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Tecno-Economic Feasibility of Pressurized Irrigation System in Canal Commands - A Case Study

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ABSTRACT

The world and more importantly, the developing countries are heading towards water stress and scarcity. To improve the management of land and water resources we concentrates on the integration of policies, technologies and management systems to achieve workable solutions to real problem - practical, relevant in the field of irrigation and water and land resources. They are left with no alternatives but to adopt a modern irrigation technology which saves water, double the area under irrigation, improve yields and quality as well as saves on labour, energy and crop production costs. The system has been designed in such a way that it provides pressurized irrigation network system up to farmer's field outlets. Shifting to pressurized irrigation in commands of flow based minor irrigation systems in plateau areas is feasible both from technical and financial point of view.

KEYWORDS :

INTRODUCTION

The Pressurized Irrigation Network System (PINS) could be done from any part of the canal system up to the farmer's land depending upon the scope existing locally. Therefore, this would have a site specific design. The adoption of PINS would be carried out by Sardar Sarovar Narmada Nigam Limited (SSNNL) in case of Sardar Sarovar Project (SSP), while respective authorities in case of other canal command areas. Related to SSP Command area PINS system as an alternative to sub-minors and field channels because(i)To minimize the land acquation problem.(ii)To restrict unregulated water lifting from canals.(iii) Conjunctive management of pipe distribution with ground water.(iv) To reduce loss due to evaporation.(v)To improve overall farm efficiency. Though the cost for establishing PINS may apparently seem to be more, yet over a long period considering the tangible as well as intangible benefit accrued it will prove to be more economical. By doing the PINS, the expenditure on the creation of networking below the minor and the subsequent expenditures and problems of maintenance, repairing and watch and ward associated with normal canal networking can be avoided. Apart from the above tangible benefits, there are many more intangible benefits like soil health improvement, less drainage problems, less soil, water and crop pollution due to lesser use of pesticides, Inorganic fertilizers, absence of leaching losses, doing away with the tail end problems, bringing "out of Command" into irrigation etc.

LOCATION OF STUDY AREA

As per canal distribution network, study area falls in the SSP command area of block no. 6H1 having Culturable Command Area (CCA) of 8488 ha. under the command of Dora branch canal. The command area served by 3 distributory (Occhan, Acchod & Dora) and 21 Minors. The study area is served by Karena minor through Occhan distributory located in Taluka – Amod, District- Bharuch (Fig 3.2).Karena is located 34.68 km distance from Bharuch city. Karena Village Service Area lie between 21°58' to 21°59'North latitudes and 73°03' to 73°04' East longitudes situated in Amod Taluka, Bharuch District (Fig 2 & 3). The total Culturable Command Area (CCA) of Occhan distributory is 458 ha out of which the study area selected for PINS and MIS design is 133 ha area.

