Global Scientific JOURNALS

GSJ: Volume 10, Issue 7, July 2022, Online: ISSN 2320-9186

www.globalscientificjournal.com

Title: Feasibility Study of Sprinkler Irrigation System For Sugarcane Production on Arid Area, In Case of Jawi Woreda, Ethiopia.

Authors;

Alemu W. Shegro[1], Temesgen T. Kidanie[2] ,

[1]*Department of Water Resources and Irrigation Engineering, Assosa University, Ethiopia.*

[2]*Department of Water Resources and Irrigation Engineering, Assosa University, Ethiopia.*

[1]alemuweyessa@gmail.com

[2]temesgentesisa@gmail.com

ABSTRACT

Water is the greatest resource of humanity that helps in survival, making life comfortable and luxurious. Besides various other uses of water, the largest use of water in the world is made for irrigating lands. As it is known irrigation is an artificial application of water to crops inorder to increase productivity. The aim of the research is, to study the efficiency of sprinkler / pressurized irrigation system for sugarcane production in the area. This can accomplished by; proper management deficiency irrigation water, by increasing the productivity of the crop, by maximizing the efficiency of irrigation systems, by providing proper land use planning management and by conducting environmental impact assessment studies. According to this, the Peak flood is estimated using *gumbel's* frequency analysis method based on 31 years river flow data and it was about 752.5m^3/s for the design period of 50 year. It has been founded that, Trapezoidal concrete lined canal is needed to off take water from the intake to the field. As The climatic condition of the area is area is desert that has annual rainfall of a bout 1447mm which comes during summer season only, pressurized irrigation /sprinkler irrigation system is very effective than surface irrigation by two reasons of which are; sprinkler irrigation is effective in use of deficit water as it minimize the loss of water and it more economical, than as surface irrigation system because of it does not require extensive land leveling cost. Therefore, the pressurized irrigation system is recommended in the area since it has scarcity of water because of its desert climatic condition.

Key words**:** Arid area, Jawi, Sprinkler-irrigation, Sugar kane,

1. INTRODUCTION

Water is the greatest resource of humanity. It is not only helps in survival but also helps in making life comfortable and luxurious. Besides various other uses of water, the largest use of water in the world is made for irrigating lands. Irrigation, in fact is nothing but a continuous and a reliable water supply to the different crops in accordance with their different needs. When sufficient and timely water does not become available to the crops, the crops fade away, resulting in lesser crop yield, consequently creating famines and disasters. Irrigation can, thus, save us from such disasters. Ethiopia is one of the developing countries and around 85% of the total population depends on agriculture most of the agricultural practice is rain fed crop production. However, due to the back ward method of farming, unreliable rainfall, less irrigation practices, the country gets less income from the sector and the people have suffered from drought and famine.

Hence, it is obvious that the agricultural system has to be improved and irrigation practice should be spread extensively to bring about sustainable food self-sufficiency and to earn foreign exchange.

Land and water are the two essential factors required for agricultural development and economic advancement of a country. Nature has bestowed Ethiopia with abundant water resources. However, due to limitations of topography, geology, physiology, dependability, quality & the present state of technology, only a part of available water resources can be utilized. Moreover, the irrigation potential is estimated to be about 4025 million hectare of which only 5.8% is irrigated (Ministry of water and energy) .The farmers have been using traditional surface irrigation for more than a century which has caused tremendous loss of not only the productive land due to waterlogging resulting from over-irrigation but also deprived the users of already shortage of irrigation water. This challenge can only be fulfilled by better & efficient use of these two natural resources. Adoption of advanced irrigation water saving methods like drip and/or sprinkler can help to achieve this goal [3].

Nowadays, implementation of small and medium scale irrigation scheme is being given priority in the water sector development strategy of Ethiopia. This project is one of medium scale irrigation scheme (based on the classification of small, medium and large scale irrigation system in Ethiopia) which constructed in *Jawi woreda* by diverting *Belles* River.

2. MATERIAL AND METHODS

2.1. Area description

This potential project is located in *Jawi Woreda* in *Amhara* Region within geographical location of Latitude of 11.31^0N and longitude of 36.41^0E at a distance of 140km from Bahir Dar.

The command area essentially comprises the upper catchments of the Main (*Enat*) and the *Gilgel Beles* rivers and their tributaries, with land elevations lying between about 1,000 m.a.sl and 1,300 m.a.sl.

2.1.1. Land use and land cover

The land use of the study area can be categorized mainly as agricultural, forest, bush, bare-land, savanna, and water bodies (feasibility study document by ADSWE, 2010). The information contained in the land use map tells how the different uses of the surface are distributed inside the area under study. Land in this area is widely covered with forest that includes, long trees and shrubs. Example; bamboo tree and savanna grass.

2.1.2. Agricultural practice;

The agricultural practice in this area is rain fed agriculture in which farmers harvesting once a year. They also practice rearing animals.

2.1.3. Geological formation;

The basal unit of the Tertiary basalt – it covers most of the project area and is composed of slightly weathered -to massive basalt. Except localized fracturing observed at few places most of the unit is massive. At places the unit becomes fractured but the fractures are widely spaced. Thin flows (which do not exceed 5m) of the unit are observed along deeply cut gorges and along Beles river banks. Degassing cavities & vesicles (filled with secondary minerals) are observed at some of the flows. Generally, the upper part of the unit is getting weathered. However, thick weathered part of the rock (about 40mthick) is observed a few places around *Jawi* town (Halcrow,2010).

