Decision Making in Water Engineering Design Projects: A Case Study of Kadera Kuoyo Village of Migori County in Kenya.

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1. Abstract

During feasibility studies, Water Engineers face a daunting task in determining the most suitable techniques to supply water for consumption. This study was done to demonstrate the basic principles that all Water Engineers should consider during decision making in water engineering design projects. Using a case study, the proposed method for water provision was arrived at by assessing various combinations of water supply system components and finally selecting the most suitable combination. Finally, this study selects the most suitable method for supplying water to Kadera Kuoyo village i.e. Rain and spring water conveyed in pipes by gravity. By implementing this system in Kadera Kuoyo, child mortality is reduced and agriculture practised throughout the year. Health and economic status of Kwoyo village will improve.

Key words: Water Supply, Sanitation, Efficiency, Sustainability.

2. Introduction

Kadera Kuoyo is a small village in the south western region of Kenya bordering Tanzania. Available water sources include; springs, boreholes, shallow wells and rainfall. Soils are Sandy and hence the shallow wells dry up yearly in dry season. Water shortage results in no farming activities, no drinking water for livestock and no water for domestic use. Cases of diarrhoea and other sanitation related illnesses increase during this time while the food prices strike an all-time high.

The water supply project for Kadera Kuoyo village will aid in achieving the Sustainable Development Goals number 1 (No Poverty), number 2 (Zero hunger), number 3 (Good health and well-being) and number 6(Clean water and sanitation).(United Nations, 2016). Water supply to Kadera Kuoyo can be achieved by careful application of technologies in a sound engineering design.

According to Ministry of Water and Irrigation-Republic of Kenya, (2005), **basic planning** for water supply involves systematic consideration of project objective and evaluation of alternatives that achieve the objective.

The **basic policy** for water supply is to be based on the following postulates;

(i) Capacity to satisfy demand up to target year – in the Horizon of 20-25 years.

(ii) Provision of safe and clean water.

(iii) Wise, effective and efficient use of the water resource.

(iv) Safe and sound O & M of Water facilities with no negative environmental impacts.

(v) The system must be in conformity with Water Act 2002.

(vi) Enhancement of quality of living standards.

(vii) Appropriate Technology relevant to beneficiaries.

In selecting the water source, the manual stipulates that sources that provide water requiring minimal treatment should be chosen first.

The Water Partnership Program, (2012) in the Rural Water Supply design manual gives the general components of a water supply system as listed in the Table 2.1 below:

Table 2.1: General components of a water supply system

Component	Examples
Water Source	Rainfall, shallow wells, springs and rivers
Transportation media	Closed channels (pipes) and Open channels (canals)
Energy driving the system	Gravity systems, Pumped systems
Consumption Points	Homes, Schools, Hospitals, Cattle dips etc.
Waste Water Treatment & Disposal	Waste water treatment plants

The manual also stipulates that the design should take into consideration the following;

1. If possible have at least 2 sources of supply at different locations.
2. Adopt energy-efficient programs and select those which require less power consumption.

Annual rainfall is about 1500 mm but Kadera Kuoyo village still experiences serious water shortages in dry season. No projects aimed at alleviating the community from this perennial problem of water shortage have been initiated.

This study is aimed at selecting a suitable and sustainable system to supply water to Kadera Kuoyo village throughout the year as a demonstration of what Water Engineers should consider during feasibility studies and designs. The above objective is to be achieved by a combination of rain water harvesting and ground water transportation into storage facilities by gravity.

3. Materials and methods

3.1 Location

Kwoyo village is located in the south western part of Kenya within Migori County, Awendo Sub-county and North Sakwa Ward as shown below.