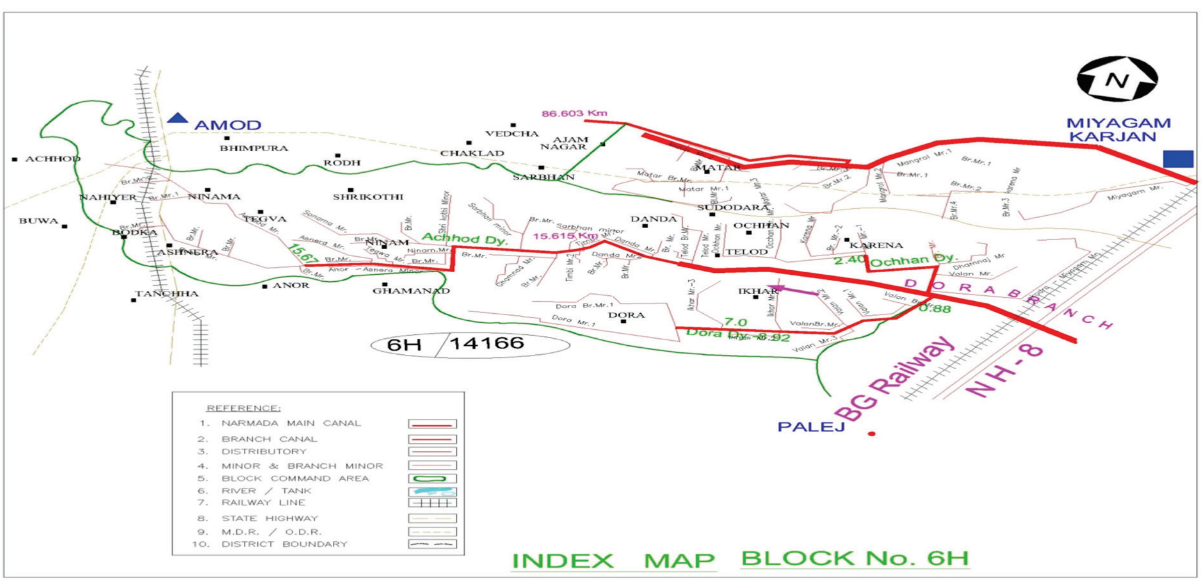


Fig 2 Index Map(Source: Narmada Canal Sub Division No-5, Karjan)

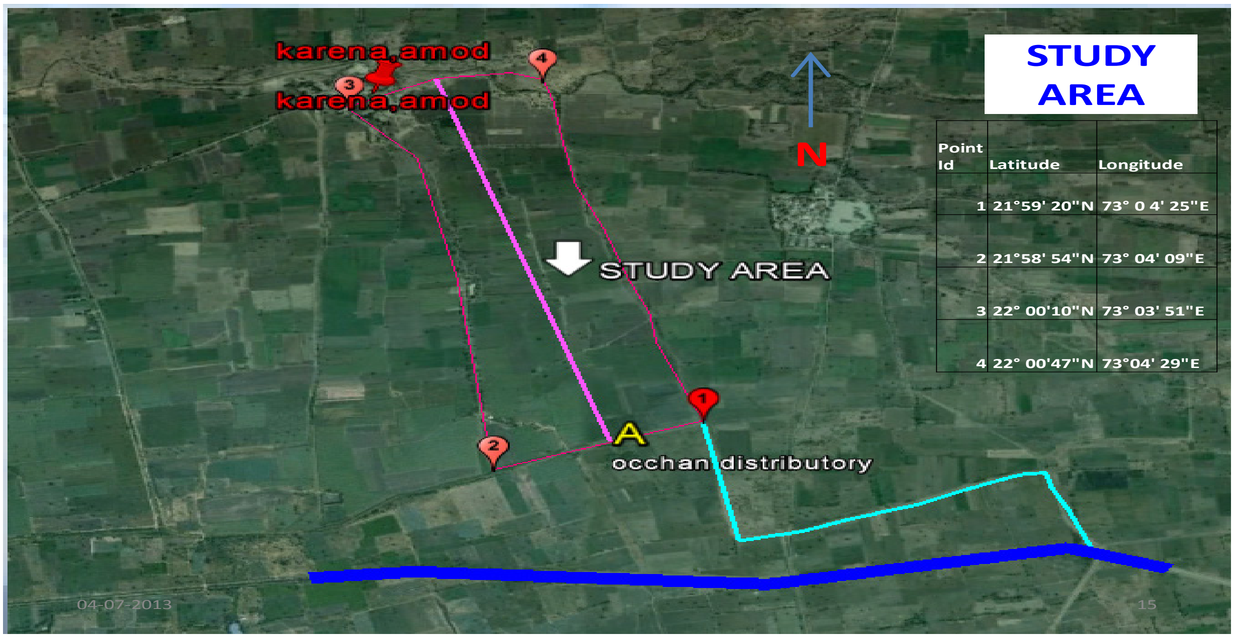


Fig-3 Google Map

FLOW CHART OF METHODOLOGY
Methodology adopted for the study to satisfy our objectives. It includes the design and layout of PINS and cost calculation for PINS per hectare (Fig-4).