Figure 2.1 Massive basalt around beles river

2.2. Data

Climatic data; includes temperature, sunshine, humidity and wind speed data which can be collected from nearby meteorological gauging station. This data is important for the determination of crop water requirement in the area

Rain fall –runoff data of the study area is also required for weir design. The annual average rain fall of the area is about 1447mm. From long year rain fall and run off data, the design discharge is determined for the selected return period. ETo of the Tana Beles project area was computed using Penman Monteith method from long years climatic data of the study area.

2.3. Methodology

2.3.1. Sprinkler system design and crop parameters

The methodology for designing sprinkler irrigation system includes:

- ✓ Reference Evapo-transpiration (ETO)
- ✓ Crop water requirement (ETC)

- ✓ Irrigation requirement (IR)
- ✓ Net irrigation requirement (NIR)
- ✓ Gross irrigation requirement (GIR)
- ✓ Net depth of water application ($_{Dnet)}$
- ✓ Irrigation interval
- ✓ Gross depth of water application (D_{groos})
- ✓ Preliminary system capacity (Q_{design})
- ✓ Design parameters of sprinkler irrigation system
- ✓ Canal system design

I) Reference Evapo-transpiration (ETo); It can be calculated using *Penman monteith* method of CROP WAT-8 computer program.

II) Crop coefficient (Kc)

A coefficient which indicates the consumptive use of water with respect to evapotranspiration and different growing stages of crops. The crop coefficient of sugarcane varies depending on the growing stages, season and climatic zones

III) Crop water requirement

The crop water requirement is certain quantity of water that crops require during their growth period. Crop water requirement for sugarcane is calculated using the climatic data, soil characteristics and crop factors. The overall project-wise net irrigation water requirement (NIWR) varies with season and cane age (as a result of different crop coefficients along the growing season).

The crop water requirement (ETc) is computed using

$$\mathrm{ETc} = \mathrm{ETo} * \mathrm{kc} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.1)}$$

IV) Effective rainfall

In many areas, seasonal rain precipitation (P) might provide part of the water requirements during the irrigation season. The amount of rainwater retained in the root zone is called effective rainfall (ER) and should be deducted from the total irrigation water requirements calculated. The effective rainfall is calculated according to the formula developed by USDA soil conservation service which is as follows.

$$ER = \frac{(p*(125-0.2*3*p))}{125} \quad \text{For p<=250/3mm} \quad \ldots\ldots\ldots\ldots \text{(2.2)}$$

$$ER = \frac{125}{3} + 0.1 * p \quad \text{, for p>250/3mm} \ldots\ldots\ldots\ldots \text{(2.3)}$$

V) Irrigation requirement (CIR);

A consumptive irrigation requirement (CIR) is the quantity of water actually required by the plant. If a part of the consumptive use is provided by the natural rainfall, the consumptive irrigation requirement will be correspondingly reduced.

CIR=consumptive use-effective rain fall.

$IR = ETc - ER$ …………………………....……………………………………………………..…………. (2.4)

VI) Net irrigation requirement;

Is the quantity of water actually required by the plant and the water required for other purposes. Such as leaching of alkaline for salty soils.

$NIR = CIR + LR$

But for sprinkler irrigation system the leaching requirement is zero, so

$NIR = CIR$ ……………………………………………………………………………….………………. (2.5)

VII) Gross irrigation requirement

The gross irrigation requirements account for losses of water incurred during conveyance and application to the field. This is expressed in terms of efficiencies when calculating project gross irrigation requirements from net irrigation requirements, as shown below:

$GIR = \frac{NIR}{E}$;……………........…...…..(2.6)

Where:

GIR = Gross irrigation requirements (mm)

NIR = Net irrigation requirements (mm)

E = Overall project efficiency

VIII) Net depth of water application

The depth of water application is the quantity of water, which should be applied during irrigation in order to replenish the water used by the crop during evapo-transpiration. The computation of the net depth of water application requires the following inputs:[1].

- The available soil moisture (FC-PWP)
- The allowable soil moisture depletion (P)
- The effective root zone depth of the crop (RZD)

The maximum net depth to be applied per irrigation can be calculated, using the following equation:

Dnet= (s_a)*RZD*P ………………………………………………………………………………… (2.7)

Where:

S_a= (FC-WP)*bulk density*10

S_a=available moisture of the soil in mm/m

Dnet = readily available moisture or net depth of water application per irrigation for the selected crop (mm)

FC = soil moisture at field capacity (mm/m)

PWP = soil moisture at the permanent wilting point (mm/m)

RZD = the depth of soil that the roots exploit effectively (m)

P = the allowable portion of available moisture permitted for depletion by the crop before the next irrigation

The maximum root depth for sugarcane is 1.2-2.0m [7].

IX) Irrigation interval at peak demand and irrigation cycle

Irrigation interval is the time it takes the crop to deplete the soil moisture at a given soil moisture depletion level.

After establishing the net depth of water application, the irrigation interval at peak water demand should be determined using the following equation [1].

Irrigation interval (II) $=\frac{Dnet}{GIR}$ ………………………………………………………………..……………….. (2.8)

Where:

II = irrigation interval (day)

Dnet = net depth of water application (mm)

GIR = Gross irrigation requirement (mm/day)

X) Gross depth of water application

The gross depth of water application (Dgross) equals the net depth of irrigation divided by the farm irrigation efficiency. It should be noted that farm irrigation efficiency includes possible losses of water from pipe leaks.

