# Design of Lift Irrigation System- Angar as A Case Study

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**Abstract -***As per the NABARD – National Bank for Agricultural and Rural Development (India), there are 1401 LIS financed by them. The total financial outlay (TFO) is Rs. 6462.5 million . The proposed area under irrigation is 22000 hectare. Out of these LIS, as many as 573 LIS are defunct. The main reason is poor distribution of water. In addition there are LIS which are financed and implemented by government, sugar factories and individual farmers. In case of irrigation schemes, the importance of "Lift Irrigation Schemes" is unique and distinctive. In such schemes, many farmers can come together and implement a large lift irrigation scheme on private or co-operative basis. This way, they get certain benefits of large schemes.*

***Key Words:*** *Nabard, Lift irrigation, Head works, sumpwell, Sinha river, Bhopalebandhara*

## 1. INTRODUCTION

Such large lift irrigation schemes comprise of two main parts. To carry water by means of pumps from the source of water to the main delivery chamber which is situated at the top most point in the command area and to distribute this water to the fields of the beneficiary farmers by means of suitable and proper distribution system. Of these two, the first part is comparatively easy and there are some technical guide lines for its design. If this is properly implemented for selection of pipes (diameter and pressure rating), valves and pump sets, there does not arise any problem in this part. But the second part of distribution is very important and comparatively complicated. The reasons are: The distribution system totally comprises gravity pipe lines. The gravity lines are designed totally on the basis of the available head, without any pumping system. This limits the job of design engineer. The area under the irrigation is scattered with varying topography. Therefore, each gravity pipe line has different available heads and different lengths. The area of individual farmers is different. The design engineer has to select the diameter of pipe from the standard diameters available in the market. The pipe diameter selected is the next higher diameter (than the design diameter) available in market. Higher diameter pipes are used and this affects the discharge through the pipes. The pipe line carrying water to the low level fields carry more water than the similar requirement on the elevated field. The distribution is not proper and dissatisfaction and frustration on the part of farmers leads to indifference and apathy towards scheme. The distribution system is controlled by valves on the basis of time schedule. The farmers operate the valves to their benefit which results in altercation and quarrels among the farmers. India is basically an agricultural country and most of its resources depend on the agricultural output. Water is evidently the most vital element in the plant life. Water is normally supplied to the plants by nature through rains. However to get maximum yield, it is essential to supply the optimum quantity of water and to maintain correct timing of water. It is possible only through a systematic irrigation system by collecting water during period of excess rainfall and releasing it to the crop as and when required. Irrigation is defined as the process of artificially supplying water to soil for raising crops. It is the science of raising an efficient, low cost, economic irrigation system tailored to fit natural conditions. It is the engineering of controlling and harnessing various natural sources of water, by the construction of the dams and reservoirs, canals and headworks and finally distributing the water to the agricultural fields. Lift irrigation system is that system of irrigation in which irrigation water is available at a level lower than that of a land to be irrigated and hence water is lifted up by pumps or other mechanical devices for lifting water and then conveyed to the land to be irrigated. The irrigation from wells is an example of lift irrigation system. In some cases the irrigation water may also be required to be lifted up from a canal or any other source of water when the level of water is lower than that of the land to be irrigated.