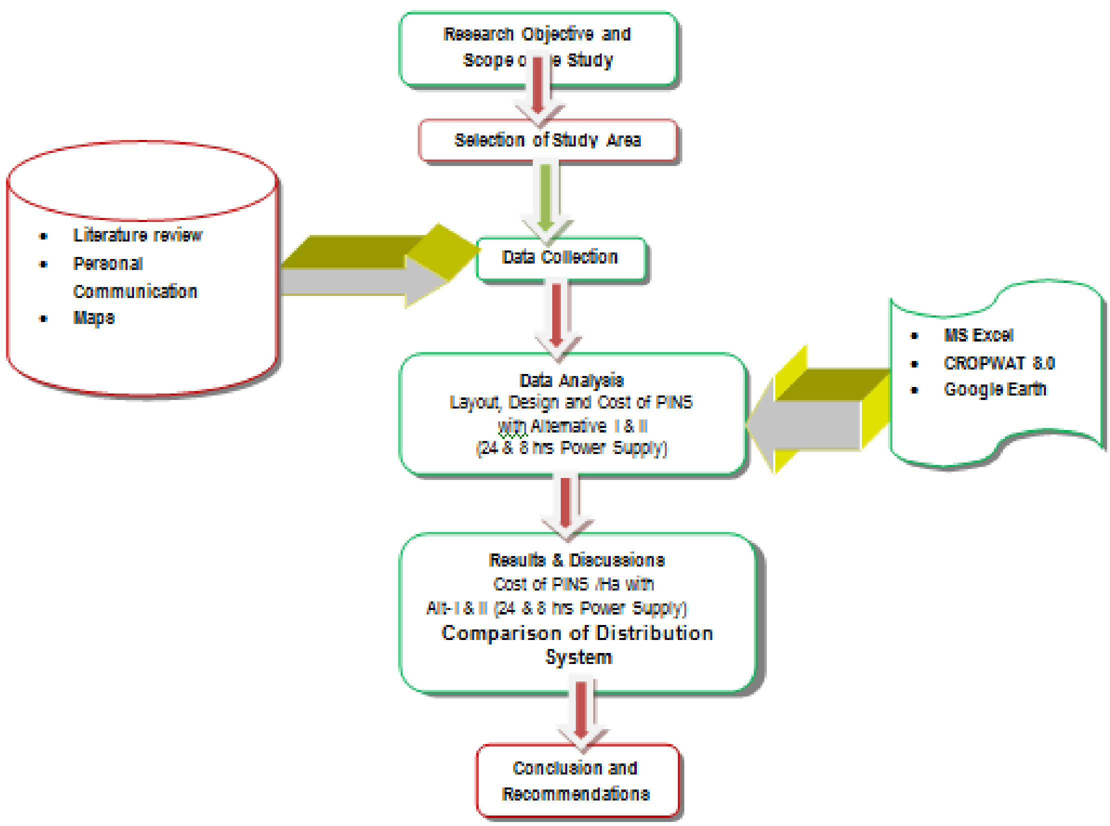
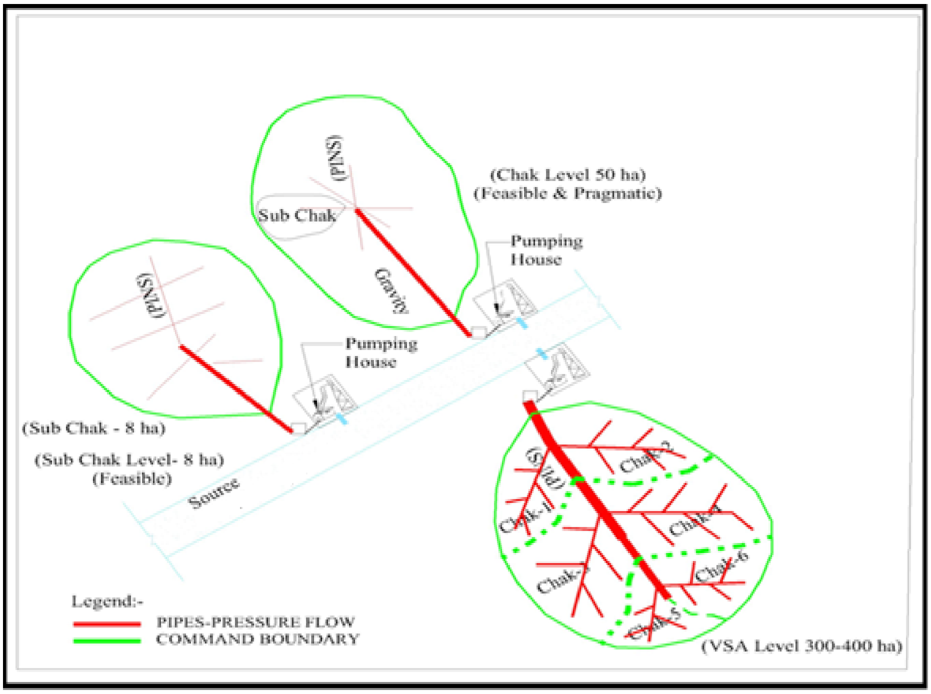