$D_{gross}=\frac{Dnet}{E}$……………………………………………………………………………………..…………….. (2.9)

Where:

E = the Farm (or unit) irrigation efficiency

Table 2.1 Farm irrigation efficiency for sprinkler irrigation in different climates [3].

Climate	farm irrigation efficiency
Cool	80%
Moderate	75%
Hot	70%
Desert	65%

XI) Preliminary system capacity

Is the total discharge needed for irrigating the field and for other uses. The next step is to estimate the system capacity. The system capacity (Q) can be calculated using; [1].

$$Q=\frac{10*A*Dgross}{I*T} \quad (2.10)$$

Where:

Q = system capacity (m3/hr)

A = design area (ha)

d = gross depth of water application (mm)

I = irrigation cycle (days)

T = irrigation time per shift (hr)

However, the minimum flow of the system should be the one that enables the completion of irrigation at least two days before the next irrigation. This allows time to repair any damage to the system or pumping unit. Therefore, the value of I in the above formula should be reduced by two days.

3. RESULT AND DISCUSION

3.1. Crop water requirement

Table 3.1 ET_o for Upper Beles command area

Month	**Min. Temp (°C)**	**Max. Temp (°C)**	**Average Temp (°C)**	**Humidity (%)**	**Wind (km/day)**	**Sunshine (hr)**	**ET_o (mm/day)**
January	12.4	34.5	23.4	65.3	41.1	9.6	3.95
February	14.3	36.2	25.3	63.6	55.1	9.3	4.51
March	17.6	37.4	27.5	59.1	75.6	8.7	5.09
April	19.0	37.3	28.2	62.9	74.5	8.8	**5.32**
May	19.3	34.5	26.9	65.4	82.1	8.0	4.97
June	18.1	29.8	23.9	81.0	81.0	6.3	3.97
July	17.8	27.7	22.8	86.0	60.5	4.6	**3.31**
August	17.6	27.7	22.7	89.6	57.2	4.8	3.33
September	17.3	29.0	23.2	85.8	49.7	6.1	3.67
October	16.9	30.4	23.7	85.0	33.5	7.3	3.79
November	14.4	32.3	23.3	77.2	30.2	9.4	3.93
December	12.3	33.6	23.0	69.0	35.4	9.8	3.81
Mean	**16.4**	**32.5**	**24.5**	**74.2**	**56.3**	**7.7**	**4.14**

ETO is calculated using *penman monteith* method of CROP WAT-8 computer program from the above long year climatic data.

Table3.2 crop water requirement (ETC) in mm/month

Crop, factor	Age of cane	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.4	0-30	47	47.2	47.2	49	50.5	63.1	63.8	61.6	47.6	41	41.3	44
0.6	31-60	70.5	70.7	70.9	73.5	75.8	94.7	95.8	92.4	71.5	61.6	61.9	66.1
0.8	61-90	94	94.3	94.5	98	101	126.2	127.7	123.3	95.3	82.1	82.6	88.1
0.95	91-120	111.6	112	112.2	116.3	120	149.9	151.6	146.4	113.1	97.5	98.1	104.6
1.1	121-150	129.2	129.7	129.9	134.7	138.9	173.6	175.6	169.5	131	112.9	113.6	121.1
1.25	>150	146.9	147.4	147.6	153.1	157.9	197.2	199.5	192.6	148.9	128.3	129	137.6
0.7	30d before off	82.2	82.5	82.7	85.7	88.4	110.5	111.7	107.8	83.4	71.8	72.3	77.1
0	30d before harvest	0	0	0	0	0	0	0	0	0	0	0	0
1.25	Promoted	146.9	147.4	147.6	153.1	157.9	197.2	199.5	192.6	148.9	128.3	129	137.6

Crop water requirement (ETc) at each crop age is calculated by equation (3a). The maximum value from each month is taken as crop water requirement of that crop.

Table 3.3 Long term average rainfall, CIR, ETC, and effective rainfall for command area.

Month	**Long term average rainfall (mm)**	ETC(mm/month)	**Effective rainfall (mm)**	CIR(mm/month)
January	1.5	153.1	1.5	151.6
February	1.6	157.9	1.6	156.3
March	11.6	197.2	11.4	185.8
April	27.5	199.5	26.3	173.2
May	111.8	192.6	91.8	100.8
June	240.7	148.9	148	0.9
July	366.7	128.3	161.7	0
August	333.7	129	158.4	0
Septembe	216.5	137.6	141.5	0
October	119.9	146.9	96.9	50
Novembe	11.4	147.4	11.2	136.2
December	4.2	147.6	3.9	143.7
Annual	**1,447**	1886	854.2	1098.5

Net application depth ($D_{net)}$=112.5mm/m(equation3f)

D_{gross}=160.7mm/m(equation 3h)

Operating hour$=10 * A * Dgross/I * Q$

Table 3.4 CIR, NIR, GIR Irrigation interval, operating hour and system discharge

Month	CIR(mm/day)	NIR(mm/day)	GIR(mm/day)	II(day)	Operating hour(hour)	Discharge (m^3/s)
January	5.03	5.03	6.71	16	10	3.19
February	5.2	5.2	6.93	16	10	3.19
March	6.19	6.19	8.25	13	12	3.38
April	5.77	5.77	7.69	14	11	3.38
May	3.36	3.36	4.48	25	6	3.23
June	0.03	0.03	0.04	*	*	*
July	0	0		*	*	*
August	0	0		*	*	*
September	0	0		*	*	*
October	1.67	1.67	2.23	*	*	*
November	4.54	4.54	6.05	18	8	3.49
December	4.79	4.79	6.39	17	9	3.31
Annual	36.58	36.58	48.77			19.98

In the above table * indicates the months those not requires irrigation water. Because those season belong to summer. 3.49m^3/s is the maximum system capacity discharge which is found in November and this is our system design discharge (canal design discharge) [8].

