65kW, Cosα=0.85 including all accessories and fittings in PN 40 with respectives piping dimensions	59,000,000
Two units of KSB Pumps (Q = 18 m ³ /hr, TDH = 170 m) and their equivalent motors (with power less than 37 kW) with Electrical control panel and other accessories including installation Automatic Switch Water tank float- Electric water level switch (Water pump float switch) and Automatic Water Pump Pressure Controller Electronic Switch Control Unit,Valves PN 25,Elbows PN 25,Flanges,Gaskets,manometers 30bars etc...	20,000,000

The table above gives an overview of the reference prices of different types of pipes that were used previously by different institutions over the last three years. The table plays an indication role for those who need to make a choice among pumps and also gives a reference for prices.

5.2.1.2 Reference Price of a Surge Vessel

The surge vessel cost is among the key cost drivers of water systems. The surge vessel plays an important role of absorbing the shocks resulting from the pump closure.



Table 15: Reference price of surge vessel

Sample of projects	Reference Unit price in RWF
Supply and installation of an air (Pressure) vessel, 300 Litres and 25 bars	4,350,000
Supply and installation of a counter water hammer vessel of 40 bars and 500 litres capacity	8,260,000
Supply and installation of Shock absorber of 500l water hammers, PN40 (Q max 30 m ³ / h, H mano 250mCE, CISDN 100 mm PN 40 (558.65m), HDPE 110mm PN25 (985.95m) , Max length discharge pipe = 1544.60m) including all accessories and fittings for complete connection and operation	11,800,000
Supply and installation of a counter water hammer vessel of 30 bars and 300 litres capacity	8,000,000

5.2.1.3 Reference Price of Pipes

Pipes constitute the main cost drivers of water system. We have identified different type of pipes, including the ductile iron pipes (DI), flexible plastique pipes (HDPE), galvanized pipe (GI) and polyvinyl chloride (PVC) pipes. In this study, we listed a number of pipes that are commonly used and their references prices. The table below illustrates different types of pipes that were acquired by districts and their respective prices, inclusive of supply and fixing costs.

Table 16: Reference price of pipes

Type of pipes	Average Unit price in RWF per 1m	Minimum unit price in RWF per 1m	Maximum Unit price in RWF per 1m	Standard deviation	Coefficient of variation
DI pipe DN 150 PN 30	69,473	69,473	69,473	-	-



Type of pipes	Average Unit price in RWF per lm	Minimum unit price in RWF per lm	Maximum Unit price in RWF per lm	Standard deviation	Coefficient of variation
DI pipe DN 125 PN 25	63,400	63,400	63,400	-	-
D.I pipes DN 100 PN 40, with automatic joints	57,464	21,000	145,000	31,507	55
D.I pipes DN 100 PN 25, with automatic joints	57,464	21,000	145,000	31,507	55
D.I pipes DN 80 PN 40, with automatic joints	40,000	35,000	45,000	4,082	10
D.I pipes DN 80 PN 25, with automatic joints	40,000	35,000	45,000	4,082	10
HDPE DN 125 PN 16	28,916	16,000	41,831	12,916	45
HDPE DN 125 PN 10	20,110	40,220	40,220	-	-
HDPE Pipe of 110mm PN 16	18,000	15,000	21,000	3,000	17
HDPE Pipe 110mm PN 25	30,000	30,000	30,000	-	-
HDPE Pipe of 90mm PN 25	18,000	18,000	18,000	-	-
HDPE Pipe of 90mm PN 16	10,297	6,890	12,000	2,409	23
HDPE Pipe of 90mm PN 10	9,290	6,890	12,000		



Type of pipes	Average Unit price in RWF per lm	Minimum unit price in RWF per lm	Maximum Unit price in RWF per lm	Standard deviation	Coefficient of variation
HDPE Pipe of 75mm PN 10	4,100	4,100	4,100	-	-
HDPE Pipe of 75mm PN 25	7,945	6,890	9,000	1,055	13
HDPE Pipe of 75mm PN 16	5,300	5,300	5,300	-	-
HDPE Pipe of 63mm PN 16	5,901	3,405	7,500	1,549	26
HDPE Pipe of 63mm PN 25	7,100	6,700	7,500		
HDPE Pipe of 63mm PN 10	3,500	3,500	3,500	-	-
HDPE Pipe of 50mm PN 10	3,500	3,000	4,000	500	14
HDPE Pipe of 50mm PN 16	5,000	5,000	5,000	-	-
HDPE Pipe of 50mm PN 25	6,500	6,500	6,500	-	-
HDPE Pipe of 40mm PN 10	2,500	2,000	3,000	500	20
HDPE Pipe of 40mm PN 16	3,750	3,750	3,750	-	-
HDPE pipes 32mm PN 16	2,325	1,650	3,000	675	29
HDPE DN 25 PN 16	1,100	800	1,500	294	27



