Impact of Numbers of Sub-Units on Hydraulic and Economic Results of Drip Irrigation System on a Square Field

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Abstract *Drip Irrigation System (DIS) offers application efficiency greater than 90% whereas other traditional irrigation methods gives application efficiency up to 60-70%, other advantage of DIS is, it can be use in most of the field condition and for almost any kind of crops. Amongst various DIS design, design with multiple sub-units is best option for better design, operation and control. However, little information is available on division of field in sub-units. Sub-units are very useful in simplifying the DIS design for field as only for one sub-unit we need to design and then we can apply the same design to each and every sub-units. The objective of this study was to analyze the hydraulic result and economic result for different numbers of sub-unit on a two different square fields one with length and width of 100 m and other having length and width of 200 m, wherein other parameters like crop, infiltration rate, power availability, application efficiency, available discharge, temperature, evapotranspiration remains same. The study is carried out for two possibilities of source of water either at corner or at center. For hydraulic analysis head loss and head required at source is taken into consideration and for economic analysis only cost of pipes are taken into consideration because all other costs like operation cost and of cost other components remains almost same. For economic analysis laterals of LLDPE and manifold, submain and main are of PVC and HDPE material is considered.*

Keywords *Drip Irrigation System, Best/Worst Sub-units, Hydraulic analysis, Economic Analysis, Square Field*

I. INTRODUCTION

Irrigation is essential for agriculture because water requirement of crop is supplied by precipitation but as we know precipitation is not uniformly distributed so whenever and wherever water requirement by crop is not fulfilled by precipitation then that requirement needs to fulfill artificially, by irrigation. As we know several irrigation methods are available for irrigation, selection of one depends upon many factors like type of crop, topography, water availability, soil characteristics, available cost etc. Among all the irrigation methods (Surface and Pressurized methods) available, DIS offers highest application efficiency greater than 90% though DIS is not widely used as all other traditional methods with application efficiency up to 60-70% are being used because of high capital cost associated with DIS. Capital cost of DIS can be reduced by proper design which can be achieved by dividing field into sub-units but there can be many possibilities of dividing field into sub-units. For finding out best or optimum design, there is need of analyze all the possibilities. For that for all the hydraulic and economic results related with respective possible sub-units needs to compare and analyze.

Kaneria and Suryanarayana(2017) presented hydraulic and economic analysis of best and worst possibilities of sub-units of drip irrigation system on a rectangular field and conclude that hydraulically best designs and economically best designs are different and hydraulic parameters as well as cost of Drip irrigation system highly depends upon the numbers of sub-units selected for field division.

So objective of this study is to compare and analyze all the possible sub-unit size and its hydraulic and economic results for a square field of dimension 100mx100m and 200mx200m with source of water either at corner or at center, to understand significance of sub-unit size on DIS design. For hydraulic analysis head loss and head required at source is taken into consideration and for economic analysis only pipe cost is considered as cost of all other components and operating cost are almost same. For economic analysis laterals of LLDP and manifold, submain, main of PVC and HDPE material is considered to compare the result of both the materials. For cost consideration guidelines of Gujarat Green Revolution Company Limited is followed.

Main reasons for partitioning field into sub-units

- Smaller the sub-unit better the control over application
- In case of limited availability of water field can be irrigated unit by unit
- Usually higher field size requires higher diameter pipe and also long length of pipe is required. Larger diameter and longer length tends to high head loss.
- By dividing field into sub-units smaller and shorter pipe will be required and thus reduction in head loss

II. METHODOLOGY

For designing any irrigation system first parameter required is water requirement of field which depends on crop water requirement. Water requirement can be find out easily if reference crop evapotranspiration (Eto) and crop coefficient (Kc) is known. For designing DIS also we need Net irrigation depth (NID) which is crop water requirement, then assuming application efficiency 98% we can find gross irrigation depth (GID) from NID. Maximum numbers of sub-units or sets in which field can be divided is depend upon power availability and required operation time, operation time depends upon GID, infiltration rate, emitter discharge, emitter spacing and power availability is generally taken as 12hrs because in India power availability for irrigation purpose in rural area is less than 12hrs. In this study, Maximum number of field divisions came out to be 37. After determining maximum numbers of sub-units, one needs to design DIS for all the possible numbers of sub-units, sub-units cannot be prime number (one cannot divide field into 37 sub-units), and therefore the maximum numbers of the field divisions is considered to be 36 and similarly the minimum number is considered as 4. From the sub-unit one can work out length of laterals, manifolds, submain and main then head loss is computed by Darcy-Weisbach equation and for finding friction factor Churchill's equation is used, at the end of design head required at source should be less than 40 m because components considered for this study are of grade 4 so if at the end head required at source is more than 40 m then one needs to redesign the DIS. For the economic analysis laterals are of LLDPE material and manifolds, submains and mains are of PVC & HDPE material are considered. The range of diameter for various components used in this study is given in Table I

Table I: Range of Diameter of Different Components

Sr.no	System Component	Range of Diameter of pipe, mm
1	Lateral	12,16,20,25
2	Manifold, Submain	20,25,32,40,50,63,75,90, 110,125
3	Main	32,40,50,63,73,90,110, 125

Table II: Various sub-possibilities For 36 Sub-Units

Number of Sub-Units	Column	Row
36	18	2
	2	18
	12	3
	3	12
	9	4
	4	9
	6	6

As shown in Table II for 36 sub-units, several combinations of columns and rows are possible, similarly for all other possible numbers of sub-units, various combination are considered and thus 69 possible designs for DIS are worked out for carrying out hydraulic and economic analysis of DIS design.