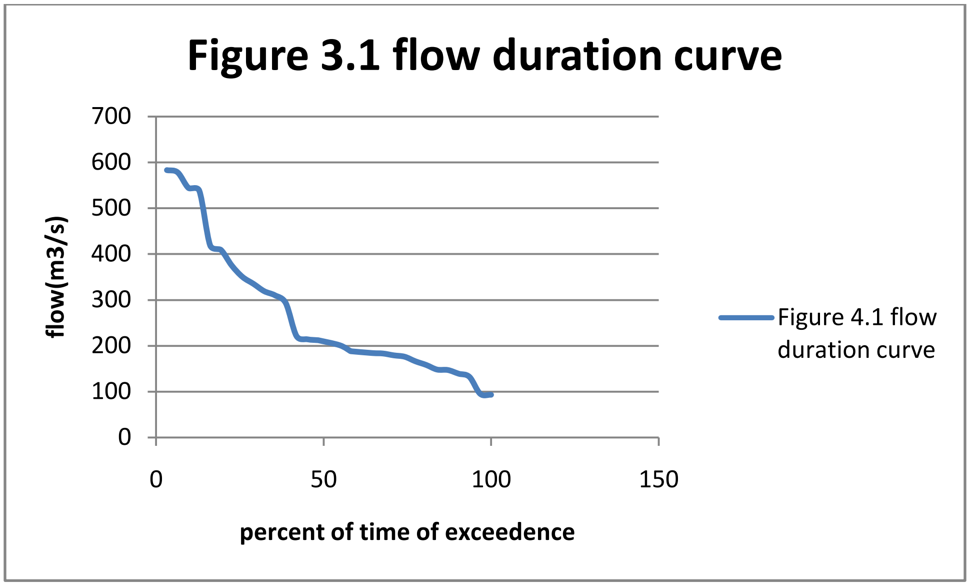
3.2. Checking the quality of hydrological data (Consistency);

Before using stream flow data, it should be carefully reviewed and adjust for errors resulting from; the records for different gauging stations over different period of time. The quality of data can be checked by flow duration curve.

Table4.5 maximum yearly flow

Year	Q max(m^3/s)	year	Decreasing order	Rank(m)	% age of T=(m/n)*100
1973	148	1975	583	1	3.23
1974	310	1998	578	2	6.45
1975	583	1993	544	3	9.68
1976	214	1996	538	4	12.9
1977	221	1999	419	5	16.13
1978	179	1983	409	6	19.35
1979	166	1991	375	7	22.58
1980	95	1981	350	8	25.8
1981	350	1990	335	9	29.06
1982	212	1989	319	10	32.26
1983	409	1974	310	11	35.48
1984	139	1992	293	12	38.71
1985	188	1977	221	13	41.92
1986	184	1976	214	14	45.16
1987	93	1982	212	15	48.39
1988	183	2003	212	15	48.39
1989	319	2000	201`	17	54.84
1990	335	1985	188	18	58.06
1991	375	1995	188	18	58.06
1992	293	1986	184	20	64.52
1993	544	1988	183	21	67.74
1994	147	1978	179	22	70.97
1995	188	2001	176	23	74.19
1996	538	1979	166	24	77.42
1997	132	2002	158	25	80.65
1998	578	1974	148	26	83.87
1999	419	1994	147	27	87.1
2000	201	1984	139	28	90.32
2001	176	1997	132	29	93.55
2002	158	1980	95	30	96.77
2003	212	1987	93	31	100

Using the above flow data and calculated percentage of time of exceedence, flow duration curve can be developed as follow.



From this flow duration curve, the consistency of data can be checked by reading the corresponding flow data [1].

3.3. Determination of peak discharge

Table 3.6 Determination of maximum monthly discharge by *gumbel's* distribution method [1].

Year	Q max(m^3/s)	Decreasing order	Rank(m)	% age of T=(m/n)*100	P=1/T (%)	X-X̄	$(X-\bar{X})^2$
1973	148	583	1	3.23	30.96	315.61	99609.67
1974	310	578	2	6.45	15.5	310.61	96478.57
1975	583	544	3	9.68	10.33	276.61	76513.09
1976	214	538	4	12.9	7.75	270.61	73229.77
1977	221	419	5	16.13	6.2	151.61	22985.59
1978	179	409	6	19.35	5.17	141.61	20053.39
1979	166	375	7	22.58	4.43	107.61	11579.91
1980	95	350	8	25.8	3.88	82.61	6824.41
1981	350	335	9	29.06	3.44	67.61	4571.11
1982	212	319	10	32.26	3.1	51.61	2663.59
1983	409	310	11	35.48	2.82	42.61	1815.61
1984	139	293	12	38.71	2.58	25.61	655.87
1985	188	221	13	41.92	2.39	-42.39	1796.91
1986	184	214	14	45.16	2.21	-53.39	2850.49
1987	93	212	15	48.39	2.07	-55.39	3068.05
1988	183	212	15	48.39	2.07	-55.39	3068.05
1989	319	201`	17	54.84	1.82	-66.39	4407.63
1990	335	188	18	58.06	1.72	-79.39	6302.77
1991	375	188	18	58.06	1.72	-79.39	6302.77

