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Determination of Best and Worst Possibilities of Sub-Units of Drip Irrigation System on a Rectangular Field Considering Hydraulic and Economic Analysis

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Abstract: *Amongst all the irrigation systems, Drip Irrigation System (DIS) offers highest application efficiency greater than 90% and it can be used for most of the crops in most of terrain. For better design, operation and control of DIS, division of field into several sub-units is best option. However, little information is available on division of field into 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 results and economic results for different numbers of sub-unit on a rectangular field having area of 2 ha with two different fields one with length of 100 m and width of 200 m and other having length of 200 m and width of 100m, 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, Rectangular 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. So objective of this study is to compare and analyze all the possible sub-unit size and its hydraulic and economic results for a rectangular field of dimension 100mx200m and 200mx100m 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 (Et_o) and crop coefficient (K_c) 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 1

Table 1: 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 2: 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 2 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.

III. EconomicAnalysis

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,

$$Cost = (C_L*L_L*N_L*N_{SU}) + (C_{Mn}*L_{Mn}*N_{Mn}) + (C_S*L_S*N_S) + (C_M*L_M*N_M)$$

Where,

C_L, C_{Mn}, C_S, C_M are unit cost of lateral, manifold, submain and main respectively

L_L, L_{Mn}, L_S, L_M are length of lateral, manifold, submain and main respectively

N_L is nos. of laterals in one sub-unit

N_{SU} is total nos. of sub-units

N_{Mn}, N_S, N_M 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 200 m and source of water at corner

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

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

Case-4 field having length of 200 m and width of 100 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

IV. Design Layout

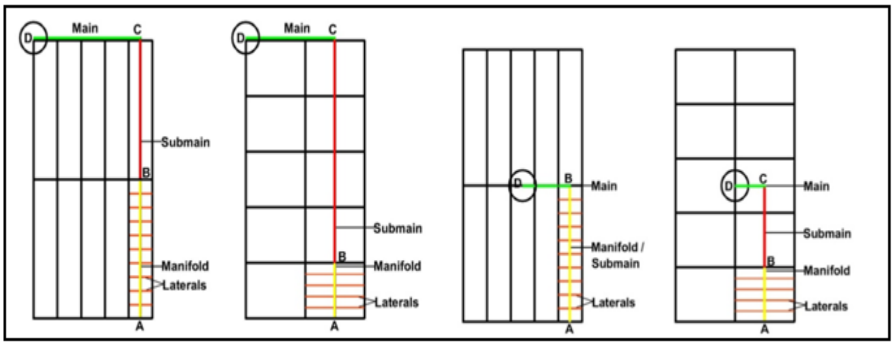

Fig.1: Design Layout For Field of Dimension 100m x 200m with Location of Source of Water at Corner and at Center, Having 10 Sub-units

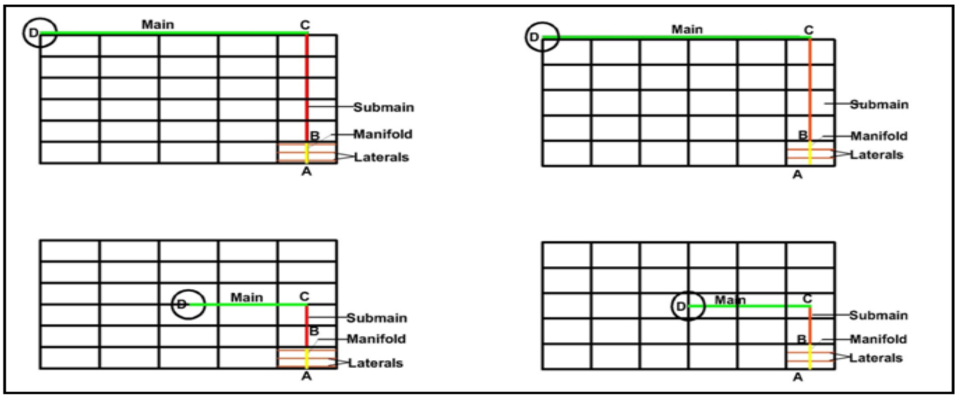

Fig.2: Design Layout For Field of Dimension 200m x 100m with Location of Source of Water at Corner and at Center, Having 30 Sub-units