ECONOMIC ANALYSIS

For economic analysis of DIS only cost of pipes are taken into consideration as it is a variable costs. Following equation is used for finding out cost of DIS,

Cost = (CL*LL*NL* NSU) + (CMn*LMn*NMn) + (CS*LS*NS)+ (CM*LM *NM)

Where,

CL, CMn, CS, CM are unit cost of lateral, manifold, submain and main respectively
LL, LMn, LS, LM are length of lateral, manifold, submain and main respectively
NL is nos. of laterals in one sub-unit
NSU is total nos. of sub-units
NMn, NS, NM is nos. of manifold, submain and main in system respectively

Cases considered for this study are as following,

Case-1 field having length of 100 m and width of 100 m and source of water at corner
Case-2 field having length of 100 m and width of 100 m and source of water at center
Case-3 field having length of 200 m and width of 200 m and source of water at corner
Case-4 field having length of 200 m and width of 200 m and source of water at center

For DIS design, layout of all the components is very important which is governed by numbers of sub-units selected for a field division and it also depends on combination of columns and rows selected for particular number of sub-unit. Figure 1 shows design layout of various sub-possibilities of 10 sub-units, which is one of the best hydraulic designs, as for case 1 and case 2 and figure 2 shows various layouts for 30 sub-units which is one of the best economical design, as for case 3 and case 4.

DESIGN LAYOUT

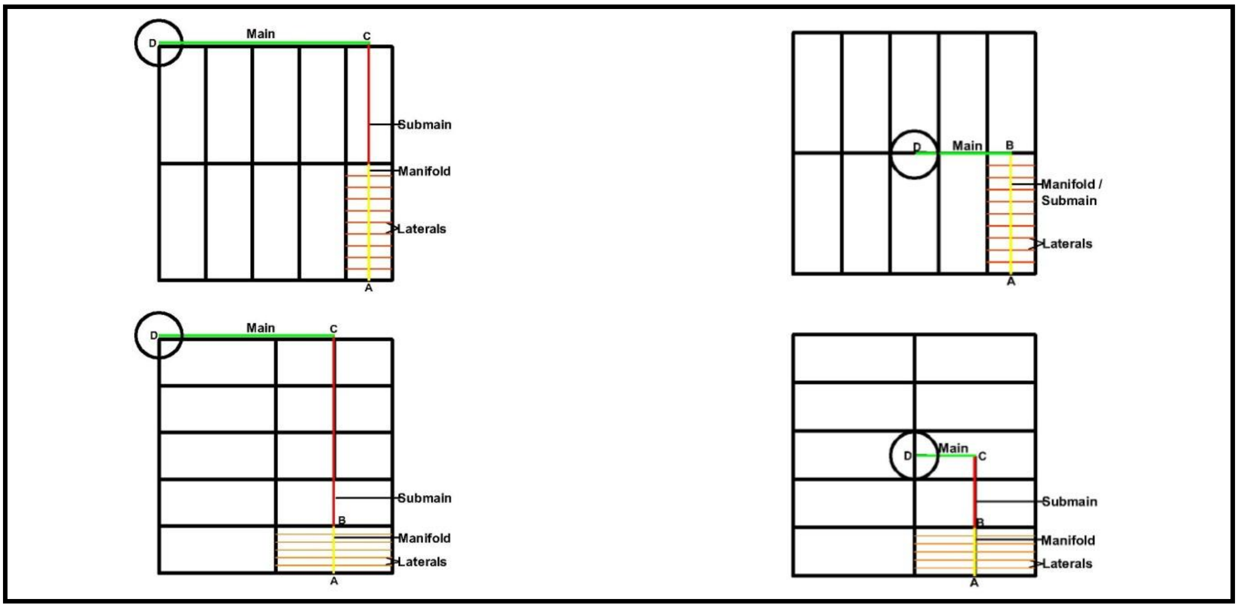

Fig.1: Design Layout For Field of Dimension 100m x 100m with Location of Source of Water at Corner and at Center, Having 10 Sub-units

