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DESIGN OF IRRIGATION CHANNEL SYSTEM TO PROMOTE MODERN AGRICULTURE IN JALLE-PAYAM BOR, SOUTH SUDAN.

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ABSTRACT

The fundamental goal of this thesis is to promote and improve modern agricultural practices by addressing the critical need for building a well-designed irrigation channel system in Jalle-Payam Bor, South Sudan. The lack of a substantial irrigation infrastructure has hampered the region's agricultural potential, resulting in inadequate crop yields and an emphasis on rain-fed agriculture. To overcome these issues, this research focuses on comprehensive planning and design solutions for an effective irrigation network adapted to the Jalle-Payam Bor region's specific demands and environment. The fundamental goal of this thesis is to promote and improve modern agricultural practices by addressing the critical need for building a well-designed irrigation channel system in Jalle-Payam Bor, South Sudan Based on the facts and analysis presented in Chapter 4, the Jalle Irrigation Channel System is intended to enable modern agriculture in Jalle-Payam Bor, South Sudan. The plan efficiently distributes water across 76 plots totaling 100 hectares, resulting in uniform water dispersion and higher agricultural productivity. The maximum irrigation water need of 1.487 liters per second per hectare was precisely calculated, ensuring adequate water delivery to meet crop demands. The program consumes only 0.8% of the Nile Water Discharge, ensuring a consistent water supply even during dry spells, and has the potential to expand if other conditions allow. The irrigation channels are well-designed, with capacities ranging from 1.575 to 0.093 cubic meters per second, ensuring effective water supply and ideal velocities. The project has a solid budget of Rp 605.456.372,23 ($37,132.64), which includes all material, labor, and equipment expenditures, ensuring economic feasibility and sustainability.

***Keywords**: Irrigation, Channel, Design, Jalle, Modern Agriculture, Irrigation.*

1. INTRODUCTION

Agriculture is the backbone of the economy of Jalle-Payam Bor, South Sudan, sustaining livelihoods and fostering community development. However, the region confronts considerable obstacles, due to its dependence on rain-fed agriculture and the lack of a modern irrigation infrastructure. Erratic rainfall patterns, prolonged dry spells, and unpredictable climate conditions have resulted in inadequate crop yields, preventing the area's agricultural potential from fully realized.

Despite its potential, agriculture in Jalle-Payam Bor is severely constrained by inadequate irrigation infrastructure. Farming in this region is heavily dependent on the wet season, which results in short growing seasons and low crop yields. Traditional irrigation technologies, which are still in use, are inefficient and unsuitable for meeting the needs of modern agriculture. The absence of a modern irrigation channel system in Jalle-Payam Bor reduces agricultural yield. Farmers in this area rely heavily on seasonal rains, limiting them to a single growing season and exposing them to the risks associated with erratic rainfall patterns. This dependency not only limits the range and quantity of products that may be farmed, but it also has an impact on the farming communities' general economic stability.

The implementation of a new irrigation system in Jalle-Payam Bor has the potential to completely reshape the region's agricultural environment. Farmers may improve food security by ensuring a continuous and efficient water supply. As a result, local communities may see greater economic stability and progress.

The fundamental goal of the research title above is to design an efficient irrigation system that maximizes water distribution for agricultural areas in Jalle-Payam Bor. This entails creating a network that guarantees water reaches all portions of the agricultural fields efficiently, avoiding problems like waterlogging or drought, and supporting optimal crop growth. An effective system would provide consistent agricultural productivity, which is critical for the region's food security and economic growth. Another critical goal is to accurately anticipate the irrigation water requirements of various crops in the area. Crops have different water requirements, and accurate projections are critical to ensuring that each crop receives the appropriate amount of water. This precision aids in irrigation scheduling, water conservation, and crop production enhancement by providing the best-growing conditions for each crop grown in Jalle-Payam Bor. A detailed cost estimate for the irrigation system's construction and maintenance is required. A thorough cost study will consider all factors, including materials, labor, equipment, and continuing maintenance costs. This cost estimate is critical for budgeting and obtaining necessary funds, ensuring that the project is financially viable and sustainable in the long run. It helps stakeholders comprehend the financial requirements and potential returns on investment. Finally, having a clear project timeline to ensure the irrigation system is completed on time is critical. A well-defined timeframe guarantees that the irrigation system's development and installation proceed systematically, minimizing delays and disruptions. Meeting project deadlines is crucial for reaping the benefits of the new system as soon as possible, supporting agricultural activities in Jalle-Payam Bor and improving overall efficiency and productivity of farming techniques in the region.