V. Input Data

Table 3: Input Data for Study

Field Size (m^2)	100x200/200x100
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

Assumptions

- 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 also changes 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
- Field considered have negligible slope

VI. 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 3 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 0.5% to 25.6% more costly than design with PVC material. Form the study following results are obtained

For first case, as shown in Table 4, 5, 6, 7 field having length of 100 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 28 sub-units having 14 columns and 2 rows, for this design head loss is 4.4662 m and head required at source is 21.9109 m with cost for PVC is RS. 3,96,278 and for HDPE is Rs.4,67,473.Whereas worst design according to hydraulic parameters is found out for field division into 35 with 7 columns and 5 rows, for this head loss is 20.8581 m and head required source is 39.9361m with cost of Rs.3,12,817 and Rs.3,34,235 for PVC and HDPE respectively. According to economic results best design is found out for field division into 24 with 3 columns and 8 rows having head loss of 17.1796 m and head required at source is 35.8048 m with cost of PVC is Rs.3,12,817 and cost of HDPE is Rs.3,34,235 and economically worst result is found for field division into 36 with 18 columns and 2 rows having head loss of 10.5421 m and head required at source is 28.5951 m with cost of PVC is Rs. 4,14,130 and HDPE is Rs. 4,36,572.

For second, as shown in Table 8, 9, 10, 11 field having length of 100 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 28 sub-units having 14 columns and 2 rows, for this design head loss is 1.5718 m and head required at source is 18.7271 m with cost for PVC is RS. 3,96,121 and for HDPE is Rs.4,67,226.Whereas worst design according to hydraulic parameters is found out for field division into 26 with 2 columns and 13 rows, for this head loss is 20.8808 m and head required at source is 39.9044 m with cost of Rs.3,43,172 and Rs.3,46,189 for PVC and HDPE respectively. According to economic results best design is found out for field division into 27 with 3 columns and 9 rows having head loss of 19.1053 m and head required at source is 37.9230 m with cost of PVC is Rs.2,85,447 and cost of HDPE is Rs.2,89,913 and economically worst result is found for field division into 36 with 18 columns and 2 rows having head loss of 3.7232 m and head required at source is 21.0943 m with cost of PVC is Rs. 4,14,020 and HDPE is Rs. 4,36,445.

For third case, as shown in Table 12, 13, 14, 15 field having length of 200 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 20 sub-units having 10 columns and 2 rows, for this design head loss is 9.5449 m and head required at source is 27.4761 m with cost for PVC is RS. 3,19,882 and for HDPE is Rs.3,49,132.Whereas worst design according to hydraulic parameters is found out for field division into 28 with 4 columns and 7 rows, for this head loss is 20.8632 m and head required at source is 39.8851 m with cost of Rs.2,87,210 and Rs.2,94,220 for PVC and HDPE respectively. According to economic results best design is found out for field division into 28 with 4 columns and 7 rows having head loss of 20.8632 m and head required at source is 39.8851 m with cost of PVC is Rs.2,87,210 and cost of HDPE is Rs.2,94,220 and economically worst result is found for field division into 4 with 2 columns and 2 rows having head loss of 10.1861 m and head required at source is 28.0686 m with cost of PVC is Rs. 4,01,711 and HDPE is Rs. 4,46,693.

For fourth case, as shown in Table 16, 17, 18, 19 field having length of 200 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 4 sub-units having 4 columns and 2 rows, for this design head loss is 3.5011 m and head required at source is 20.7151 m with cost for PVC is RS. 3,95,378 and for HDPE is Rs.4,33,934.Whereas worst design according to hydraulic parameters is found out for field division into 15 with 3 columns and 5 rows, for this head loss is 20.7054 m and head required at source is 39.6328 m with cost of Rs.4,30,784 and Rs.4,34,415 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 15.7852 m and head required at source is 34.2083 m with cost of PVC is Rs.2,86,256 and cost of HDPE is Rs.2,90,725 and economically worst result is found for field division into 15 with 3 columns and 3 rows having head loss of 20.7054 m and head required at source is 39.6328 m with cost of PVC is Rs. 4,30,784 and HDPE is Rs.4,34,415