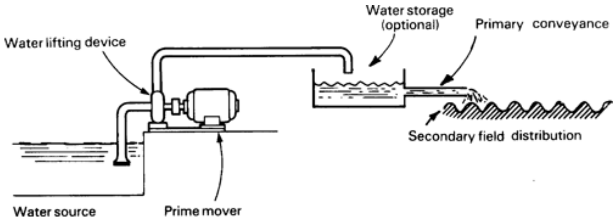


Fig.2 Key components of lift irrigation system

## 2. STUDY AREA

The post monsoon flow in the Deccan Rivers usually carries huge stone bank. The site for pumping operation is located on that bank along which water flows. If the river water is at opposite bank it will necessitate the laying of pipeline in riverbed, which would not only be expensive but troublesome. The site for well must be such that inlet pipe level is short & it must be situated above the high flood level.The location should be such that the length of rising main is shortest & also alignment of rising main should not follow any depression or high mounds, which will cause either excessive cutting due to need of lowering pipeline below the depression or requires provision of bends in the rising main which is not desirable.As far as possible the site should be at the upstream end of command. If the site is situated at the downstream end of command, it will be unnatural since it runs the channel contrary to the direction of flow of river as the command area would normally be rising from downstream to upstream. This in turn results in installation of more H.P. pump. The village Angar comes in Moholtaluka of Solapur district. This village is situated on Mohol – Modnimb road & is on left bank of Sinariver. Rainfall in the area is very low & it is unevenly distributed due to which main crops like Jawar dwindles if rains are not in time.Hence, Farmers of this village came forward for implementation of lift irrigationscheme on back water of Bople Bandhara on Sinariver so that sufficient water is available for this scheme.

- Name of work: Proposed lift irrigation scheme
- River: Sina river, Boplebandhara
- Taluka: Mohol
- District: Solapur
- Near railway station:Mohol on Solapur-Pune railway line
- Command Area: 30 Ha
- Area to be irrigated: 30 Ha
- Type of soil available: Black Cotton Soil-This soil has been named Black Cotton soil because it is black in color & good for taking cotton crop in it.
- Source of water: Sina river Boplebandhara back water Gut No. 1 at Pasalewadi

**Table 1** Economical suggested cropping pattern

| Sr. No. | Name of crop | Area in acre | Income per acre | Total Income |
|---|---|---|---|---|
| 1 | Cotton | 2.0 | 12000 | 24000 |
| 2 | Vegetable | 3.0 | 18000 | 54000 |
| 3 | Onion | 4.0 | 22000 | 88000 |
| 4 | Tomato | 3.0 | 41500 | 124500 |
| 5 | Sun Flower | 4.0 | 19800 | 79200 |

## 3. DATA ANALYSIS

The Executive Engineer starts survey work or fieldwork only after the inspection of site. As a thorough inspection it is necessary to fix the sites for inlet, jack well& delivery chamber, so that finally minor works are taken in hand. It is experienced that much efforts are likely to be wasted if the site is not inspected & subordinates are not properly instructed. Firstly the copies of village maps in which area it is situated are obtained& entire village map is copied. Where more than one village is covered, combined tracing is done. Except in the flat area where the contour map having not much meaning & where the visual inspection is necessarily not advisable its better if entire area is contour surveyed. It determines the economical lift. After the completion of above work sites for jack well, delivery chamber are fixed by checking. L-section for inlet pipe & rising mainare surveyed. Here, levels along with fixed interval of the change of ground slope pointsare taken giving correct profile. The extension of level beyond edge of water is at least about 8m.The lowest water level & highest flood level must be marked accurately on the L-section. Many times H.F.L. can be found recorded on a nearby structure like a bridge. Centers of jack well, delivery chamber & inlet chambers should be marked with long headers (at least 75 cm above ground) & buried flush into the ground. As inlet chamber center usually situated in water, marking stone or pit is located clearly away indicating accurately the chainage. All the points of rising main having turns, sudden change in slope are also marked. These markings are of much use while the work is in hand.The instruments used areTripod stand, Dumpy level,Staff,Altimeter and the difficulties occurred during implementation of main pipeline areroad-cut, Railway crossing, M.S.E.B. Line, Water supply pipeline.

## 4. TECHNICAL ASPECTS FOR DESIGN OF LIFT IRRIGATION SCHEMES

Lift irrigation schemes primarily consist of two type of works (i) Civil works and (ii) Electrical and Mechanical works. These are mainly as given below.