2. METHODOLOGY

2.1 Data Collection.

To gather all the research data necessary for studying hydrology, hydraulics, planning new channels, etc., data collection is done. The topographic map, water source, and maximum daily rainfall data are based on numerous stations' annual rainfall data from 2014 to 2023, according to the Bor Meteorology, Climatology, and Environmental Conservation Agency (Bor Weather Station, 2022).

2.2 Secondary Data.

with the help of my Uncle Garang Anyieth who usually visited concerned institutions in South Sudan on my behalf, I can obtain Secondary data. The secondary data came from associated organizations, such as the agencies of meteorology, climatology, geophysics, and water management systems, in the form of data gathering. The Bor Meteorology, Climatology, and Environmental Conservation Agency (AMCECA, 2023) provided secondary data on maximum monthly rainfall from 2013 to 2023, while the Digital Elevation Modem provided topographic data. An examination of the literature on irrigation system analysis. This literature review is a continuation of the literature review. of the South Irrigation Report.

2.3 Data Processing and Analysis.

Depending on the literature review and the Data collected from various related agencies. Each data attribute component can be carried out. Here are the steps follows;

2.4 Irrigation Layout.

Figure out the irrigated areas and non-irrigated areas, flow by interpolation.

2.5 Irrigation Water Requirement.

i. Crop Patterns

Jalle Payam's crop rotation includes rice, maize, and beans. The Local farmers in the region typically practice crop rotation since these crops are well-suited to the local climate and soil conditions. The crop pattern of rice-maize-bean in Jalle Payam will involve precise irrigation planning and design to accommodate the different water demands of each crop throughout the season.

ii. Crop Water requirements

After the irrigated field is figured out, then Irrigation begins with determining crop water requirement. various methods for doing so have been discussed in the literature review but the best one is to use the Blaney Criddle Method. This uses temperature as the only parameter to be measured, resulting in either overestimation or underestimation in certain conditions.

$$ET0 = K\,P\,(0.457\,t + 8.13) \ldots\ldots\ldots \qquad (35.3)$$

Notes:

ET0: daily potential evapotranspiration (mm/day)

$$K\text{: adjustment coefficient} = Kt + Kc\ldots \qquad (35.4)$$

$$Kt = 0.0311\,t + 0.240 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (35.1)$$

Kc: monthly plan coefficient

P: comparison of monthly daylight hours in a year

t: monthly average temperature.

iii. Net Irrigation Requirement

It is calculated using the following formulas:

$$NIR = ETc - Pe + (SAT+PERC+WL) \ldots \qquad (35.2)$$

Notes:

ETc=Evapotranspiration Crop, ETc = Eto × k.

Rainfall should be both efficient and effective.

SAT = Water required for pudding (mm/day).

PERC =The percolation

seepage losses are denoted WL = depth of the water layer

iv. Effective Rainfall

FAO Method (Suggested Method); Pd: Dependable Rainfall (Probability=80%)

Pe = 0.6*Pd-10 (Pd < 70mm/month) …… (36.5)

Pe=0.8*Pd-24 (Pd＞70mm/month…… (36.6)

Pe = Effective rainfall

Pd = Rainfall or precipitation (mm/month)

Notes:

Pe is always equal to or larger than zero; never negative

v. Gross Irrigation Requirement

This takes into account losses incurred during the application, conveyance, and distribution:

$$\boldsymbol{GIR = \frac{NIR}{Eff}} \text{ ………………………...} \quad (36.7)$$

Where NIR = Net Irrigation Requirement.

EFF= Efficiency of the Irrigation.

vi. Scheme Water Requirement (SWR)

The total amount of water in cubic meters must be supplied for the area under consideration. It is calculated as follows:

SWR = GIR X A ……….. (36.8)

Where;

GIR = gross irrigation requirement

A = area (mm).

2.6 Irrigation channel.

The most prepared shape of the channel is trapezoidal cross-sections.

$$Q = V \times A \text{ ……………………………} \quad (36.9)$$

$$V = \frac{1}{n} \times R^{2/3} \times S^{1/2} \text{……………………} \quad (36.10)$$

$$R = \frac{A}{P} \text{…………………………………} \quad (36.11)$$

$$A = (b + h \times m) \times h \text{…………………………} \quad (36.12)$$

$$P = + 2h \times (m^2 + 1)^{1/2} \text{ ………………………} \quad (36.13)$$

$$b = n \times h \text{ ……………………………….} \quad (36.14)$$

A = cross section (m^2)

R = hydraulic radius (m)

S = Channel slope

P = wetted perimeter (m)

b = bottom width of the Channel (m)

h = water height(m)

m = side slope of the canal (1 vert: Mhor)

n = Manning roughness coefficient

vii. Conveyance Structures.