Type of pipes	Average Unit price in RWF per lm	Minimum unit price in RWF per lm	Maximum Unit price in RWF per lm	Standard deviation	Coefficient of variation
PVC 160 PN 10, with automatic joint	22,000	22,000	22,000	-	-
PVC 110 PN 16, with automatic joint	8,500	8,500	8,500	-	-
PVC 110 PN 10, with automatic joint	7,820	5,600	10,040	2,220	28
PVC 90 PN 10, with automatic joint	5,986	4,800	7,172	1,186	20
PVC 75 PN 25, with automatic joint	8,500	8,500	8,500	-	-
PVC 75 PN 10, with automatic joint	4,620	2,300	6,000	1,289	28
PVC 63 PN 25, with automatic joint	6,500	6,500	6,500	-	-
PVC 63 PN 10, with automatic joint	4,000	4,000	4,000	-	-
PVC 63 PN 16, with automatic joint	5,500	4,500	6,500	1,000	18
PVC 50 PN 10, with automatic joint	3,000	3,000	3,000	-	-
PVC 50 PN 16, with automatic joint	3,800	3,800	3,800	-	-
PVC 40 PN 10, with automatic joint	2,000	2,000	2,000	-	-



Type of pipes	Average Unit price in RWF per 1m	Minimum unit price in RWF per 1m	Maximum Unit price in RWF per 1m	Standard deviation	Coefficient of variation
PVC 32 PN 16, with automatic joint	2,000	2,000	2,000	-	-
G.S pipes 8"	80,000	80,000	80,000	-	-
G.S pipes 6"	59,200	59,200	59,200	-	-
G.S pipes 5"	45,833	36,000	59,000	9,681	21
G.S pipes 4"	31,689	18,000	47,200	9,016	28
G.S pipes 3"	26,375	17,600	38,000	6,762	26
G.S pipes 2 1/2"	17,871	11,100	29,500	8,806	49
G.S pipes 2"	16,131	10,000	23,600	4,433	27
G.S pipes 1 1/2"	12,500	12,500	12,500		
G.S pipes 1 1/4"	10,500	10,500	10,500		
G.S pipes 1"	8,500	8,500	8,500		

5.3 Reference Unit Prices of one ha of Radical Terraces

Due to geographical characteristics of Rwanda, the government of Rwanda introduced a number of erosion control measures, including radical terraces. Radical terraces are put in place to meet the following objectives:

- Reduce soil losses through enhanced retention and infiltration of runoff
- Promote permanent agriculture on steep slopes
- Promote land consolidation and intensive land use
- Protect water catchment against water pollution.

Radical terraces are protected at their risers and outlets, especially in the first or second year of the establishment. Calliandra, French camerron, and grevillia are commonly used to protect terraces. The figure below illustrates the typical layout of radical terraces.

