Sizing and costing of Road water harvesting Ponds for the 18.1 km Road Rehabilitated by IFDC in Rubanda District.

Contents

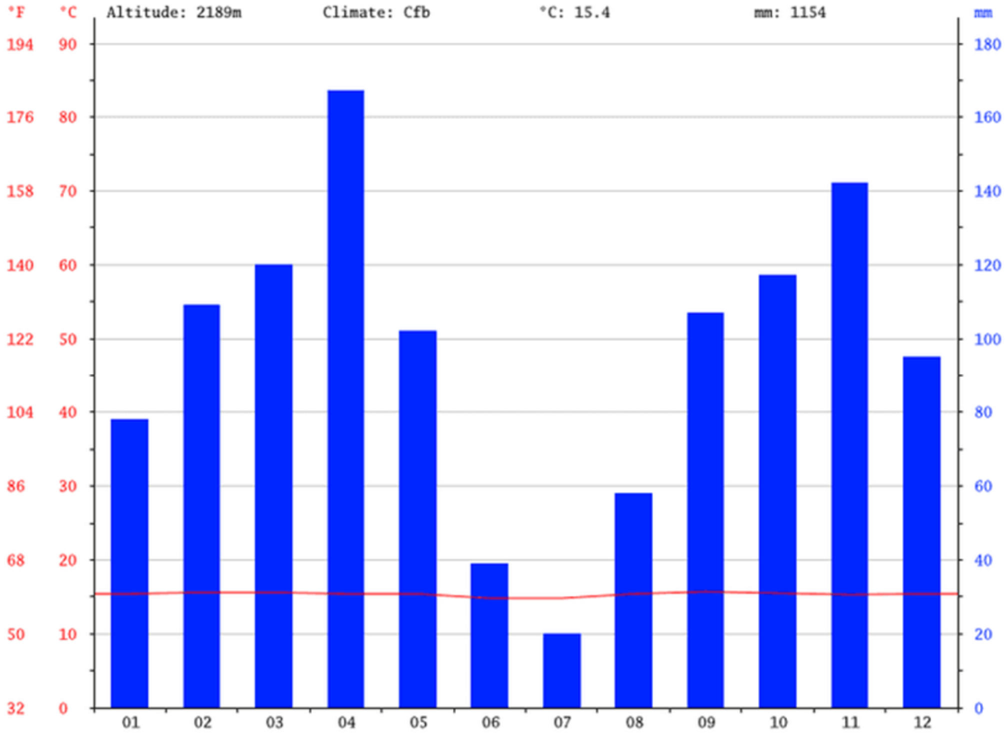
1. Introduction

The main purpose of the road water harvesting components is to augment the harvesting and storage of water for the farmers living alongside the road and to improve their livelihood through enhanced economic growth.

Rainfall

Rubanda District experiences a diversity of climatic conditions. Annual rainfall ranged between 600 mm and 1600 mm, mostly distributed in low land and in the highlands zone. Most rainfall (rainy season) occur in January, February, March, April, November and December. The pattern of rainfall is bimodal with the rainy season lasting from August–December and

February-May followed by a prolonged dry season. Precipitation is reliable and allows a wide range of crops to be grown with some double planting of short season crops (1).