Fig 4 Flow Chart of Methodology

Design of Pressurized Irrigation Network System (PINS)
Design of pressurized irrigation network system for the study area is done by considering two alternatives

Alternative – I considering continuous canal flow with 24 hrs power supply .

Alternative - II considering continuous canal flow 8 hrs power supply (Fig 5).



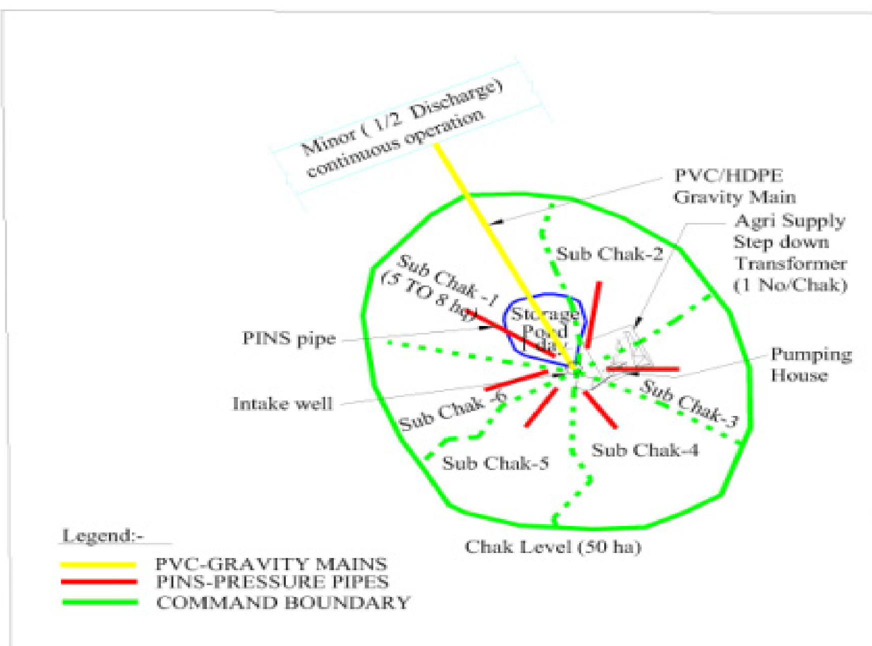


Fig 5 Schematic Diagram of PINS (24 hrs Power Supply)

ANALYSIS AND RESULTS

The design of Pressurized Irrigation Network System (PINS) could be done from any section of the canal system upto the farm depending upon the scope of existing locally. Therefore, this would have a site specific design.

Layout of Pressurized Irrigation Network System

Layout of Pressurized Irrigation Network System (PINS) for the study area is prepared by using AutoCAD 2009 for the study area by considering two alternatives. Length of PINS pipe, connecting pipe and other details are calculated using formulas as per layout within study area for selected alternative (Table 1).

Table 1 Length of Connecting Pipe, PINS Pipe, Number of Chak and Sub-chak

Chak Number	Chak 1	Chak 2	Chak 3	Chak 4
Connecting pipe Length (m)	460	680	540	640
PINS length in (m)	845	856	471	381
CCA (Total-133 Ha)	CCA_1 37.50	CCA_2 33.74	CCA_3 34.26	CCA_4 27.50
Number of sub-chak for each chak area	5	5	4	4

The layout of PINS is done considering source of water in the center of chak area and then laying PINS pipes in radial direction from the source. The layout represents source of water, chak area, sub chak boundary for each chak, laying of connecting pipe from canal to well and also from well to another well respectively.. For design whole study area is divided into four parts which classified as chak 1, chak 2, chak 3 and chak 4, after that sub divided all chak area into number of sub-chak. Generally chak area divide within limit of 30-60 Ha and sub chak area divide within limit of 8-10 Ha.The blue colour lines are connecting pipes and red colour lines are PINS pipe and sea blue colour circles are wells (Fig 6).