1992	293	184	20	64.52	1.55	-83.39	6953.89
1993	544	183	21	67.74	1.48	-84.39	7121.67
1994	147	179	22	70.97	1.41	-88.39	7812.79
1995	188	176	23	74.19	1.35	-91.39	8352.13
1996	538	166	24	77.42	1.29	-101.39	10279.93
1997	132	158	25	80.65	1.24	-109.39	11966.17
1998	578	148	26	83.87	1.19	-119.39	14253.97
1999	419	147	27	87.1	1.15	-120.39	14493.33
2000	201	139	28	90.32	1.11	-128.39	16483.99
2001	176	132	29	93.55	1.07	-135.39	18330.45
2002	158	95	30	96.77	1.03	-172.39	29718.31
2003	212	93	31	100	1	-174.39	30411.87

$\sum X=8289$ $\sum(X-\bar{X})^2=620955.75$

Mean peak discharge $\bar{X}=267.39 m^3/s$

Mean of squares $\bar{X}^2=91365.42$

Standard deviation (δ) =143.28

From the table 3.7 when n is 31 the value of y_n and s_n are determined by interpolation

N	Y_n	s_n
30	0.5362	1.1124
31	Y_n=?	$S_{n=?}$
40	0.5436	1. 1413

$y_n=0.53694$

In the same way $s_n=1.1152$

By using selecting criteria of return period (T) the value of diversion weir (life span) is 50-100. In our design we take the value of T=75

$Y_T=4.31$ (equation 1e)

K=3.383(equ.1i)

Therefore $X_{T=}752.1 m^3/s$ (equation1h) $=Q_{max}$

This is weir design discharge.

Q_{max} has the probability of occurrence once in 75 years.

Since the design discharge is greater than the maximum of 31-years stream flow data of the study area, this makes the weir to resist any flood occurs within its design period [1].

The maximum design discharge is used in the design, to determine the backwater curve results from constructing the weir in order to predict the highest water level that occurs, on average once every (T) years, where T is the selected return period of the discharge [1].

3.4. Sprinkler design

Sprinkler spacing=12x18 i.e 12m between sprinklers and 18m between laterals.

Nozzle size=4mm

Wetted diameter=30.5m

One sprinkler irrigates 232.56m^2

Pressure=350kpa

Nozzle discharge (q)=0.32l/s=1.152m^3/hr

Sprinkler precipitation rate=5.37mm/hr

Simultaneously operating sprinklers=10906(equation, 2a)

Number of sprinklers per lateral=25 (equation, 2b)

Number of laterals per shift=436 (equation, 2d)

System capacity discharge=3.48m^3/s (equation, 2c)

But the preliminary system capacity discharge is 3.49m^3/s which is greater than system capacity discharge (3.48m^3/s) .Therefore *Hazen William*, our system capacity design discharge is 3.49m^3/s [2].

3.5. Determination of head loss and diameter of laterals and main lines

Allowable head loss through the laterals (Ha) =35.7m (equation, 2e)

Head difference along the lateral (He) =-1.5m (equation,2f)

Allowable head loss due to friction (HL) =0.028m

For lateral, the pipe is steel pipe and friction coefficient is 130.

Assume D=150mm

Head loss (h) =1.062m

To express the head loss per meter length,

hl/L=0.0035<0.028m……………………………………………OK

3.6. Design of main fold

Fixing the diameter of the pipe of main line with in allowable head loss

He = -5[1] = 0 S≈0 H_l = 0.02734m/m

Trial one D=200 mm

Head loss =0.000434m/m which is less than Hl=0.02734m/m…………..OK

Total head= level of the heights irrigable land + head losses +crop height

=1119m +1.062 +0.1302 +2.5=1122.69m

The intake level is 1230.5m above sea level which is much greater than total head (1122.69m), therefore the field can be irrigated by gravity flow.(i.e 1122.69m<1230.5m