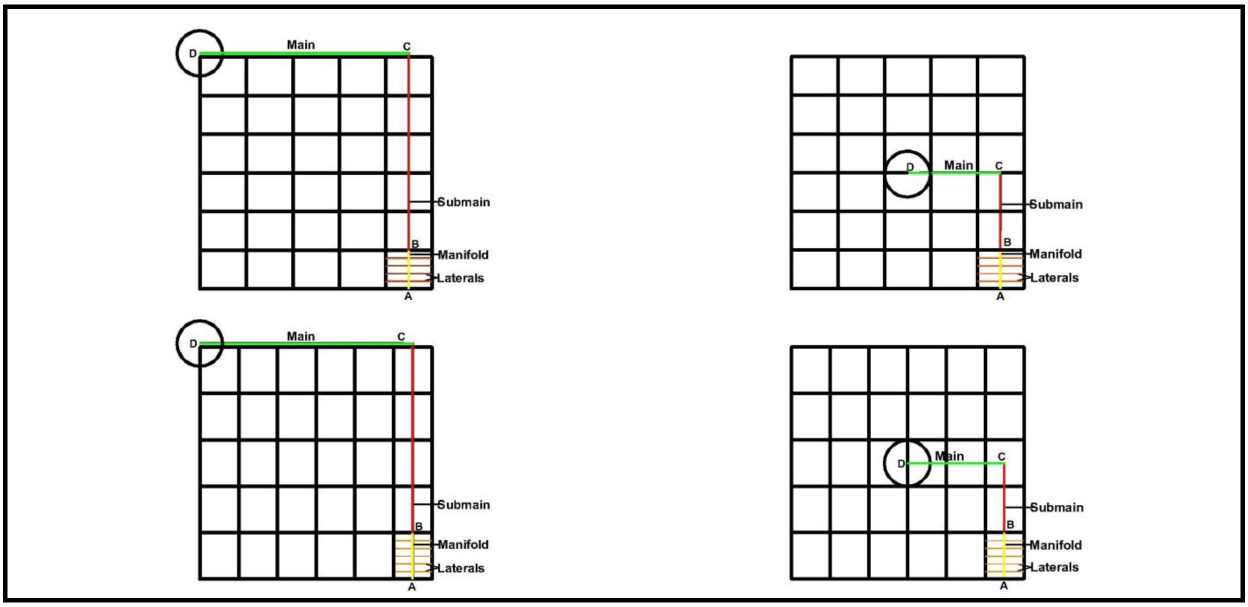

Fig.2: Design Layout For Field of Dimension 200m x 200m with Location of Source of Water at Corner and at Center, Having 30 Sub-units

INPUT DATA

Table III: Input Data for Study

Field Size (m^2)	100x100/200x200
Source Location	Corner/Center
Crop Spacing (m)	0.5
Row Spacing (m)	0.6
infiltration rate (mm/hr)	25
Et_o (mm/day)	5
K_c	1
Emitter Discharge (lph)	4
Appli. Efficiency (%)	98
Power availability (hr)	12
Temperature (^oC)	27

ASSUMPATIONS

- At a time only one sub-unit is irrigated
- Diameter of manifold and submain is kept same, hence if there is need to change in diameter of manifold, diameter of submain is also change and vice versa
- Diameter of main is taken equal to or greater than diameter of submain
- First emitter is considered at half spacing from manifold
- Inline emitter is taken into consideration for this study
- There is no slope in the field

III.RESULTS & ANALYSIS

In this study four different cases are taken into consideration as we can see in input data. For the data given in Table III maximum 37 numbers of sub-units worked out. As stated earlier sub-units cannot be prime number so in all the cases maximum 36 sub-units can be possible which means we cannot divide field into more than 36 number. So starting from 36 and ending at 4 all the possibilities with various sub-possibilities had been worked out and it is found out that total 69 possibilities are under each case. For an economic comparison cost of PVC material is considered because as shown in table 3 to table 18 cost of DIS design with DIS design with HDPE material is 0.42% to 25.63% more costly than design with PVC material. Form the study following results are obtained

For first case, as shown in Table IV, V, VI, VII field having length of 100 m and width of 100 m and source of water at corner, according to hydraulic parameters for best design one needs to divide field into 10 sub-units having 5 columns and 2 rows, for this design head loss is 5.8739 m and head required at source is 23.4380 m with cost for PVC is RS.1,59,721 and for HDPE is Rs.1,74,223.Whereas worst design according to hydraulic parameters is found out for field division into 18 with 6 columns and 3 rows, for this head loss is 20.8229 m and head required source is 39.8908m with cost of Rs.1,50,776 and Rs.1,55,458 for PVC and HDPE respectively. According to economic results best design is found out for field division into 30 with 10 columns and 3 rows having head loss of 8.2280 m and head required at source is 26.0471 m with cost of PVC is Rs.1,35,098 and cost of HDPE is Rs.1,42,511 and economically worst result is found for field division into 36 with 18 columns and 2 rows having head loss of 6.4983 m and head required at source is 24.1469 m with cost of PVC is Rs. 1,84,051 and HDPE is Rs.1,96,895.