The structure of a conveyance's speed. The Froude number should be less than or equal to 0.5 as given in the formulae below to prevent standing waves from forming at the water's surface and ensure that the flow does not become critically important.

$$Fr = \frac{V}{\sqrt{g \times D}} \text{……………………………………...} \quad (36.15)$$

Notes: Fr = Froude number

V_a = Average velocity in the building, m/s

g = gravity acceleration, m/dt^2 (=9.8)

A = wetted area, m^2

B = width of water surface, m

2.7 Cost Estimation.

Cost estimation is the process of projecting the financial resources needed to plan, build, and implement the Jalle Irrigation Channel Project. This includes estimating the expenses for materials, labor, equipment, land purchase, and other related charges. Accurate cost estimation is vital for budgeting, obtaining funding, and assuring the project's financial viability.

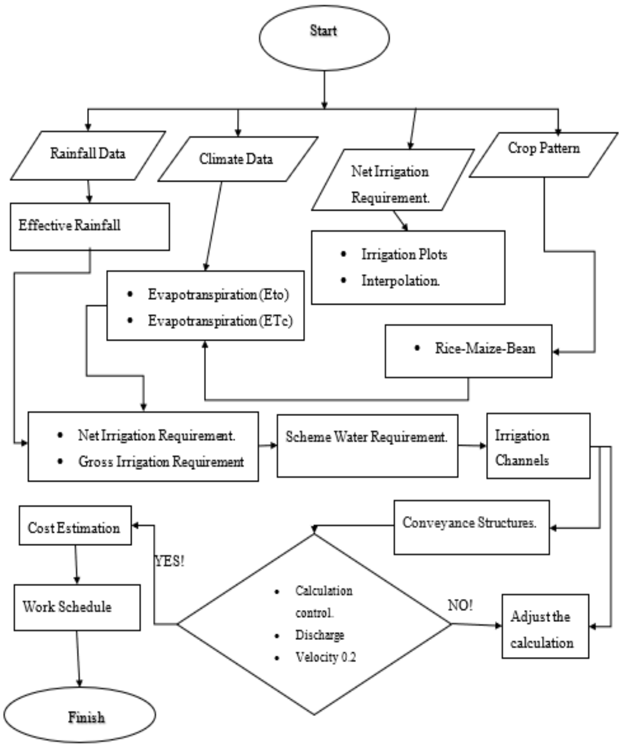


Figure 1 flow chart.

3. RESULTS AND DISCUSSION

3.1. Irrigation Area

The main irrigated zone in Jalle Payam is 80 square kilometers in size. There are smaller, one square kilometer pieces of land for secondary irrigation within this main irrigated area. This points to a well-organized hierarchical irrigation system that divides the larger primary area into smaller plots for better agricultural management and water distribution. In such a setup, the main irrigated field could serve as the main hub for resource management and water distribution, with the minor irrigation plots designated for particular crops or farming operations. This design aims to maximize water use and improve agricultural output in the area. The shaded green area in the map below is the primary irrigation field, divided into one square kilometer of secondary irrigation plots.

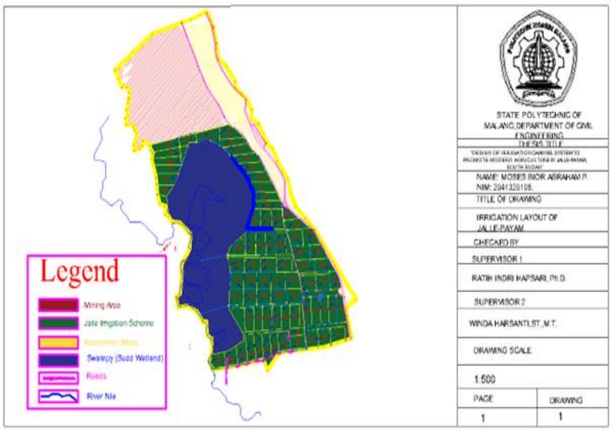


Figure 2 Jalle Irrigation Layout Map.