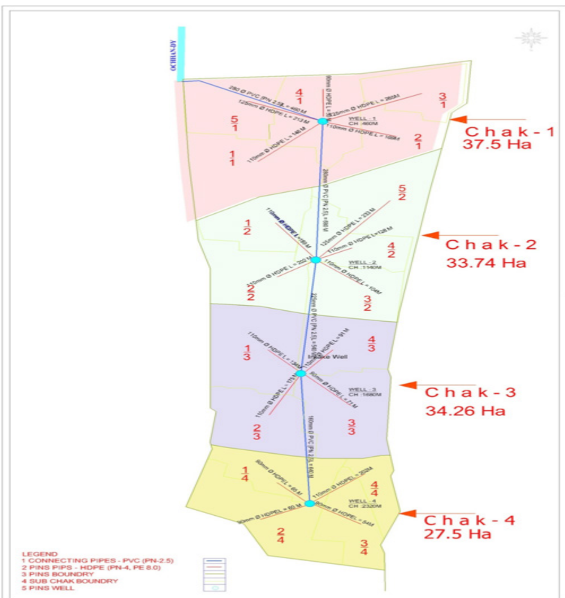


Fig 6 Layout of Pressurized Irrigation Network System (24 hrs Power Supply)

Design of Pressurized Irrigation Network System (PINS)

Recent SSNNL system of canal operation suitable for surface irrigation. However, considering high efficiency of canal system (60%) and limited availability of delta, it would be too difficult to supply adequate irrigation demand. Also, some of the areas are problematic from soil / irrigabilty point of view. Under these circumstances, it is an appropriate and effective solution and thus SSNNL is actively considering its implementation through PINS. Following options are available.

Direct drafting from perennial canals like Branch canal and distributaries.

- To create an adequate storage facility at VSA / Chak level.
- To integrate the existing storage facilities with the canal system.

Design Components of PINS

Design components of PINS like connecting pipe diameter and length upto canal to well and well to well, storage well cross-section (as per volume of water stored), diameter and length of PINS pipe from storage upto the point of pressurization which flows water to each sub chak by using pumps and electric connection. As per the policy of SSNNL, an adequate storage facility is created for selected alternatives viz (1) 24 hrs power supply (2) 8 hrs power supply. Sample design steps only for Alternative I are represented herewith in following paragraphs and tables.

(i) Connecting Pipes

For this, generally low pressure gravity mains of PE 80 class of PN 2.5 (2.5 kg/cm^2) would be sufficient. Design discharge for the study area is calculated using BDC = 0.8 considered for region III. Design discharge Q = (BDC x CCA) (24 Hrs) or (BDC x CCA x 3) (8 Hrs)

Diameter of connecting pipe

Head –loss $h_f = 6.377\ fLQ^2/D^5$ (find diameter)

Table 5.3 Design of Connecting Pipe (24 hrs Power Supply)

Chak No.	Area (ha)	Design Discharge (lps)	Total Length (m)	Velocity (m/sec)	Reynolds No. (Re)	D-W Friction Factor	Internal Dia. of Pipe (mm)		Outer Dia. of pipe (mm)
							Designed	Available	
1	133	93.10	460	1.62	454177	0.012	252.04	270.40	280
2	95.51	66.86	680	1.16	326153	0.013	242.58	270.40	280
3	61.77	43.24	540	1.17	262705	0.014	197.49	217.20	225
4	27.51	19.26	640	1.03	164643	0.016	151.84	154.40	160

(ii)Storage Facility

As per SSNNL policy minors are operated on 7 days ON-OFF basis. But to give continuous water is supplied on daily basis and as such for off period of 7 days, slight modification made in the operation policy of the minor i.e. operating minors for all 14 days at half design discharge. So due to continuous supply of half design discharge satisfies the basic need but for alternative I -24 hrs power supply has no need storage facility. This facility is required for 8 hrs power supply. For practical purpose, 1 day storage facility is to be designed. (Fig 5.19)

Total 1 day storage = (BDC x CCA_1 x 3600 x 24) / 1000 m^3 (8 hrs)

Creating storage facility is costlier and requires land acquisition. Hence, it is suggested to utilize existing water body or natural depressions available.