For second case, as shown in Table VIII, IX, X, XI field having length of 100 m and width of 100 m and source of water at center, according to hydraulic parameters for best design one needs to divide field into 10 sub-units having 5 columns and 2 rows, for this design head loss is 2.2028 m and head required at source is 19.3998 m with cost for PVC is RS.1,59,281 and for HDPE is Rs.1,73,538.Whereas worst design according to hydraulic parameters is found out for field division into 36 with 3 columns and 12 rows, for this head loss is 20.6769 m and head required at source is 39.6518 m with cost of Rs.1,44,654 and Rs.1,45,358 for PVC and HDPE respectively. According to economic results best design is found out for field division into 33 with 3 columns and 11 rows having head loss of 11.6724 m and head required at source is 29.7469 m with cost of PVC is Rs.1,41,598 and cost of HDPE is Rs.1,42,731 and economically worst result is found for field division into 36 with 18 columns and 2 rows having head loss of 2.5493 m and head required at source is 9.8029 m with cost of PVC is Rs.1,83,977 and HDPE is Rs.1,96,803.

For third case, as shown in Table XII, XIII, XIV, XV field having length of 200 m and width of 200 m and source of water at corner, according to hydraulic parameters for best design one needs to divide field into 12 sub-units having 6 columns and 2 rows, for this design head loss is 6.9760 m and head required at source is 24.5808 m with cost for PVC is RS.7,97,742 and for HDPE is Rs.8,87,523.Whereas worst design according to hydraulic parameters is found out for field division into 16 with 2 columns and 8 rows, for this head loss is 21.0082 m and head required at source is 39.9728 m with cost of Rs.7,48,790 and Rs.7,83,679 for PVC and HDPE respectively. According to economic results best design is found out for field division into 35 with 5 columns and 7 rows having head loss of 17.2957 m and head required at source is 35.8719 m with cost of PVC is Rs.5,84,573 and cost of HDPE is Rs.6,13,578 and economically worst result is found for field division into 8 with 4 columns and 2 rows having head loss of 13.9398 m and head required at source is 32.2693 m with cost of PVC is Rs.7,88,162 and HDPE is Rs.9,13,469.

For fourth case, as shown in Table XVI, XVII, XVIII, XIX field having length of 200 m and width of 200 m and source of water at center, according to hydraulic parameters for best design one needs to divide field into 12 sub-units having 6 columns and 2 rows, for this design head loss is 2.7942 m and head required at source is 19.9809 m with cost for PVC is RS.7,07,627 and for HDPE is Rs.8,83,262.Whereas worst design according to hydraulic parameters is found out for field division into 30 with 2 columns and 15 rows, for this head loss is 20.6555 m and head required at source is

39.5849 m with cost of Rs.7,26,315 and Rs.7,31,201 for PVC and HDPE respectively. According to economic results best design is found out for field division into 35 with 5 columns and 7 rows having head loss of 8.0438 m and head required at source is 25.6928 m with cost of PVC is Rs.5,83,693 and cost of HDPE is Rs.6,12,206 and economically worst result is found for field division into 8 with 4 columns and 2 rows having head loss of 5.0747 m and head required at source is 22.5177 m with cost of PVC is Rs.7,84,995 and HDPE is Rs.9,07,089.

From table IV and table VIII it is observed that for case 1 and case 2 hydraulically best possibilities of sub-units are same but hydraulic and economic results are different. However, economic results are more or less same but there is a large difference in hydraulic results so, location of source of water at center is better option. From table XII and table XVI similar results are observed for case 3 and case 4.

TABLE IV: HYDRAULICALLY BEST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CORNER

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	18	2	6.4983	24.1469	184050.504	196894.548	12844.044	6.9785
34	17	2	6.4921	24.1400	178511.036	190677.403	12166.367	6.8155
32	16	2	6.4852	24.1323	176714.450	188202.463	11488.013	6.5009
18	9	2	6.3528	23.9847	173907.112	179943.120	6036.008	3.4708
10	5	2	5.8739	23.4380	159721.100	174223.300	14502.200	9.0797

TABLE V: ECONOMICALLY BEST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CORNER

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
34	2	17	17.5242	36.2124	143117.500	144243.250	1125.750	0.7866
33	3	11	17.3361	35.9771	142093.132	143584.073	1490.941	1.0493
30	10	3	8.2280	26.0471	135097.500	142510.650	7413.150	5.4873
30	3	10	20.3803	39.3255	142093.132	143584.073	1490.941	1.0493
26	2	13	10.9041	28.9300	142502.500	144364.250	1861.750	1.3065

TABLE VI: HYDRAULICALLY WORST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CORNER

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
32	2	16	19.0512	37.8919	174611.500	175737.250	1125.750	0.6447
30	5	6	20.6759	39.7202	149407.600	151561.900	2154.300	1.4419
28	4	7	20.4888	39.4946	148009.875	149777.000	1767.125	1.1939
27	3	9	20.6036	39.5712	144800.600	147775.114	2974.514	2.0542
18	6	3	20.8229	39.8908	150775.732	155458.541	4682.809	3.1058