3.2 Net Field Requirement (NFR).

The net field requirement (NFR) is important in determining crop irrigation water requirements. It represents the water required to meet the crop's evapotranspiration demand while compensating for any water shortfall in the soil root zone. Let's continue with March as we proceed with calculating the Jalle Irrigation Scheme.

NFR = (Evapotranspiration with Area Ratio + Percolation + Pd with Area Ratio + WLR with area Ratio) – Effective Rainfall

Evapotranspiration = 3.624 mm/day
Percolation = 3 mm/day
Pd = 14.954 mm/day
WLR = 0 mm/day
Effective rainfall = 15 mm/day (given in the calculation).
NFR = (3.624 + 3 + 14.954 + 0) – 15
NFR = **6.577 mm/day**

Effective rainfall = 15 mm/day (given in the calculation)
NFR = (3.624 + 3 + 14.954 + 0- 15
NFR = 6.577 mm/day
Converted 6.577 mm/day to lt/sec/ha.
Net field need = 6.577 mm/day = (65.77 m3/ha/day = 65.77 × 1,000)/86,400
NFR = 0.761 lt/sec/ha

Maximum Net Field Requirement = 1.49 lt/sec/ha

The calculated NFR for March using the provided data is 6.577 mm/day, which equates to 0.76 lt/sec/ha. This figure represents the amount of water required to meet the crop's evapotranspiration demand while also compensating for any water deficiency in the soil root zone for optimal crop growth. The monthly NFR varies greatly due to changes in temperature, crop coefficients, and effective rainfall, with the highest NFR of 1.49 lt/sec/ha in April.

3.3 Dependable Discharge.

A consistent discharge is critical for guaranteeing a steady water supply for irrigation. Manning's equation yields a discharge rate of 286.27 m³/s, exceeding the intake channel capacity of 1.575 m³/s. This comparison demonstrates that the available water from the Nile River is enough to cover the irrigation needs of the Jalle Irrigation Scheme, even during peak demand seasons.

3.4 Scheme water requirement

Scheme water requirement (SWR) is important for building irrigation channels and canal systems. It denotes the total amount of water that must be delivered at the head of an irrigation canal or distribution system to meet the water needs of the entire command area. The total area of the Jalle Irrigation Scheme is 80km2, and the tertiaries areas are seventy-four (74) plots, each with 100 hectares as the rest of

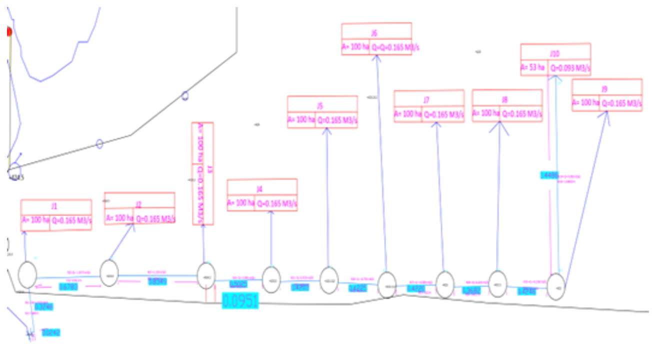


Figure 3 Schematic at Intake One.

the areas are set aside for farm accessibility. Below is the schematic of Jalle Irrigation Scheme at Intake One.

Calculation of Channel Capacity (Q in m3/s).

Channel capacity refers to the maximum flow rate that the Jalle Irrigation Channel can transport without exceeding its design restrictions.

Given; Intake One Channel

Channel Name: RJ10, Area to be supplied = J10= 53 ha, Channel Level: Secondary Channel.

Upstream: BJ9

Downstream: BJ10

NFR Max (l/s/ha) = **1.4874277 lt/sec/ha**

Efficiency = **85%**

Downstream Channel = Nil

Q Downstream Channel (m3/a) = 0 M3/s

RJ10 Capacity (Q m3/s) = Area $\times \frac{\text{NFR}}{1000} \div 85\%$

RJ10 Capacity (Q m3/s) = 100 $\times \frac{1.4874277}{1000} \div 85\%$

RJ10 Capacity (Q m3/s) = **0.093 m3/s**

RJ10 Capacity Qcap m3/s = RJ10 (Q m3/s) + Q Downstream Channel (m3/a).