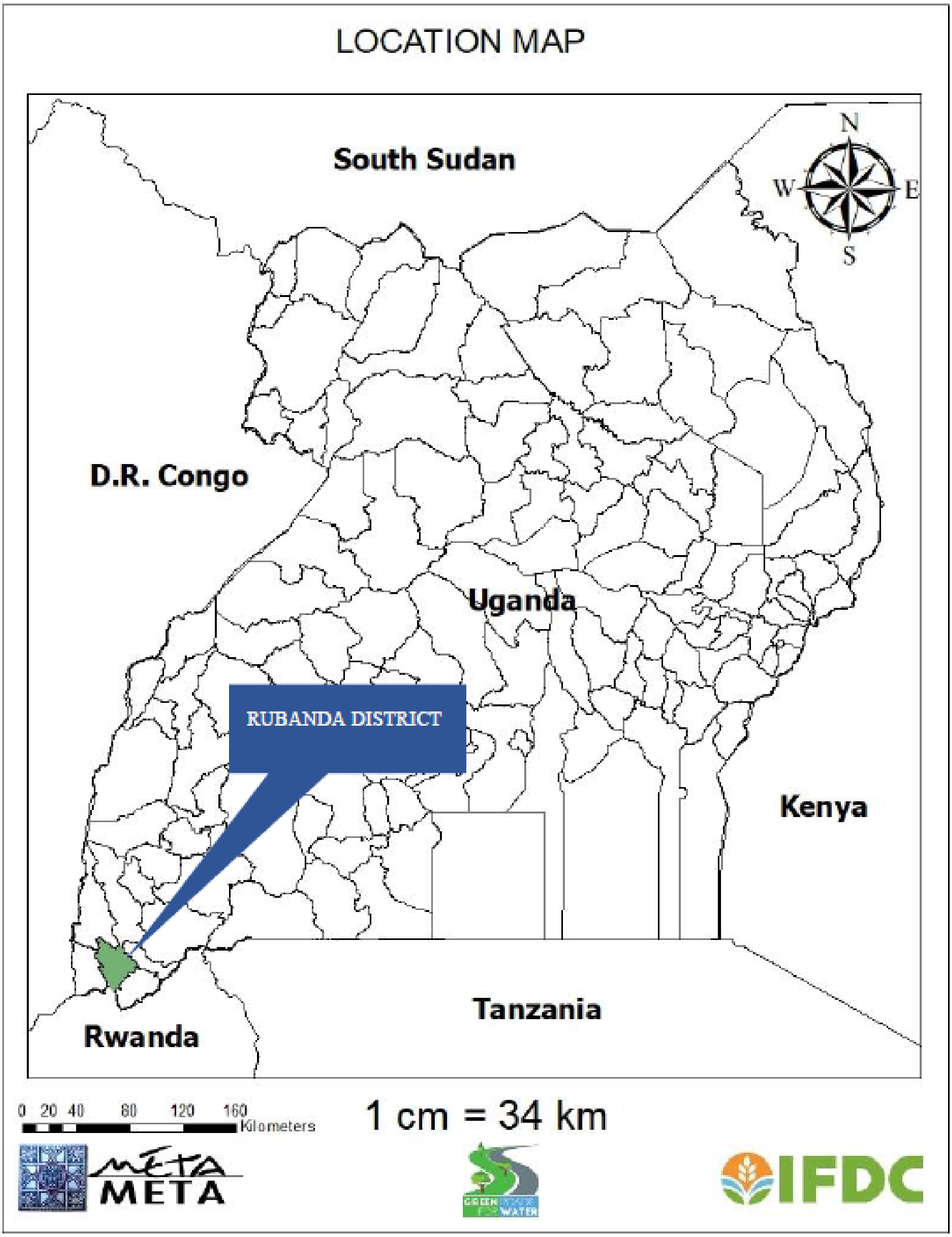


Source: Climate data organization website at https://en.climate-data.org/africa/uganda/western-region/rubanda-786505/

Precipitation is the lowest in July with an average of 20mm. most precipitation falls in April, with an average of 167 mm.

Location

The project area is located along Kabale-Kisoro highway in Rubanda district, which is bordered by Kisoro District in the West, Kabale District in the East, Rukiga District in the North-East, Kanungu District in the North-West, Rukungiri District in the North and the Republic of Rwanda in the South. The project road crosses through three sub counties of Hamurwa, Bubaare and Rubanda TC.



Soils

According to ISRIC Global soil database soilgrids.org the soils physical composition is about 41-47% clay, 19% silt and 34-40% sand. This implies that the soil is classified as clay soil.

Interventions to be adopted.

From the field assessment report, a meeting was held 25th February 2020 between Mr David as a representative from IFDC with Hilary and Enock as representatives from METAMETA Research and the following structures were adopted for implementation under the Rubanda Project road:

Roadside farm ponds:

Farm ponds are dug-out structures with definite shape and size, and with proper inlets and outlets for collecting the surface runoff flowing from a small catchment or part of a catchment, including the water guided by road bodies. The water leading to farm ponds can come from the roadside drainage system or its culverts, or can be guided by road embankments.