GSJ: Volume 10, Issue 7, July 2022
ISSN 2320-9186

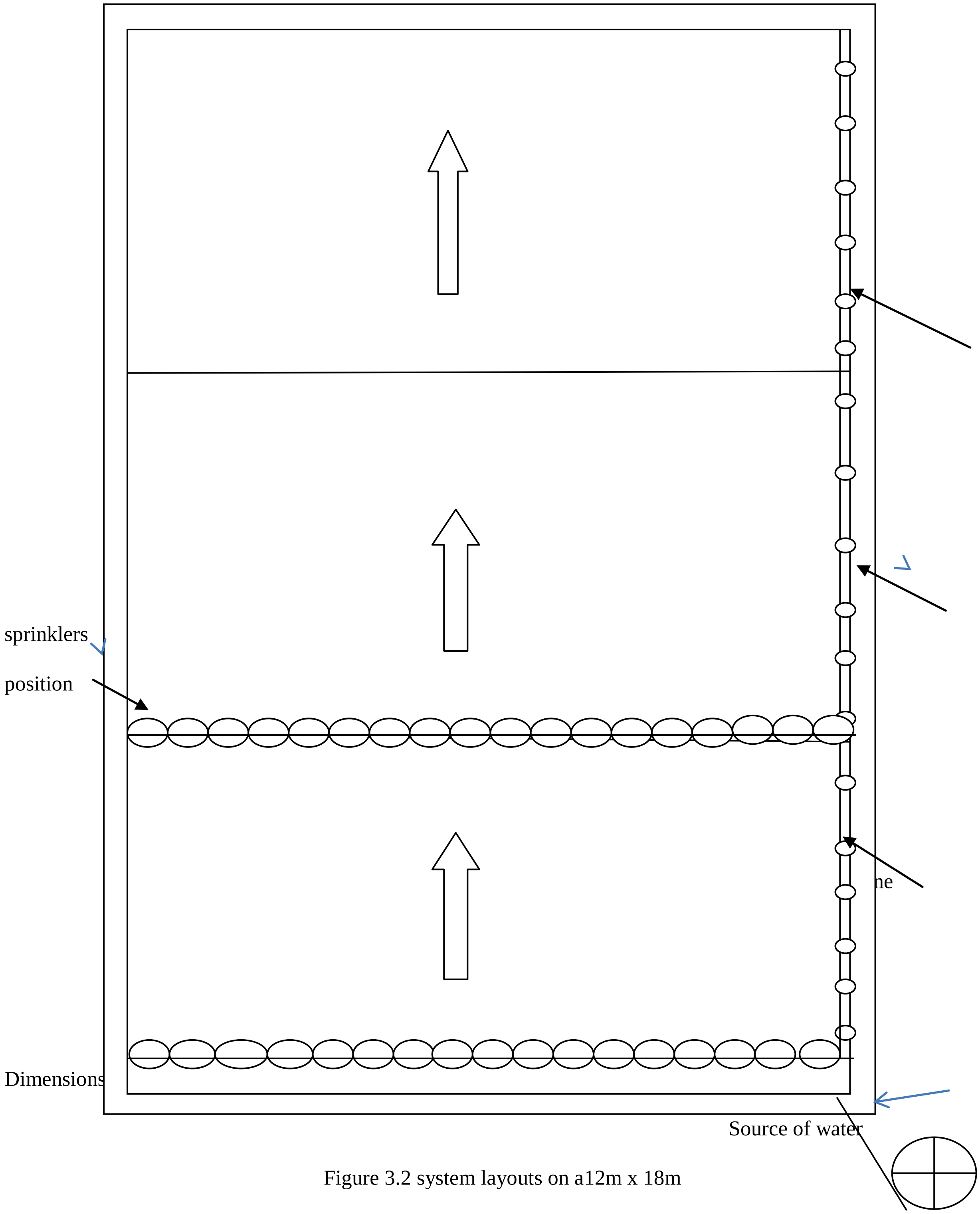


Figure 3.2 system layouts on a12m x 18m

3.7. Canal design

Canal design discharge from field irrigation requirement=3.49m^3/s

Canal side slope for lined canal=1.5:1 (H: V)

Roughness coefficient for concrete lining (n) = 0.015 to 0.02(Table 3.9)

Permissible velocity in lined canal up to 2.5m/s (Table 3.10)

Free board=0.43m (equation, 3a)

Thickness of concrete lining =5cm (Table 3.11)

The system capacity discharge is in the range of 0-5m^3/s, therefore, we take the above value.

Canal shape is trapezoidal

Canal bed slope =1:1000=0.001

Canal depth=1.24m (by equating equation 3d &3h)

Therefore the total canal depth=1.24+0.43(FB)=1.67m

Canal bed width=0.75(equation 3g)

Flow velocity=1.08m/s,

The flow velocity should be less than the permissible velocity. 1.08m/s<2.5m/s (permissible velocity)

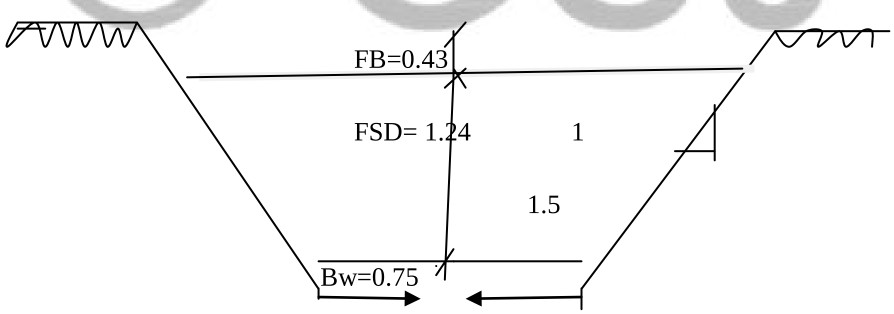


Figure 3.3 canal cross sectio

3.8. Head work structure Design

3.8.1. Weir design

General information

- Design flood=752.1 m ^{3}/s
- Intake discharge = 3.49 m ^{3}/s
- Command area= 1000 ha (This is the potential command area).
- Nature of the wadi bed= continuous hard welded tuff bed rock
- -Intake level= 1230.5 (A Sill height= 0.5m is provided.
- -The *Upper Belles* is intermittent with average or usually flow of 267.39 m ^{3}/s

- Average level of the highest irrigated field = 1119 m a.m.sl
- Geologically the foundation condition is okay at study stage,

Pond level=1232.54; by taking working head =0.8(equation 3i)

Crest height (H)=1232.54-1230=2.54m (equation 3j)

Water way length (Le) =126.15m (equation 3l)

Design head determination

He (head of flow over the weir during high flood level) =1.94m (equation 3n)

Check $P/H_e > 4$, $P/H_e = 2.54/1.94 = 1.31 < 4$

However the rearrangement of the value of C_d is need from the table.