RJ10 Capacity Qcap m3/s = **0.093 + 0**

RJ10 Capacity Qcap m3/s = **0.093 m3/s**

RJ9 Capacity Qcap m3/s = 0.258 m3/s

RJ8 Capacity Qcap m3/s = 0.423 m3/s

RJ7 Capacity Qcap m3/s = 0.589 m3/s

RJ6 Capacity Qcap m3/s = 0.754 m3/s

RJ5 Capacity Qcap m3/s = 0.919 m3/s

RJ4 Capacity Qcap m3/s = 1.084 m3/s

RJ3 Capacity Qcap m3/s = 1.250 m3/s

RJ2 Capacity Qcap m3/s = 1.410 m3/s

RJ1 Capacity Qcap m3/s = 1.575 m3/s

The Jalle Irrigation Scheme has the potential to significantly enhance agricultural productivity in the region. With careful planning, efficient water management, and infrastructure improvements, the scheme can support modern agriculture, ensuring food security and economic growth in Jalle Payam, Bor, South Sudan.

Table 1 Section A Channel Capacity.

No. of Channel	Upstream Point	DownStream Point	Channel Level	Tertiary Plots	A (ha)	NFR Max (l/s/ha)
RJ10	BJ9	BJ10	Secondary	J10	53	1.4874277
RJ9	BJ8	BJ9	Primary	J9	100	1.4874277
RJ8	BJ7	BJ8	Primary	J8	100	1.4874277
RJ7	BJ6	BJ7	Primary	J7	100	1.4874277
RJ6	BJ5	BJ6	Primary	J6	100	1.4874277
RJ5	BJ4	BJ5	Primary	J5	100	1.4874277
RJ4	BJ3	BJ4	Primary	J4	100	1.4874277
RJ3	BJ2	BJ3	Primary	J3	100	1.4874277
RJ2	BJ1	BJ2	Primary	J2	97	1.4874277

Table 2 Section B Channel Capacity

Efficiency		Q (m3/s)	Downstream Channel	Q Downstream Channel (m3/a)	Qcap m3/s
85%		0.093	-	0.000	0.093
90%		0.165	RJ10	0.093	0.258
90%		0.165	RJ9	0.258	0.423
90%		0.165	RJ8	0.423	0.589
90%		0.165	RJ7	0.589	0.754
90%		0.165	RJ6	0.754	0.919
90%		0.165	RJ5	0.919	1.084
90%		0.165	RJ4	1.084	1.250
90%		0.160	RJ3	1.250	1.410
90%		0.165	RJ2	1.410	1.575

Calculation of Channel Dimensions of the Jalle.

Let's take the first channel data to calculate the kind of dimension that will be appropriate to convey water from the water source to the farming area.

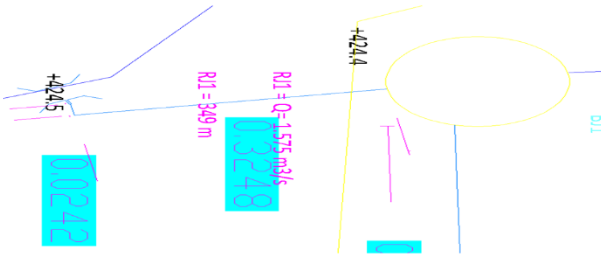


Figure 4 Overview of RJ1 Channel

Name of the channel: RJ1.

Type: Primary Channel.

Upstream: Intake One.

Downstream: BJ1. Channel Material: Concrete

Channel Capacity (Q planning) = **1.575 m3/ha (Table 28).**

Length of the channel or its distance (ls) = **349.000 M (AutoCAD).**

Existing Soil Elevation; Upstream = **+424.500m**, Downstream = **+424.362m**

Existing Slope = (Upstream – Downstream) ÷ Length of the channel.

Existing Slope = (**424.500- 424.362)** ÷ 349.000

Existing Slope = **0.0004**

Roughness Coefficient (n) = **0.016** (as it is specified in the South Sudan Irrigation Report, 2015).

RJ1 dimensional calculation

Below are the most appropriate channel dimensions.

B (base) = 1.5 m

h (height) = 0.7 m

m = 0.7 (as specified in South Sudan Irrigation Report, 2015)

T (Top Width) = b + 2×m×h

T = 1.5 + (2×0.7 ×0.7)

T = 2.48 m

A (area) = (b + m ×h) × h

A (area) = (1.5 + 0.7 ×0.7) × 0.7

A (area) = 1.393 m²

P (Wet Perimeter) = b + (2) × (h) × ((1 +M^2)$^{0.5}$)

P (Wet Perimeter) = 1.5 + (2) × (0.7) × ((1 +0.7^2)$^{0.5}$)

P (Wet **Perimeter) = 3.209 m**

R (Hydraulics Radius) $= \frac{A}{P}$

R (Hydraulics Radius) $= \frac{\mathbf{1.393}}{\mathbf{3.209}}$

R (Hydraulics Radius) = **0.434 m**

D (Average Depth) $= \frac{A}{T}$

D (Average Depth) $= \frac{1.393}{2.48}$

D (Average Depth) **= 0.562 m.**

Table 3 channel dimension design data.