Intake well

Pump set

Jackwell

Electrical accessories and fittings

Sump well

Transformer and power connection

Pump house

Protective devices

Pipes both at intake and distribution side

Delivery/distribution chambers

Distribution System

Scheme providing for shifting of pumpsets with change in water level are not desirable specially for large lift irrigation schemes where an individual pumpset is over 15 HP. Shifting of pumping unit is cumbersome and may result in damage to the units. The general guidelines for design of different civil works are briefly discussed below:

**Intake well:**An intake well is a small diameter well-constructed in the river near its bank to collect river water and deliver it to the jackwell through a conduit pipe. An intake well is always located in the river bed. For lift irrigation schemes on canals an intake well in not necessary and intake pipe is fixed in a head wall constructed on the canal bank. It is desirable to locate the well at place where there is a continuous flow even under low water conditions and where foundation conditions are good. For curved reaches of a stream the convex side is more suitable as the main channel always flows close to the convex bank of a river. If intake works are located on the concave side then river training works may be necessary which may unnecessarily increase the cost of the works. The other guidelines are :

(i) The foundation of the intake structure in erodible river bed should at least be upto the scour depth computed from Lacey's formula

$$R = 1.35\left(\frac{q^2}{f}\right)^{\left(\frac{1}{3}\right)}$$

Where R = Scour depth below FSL (m)

Q = Discharge Intensity/unit width of river (cumec/m)

f = Lacey's silt factor, generally taken as 1.0, f can also be calculated by the equation, f = 1.76d, where d = mean particle size in mm.

Where hard rock is available within a reasonable depth below the river bed, foundation of the intake structure should be taken so as to be at least 0.6m in the hard rock strata.

(ii) The diameter of the intake well should be minimum 1.5 m or twice the diameter of intake pipe whichever is more.

(iii) The height of the intake well is governed by the lowest water level in the river and its depth below the river bed. The height of the well should be such that at least 0.5m water head is always available above the top of outlet pipe from the well.

(iv) The top of the well should be covered with a RCC slab with suitable provision for access to inside of the well for de-silting and repair work.

(v) The outside exposed surface of the well should be plastered in 1:4 cement mortar.

For entry of water an opening in the intake well is provided on the downstream side so as to avoid entry of floating debris. Bottom of this opening should be at least 150mm above the river bed. The intake well opening should be provided with a mild steel grating to prevent entry of floating debris. The open area of the grating should be adequate to permit entry of water at a velocity not exceeding 0.6m/sec. Sometimes a horizontal screen is provided on top of the well to serve as an inlet for water when the water level is high. This practice is however, not desirable as it may lead to heavy silting of well especially during the flood period when silt charge in the river is very high.

In case the intake well is to be utilized to tap sub-surface water from the river fill, the diameter of the well shall be designed based on Thiem's formula. The inner and outer walls of intake well in such cases are generally of precast 1:2 cement mortar. Properly designed filter screen should be provided to permit flow of water into the well. The top of well should be covered with an RCC slab. The space between the inner and outer filter screen is filled with gravel to serve as filters.

**Intake pipe :** Water from the intake well carried to the jack well or sumpwell through an intake pipe. The size of pipe is governed by the discharge to be carried but it is generally of 750mm diameter for lengths upto 15m. For larger length of pipe a 1200 mm diameter pipe is mostly used. The main deciding factor however, is the discharge to be carried. When the length of the intake pipe exceeds 100 m. an inspection chamber called a manhole should be provided in the middle for inspection and de-silting purposes. Depending upon local relief and the level at which the intake pipe is to be laid it is subject to earth pressure against which it should be safe. Since the hydrostatic pressure inside the pipe is negligible, non-pressure pipes can be used as intake pipes. Normally upto 2.5m overburden NP2 class and for higher over burden NP3 class pipes are adequate. The class of RCC pipe should confirm to 1S : 458 of 1971. Since the purpose of intake pipe is to draw water from intake well and carry it to the jackwell/ sumpwell under gravity it is laid with a flat gradient. This gradient is determined by the comparative water levels in the river and the bottom of jackwell/sumpwell and is generally kept at 1:400. In rare case a sharp gradient of about 1:100 may be necessary if bottom of the jackwell has to be taken very deep The pipes should be designed for flowing full and the maximum velocity in the pipe may be limited to 1.2m/sec.