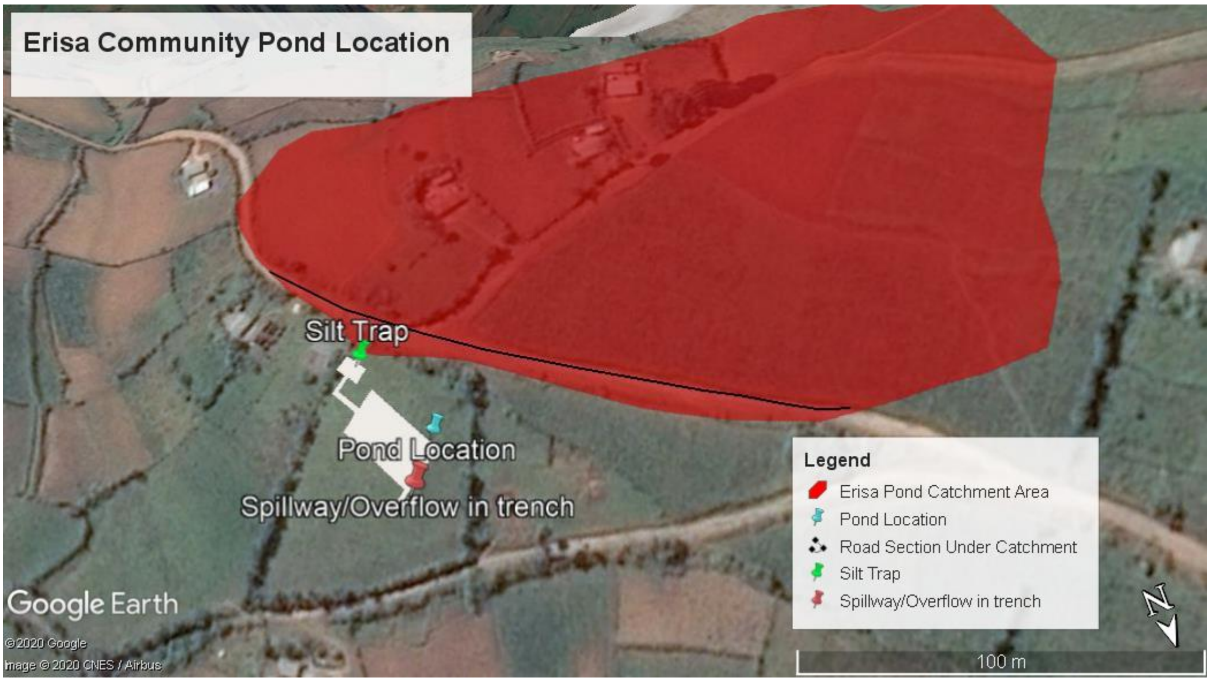
Three farm ponds shall be constructed at least one within each sub-county through which the project road runs. The design adopted for these farm ponds is referenced from the World Bank guidelines for green roads for water (2). These criteria adopted is explained below.

Runoff Diversion: Runoff from the road will be diverted from the roadside drains by use of simple diversion structures like trenches extending from Mitre drains and using loose stone barriers that slow down the runoff and divert it to the pond location. The water can be brought to the target storage with infiltration ditches with a very gentle side slope to avoid erosion (<3%).

Rainfall – runoff relationships

The run-off considered in this design will be generated from both the catchment and the road depending on the site location of the pond.

Being a rural murram road, the width adopted was 4 -5 meters taken as 4.5m. The catchment areas other than the road, have been delineated using the Google Earth Pro by drawing and observing different elevation profiles along the road and suggested pond location as shown in the figures below.



Monthly estimates of runoff volume from roof areas and small catchments (i.e. less than 80 ha) can be made using the equation (01). Therefore, this method has been adopted for rainfall-runoff transformation.

$$V_m = C*A.*R_m / 1000 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (01)$$

Where:

V_m = runoff volume in month m [m^3]

C = Runoff coefficient (Tabulated below)

A = Catchment area [m^2]

R_m = Rainfall in month m [mm]

Rural catchments are classified as per their surface slope, permeability of the soil and vegetation cover. Surface slope is characterised by Cs, permeability by Cp and vegetation cover by Cv. The total sum of these coefficients amounts to the runoff coefficient C. therefore the table below has been adopted for determining runoff coefficients for the project area.