TABLE VII: ECONOMICALLY WORST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CORNER

Source at Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	18	2	6.4983	24.1469	184050.504	196894.548	12844.044	6.9785
34	17	2	17.5242	36.2124	178511.036	190677.403	12166.367	6.8155
12	2	6	13.8985	32.2238	178468.750	180138.000	1669.250	0.9353
6	2	3	14.2705	32.6331	178264.250	185023.750	6759.500	3.7918
4	2	2	12.2651	30.4272	183883.75	199465.250	15581.500	8.4736

TABLE VIII: HYDRAULICALLY BEST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	18	2	2.5493	19.8029	183977.872	196802.960	12825.088	6.9710
34	17	2	2.5455	19.7987	178435.810	190582.544	12146.734	6.8073
32	16	2	2.5379	19.7903	176634.036	188101.062	11467.026	6.4920
18	9	2	2.4400	19.6807	173687.088	179689.104	6002.016	3.4556
10	5	2	2.2028	19.3998	159281.200	173537.600	14256.400	8.9505

TABLE IX: ECONOMICALLY BEST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
33	3	11	11.6724	29.7469	141597.996	142730.790	1132.794	0.8000
30	3	10	13.6713	31.9457	141597.996	142730.790	1132.794	0.8000
27	3	9	16.5420	35.1034	142801.899	143934.693	1132.794	0.7933
24	3	8	20.4257	39.3754	144005.802	145138.596	1132.794	0.7866
15	3	5	11.7719	29.8563	143945.439	146427.321	2481.882	1.7242

TABLE X: HYDRAULICALLY WORST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
36	3	12	20.6769	39.6518	144653.850	145358.112	704.262	0.4869
26	2	13	16.9101	35.5367	174914.500	175687.000	772.500	0.4416
25	5	5	19.4407	38.3615	148673.300	150465.500	1792.200	1.2055
24	3	8	20.4257	39.3754	144005.802	145138.596	1132.794	0.7866
20	2	10	18.5337	37.3226	170969.000	171925.500	956.500	0.5595

TABLE XI: ECONOMICALLY WORST DESIGNS FOR FIELD SIZE 100 M X 100 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	18	2	2.5493	19.8029	183977.872	196802.960	12825.088	6.9710
34	17	2	2.5455	19.7987	178435.810	190582.544	12146.734	6.8073
10	2	5	7.3678	25.0401	176987.500	178505.000	1517.500	0.8574
6	2	3	5.1258	22.5739	177164.500	183309.500	6145.000	3.4685
4	2	2	3.8343	21.1533	182318.500	196483.500	14165.000	7.7694

TABLE XII: HYDRAULICALLY BEST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CORNER

Source at Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
32	16	2	8.5062	26.3514	750213.285	942500.327	192287.042	25.6310
30	15	2	8.4971	26.3411	736065.843	916998.221	180932.378	24.5810
20	10	2	7.6020	25.3389	727149.600	905634.600	178485.000	24.5458
18	9	2	9.0050	26.8749	708830.850	870926.200	162095.350	22.8680
12	6	2	6.9760	24.5808	709741.710	887523.426	177781.716	25.0488

TABLE XIII: ECONOMICALLY BEST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CORNER

Source at Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	6	6	16.0095	34.5177	595384.299	629385.813	34001.514	5.7109
35	5	7	17.2957	35.8719	584573.200	613577.600	29004.400	4.9616
30	6	5	15.6300	34.1002	597994.743	637876.521	39881.778	6.6693
30	5	6	16.3540	34.8340	588725.800	623504.600	34778.800	5.9075
25	5	5	18.1105	36.7662	592574.200	631824.200	39250.000	6.6236

TABLE XIV: HYDRAULICALLY WORST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CORNER

Source at Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
26	2	13	20.6300	39.5569	736397.500	754728.500	18331.000	2.4893
24	2	12	20.6357	39.5631	749902.000	771959.000	22057.000	2.9413
20	5	4	20.1615	39.0223	608947.800	675806.600	66858.800	10.9794
16	2	8	21.0082	39.9728	748790.000	783679.000	34889.000	4.6594
12	3	4	20.2591	39.1419	733804.284	796290.334	62486.050	8.5154

TABLE XV: ECONOMICALLY WORST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CORNER

Source at Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
12	2	6	19.6314	38.4584	761262.000	806087.000	44825.000	5.8882
10	2	5	18.9882	37.7509	765925.000	817803.000	51878.000	6.7732
8	4	2	13.9398	32.2693	788161.500	913468.500	125307.000	15.8986
8	2	4	14.6428	32.9710	784423.000	855109.000	70686.000	9.0112
6	2	3	13.0787	31.2505	782283.000	852969.000	70686.000	9.0359