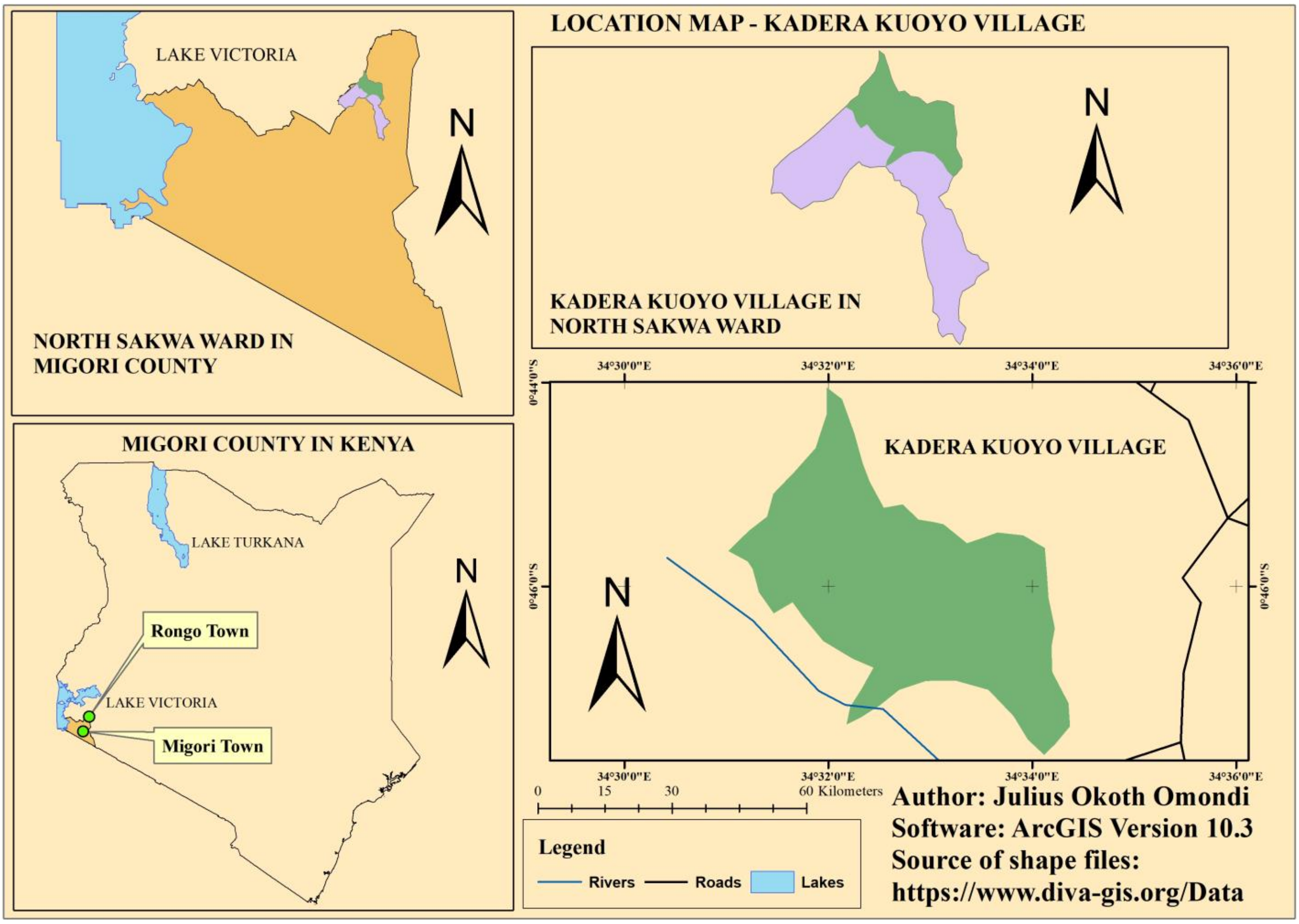

Figure 1: Location of Kwoyo village

Shapefiles source: Hijmans, Guarino, & Mathur, (2012)

3.2 Soils

The soils of Kadera Kuoyo village are predominantly sandy and the ground water table fluctuates between the dry season and rainy season. During the dry season, the well-drained sandy soils lose most of the water that would be available for plants and for consumption in wells.

3.3 Precipitation

The precipitation varies 184 mm between the driest month and the wettest month.