Factor		Description	Runoff Coefficient
Cs	Average slope of catchment	< 3.5% Flat	0.05
		3.5% - 10% Soft to moderate	0.1
		10% - 25% Rolling	0.15
		25% - 45% Hilly	0.2
		> 45% Mountainous	0.25
Cp	Permeability of soil	Well drained soil e.g. sand and gravel	0.05
		Fair drained soil e.g. sand and gravel with fines	0.1
		Poorly drained soil e.g. silt	0.15
		Impervious soil e.g. clay, organic silts and clay	0.25
		Water-logged black cotton soil	0.5
		Rock	0.4
Cv	Vegetation	Dense forest/thick bush	0.05
		Sparse forest/dense grass	0.1
		Grassland/scrub	0.15
		Cultivation	0.2
		Space grassland	0.25
		Barren	0.3
C = Cs + Cp + Cv			

The project area being in a hilly terrain with a fairly drained soil and under cultivation, the runoff coefficient adopted was 0.50. The areas delineated for ponds (01), (02), and (03) were 3753, 26900 and 3248 square meters respectively.

The maximum peak volume for the pond shall be computed using equation 01. For economical purposes, a standard project flood (SPF) approach has been adopted to obtain the design volume. The maximum volume therefore shall be multiplied by 75% to obtain the SPF. For consideration of climate change conditions, the SPF has been increased by 10% for extreme weather conditions in order to obtain the design discharge for each pond shown in the table below:

Table showing design volume computations for the three ponds to be constructed.

Volume (m3)		MaximumV_p (m^3/s)			Design V_d (m3/s)		
Month	**Precipitation depth (mm)**	**Pond (01)**	**Pond (02)**	**Pond (03)**	**Pond (01)**	**Pond (02)**	**Pond (03)**
Jan	78	146.37	1049.10	126.67	120.75	865.51	104.50
Feb	109	204.54	1466.05	177.02	168.74	1209.49	146.04
Mar	120	225.18	1614.00	194.88	185.77	1331.55	160.78
Apr	**167**	**313.38**	**2246.15**	**271.21**	**258.53**	**1853.07**	**223.75**
May	102	191.40	1371.90	165.65	157.91	1131.82	136.66
Jun	39	73.18	524.55	63.34	60.38	432.75	52.25
Jul	20	37.53	269.00	32.48	30.96	221.93	26.80
Aug	58	108.84	780.10	94.19	89.79	643.58	77.71
Sep	107	200.79	1439.15	173.77	165.65	1187.30	143.36
October	117	219.55	1573.65	190.01	181.13	1298.26	156.76
Nov	142	266.46	1909.90	230.61	219.83	1575.67	190.25
Dec	95	178.27	1277.75	154.28	147.07	1054.14	127.28
Name of owner of the plot		**Enock (Mast)**	**Erisa**	**Callist**	**Enock (Mast)**	**Erisa**	**Callist**

2. Pond sizing design & costing

The peak expected annual runoff volume is 258.53, 1853.07 and 223.75 m^3 in the month of April for ponds (01), (02), and (03) respectively. It is thus expected that the ponds constructed should be able to hold this volume.

Pond dimensions

Storage volume has been determined from runoff estimations as 258.53, 1853.07 and 223.75 m3 in the month of April for ponds (01), (02), and (03) respectively. Taking a trapezoidal pond recommended for its slope stability;

And that:

H = depth of water

BL = bottom length of pond

BW = bottom width of pond

1: S = slope of pond wall

Then:

Upper length of pond UL can be given by **BL+2HS**
Upper width of pond UW can be given by **BW+2HS**

With this then, total volume of trapezoidal pond can be determined from:

(H *BL *BW) + (H*SH*BL) + (H*S*H*BW) + (SH*SH*H*4/3)

Inputting this in an appropriate excel spreadsheet allows for iteration of different pond dimensions with fixed height and slope to get different volumes. Thus,

- Total required Volume is 2,335.35 m3 (Approximately 2,400 m3)
- Pond height taken as 3m r 3.5m. (This will allow for the pond water to remain oxygenated)
- Wall slope taken as 0.5

Pond No.	Pond volume (m3)	Bottom length (m)	Bottom width (m)	Top length (m)	Top width (m)	Pond height
Pond (01)	258.53	11.7	5	14.7	8	3
Pond (02)	1853.07	29.8	15	33.3	18.5	3.5
Pond (03)	223.75	10	5	13	8	3

Excavation: The cost depends on the mode of excavation (manual/excavator) and the cost of labour in the area. From the interviews and experience for such work, using manual labour the cost of excavating 3 ponds is UGX. 37,500,000/= and this goes up to UGX. 47,948,960/- if we are to use hired equipment.