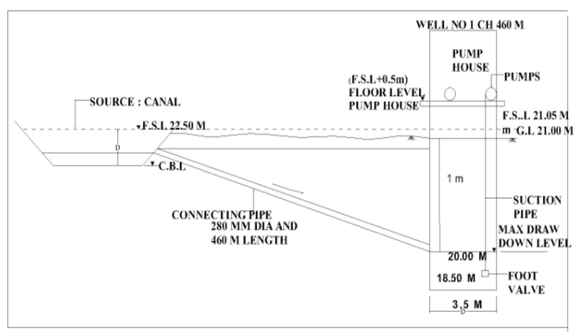


Fig 5.19 Cross-section of Occhan Distributory Canal to Well No. 1 (24 hrs Power Supply)

(iii) Design of PINS pipe

PINS are primary a pipe network carrying required discharge at an adequate pressure, finally delivering it to the attached MIS network.In this study for pressurized flow HDPE pipe is preferred.

Design discharge Q = BDC x CCA_1 / 2 (24 hrs)

Design discharge Q = (6 / n) x [BDC x CCA_1] /2 (8 hrs)

Diameter of PINS pipe

Same procdure follows of connecting pipe by using Darcy-Weisbach formula

Length of PINS Pipe

Length of PINS pipe should be considered from intake well to the head of a sub-chak. Under the MIS installations main pipes (PINS) are further extended into the sub-chak as per the layout requirement.

Table 5.4 Design of PINS Pipe (24 hrs Power Supply)

Chak No	CCA (ha)	Discharge (lps)	Sub chak No	Length of PINS (m)	Velocity (m/sec)	Reynolds No. (Re)	D-W Friction Factor	Pipe Inside Dia (mm)		Pipe OD (mm)
								Designed	Available	
1	37.50	13.13	1	148	1.67	183917	0.015	95.94	100.00	110
			2	169	1.67	183917	0.015	99.80	100.00	110
			3	265	1.29	161382	0.016	109.20	113.80	125
			4	50	2.50	224888	0.015	77.22	81.80	90
			5	213	1.29	161382	0.016	104.53	113.80	125
TOTAL OF CHAK 1	37.50	13.13		845						
2	33.74	11.81	1	189	1.50	165427	0.016	97.82	100.00	110
			2	202	1.50	165427	0.016	99.14	100.00	110
			3	104	1.50	165427	0.016	86.81	100.00	110
			4	128	1.50	165427	0.016	90.49	100.00	110
			5	233	1.16	145158	0.016	102.01	113.80	125
TOTAL OF CHAK 2	33.74	11.81		856						
3	34.26	11.99	1	134	1.53	168027	0.016	91.89	100.00	110
			2	175	1.53	168027	0.016	96.93	100.00	110
			3	71	2.28	205457	0.015	79.89	81.80	90
			4	91	1.53	168027	0.016	85.05	100.00	110
TOTAL OF CHAK 3	34.26	11.99		471						
4	27.50	9.63	1	65	1.83	164918	0.016	72.82	81.80	90
			2	60	1.83	164918	0.016	71.67	81.80	90
			3	54	1.83	164918	0.016	70.17	81.80	90
			4	202	1.23	134873	0.016	91.36	100.00	110
TOTAL OF CHAK 4	27.50	9.63		381						
TOTAL FOR CCA	133	46.55		2553						

(iv) Computing Pumping Efforts

To pressurize the PINS, adequate and appropriate pumping system is necessary. For this intake well, suitable pumps, a pump house with necessary control arrangement etc. are to be considered.