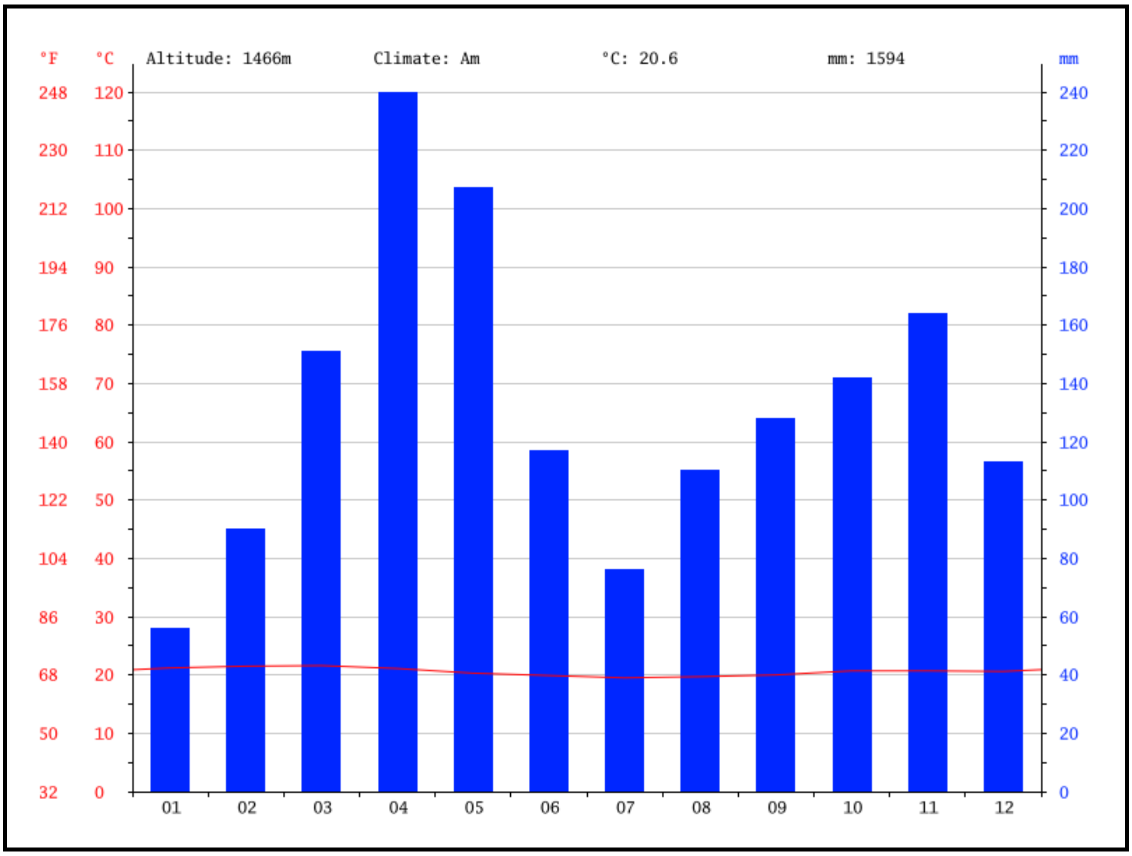

Figure 2: Precipitation of Kwoyo village

Source : Climate-Data.org, (2019)

3.4 Socio-economic activities

Majority of the people practise subsistence farming and sell surplus produce to pay school fees and other needs. A mixture of Christianity and some of the traditional Luo cultural practices are common.

Sugarcane is the cash crop in Kadera Kuoyo but other crops such as maize, beans, potatoes, cassava, vegetables, millet and sorghum are also grown. Livestock including cattle, goats and sheep are kept and slaughtered for food while some are sold or issued as dowry.

3.5 Methods

Combining knowledge of the area and the design considerations from the Rural Water Supply Design Manual Volume 1 for Philippines (Water Partnership Program, 2012), the alternative combinations for water supply were determined as below.

Firstly, all the components were awarded marks as shown below:

Table 3.1: First level of assessment

Awarding marks to each component of the system based on its suitability to the prevailing conditions in the project area.

Components	Performance			
Water Source	Rainfall (10)	Wells (5)	Springs (10)	Rivers (5)
Transportation media	Closed channels (pipes) (10)		Open channels (canals) (5)	
Energy driving the system	Gravity systems, (10)		Pumped systems (5)	

*Marks awarded in bracket out of 10 i.e. (x)

Three alternatives were selected and awarded marks as below:

Table 3.2: Alternative 1

Components	Selected Components	
Water Source	Rainfall (10)	Springs (10)
Transportation media	Closed channels (pipes) (10)	
Energy driving the system	Gravity systems, (10)	
Total marks	40 Marks	

Table 3.3: Alternative 2

Components	Selected Components	
Water Source	Wells (5)	Rivers (5)
Transportation media	Open channels (canals) (5)	
Energy driving the system	Pumped systems (5)	
Total marks	20 Marks	

Table 3.4: Alternative 3

Components	Selected Components	
Water Source	Wells (5)	Springs (10)
Transportation media	Open channels (canals) (5)	
Energy driving the system	Gravity systems, (10)	
Total Marks	30 Marks	

Alternatives 1 and 3 Passed the first stage of assessment and proceeded to the second stage where the basic policies laid out in the Ministry of Water and Irrigation-Republic of Kenya, (2005) Practice Manual for Water Supply Services in Kenya were used as an assessment tool as shown below:

Table 3.5: Second level of Assessment

Awarding of marks was based on how well the alternative satisfies the basic policy of water supply in the country.

Guideline	Marks awarded	
	Alternative 1	**Alternative 3**
1.Capacity to satisfy demand up to target year – in the Horizon of 20-25 years.	9	5
2.Provision of safe and clean water.	8	6
3.Wise, effective and efficient use of the water resource.	9	7
4.Safe and sound O & M of Water facilities with no negative environmental impacts.	9	8
5.Enhancement of quality of living standards.	10	9
6.Appropriate Technology relevant to beneficiaries.	9	5
Total marks	54	40

*Marks awarded in bracket out of 10 i.e. (x)

4. Results and Discussion

First assessment of the 3 alternatives resulted in Alternatives 1 and 3 having the highest marks as shown in table 4.1 below:

Table 4.1: Results of the First level of Assessment

Alternative	Marks Attained
Alternative 1	40*
Alternative 2	20
Alternative 3	30*

*Shows the Highest Mark.

Alternatives 1 and 3 proceeded to the second assessment stage and Alternative 1 emerged the best as shown in table 4.2 below:

Table 4.2: Results of the Second level of Assessment

Alternative	Marks Attained
Alternative 1	54*
Alternative 3	40

*Shows the Highest Mark.

Alternative 1 was found to be the most suitable option in supplying water to the village. It is highly efficient since evaporation is eradicated by use of pipes. Being gravity driven also makes it less costly and environmentally friendly. The Alternative 2 is less efficient and would have high evaporation losses as well as huge pumping costs. Both options will incorporate a storage facility that will store the water first and then release it to consumers.

5. Conclusion

Alternative 1 is thus the most suitable at this stage but designs must be done and Bill of Quantities prepared to determine which alternative is more expensive. Then by comparing the technical and the financial aspects, the better option can be chosen. The two levels of assessment are therefore a starting point for Water Engineers to consider during Feasibility and Design stages for all water engineering projects.

6. References

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