Table 4: Hydraulically best designs for field size 100m x 200m when source at corner

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
30	15	2	4.4714	21.9168	400289.503	476406.389	76116.886	19.0155
28	14	2	4.4662	21.9109	396279.500	467473.012	71193.512	17.9655
26	13	2	5.6634	23.2275	382138.042	448410.638	66272.596	17.3426
24	12	2	5.6545	23.2174	378657.106	440003.870	61346.764	16.2011
10	5	2	5.2826	22.7875	363132.600	451967.600	88835.000	24.4635

Table 5: Economically best designs for field size 100m x 200m when source at corner

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
33	3	11	12.8500	31.0433	296119.828	300267.459	4147.631	1.4007
30	3	10	15.0727	33.4872	295718.527	299866.158	4147.631	1.4026
27	3	9	17.8486	36.5407	294113.323	298260.954	4147.631	1.4102
24	3	8	17.1796	35.8048	293702.231	299391.745	5689.514	1.9372
21	3	7	20.0364	38.9473	296280.678	305209.056	8928.378	3.0135

Table 6: Hydraulically worst designs for field size 100m x 200m when source at corner

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
35	7	5	20.8581	39.9361	312817.219	334234.727	21417.508	6.8467
25	5	5	20.1209	39.1097	309158.600	315774.900	6616.300	2.1401
22	2	11	20.8337	39.8526	353844.250	358115.750	4271.500	1.2072
20	4	5	20.4556	39.4582	305503.000	317490.250	11987.250	3.9238
8	2	4	20.6959	39.7000	363071.750	389985.250	26913.500	7.4127

Table 7: Economically worst designs for field size 100m x 200m when source at corner

Corner								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
36	18	2	10.5421	28.5951	414129.852	436571.856	22442.004	5.4191
34	17	2	10.5378	28.5902	400399.797	421627.194	21227.397	5.3016
32	16	2	10.5290	28.5805	394134.337	414146.520	20012.183	5.0775
30	15	2	4.4714	21.9168	400289.503	476406.389	76116.886	19.0155
28	14	2	4.4662	21.9109	396279.500	467473.012	71193.512	17.9655

Table 8: Hydraulically best designs for field size 100m x 200m when source at center

Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
30	15	2	1.5770	18.7330	400144.336	476180.108	76035.772	19.0021
28	14	2	1.5718	18.7271	396121.136	467226.160	71105.024	17.9503
24	12	2	1.9807	19.1763	378472.348	439715.876	61243.528	16.1818
10	5	2	1.8034	18.9604	362248.200	450268.200	88020.000	24.2983
6	3	2	1.7488	18.8309	346192.200	424941.228	78749.028	22.7472

Table 9: Economically best designs for field size 100m x 200m when source at center

Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
36	3	12	14.7591	33.1422	286965.876	291478.758	4512.882	1.5726
33	3	11	17.0120	35.6204	286564.575	291077.457	4512.882	1.5748
32	4	8	17.7124	36.4406	288629.500	294553.250	5923.750	2.0524
30	3	10	19.8792	38.7743	286163.274	290676.156	4512.882	1.5770
27	3	9	19.1053	37.9230	285447.180	289913.442	4466.262	1.5647

Table 10: Hydraulically worst designs for field size 100m x 200m when source at center

Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
30	3	10	19.8792	38.7743	286163.274	290676.156	4512.882	1.5770
28	2	14	18.8834	37.7073	347668.500	350680.000	3011.500	0.8662
27	3	9	19.1053	37.9230	285447.180	289913.442	4466.262	1.5647
26	2	13	20.8808	39.9044	343177.500	346189.000	3011.500	0.8775
16	2	8	18.5978	37.3931	349016.500	351748.000	2731.500	0.7826

Table 11: Economically worst designs for field size 100m x 200m when source at center