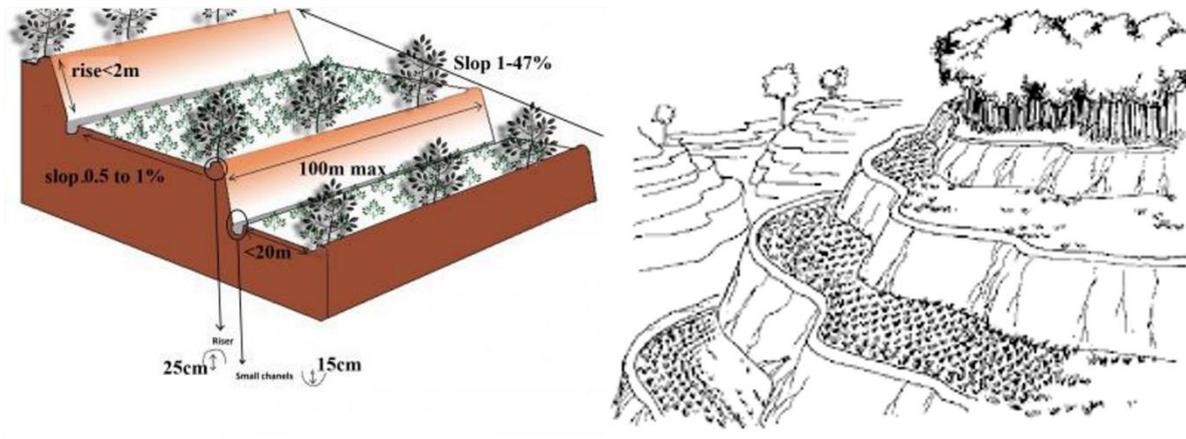


Figure 8: Presentation of a radical terraces (Source: WACAT - World Overview of Conservation Approaches and Technologies, 2014)

In order to calculate the reference price of one ha of radical terraces, we worked with agronomist engineers and established a number of BOQ elements: Site clearing, site picketing & topographic work, terracing, cut of drains, man-made water ways, natural water ways, check dams (dead & alive), tree planting components, and fertilizer application. The below table illustrates the information related to the average, minimum, and maximum unit price of one ha of a radical terrace.

Table 17 : Reference price of one ha of radical terraces

Statistical data (ha of radical terraces)	Reference Unit price in RWF
Reference unit Price per ha	2,294,295
Minimum unit Price per ha	1,727,4002
Maximum Unit price	2,795,000
Standard deviation	438,352
Coefficient of deviation	19

The table above demonstrates that the average unit price of radical terraces is 2,294,295 per ha.



5.3.1 Cost Drivers of Radical Terraces

The table below summarizes key elements that constitute the main cost drivers of one ha of radical terraces.

Table 18: Cost drivers of radical terraces and their unit prices

Radical terraces	BOQ elements	UoM	Qty	Average reference price in RWF per item
<i>1. Works</i>				
1	Site clearing	ha	1	22,647
2	Site picketing & topographic work	ha	1	60,324
3	Terracing	ha	1	1,238,235
4	Cut of drains	m	100	495
5	Man-Made water ways	m	200	719
6	Natural water ways	m	100	392
7	Lining of CD&WW	m	400	800
8	Check dams (dead &live)	number	60	1,706
9	Embarkment protection (Reeds)	Cuttings	8,333	8
<i>2. Tree planting</i>				
1	Calliandra	No	925	59
2	Grevellia robusta	No	156	59
<i>3. Application of agricultural inputs</i>				
1	Lime application	kgs	2,500	47
2	Organic manure	kgs	1,000	35



5.4 Reference Unit Price of Buildings

Every year, the local government invests a significant share of their budgets in the construction of building infrastructures that serve as premises of a given service delivery. Local Government has to build and operate health infrastructures, market infrastructures, education infrastructures, and office infrastructures, which take approximately 10% of the budget every year

In order to calculate the reference prices of building infrastructures, we consolidated data of 26 contracts that informed our analysis. Through the analysis, the primary information collected through the unit price study shows that each infrastructure’s specific size and price is highly influenced by its geographical location. Therefore, it was not feasible to aggregate their reference prices to get one reference price for each type of infrastructure. Engineers advised us to consider BOQ as the best basis for estimating, tender comparisons and contract administration of building infrastructures. The pictures below represent two different sizes of maternity ward.



Figure 9 : Selected pictures of maternity

Though building infrastructures differ on size, they have similar elements that constitute the bills of quantities. In order to calculate the reference price of building infrastructures, we discussed with engineers and opted to calculate the reference price of BOQs elements that are common to



all building infrastructures. The table below summarizes the reference unit prices of those common BOQ elements from the excavation to the painting.

Table 19: Reference price of common BOQ elements for building infrastructures

Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
<i>1. Earth works / Foundation</i>						
Excavation	m ³	2,471	1,000	8,000	1,307	53
Foundation 40cm width and 100cm with natural hard approved quarry stonewalling with a crushing strength of 7.5 N/mm ² ,	m ³	55,538	35,000	94,400	12,754	23
<i>2. Reinforced concrete work</i>						
RC isolated footings (1x1x0.25) in cement mortar +aggregates, C25 equivalent to 1:2:4 of ratio + formwork of wood planks. T12@150mm	m ³	319,103	212,400	431,765	64,689	20
RC Columns and sub columns of 0.2x0.2, in cement mortar +aggregates of C20 equivalent to 1:2:4 of ratio + shuttering works, 4T12 , stirrup of T8@175mm	m ³	314,329	194,000	431,765	65,855	21