Sometimes at certain places hard rock is encountered right from ground level itself . In such cases of the length of intake section is less than 25 m, open channel with bell mouth entry is preferable to a pipe. The slope of the channel should be about 1:1500 with the following side slopes.

(a) Soils : 1.5 horizontal to 1.0 vertical

(b) Fractured Rock Formation 1.0 horizontal to 1.0 vertical

(c) Compact Rock Formation : 0.5 horizontal to 1.0 vertical

The excavated earth should be suitably disposed off away from the intake channel

**Jackwell / Sumpwell:** The water diverted from the river and carried through the intake pipe is collected in a well called jackwell/Sumpwell from where it is pumped to the command area. The term jackwell is used when the pump house is directly over the well in which case vertical turbine pumps are mostly used. When the pump house is located on ground and is near to it the well as called a sumpwell. The design of the well is determined by the lowest water level and high flood level of the river as well as the relief of the river banks. If the difference between the lowest water level and the high flood level is within 4.5m then centrifugal pump set can be used and sumpwell constructed near the river bank. If the difference between lowest water level and high flood level of the river is more than 4.5m necessitating use of either vertical turbine or submersible pump sets it is necessary to construct a jackwell. Functionally, jackwell and sumpwell are the same but their design is based on the relative river water stages. Where the river bank has high relief it is preferable to construct a jackwell instead of sumpwell though the difference between the lowest water level and high flood levels may not be more than 4.5m . This is mainly due to convenience of construction and approach to the well.

### 4.1 JACKWELL

A jackwell is an important item of civil works in a lift irrigation scheme. It is generally circular in shape. The jackwell should be located close to the river but should be so cited as to be safe against river attack during floods. It should have a free board of about 1 m above the high flood level.

Size of Jackwell: The internal diameter of a jackwell depends upon the size and number of pumpsets to be installed. Normally 3 pumping units are adequate for most of the lift irrigation schemes. Other important parameters that govern the diameter of ajackwell are the accessories and electrical fittings to be installed in the pump house which is constructed above the jackwell. These accessories are the sluice valve, reflex valve, electrical panel board, starters, switchgers, capacitors etc. Generally a sluice valve is installed inside the pumhouse above jackwell and a reflex valve outside it to keep the well diameter to a minimum. All electrical installations have necessarily to be installed inside the pump house above jackwell.A table indicating the discharge of a lift irrigation scheme and the corresponding diameter of jackwell is given in Table 2. The suze indicated is for guidance only and each scheme should be designed on the basis of specific field conditions in an area.

Table 2Diameter of Jackwell

| Sr. No | Discharge per pump (Lps) | Internal dia of Jackwell (m) | Minimum Water Column above Strainer in Jackwell (m) |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 1 | 25 | 4.0 | 1.5 |
| 2 | 50 | 4.5 | 1.5 |
| 3 | 100 | 4.5 | 1.5 |
| 4 | 150 | 5.0 | 1.5 |
| 5 | 200 | 5.0 | 1.5 |
| 6 | 300 | 5.5 | 1.5 |
| 7 | 350 | 5.5 | 2.0 |
| 8 | 450 | 5.5 | 2.0 |
| 9 | 550 | 6.0 | 2.0 |
| 10 | 700 | 6.0 | 2.0 |

The above are optimum diameters but a slightly larger diameter can also be provided so as to have adequate operating room after leaving enough space for electrical and mechanical fitting in pump house above jackwell.

b. Height: The height of jackwell is governed by location of pump intake and the high flood level. The intake section of the vertical turbine pump should be kept about 2 m. below the lowest level. This is aimed to provide equitable distribution of water to all the pumps without causing excessive turbulence. In case of centrifugal pumps the water cover should not be less than 1.4m. The top of the jackwell should be 1.0m above the high flood level or 0.3m above grand level whichever is more. These two mainly govern total height of a jackwell.