TABLE XVI: HYDRAULICALLY BEST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
32	16	2	3.3393	20.6678	749818.842	941748.926	191930.084	25.5969
30	15	2	3.3302	20.6575	735646.356	916199.112	180552.756	24.5434
20	10	2	2.9631	20.2361	726265.200	903935.200	177670.000	24.4635
18	9	2	3.4980	20.8172	707849.166	869039.866	161190.700	22.7719
12	6	2	2.7942	19.9809	707626.488	883261.920	175635.432	24.8204

TABLE XVII: ECONOMICALLY BEST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	Cost PVC	Cost HDPE	Difference	% Increase
36	6	6	14.5178	32.8768	589009.666	600388.694	11379.028	1.9319
35	5	7	8.0438	25.6928	583693.400	612206.200	28512.800	4.8849
30	6	5	9.7752	27.6599	593847.064	627438.092	33591.028	5.6565
30	5	6	10.2637	28.1347	584494.400	613007.200	28512.800	4.8782
25	5	5	13.6273	31.8347	583693.400	612206.200	28512.800	4.8849

TABLE XVIII: HYDRAULICALLY WORST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
36	2	18	20.1080	38.9827	732265.000	735300.000	3035.000	0.4145
33	3	11	18.5318	37.2419	698430.608	705351.580	6920.972	0.9909
32	2	16	19.1297	37.9065	739155.000	744041.000	4886.000	0.6610
30	2	15	20.6555	39.5849	726315.000	731201.000	4886.000	0.6727
28	2	14	20.6514	39.5804	747422.000	762702.000	15280.000	2.0444

TABLE XIX: ECONOMICALLY WORST DESIGNS FOR FIELD SIZE 200 M X 200 M WHEN SOURCE AT CENTER

Source at Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost	HDPE Cost	Difference	% Increase
9	3	3	4.9583	22.3110	756895.776	851152.344	94256.568	12.4530
8	4	2	5.0747	22.5177	784995.000	907089.000	122094.000	15.5535
8	2	4	5.7295	23.1663	778090.000	842350.000	64260.000	8.2587
6	3	2	4.7092	22.0370	756895.776	851152.344	94256.568	12.4530
6	2	3	4.8589	22.2087	775950.000	840210.000	64260.000	8.2815