At $P/H_e = 1.3$, $C_d = 2.09$

From previous equation He=1.94m
Discharge intensity (q)=5.96m^2/s(equation 3o)
Scour depth(R)=4.43m(equation 3r)

Normal velocity of flow (v)=1.34m/s(equation 3p)
Velocity head (Ha)=0.1m/s (equation 3q)
Design head (Hd)=1.84m(equation 3m)
Top width of the weir=1.74 m (from equation 3u)
Bottom width of the weir=4.0 m(equation 3v)

Determination the total energy level

Upstream high flow level (U/S HFL) =1234.38 a.m.sl
Upstream total energy level (U/S TEL) =1234.48 a.m.sl
Downstream high flow level (D/S HFL) =1233.38 a.m.sl
Downstream energy level (D/S TEL) =1233.48 a.m.sl

3.8.2. Protection work

Level of u/s pile=1227.72 a.m.sl (equation 4a)
Depth of u/s pile ($d_{1)}$ =2.28m
Level of d/s pile=1224.51 a.m.sl
Depth d/s pile (d_2) =5.49m
Seepage head (Hs) = 30.48m
Length of d/s impervious floor (L_2) =13.4m take 13m (equation 4f)
Length of u/s impervious floor= 2m (equation 4g)

According to Bligh if the hydraulic gradient $H/L \leq 1/c$, there is no danger of piping

$2.54/30.4 \leq 1/12$

$0.083 \leq 0.083$; So that there is no piping

Length of the basin d/s of the weir (L3) =17.3m (equation 4h)

Length of U/s protection work is half of l_3 i.e L_4=8.64m (equation 4i)

a) d/s protection work

Length of d/s protection= 8.64m

Minimum length d/s concrete block =8.24m

Minimum length of d/s launching apron =8.24

Thickness of launching apron t=2m

Provide the d/s concrete block of 1.5m

Provide the d/s inverted filter of 0.5m

b) u/s protection work ;