Center								
No of Sub-units	Column	Row	Head Loss (m)	Head at Source (m)	PVC Cost (Rs.)	HDPE Cost (Rs.)	Difference	% Increase
36	18	2	3.7232	21.0943	414019.840	436444.848	22425.008	5.4164
34	17	2	3.7188	21.0984	400285.856	421495.650	21209.794	5.2987
32	16	2	3.7101	21.0797	394012.538	414005.904	19993.366	5.0743
30	15	2	1.5770	18.7330	400144.336	476180.108	76035.772	19.0021
28	14	2	1.5718	18.7271	396121.136	467226.160	71105.024	17.9503

Table 12: Hydraulically best designs for field size 200m x 100m when source at corner

Corner								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
36	18	2	10.2656	28.2888	348034.248	360140.256	12106.008	3.4784
25	5	5	11.7223	29.7392	295898.200	303357.600	7459.400	2.5209
24	12	2	11.0810	29.1747	322044.747	334040.733	11995.986	3.7249
20	10	2	9.5449	27.4761	319882.100	349132.300	29250.200	9.1441
4	2	2	10.1861	28.0686	401711.000	446693.000	44982.000	11.1976

Table 13: Economically best designs for field size 200m x 100m when source at corner

Corner								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Row**	**Head Loss (m)**
36	6	6	18.0923	36.8088	292440.129	297614.760	5174.631	1.769
35	5	7	19.6287	38.4362	289178.200	293655.800	4477.600	1.548
30	6	5	17.6985	36.3756	292499.037	301066.551	8567.514	2.929
30	5	6	18.6296	37.3372	290024.200	297833.600	7809.400	2.693
28	4	7	20.8632	39.8851	287210.250	294219.750	7009.500	2.441

Table 14: Hydraulically worst designs for field size 200m x 100m when source at corner

Corner								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
28	4	7	20.8632	39.8851	287210.250	294219.750	7009.500	2.441
24	2	12	20.8487	39.7974	373271.500	375396.000	2124.500	0.569
18	3	6	20.6233	39.5425	354112.805	360031.291	5918.486	1.671
14	2	7	20.8065	39.7510	386377.000	406869.000	20492.000	5.304
8	4	2	20.6959	39.7010	369332.750	401912.250	32579.500	8.821

Table 15: Economically worst designs for field size 200m x 100m when source at corner

Corner								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
14	2	7	20.8065	39.7510	386377.000	406869.000	20492.000	5.304
12	2	6	14.9478	33.3064	377709.500	391124.500	13415.000	3.552
8	2	4	20.0060	38.8705	377153.500	396984.500	19831.000	5.258
6	2	3	13.8029	32.0470	387264.000	415789.000	28525.000	7.366
4	2	2	10.1861	28.0686	401711.000	446693.000	44982.000	11.198

Table 16: Hydraulically best designs for field size 200m x 100m when source at center

Center								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
36	18	2	4.3964	21.8327	347814.224	359886.240	12072.016	3.471
20	10	2	4.0383	21.4189	319442.200	348446.600	29004.400	9.080
18	9	2	4.7538	22.1986	314678.888	341171.212	26492.324	8.419
6	2	3	5.0601	22.4299	382842.000	407292.000	24450.000	6.386
4	2	2	3.5011	20.7151	395378.000	433934.000	38556.000	9.752

Table 17: Economically best designs for field size 200m x 100m when source at center

Center								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
36	6	6	14.7591	33.1422	289559.876	294749.758	5189.8820	1.7923
35	5	7	15.7852	34.2083	286256.400	290724.600	4468.2000	1.5609
30	6	5	19.8792	38.7743	288757.274	293947.156	5189.8820	1.7973
30	5	6	20.3739	39.2559	286256.400	290724.600	4468.2000	1.5609
28	7	4	12.0539	30.1958	291090.238	296869.636	5779.3980	1.9854

Table 18: Hydraulically worst designs for field size 200m x 100m when source at center

Center								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
30	5	6	20.3739	39.2559	286256.400	290724.600	4468.200	1.561
20	2	10	20.5886	39.5113	362217.000	364178.000	1961.000	0.541
16	4	4	18.5978	37.3931	352945.500	356284.000	3338.500	0.946
15	3	5	20.7054	39.6328	430784.116	433414.854	2630.738	0.611
14	2	7	20.4153	39.3207	371307.000	373128.000	1821.000	0.490