Table: Cost of 3 Ponds using the Labour based approach

Sn.	Description	Rate (UGX)	Units	Total
1	Excavation using 20 casual workers considering each person excavates 6m3 per day	15,000	2400 m^3	36,000,000
2	Compaction at edges	500,000	3	1,500,000
	TOTAL			**37,500,000**

Table: Cost of 3 ponds using Hired Equipment

Sn.	Description	Rate (UGX)	Units	Total
1	Excavator Hire	1,450,000	16	23,200,000
2	Jumping Compactor	250,000	16	4,000,000
3	Excavator Fuel (25 l/hr) considering 5 working hours	3,900	16	7,800,000
4	Jumping Compactor Fuel (25 l/day)	3,900	16	1,248,000
5	Provide for mobilization and demobilization	9,000,000	1	9,000,000
6	Provide for 6% for Miscellaneous	N/A	N/A	2,700,960.0
	TOTAL			**47,948,960**

Silt trap: An automated silt trap is similarly useable in this condition. It allows for inflow and overflow from the water pan when full as illustrated below

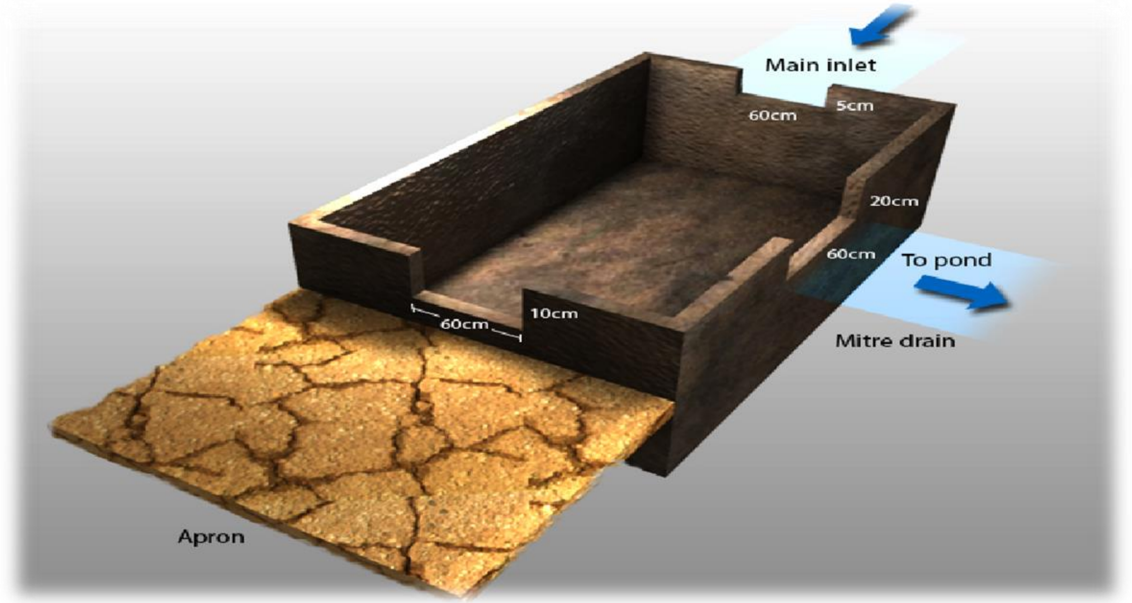


Image: courtesy ICRAF/Internet sources

The inner dimensions **(L x W x D)** of the automated Silt Trap should be (1.2m x 0.9m x 0.9m) or approx. (4ft x 3 ft x 3ft)

Water Pan Lining: Given the soils in the area have got high clay contents this minimises seepage losses, however a more efficient way is to use lining is recommended. A variety of dam liners are available for use in ranging from UPVC liners to PE liners with varied thickness from 0.3mm-1mm. The UV treated 0.5mm thick LDPE liner offers a good balance between cost and quality with a lifespan of 10yrs and beyond if well maintained.

Liner Thickness	Cost on the market / m² (UGX)
0.3mm	20,000
0.5mm	30,000
1.0 mm	70,000

Safety: It is essential to fence-off the water pan for safety reasons. The community is expected to contribute to this in kind and do the live fencing besides the pond. This will be emphasised during training and community work.

3. Budget

Find the attached budget.