Length of u/s protection= 8.64m

Take a minimum value of protection length=6m

Minimum length of u/s concrete blocks =2.28m take 3m

Minimum length of u/s launching apron=4.56m take 2m

Launching apron thickness will be t=1.2m take 1.5m

Provide the u/s concrete block of 1m

Provide the u/s inverted filter of 0.5m

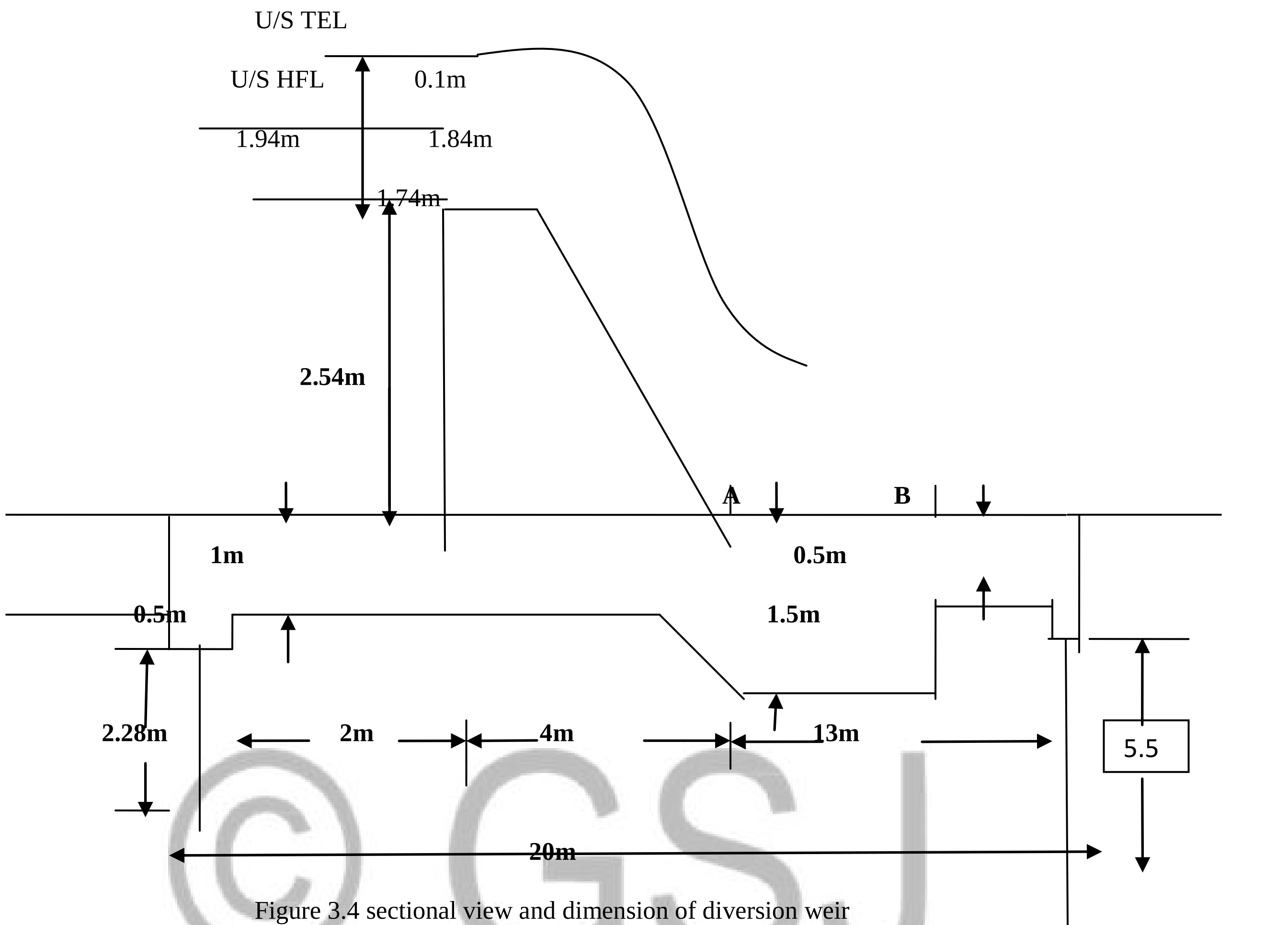


Figure 3.4 sectional view and dimension of diversion weir

4.7.3 Stability analysis of weir

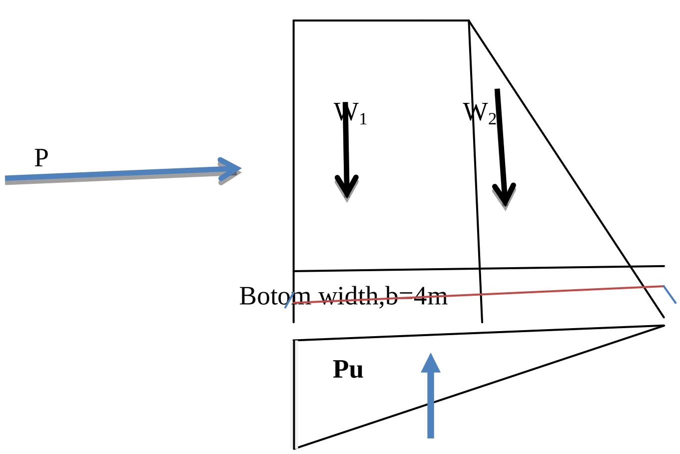


Figure 3 .5 forces acting on the weir

Table 3.8 forces and moments act on the weir

Name 0f force	Symbol	Magnitude in KN	Lever arm	Moment about toe inKN*m
Vertical forces				
Downward weight of weir	W1 W_2 Σ_V	1.74*2.54*23.5=103.86 ½(2.54*2.26)*23.5=67.45 Σv_1=171.31	3.13 1.5	(+)325.08 (+)101.17 Σm=426.25
Uplift pressure	U	½(1*4*24.92)=49.84= Σv_2=-49.84 Σv=121.47	2.67	(-)133.07 Σm_2=-133.07
Horizontal water pressure on upstream faces	PH	2.54*1*24.92=63.30 ΣPH=63.30(towards downstream)	1.27	(-)80.39 Σm_3=-80.39

Failure Due to Overturning,

Fo=2, (equation4j)

Since it is greater than 1.5, So it is safe. i.e, 2 > 1.5, the structure is Safe against overturning. Therefore, there is no problem of overturning.

Failure Due to Sliding

Sliding force (F)= 0.52,(equation4k),

0.52 **<0.7 ………………………………..OK!**

Therefore, the structure is safe against sliding.

Frailer Due to Overstress

X mean=1.75m=$\frac{\Sigma M}{\Sigma V} = \frac{212.79}{121.47} = 1.75M$

Eccentricity = 0.25<B/6 i.e 0.25 <0.667……………………………………………OK

Since e <$\frac{B}{6}$, therefore weir is safe against over stress problem.

3.8.3. Intake design

Intake level=1230.5 m.s.a.l

Q=VA ; hence , Q=3.49M^3/S intake discharge

V=1.34m/s

A= 2.6m^2

Intake Diameter=1.82m ≈ 2m

Redesign the velocity

V= 1.11m/s ……………………..OK [8].

4. Conclusion

The climatic condition indicates that the area is desert, but the annual rainfall is about 1447mm which comes during summer season. From the background of the area and living standard of the people irrigation project is required to harvest more than one in a year.

From the feasibility study of the area, it can be concluded that the majority of the soil is suitable for the production of crops such as sugar cane, tomato, teff, and other edible fruits.

The pressurized irrigation systems (Sprinkler) are preferable than surface irrigation methods; especially in areas of water scarcity, desert and in areas where extensive land leveling is required for surface irrigation. The design of the system is based on the peak water requirement of crops.

The selection of sprinkler spacing depends on wind speed and soil infiltration rate of the study area and precipitation rate of sprinkler. The sprinkler spacing of this project is 12m x 18m.

Penman - Monteith method is used to calculate crop water demand of the crops, which is accomplished by computer software program (CROP WAT 8.0).

Trapezoidal concrete lined canal is designed to off take water from the intake to the field.

Peak flood is estimated using *gumbel's* frequency analysis method based on 31 years river flow data. The peak discharge of 752.5m^3/s is calculated for the design period of 50 year.

Based on the peak discharge vertical u/s and sloped d/s weir and components of head work structure were also designed and relevant dimensions are provided.

The environmental impact assessment (EIA) is also assessed based on the type of the project and the measurement of its negative impact under taken and it was in significant.

References

[1] *Garg* ,S,K,L 1999 irrigation engineering and hydraulic structure 14th edition

[2] Irrigation engineering 1 hand out(2004 E.C) by Teacher *GIRMA.B*

[3] FAO-SAFR, Harare,1982

[4] FAO-SAFR, Harare,1985

[5] FAO,SAFR, Harare,2001

[6] FAO-SAFR, Harare,2002

[7] (FAO, 1998)

[8] ARORA, K.R (2001) Irrigation, water power and water resource engineering

[9] Flood and drought management hand out(2006 E.C) by Dr. *ASFAW.K*