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
Reinforced concrete Continuous lintel and ground beam 20cmx20cm in cement mortar +aggregates, C20 equivalent to 1:2:4 of ratio + formwork of wood planks, 4T12 , stirrup of T8@175mm	m ³	322,515	212,400	431,765	67,171	21
Reinforced concrete slabs C25	m ³	353,270	280,000	406,679	54,707	15
Reinforced concrete beams C25	m ³	336,203	250,000	406,679	58,522	17
Blinding concrete (5cm thick) spread on a flat horizontal surface dosed at 150Kg / m3	m ³	122,723	80,000	180,000	27,799	23
<i>3. Elevation of walls</i>						
Wall elevation with burnt bricks of 0.20m thick in cement mortar 1:4	m ³	63,836	33,000	84,706	14,372	23
External and internal walls in concrete blocks	cm	42,000	42,000	42,000	-	-
Wall elevation with cement blocs	m ³	84,705	84,705	84,705	-	-
supply and apply Ruliba bricks	m ³	118,000	118,000	118,000	-	-



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
<i>4. Roof structure</i>						
Trusses in metal tubes (60x40x1.5mm) rafters & tie beam and bracings in RHS	ml	6,509	2,000	15,000	3,470	53
Purlins in metal tubes (40x40X1.5mm)	ml	4,362	1,500	8,550	1,904	44
Metal rain gutters (200x250x1.5 mm)	ml	8,235	8,235	8,235	-	-
Metal fascia board (250x1.5 mm)	ml	4,525	2,000	7,059	1,526	34
steel gutters	ml	7,634	4,000	13,000	2,073	27
Roof covering with iron sheet 28GB A.P with 45mm side laps and 75 mm end laps laid in accordance with manufacturer's instructions or catalogue detail, colour to be approved by client.	m ²	8,545	5,500	10,588	1,482	17
Roof covering with iron sheet 30BG	m ²	6,373	4,000	7,059	1,129	18
Roof covering with iron sheet 26BG	m ²	14,167	10,000	18,000	3,274	23



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
Supply, nail and assemble structural timber trusses as indicated in structural drawings and apply antifungal grease. Timber: 40*60 rectangular	m ²	3,864	3,200	4,118	359	9
Supply, nail and assemble structural steel trusses as indicated in structural drawings and apply antifungal grease. Timber : 40*60 rectangular	lm	4,200	4,000	4,400	200	5
<i>5. Floor paving</i>						
Hardcore in crashed stones of 12cm thickness above a well compacted murrum soil, Under core with crushed stone from natural hard approved quarry stone with a crushing strength of 7.5 N/mm ² ; Pavement base with plain concrete, class 20	m ²	15,029	3,500	26,441	8,526	57



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
Supply and construction of made in Rwanda tiles (Granite type black and grey)	m ²	27,500	25,000	30,000	2,500	9
Supply and construction of 500*500*10mm granite-vitrified floor tiles bedded and jointed with clear adhesive on prepared backings.	m ²	20,985	17,700	25,000	2,643	13
Laying floor tiles 40x40 (Granite type) (toilet)	m ²	17,000	17,000	17,000	-	-
Carreaux de sol type granite(NYAGATARE) de bonne qualité de 1,5 cm d'epaisseur y compris plinthe et trottoir		36,000	17,000	55,000	19,000	53
Laying wall tiles 20x30 up to ceiling level (faience) (toilet)		14,500	14,500	14,500	-	-
cement pavement layer 5cm of thickness	m ²	57,021	4,500	105,882	45,732	80
cement pavement layer 8cm of thickness	m ²	8,471	8,471	8,471	-	-
6. Ceilings						



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
Wooden resting element using timber planks 5x5x5 cm with the quality of the planks to be approved by the engineer in conjunction with client's taste	m ²	5,294	5,294	5,294	-	-
Ceiling with PVC (languette) on a wooden resting designed as specified by engineer	m ²	14,441	11,500	18,824	3,159	22
ceiling with triplex	m ²	12,247	9,412	22,500	5,144	42
Gypsum ceiling		26,500	25,000	28,000	1,500	6
7. Painting						
Prepare the surface and apply plaster, first coat cement and sand, first coat of sand 1:3, second coat of cement 1:2 steel trawled on internal and external wall . Add water proof product to fight against the humidity dampness	m ²	4,538	2,000	7,080	1,165	26