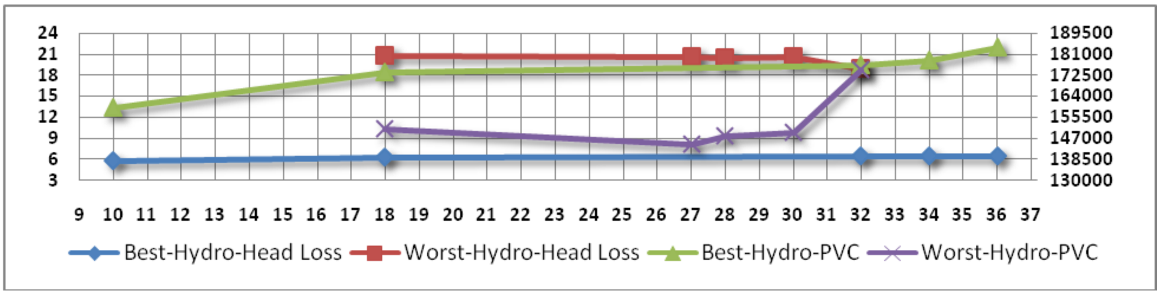

Fig.3: Hydraulically Best/Worst Results for case 1

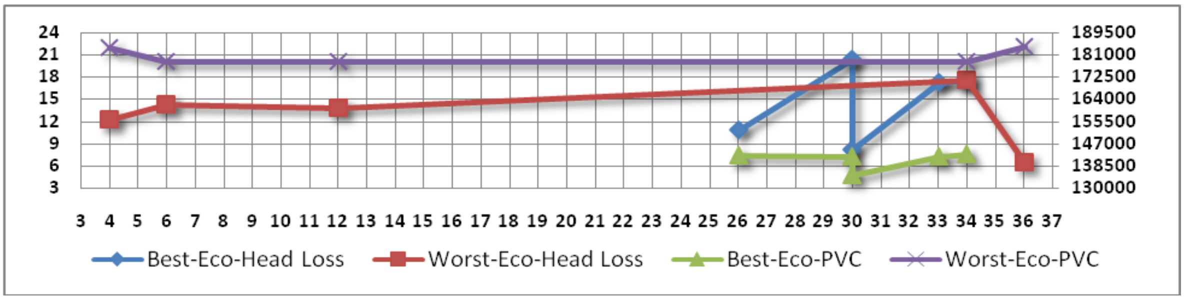

Fig.4: Economically Best/Worst Results for case 1

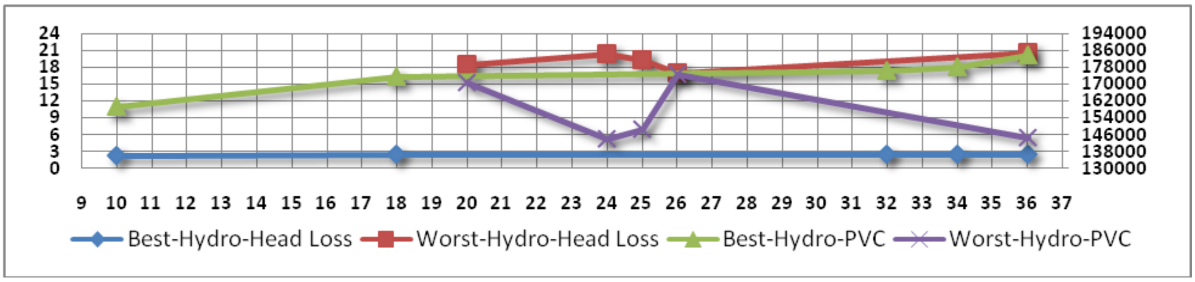

Fig.5: Hydraulically Best/Worst Results for case 2

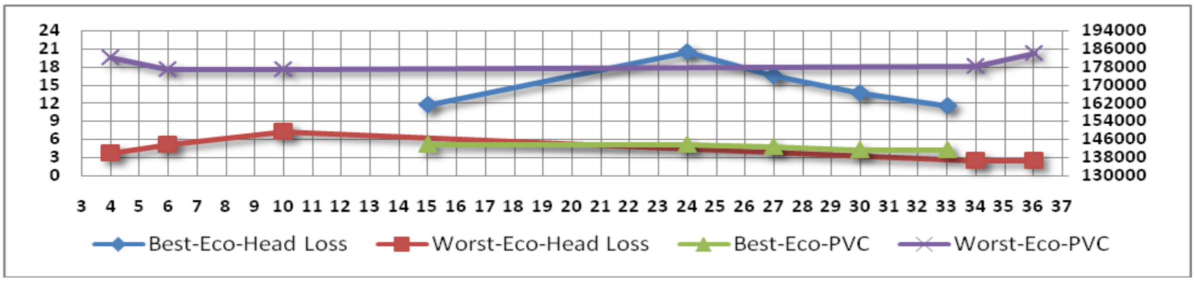

Fig.6: Economically Best/Worst Results for case 2

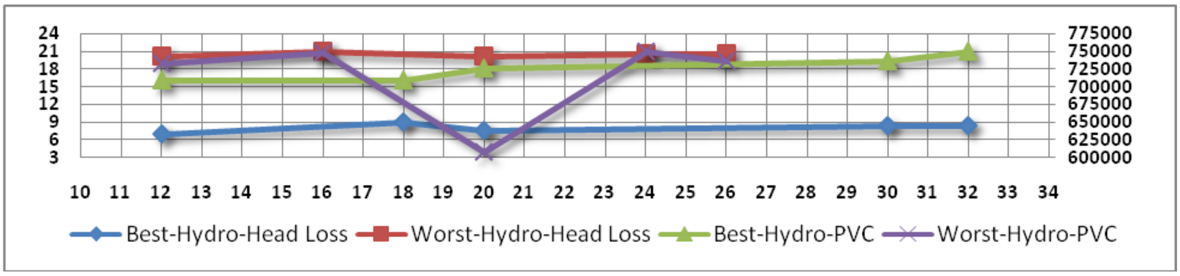

Fig.7: Hydraulically Best/Worst Results for case 3

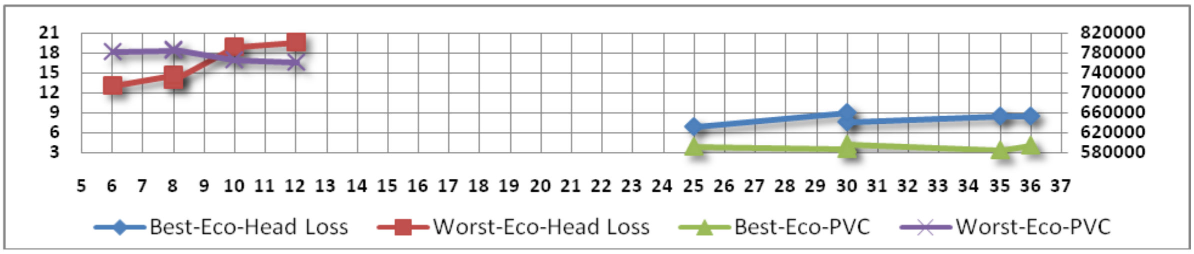

Fig.8: Economically Best/Worst Results for case 3

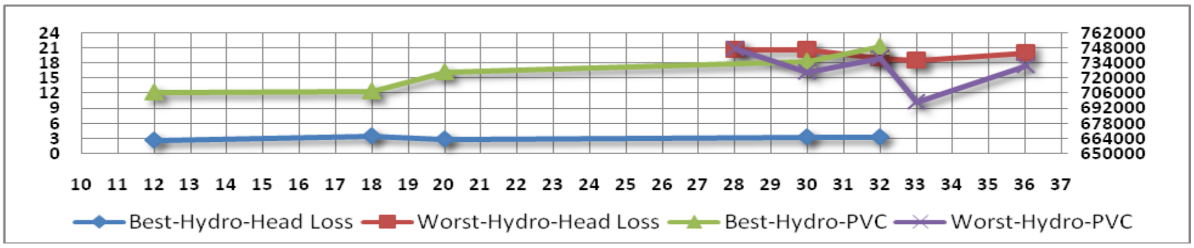

Fig.9: Hydraulically Best/Worst Results for case 4

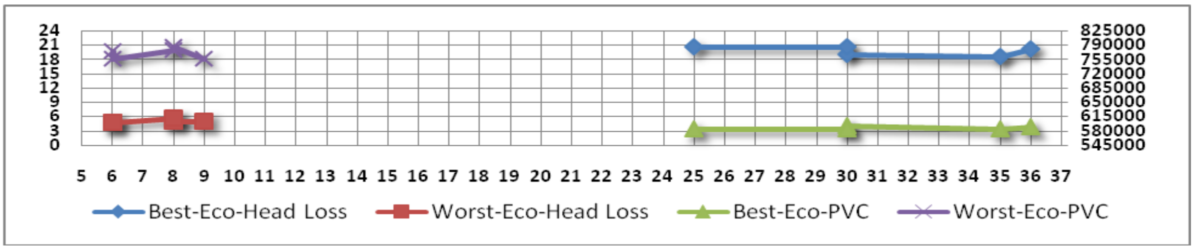

Fig.10: Economically Best/Worst Results for case 4

CONCLUSIONS

As stated earlier there are 69 possibilities for any single case and from the results we can say that there is large variation of cost as well as hydraulic parameter of DIS for different possibilities. For each case best results are stated below.

For first case, field having length of 100 m and width of 100 m and source of water at corner, according to hydraulic parameters for best design one needs to divide field into 10 sub-units having 5 columns and 2 rows, for this design head loss is 5.8739 m and head required at source is 23.4380 m with cost for PVC is RS.1,59,721 and for HDPE is Rs.1,74,223 and according to economic results best design is found out for field division into 30 with 10 columns and 3 rows having head loss of 8.2280 m and head required at source is 26.0471 m with cost of PVC is Rs.1,35,098 and cost of HDPE is Rs.1,42,511.

For second case, field having length of 100 m and width of 100 m and source of water at center, according to hydraulic parameters for best design one needs to divide field into 10 sub-units having 5 columns and 2 rows, for this design head loss is 2.2028 m and head required at source is 19.3998 m with cost for PVC is RS.1,59,281 and for HDPE is Rs.1,73,538 and according to economic results best design is found out for field division into 33 with 3 columns and 11 rows having head loss of 11.6724 m and head required at source is 29.7469 m with cost of PVC is Rs.1,41,598 and cost of HDPE is Rs.1,42,731.