Table 19: Economically worst designs for field size 200m x 100m when source at center

Center								
No of Sub-units	**Column**	**Row**	**Head Loss (m)**	**Head at Source (m)**	**PVC Cost (Rs.)**	**HDPE Cost (Rs.)**	**Difference**	**% Increase**
36	2	18	12.4105	30.5154	373722.000	375753.000	2031.000	0.543
15	3	5	20.7054	39.6328	430784.116	433414.854	2630.738	0.611
8	2	4	7.4963	25.1098	374023.000	391021.000	16998.000	4.545
6	2	3	5.0601	22.4299	382842.000	407292.000	24450.000	6.386
4	2	2	3.5011	20.7151	395378.000	433934.000	38556.000	9.752

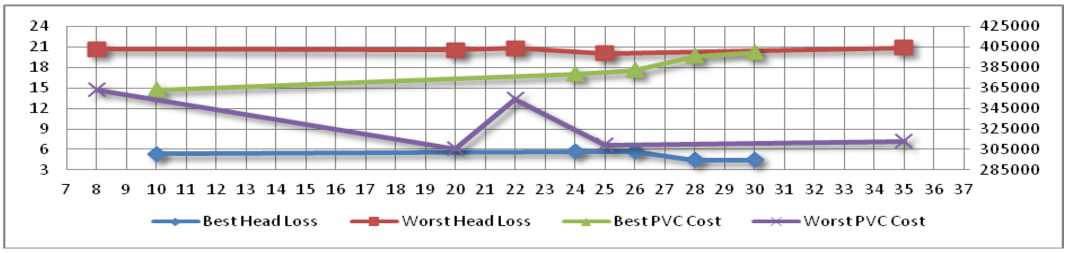

Fig.3: Hydraulically Best/Worst Results for case 1

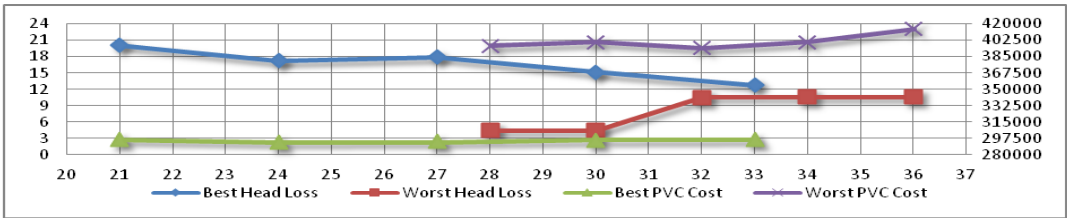

Fig.4: Economically Best/Worst Results for case 1

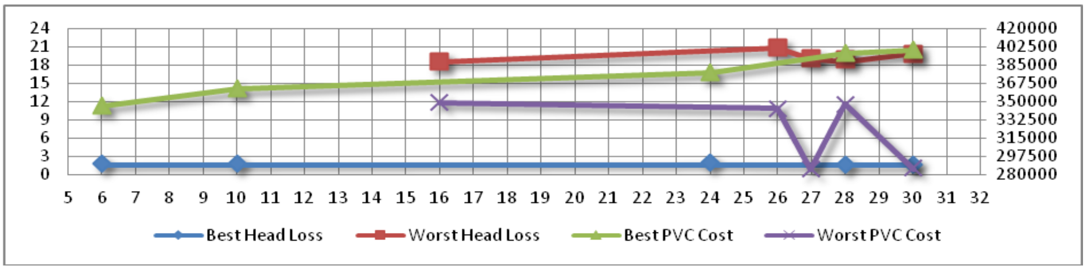

Fig.5: Hydraulically Best/Worst Results for case 2

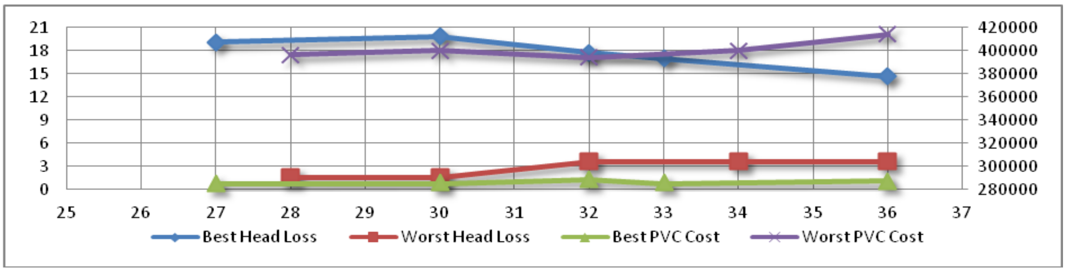

Fig.6: Economically Best/Worst Results for case 2

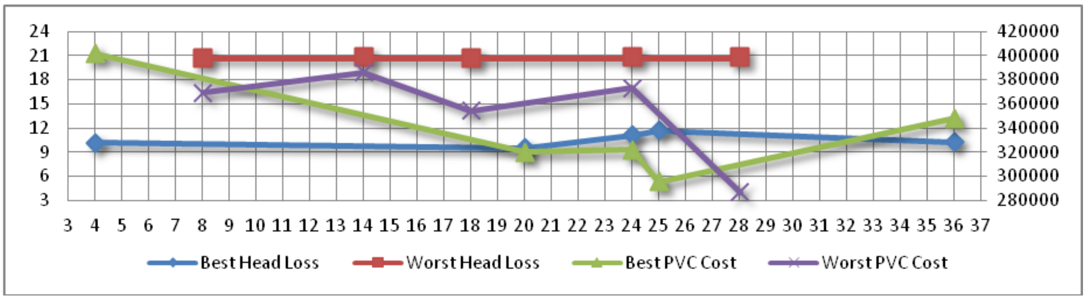

Fig.7: Hydraulically Best/Worst Results for case 3

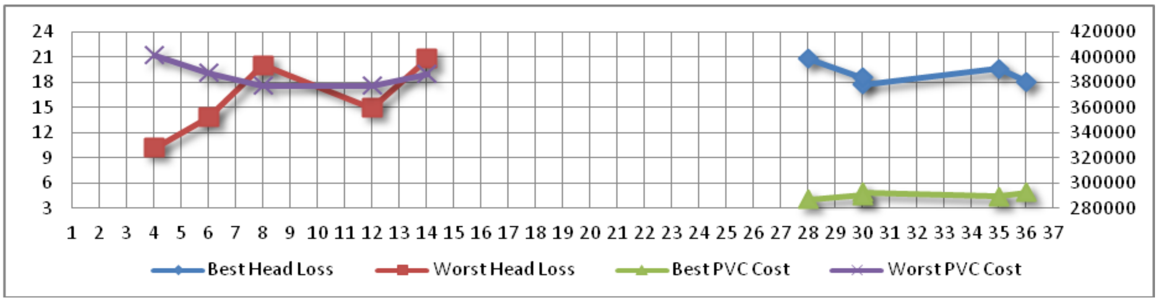

Fig.8: Economically Best/Worst Results for case 3

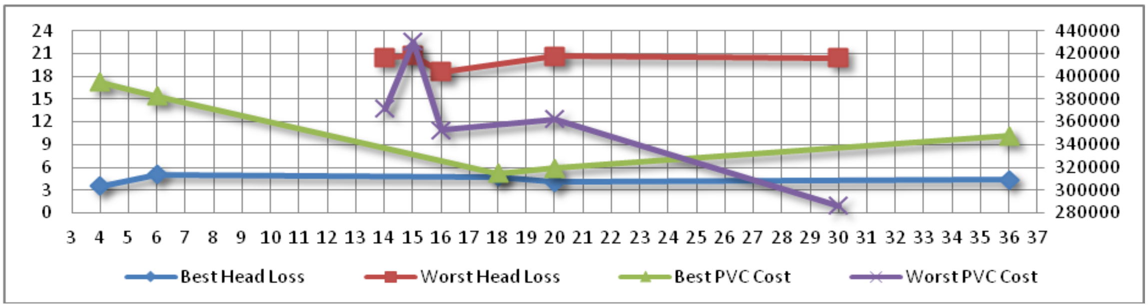

Fig.9: Hydraulically Best/Worst Results for case 4

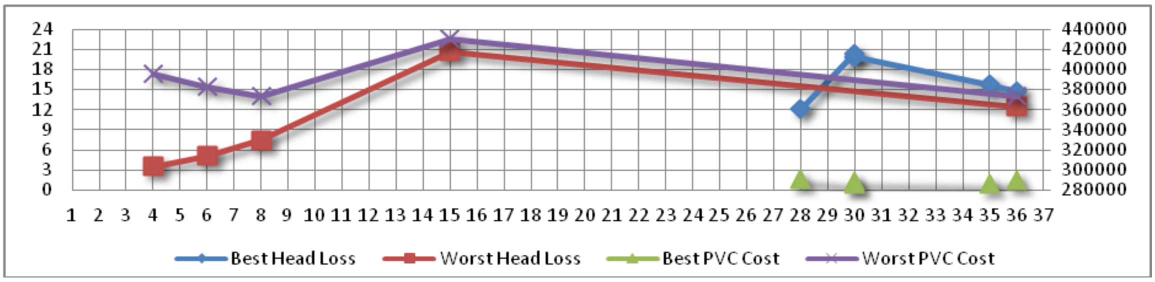

Fig.10: Economically Best/Worst Results for case 4