Channel Name	Type	Upstream	Down stream	Channel Material	Qplan (m³/sec)	Ls (m)
	[1]	[2]	[3]	[4]	[5]	[6]
RJ1	Primary	INTAKE	BJ1	Concrete	1.575	349.000
RJ2	Primary	BJ1	BJ2	Concrete	1.410	678.300
RJ3	Primary	BJ2	BJ3	Concrete	1.250	834.900
RJ4	Primary	BJ3	BJ4	Concrete	1.084	502.500
RJ5	Primary	BJ4	BJ5	Concrete	0.919	420.300
RJ6	Primary	BJ5	BJ6	Concrete	0.754	422.500
RJ7	Primary	BJ6	BJ7	Concrete	0.589	422.000
RJ8	Primary	BJ7	BJ8	Concrete	0.423	368.200
RJ9	Primary	BJ8	BJ9	Concrete	0.258	424.600
RJ10	Secondary	BJ9	BJ10	Concrete	0.093	144.880

Table 4 Jalle Irrigation Channels Dimensions

Roughness Coefficient	Calculation Dimension						
n	b (m)	h (m)	m	T (m)	D (m)	A (m²)	P (m)
0.016	1.500	0.700	0.7	2.48	0.562	1.393	3.209
0.016	1.500	0.700	0.7	2.48	0.562	1.393	3.209
0.012	1.000	0.700	0.7	1.98	0.527	1.043	2.709
0.016	1.000	0.700	0.7	1.98	0.527	1.043	2.709
0.016	1.000	0.700	0.7	1.98	0.527	1.043	2.709
0.016	0.800	0.700	0.7	1.78	0.507	0.903	2.509
0.016	0.800	0.700	0.7	1.78	0.507	0.903	2.509
0.016	0.800	0.700	0.7	1.78	0.507	0.903	2.509
0.016	0.800	0.700	0.7	1.78	0.507	0.903	2.509
0.016	0.800	0.700	0.7	1.78	0.507	0.903	2.509

Slope Design: Elevation Levels: It determines the channel's upstream and downstream elevations to maintain a consistent gradient.

Channel Gradient (Slope): It is used to design the channel's gradient to create a balance between sufficient flow velocity to prevent sedimentation and low enough to minimize erosion. Typical slopes vary based on soil type and water velocity.

Table 5 Slope Design of Jalle Irrigation Scheme

Slope Design	Velocity (m/sec)	Q of channel (m³/sec)	Discharge Difference (m³/sec)	Permissible Velocity (m/sec)		Fr	Control		
Sdes				Max	Min		Q	V	Fr
[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]
0.001	1.133	1.578	0.003	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.133	1.578	0.168	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.395	1.455	0.205	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.046	1.091	0.007	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.046	1.091	0.172	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.000	0.903	0.149	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.000	0.903	0.314	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.000	0.903	0.480	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.000	0.903	0.645	3	0.61	0.48	Appropriate	Appropriate	Appropriate
0.001	1.000	0.903	0.810	3	0.61	0.48	Appropriate	Appropriate	Appropriate

Permissible Velocity: The permitted velocity in an irrigation canal is the maximum speed at which water can flow without causing considerable erosion to the channel bed and banks. This velocity depends on the type of soil or lining material used in the channel. Hence below are the minimum and maximum permissible velocities of the Jalle Irrigation Scheme as its soil type is Clay-loam soils.

Channel RJ1 (concrete) as the Material;

maximum = **3 m/s**

Minimum = **0.61m/s**

Froude Number (Fr): The Froude number is a dimensionless measure in fluid dynamics that describes the flow regime in open channels, including channels for irrigation. It is significant in designing and analyzing such channels since it determines the flow behaviors, which might be subcritical, critical, or supercritical.