For third case, field having length of 200 m and width of 200 m and source of water at corner, according to hydraulic parameters for best design one needs to divide field into 12 sub-units having 6 columns and 2 rows, for this design head loss is 6.9760 m and head required at source is 24.5808 m with cost for PVC is RS.7,97,742 and for HDPE is Rs.8,87,523 and according to economic results best design is found out for field division into 35 with 5 columns and 7 rows having head loss of 17.2957 m and head required at source is 35.8719 m with cost of PVC is Rs.5,84,573 and cost of HDPE is Rs.6,13,578.

For fourth case, field having length of 200 m and width of 200 m and source of water at center, according to hydraulic parameters for best design one needs to divide field into 12 sub-units having 6 columns and 2 rows, for this design head loss is 2.7942 m and head required at source is 19.9809 m with cost for PVC is RS.7,07,627 and for HDPE is Rs.8,83,262 and according to economic results best design is found out for field division into 35 with 5 columns and 7 rows having head loss of 8.0438 m and head required at source is 25.6928 m with cost of PVC is Rs.5,83,693 and cost of HDPE is Rs.6,12,206

Therefore, it can be concluded that if field is of 100 m x 100 m then the best possibility may be 10 sub-units having 5 columns and 2 rows and if field is of 200 m x 100 m then the best possibility may be 12 sub-units having 6 columns and 2 rows, and in both the cases, preferably the source at center.

From the results it is observed that for case 1 and case 2, hydraulically best design costs more than the hydraulically worst design and for case 3 and case 4 for some possibilities, hydraulically best design costs less than the hydraulically worst design. Results also indicates that hydraulically best designs and economically best designs are not same, so according to one's requirement whether it may be low investment cost or it may be more concern about head loss, one needs to choose the numbers of sub-units for field division. From this study, it is also observed that DIS design with HDPE material is 0.42% to 25.63 costly than of PVC material. From the obtained results, one can conclude that hydraulic parameters, as well as cost of DIS, highly depend upon the numbers of sub-units selected for field division.

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