VII. 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 200 m and source of water at corner, according to hydraulic parameters for best design one needs to divide field into 28 sub-units having 14 columns and 2 rows, for this design head loss is 4.4662 m and head required at source is 21.9109 m with cost for PVC is RS. 3,96,278 and for HDPE is Rs.4,67,473 and according to economic results best design is found out for field division into 24 with 3 columns and 8 rows having head loss of 17.1796 m and head required at source is 35.8048 m with cost of PVC is Rs.3,12,817 and cost of HDPE is Rs.3,34,235.

For second case, field having length of 100 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 28 sub-units having 14 columns and 2 rows, for this design head loss is 1.5718 m and head required at source is 18.7271 m with cost for PVC is RS. 3,96,121 and for HDPE is Rs.4,67,226 and according to economic results best design is found out for field division into 27 with 3 columns and 9 rows having head loss of 19.1053 m and head required at source is 37.9230 m with cost of PVC is Rs.2,85,447 and cost of HDPE is Rs.2,89,913.

For third case, field having length of 200 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 20 sub-units having 10 columns and 2 rows, for this design head loss is 9.5449 m and head required at source is 27.4761 m with cost for PVC is RS. 3,19,882 and for HDPE is Rs.3,49,132 and according to economic results best design is found out for field division into 28 with 4 columns and 7 rows having head loss of 20.8632 m and head required at source is 39.8851 m with cost of PVC is Rs.2,87,210 and cost of HDPE is Rs.2,94,220.

For fourth case, field having length of 200 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 4 sub-units having 2 columns and 2 rows, for this design head loss is 3.5011 m and head required at source is 20.7151 m with cost for PVC is

RS. 3,95,378 and for HDPE is Rs.4,33,934 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 15.7852 m and head required at source is 34.2083 m with cost of PVC is Rs.2,86,256 and cost of HDPE is Rs.2,90,725.

Therefore, it can be concluded that if field is of 100 m x 200 m then the best possibility may be 28 sub-units having 14 columns and 2 rows and if field is of 200 m x 100 m then the best possibility may be 4 sub-units having 2 columns and 2 rows, and in both the cases, preferably the source at center, and while comparing these two, the former yields the better results.

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, hydraulically best design costs less than the hydraulically worst design. Results also indicates that hydraulically best designs and economically best designs are not same, one can see that for first case, second case and fourth case some of hydraulically best designs comes under economically worst designs and for third case economically best design comes under hydraulically worst design, 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 0.5% to 25.6% more costly than of PVC material. From the obtained results, one can conclude that hydraulic parameters, as well as cost of DIS, highly depends upon the numbers of sub-units selected for field division.

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