Design discharge $Q = BDC \times CCA_1 / 2$ (24 hrs)

Pump HP $= (Q \times H) / (75 \times \eta)$

Design discharge $Q = (6 / n) \times [BDC \times CCA_1] / 2$ Where n = no. of sub-chaks=5 (8 hrs)

Pump HP $= (Q \times H) / (75 \times \eta)$ Where Q = design discharge (lps)

(v)Filters

Filters remove sand and larger suspended particles before they enter the distribution network. However, the filters cannot remove dissolved minerals, bacteria and some algae. The four types generally used are screen, hydrocyclone, screen (disc) and media (sand) filters.

Capacity of media filter (m3/ hr) = Design discharge of PINS pipe X 3.6

Table 5.5 Design of Number of Pumps and Filters (24 hrs Power Supply)

Chak No.	CCA (ha)	Q (lps) considerd	Head (m)	H.P.		Nos. of Pump	Filter Capacity (m3/hr)		Nos. of Filters
				Designed	Provided		Required	Provided	
1	37.50	13.13	35	10.94	12.5	3	47.25	50	3
2	33.74	11.81	35	9.84	10	3	42.51	50	3
3	34.26	11.99	35	9.99	10	3	43.17	50	3
4	27.5	9.63	35	8.02	10	3	34.65	40	3

Same layout and design follows for Alternative –I for 8 Hrs power supply.

Cost of Pressurized Irrigation Network System (PINS)

For selection of better alternative, cost is the major factor. After design of PINS, the cost of PINS is estimated by multiplying the quantity of major component of PINS with the rates obtained from scheduled of rate of SSNNL, Gujarat Water Resource Development Corporation Ltd., Gandhinagar (2012-2013).

Cost of PINS for Alternative – I (24 hrs Power Supply)

At last total cost of each component and also cost per ha for each design component for chak 1,2,3 & 4 are summarized (Table 7). Cost comparison is represented graphically for chak 1,2,3,4 in fig 5.23.

Table 7 Total Cost of PINS (24 hrs Power Supply)

Chak No.	CCA (ha)	Cost (Rs./ha)						
		Connecting Pipes (Gravity) PVC	Pressure Pipes (PINS) HDPE	Pump	Filter	Electric connection	Total Cost Rs/ha	Cost Per ha
1	37.50	234140	214044.00	328000	15035.46	217816	1009035.46	26907.61
2	33.73	346120	246146.35	328000	15035.46	217816	1153117.81	34186.71
3	34.26	179280	118147.95	328000	15035.46	217816	858279.41	25051.94
4	27.50	102400	84922.65	328000	15035.46	217816	748174.11	27206.33
For CCA	133	861940	663260.95	1312000	60141.84	871264	3768606.79	28337.52

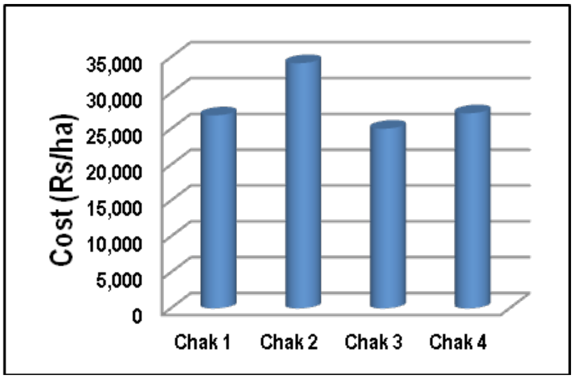


Fig 5.23 Total Cost of PINS/ha (24 hrs Power Supply)

CONCLUSION

In this study area included provision of irrigation facility to the command area adjacent to the canal where irrigation by canal is practically not possible because farmers not acquired land for construct minor canal. By using PINS in terms of degree of adoption of water saving and yield enhancing, a systematic attempt has been made to design micro irrigation system for the study area based on supply policies of SSNNL.

Also suggest to recommend successful adoption of MIS in a canal command area can be done only if a sustainable Pressurized Irrigation Network System (PINS) is created which is techno economically viable. The study area which is part of SSP command area where the process of construction of sub minors and field channels are still in progress, adoption of PINS can reduce to a great extent the problems of land acquisition and construction cost of conventional distributory system.

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