Common BOQ elements	UoM	Average Unit price in RWF	Minimum unit price in RWF	Maximum Unit price in RWF	standard deviation	Coefficient of variation
Apply one undercoats and three coats first grade silk vinyl emulsion paint to include preparation of wall surface prior to receive paint and all requirement paint works on internal part of walls. Colour to be approved by the client	m ²	3,555	2,000	5,000	981	28
Prepare and apply three coats of Weather guard paint on external walls; colour to be approved by the client	m ²	4,967	2,588	11,000	2,527	51
Prepare and apply two coats of red oxide and two coats of Oil paint on metallic casement (doors, windows), fascia board and external parts of the metallic gutter;	m ²	3,980	2,000	8,500	1,915	48

5.4.1 Use of Reference Prices of Common BOQ Elements of Buildings

The BoQ serves as tool for sharing the project information costs to all project stakeholders and is considered the best basis for estimating, tender comparisons, and contract administration of any project. In addition to being a tool for cost analysis, the BoQ gives a true figure of all materials



and elements required for any specific project. Therefore, we recommend all stakeholders to look at the BoQ details and analyse the project cost.

In order to demonstrate the use of the above listed reference prices, we took one sample contract and we applied the calculated reference prices to look at the effect on the contract cost. Taking the example of one contract, the table below illustrates changes that may occur once references were applied.



Table 20: Application of building infrastructures reference prices

Item description	UoM	QTY	Unit price per bidder contract	Average Unit price	Total price /Bidder contract	Total price /Average unit price	Change to the contract	Change in the percentage
Excavation	m ³	393.2	3,500	2,471	1,376,200	971,597	404,603	29%
Foundation 40cm width and 100cm with natural hard	m ³	262.2	55,000	55,538	14,421,000	14,561,990	-140,990	-1%
RC isolated footings	m ³	191.5	400,000	322,515	76,600,000	61,761,648	14,838,352	19%
Wall elevation with burnt bricks of 0.20m thick in cement mortar 1:4	m ³	285	60,000	63,836	17,100,000	18,193,208	-1,093,208	-6%

The table above demonstrates that by applying the aggregated reference price to the contract selected items, the excavation cost would reduce by 29%, the foundation would increase by 1%, the reinforced concrete isolated footings would reduce by 19%, and the wall elevation would increase by 6%.



6 Conclusion

It is important to know that there will always be cost differences among projects due to designs or other specific circumstances, like the geographical characteristics. However, the management always need to have a clear understanding on the cost of any infrastructure for the sake of planning and implementation. We have gone through different contracts and the following are our recommendations.

6.1 General Recommendations

- I. The information provided in this unit price study is useful for planning purposes and for obtaining the value of money. In construction industry, the value of money involves completing a project on time, cost and a level of quality that meets the need. A good project will continue to provide value for money and meet user needs throughout its lifetime and will contribute to the environment in which it is located with a wide range of social and economic benefits. We recommend to users to always think on the value of money in combination with the procurement procedures.
- II. It has been observed that some projects costs overruns are results of the poor quality of the project designs. We have cases where they are errors and omissions of some works and key items costs in the BoQ at the design stage. We recommend to users of this unit price study to plan ahead the required time and expertise to do and review the project designs. LODA has developed cost effective design guidelines for roads, waters and building infrastructures for reference in case of planning and analysing the project design.
- III. It has been observed that economies of scale play an important role in determining the project costs. Economies of scale is a result in a fall in average variable costs (average non-fixed costs) with an increase in output. It has been observed that small contracts get less attention from contractors comparatively to big tenders during the procurement process. We recommend to users of this unit price study to always think the broad picture of the project instead of dividing the projects into proportions in order to benefit from economies of scale. This should be associated with the thinking of a multi-year projects planning which helps to save time and cost resulting from the increased competition