RJ1 Froude Number = $\mathrm{Fr} = \frac{\mathrm{V}}{\sqrt{((g \times D)^{0.5})}}$

V = mean flow velocity (m/s), = **1.133** m/sec

g = acceleration due to gravity = (9.81 m/s²)

D = characteristic length, typically the hydraulic depth (D) = 0.562 m

$$\mathrm{Fr} = \frac{\mathbf{1.133}}{\sqrt{((9.8 \times 0.562))\hat{}0.5)}}$$

$$\mathbf{Fr = 0.4582715}$$

Control

Discharge Difference (D)

If the Discharge Difference is greater than zero (D≥0), then it is "Appropriate", but if the Discharge Difference is less than zero, (D ≤0) "Not Appropriate")

Discharge Difference (D) = **0.003** m^3/sec ≥ 0…… OK!

Velocity: If minimum permissible velocity< Velocity< maximum Permissible Velocity, then is ok, but on the contrary is not appropriate.

Velocity = **1.133** m^3/sec

Maximum permissible velocity = 3 m/s

Minimum permissible velocity = 0.91m/s

RJ1 Minimum = 0.91< Velocity = 2.304< Maximum = 3 m/s………………OK!

Froude Number: If Fr < 1, it is appropriate, but contrary to that, it is inappropriate.

RJ1 Fr = 0.3515< 1………………………………OK!

Freeboard: In irrigation channel design, the freeboard is defined as the vertical distance between the maximum water surface (design water level) and the top of the channel banks. It serves as a safety margin, preventing overtopping and accommodating numerous factors that could cause the water level to rise unexpectedly. The value of the Freeboard is determined based on the value of Q_{plan} (m^3/sec) as below; hence the freeboard of Jalle Irrigation Channel will be 0.25m as its Maximum Q is 1.575m^3/sec

Water Building: Water buildings are critical in irrigation channel design, such as the Jalle Irrigation Channel, for successfully regulating, controlling, and distributing water. Jalle Irrigation's design includes nine water buildings, which are used to regulate water in the ten channels of Intake One.

Elevation Design

below is the table that shows the elevation design of the Jalle Irrigation Channel.

Table 6 Elevation design of Jalle Irrigation Channel

Free Board (m)	Embankment Width (m)	Downstream Elevation			Upstream Elevation			
		Building	Water Level	Bed Channel	Embankment	Water Level	Bed Channel	Embankment
0.25	1.5	1	426.518	425.718	426.768	426.867	426.067	427.117
0.2	1.5	1	425.840	425.040	426.040	426.518	425.718	426.718
0.2	1.5	1	425.005	424.205	425.205	425.840	425.040	426.040
0.2	1.5	1	424.502	423.702	424.702	425.005	424.205	425.205
0.2	1.5	1	424.082	423.282	424.282	424.502	423.702	424.702
0.2	1.5	1	423.660	422.860	423.860	424.082	423.282	424.282
0.2	1.5	1	423.238	422.438	423.438	423.660	422.860	423.860
0.2	1.5	1	422.869	422.069	423.069	423.238	422.438	423.438
0.2	1.5	1	422.445	421.645	422.645	422.869	422.069	423.069
0.2	1.5	0	422.300	421.500	422.500	422.445	421.645	422.645

The Jalle Irrigation Channel is designed with an appropriate slope for water flow, which is crucial for continuous and efficient irrigation. The channels are designed to allow for a slow and regulated flow of water by precisely determining bed heights at both upstream and downstream places. This design eliminates standstill and excessively rapid flows, which could contribute to erosion, resulting in excellent irrigation conditions. Furthermore, the embankment height is calculated to be adequate to prevent overflow during peak flow periods. The embankment height of 1.5 meters above the bed level provides a safety margin to tolerate increased water levels without threatening overflow. This design consideration protects the surrounding area from potential flooding while also ensuring that the irrigation system is effective and reliable even under unpredictable water flow circumstances.

Figure 5 RJ1 Channel Long Section

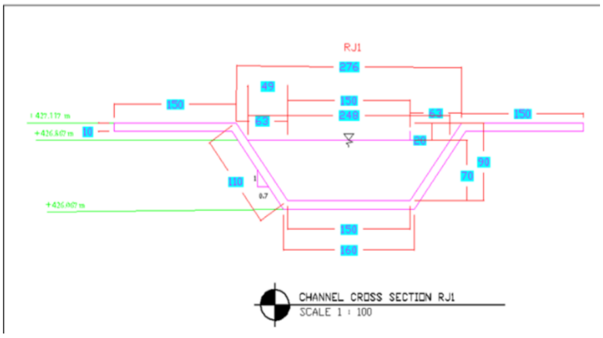
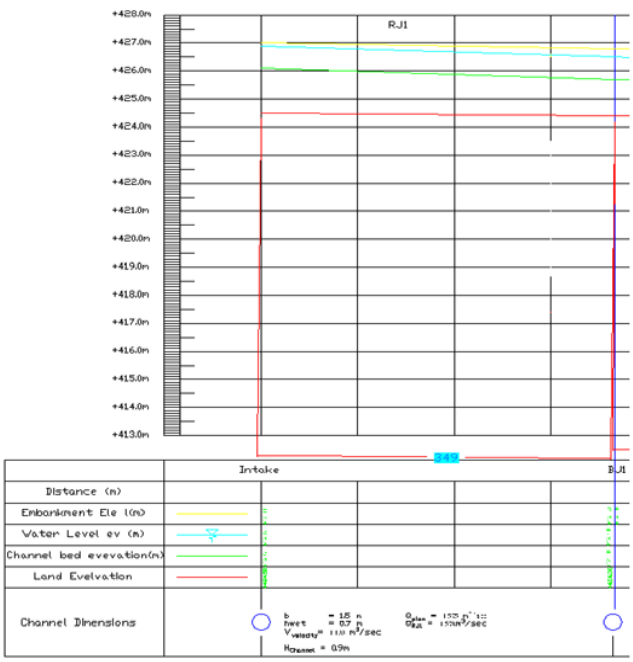


Figure 6 Channel Cross Section



D	**Channel Door Work**				
1	Lift Door IB = 300 mm	1	fruit	Rp 1,732,500.00	Rp 1,732,500.00
2	Lift Door IB = 400 mm	1	fruit	Rp 1,942,500.00	Rp 1,942,500.00
3	Lift Door IB = 200 mm	1	fruit	Rp 1,522,500.00	Rp 1,522,500.00
					Rp 5,197,500.00
E	**Water Building**				
1	concre casting Pair	3.600	m³	Rp 1,010,135.79	Rp 3,636,488.85
2	Plastering	36.000	m²	Rp 73,718.00	Rp 2,653,848.00
3	Urug Sands	3.600	m³	Rp 228,850.00	Rp 823,860.00
					Rp 7,114,196.85
F	**Finishing Work**				
1	Field cleaning	953	m²	Rp 3,103.00	Rp 2,958,511.91
	Amount				Rp 550,414,883.85
	VAT 15%				Rp 55,041,488.38
	Total				Rp 605,456,372.23

3.4 Cost Estimation

The Jalle Irrigation Scheme has a budget of **Rp 605.456.372,23 ($ 37.132,64)** indicating solid financial planning. This budget includes all material, labor, and equipment expenditures, assuring the project's economic viability and sustainability

Table 7 Cost Estimation of Jalle Irrigation Scheme

4 CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion.

Based on the calculations and analyses I accomplished during the planning of the Jalle Irrigation Project, the irrigation scheme, which includes 76 plots of irrigated fields covering 100 hectares of land, is intended to distribute irrigation channels efficiently. This system ensures that water is distributed equally and effectively throughout all plots, resulting in increased agricultural productivity. The maximum irrigation water requirement of 1.4874277 liters per second per hectare was precisely calculated. This correct estimation is crucial for ensuring that the irrigation system provides enough water to meet the crops' needs while avoiding over- and under-irrigation. Furthermore, 0.8% of the Nile Water Discharge is utilized, resulting in an abundant water supply that assures high reliability even during dry seasons. there is still tremendous potential to increase the irrigated area if other factors such as land availability, infrastructure, and demand allow. The irrigation channels, with capacities ranging from 1.575 cubic meters per second (RJ1) to 0.093 cubic meters per second (RJ10), and RJ1's specific dimensions (base = 1.5 m, wet height = 0.7 m, Q = 1.578 m³/sec, Velocity = 1.133 m/sec), demonstrate a well-planned approach to managing water flow. This ensures that water is delivered efficiently and at the optimal velocities, decreasing loss while enhancing coverage. Furthermore, the five-month implementation timeline for completing the irrigation network is both practical and feasible. This timeframe provides for meticulous planning, building, and commissioning of the system, guaranteeing that the project is completed on time and within budget. The analysis and design data support the feasibility and effectiveness of the proposed irrigation channel system in Jalle-Payam Bor. A well-designed plan, precise water requirement estimation, appropriately sized channels, a comprehensive budget, and a realistic execution schedule all help to establish modern agriculture in the region. This strategy is projected to increase agricultural productivity, enhance water management, and promote long-term development in Jalle-Payam Bor, South Sudan.

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