6.2 Recommendations for Roads Infrastructures

- I. We recommend that road engineers consider the traffic data and road bed soil characteristics (subgrade strength) before deciding on the gravel thickness (mm). We have cases where districts use more or less than the required thickness, which at the end affects costs considerably. Below are some examples:
 - a. In normal cases where we do not have unusual conditions (e.g. marshland, Expansive soil or Rock), The thickness of surface layer material for gravel road e is functional of traffic data and road soil characteristics. Example: Reference made to the RTDA Pavement design guideline; The road of 10 km planned to be constructed with the standard width size of 6m where the road traffic is >200 and CBR is >7 will have laterite (m³) = $6 \times 10.000 \times 0.2 = 12000 \text{ m}^3$
 - b. In the case of marshland where the CBR is less than 3%, it is advisable to remove all poor materials and replace with good ones (E.g., rip rap followed with fill materials.)
- II. We recommend that engineers avoid added value related to material transport costs where possible. It is advisable to consider the nearest road construction (E.g.: laterite materials) and also think of the alternative of improving the laterite material when not complying with technical specifications of the road construction material. The good choice of laterite materials combined with laterite testing at every 1000 m³ improves the quality and cost performance.
- III. During the design of the chip seal or asphalt concrete roads in urban areas, it is advisable to determine the costs related to street lights, covering the drainage system and the cost of constructing the non-motorized traffic (walkways and cycle ways).
- IV. During the asphalt road project execution, we have cases where districts prefer to use the stone base layer over the laterite base layer. It is advisable to compare both before making a decision, as both may serve the same purpose. Normally the average cost of stone base is 45,000RWF per m³ while the average cost of laterite base is 15,000 RWF.
- V. We recommend that engineers consider the drainage size that is equivalent to the estimated water quantities. We observed cases where the drainage size is set to be 40/60 without any consideration of water quantities.
- VI. The Rwanda Bureau of Standards states that the drainage should be considered where the gradient is 7% of topography. We have cases where districts forget the drainage or put the drainage where it is not required. There is a possibility of managing costs through better positioning of the drainage system.



- VII. The Rwanda Bureau of Standards states that the culverts setting should be at every 300m in mountainous regions. We recommend districts avoid reducing the number of culverts in the spirit of cutting costs.
- VIII. We recommend being mindful that the cheapest bid might not always be the best. It is advisable to do a market research and ask previous clients for testimonials. This would help to understand how the contractor performed previously and decide if he fit for the project

6.3 Recommendations for Water Supply Systems

- i. It has been observed that districts most often procure pumps with the head exceeding 300m. Pumps with more than 300m fall under the category of big pumps, which are associated with a huge operational and maintenance costs, and their spare parts are not frequently available on the local market. It is also important to remember that the higher the head pump, the higher the size of required pressure pipes. Example: Pipes exceeding PN 40 fall under big pipes and are not preferred due to their high associated costs.
- ii. For rational planning and cost minimization, districts are advised to plan for electricity connection to pumps instead of planning for oil because of oil's higher costs associated with operational and maintenance. Initially the cost of a generator seems to be smaller, however the maintenance cost keeps increasing in the long run.
- iii. We observed that engineers specified pipes in inches (in) and millimetres (mm), which confuses contractors during the tendering and implementation. The recommended diameter for plastic pipe is in millimetre while the diameter for steel pipe is inches. Example: HDPE pipe is DN 110 while DI is 4".
- iv. We observed that engineers confuse the internal and external pipe diameter. It is recommended to consider only the internal diameter as the external diameter keeps changing with the pipe's pressure.

6.4 Recommendations for Building Infrastructure

- i. We observed that some office infrastructures do not fit with the needs of users where some parts of the infrastructures are not enough to accommodate users or have an unused space. We recommend that planners undertake a proper needs assessment that



considers current users and also projects possible future needs. Engineers recommend 175 square feet of space for each person who works in the office. Leaders and executives usually require between 200- and 400- square feet. Open office workstations only require about 100 square feet per person.

- ii. We recommend that engineers optimize building design elements and take the minimal dimension and size where applicable. Example: In building code, the standard size of wall in burnt bricks is 0.20m and it would not be an ideal solution to take 0.25.
- iii. We recommend that engineers consider simpler designs, because the more sophisticated the design, the higher the project investment costs and the operation and maintenance costs. Example: Imagine the case where a given district in the rural area is renting a grass cleaning machine from Kigali twice per month. This would have been considered when choosing the type of grass.
- iv. We recommend that engineers consider Made in Rwanda materials during the design of building infrastructures in order to save costs and time of importation, which negatively affect the schedule of the project.
- v. We recommend that engineers consider the relationship between the design structure capacity and type of building materials. Example: We have cases where engineers specify the steel concrete where masonry would be the best approach. We recommend the search for materials and products that are more economical, yet still provide the desired finish level and appearance.
- vi. We recommend to be mindful that the cheapest bid might not always be the best. It is advisable to do market research and ask previous clients for testimonials. This would help to understand how the contractors performed previously and decide whether they are fit for the project.