c. Steining : The thickness of the well steining is governed by the earth pressure and the super imposed load consisting of pump, motor, valves etc. In order that this load is evenly distributed over the entire steining an RCC ring of 300mm thickness should be provided on top of steining. If the height of jackwell is more than 10m RCC ring may be provided at intermittent levels also. The thickness of steining above ground level is controlled by requirements for stability. Generally the thickness of steining below ground level should be 750 mm to 900 mm and it should be 380 to 450 mm above ground level. The well should be founded on hard strata strata which it not available, an RCC raft can be provided at the bottom. For inspection of well bottom, steps made of 20 mm diameter U shaped MS bars embedded in well steining may be provided. If the length of column pipes of the vertical turbine pumps in more than 8 m. MS girders should be provided at intermittent levels for convenience of erection and maintenance of the equipment. Two mild steel crossgirders of suitable size should be provided on top of the jackwell to install the pumps. These girders should be fixed in RCC blocks and covered with 50mm thick teak wood planks to provide the working platform.

**4.2 Sumpwell**

Where the river water level is within the suction lift of a centrifugal pump a sumpwell is provided instead of a jackwell. A sumpwell is an open dug well excavated underground and having a parapet wall above the ground level. The dimensions of a sumpwell i.e, diameter and its height depend upon the following factors.

a. Spacing between suction pipes.
b. Diameter of suction pipes
c. Size of foot valve or bell mouth as the case may be
d. Clearance between bottom of bell mouth/foot valve and floor level of well
e. Minimum and maximum water levels.

In case of schemes envisaging more than one stage pumping, a sumpwell is required at each pumping stage. However, at times specially when the pumpsets at two or more stages are not connected through the same electricfeeder line, chances of over flowing of one or more sumpwells by sudden break down of pumping units near one sumpwell are not ruled out. This overflowing at any of the intermediate sumpwell may damage the land and crop around it unless arrangement to dispose off the excess water is made and it is attended to immediately. An arrangement for disposal of such over flowing water from any sumpwell should be made on a permanent basis. If the pumpsets at jackwell and sumpwells at various stages are connected with the same power line, no extra capacity in a sumpwell at any stage is necessary. However, when such an arrangement is not possible it is desirable to provide sumpwells with a maximum 5 minute retention capacity and also proper overflow arrangements. The sumpwell can either be circular or rectangular in shape. The dimensions of a sumpwell for various discharge, both for circular and rectangular wells are given in Table 3.

Table 3 Size of Sumpwell

| S No | Discharge of each Pump set (lps) | Circular sumpwell Diameter (m) | Rectangular Sumpwell | | Clearance between well bottom and footvalve of pump (m) | Minimum water above foot valve in sumpwell (m) |
|---|---|---|---|---|---|---|
| | | | Length (m) | Width (m) | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 25 | 2.50 | 5.0 | 2.5 | 0.6 | 1.4 |
| 2 | 50 | 2.75 | 5.5 | 2.5 | 0.6 | 1.4 |
| 3 | 100 | 2.75 | 5.5 | 2.5 | 0.6 | 1.4 |
| 4 | 150 | 3.25 | 6.0 | 3.0 | 0.6 | 1.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 200 | 4.00 | 8.0 | 3.5 | 0.6 | 1.4 |
| 6 | 300 | 5.00 | 7.5 | 4.0 | 0.6 | 1.4 |
| 7 | 350 | 6.00 | 8.5 | 4.0 | 0.6 | 1.4 |
| 8 | 450 | 6.50 | 9.0 | 4.0 | 0.6 | 1.4 |
| 9 | 550 | 7.50 | 9.5 | 4.0 | 0.6 | 1.4 |
| 10 | 700 | 8.50 | 10.5 | 4.5 | 0.6 | 1.4 |

The thickness of steining in stone or brick masonry in cement mortar (1:4) should be 0.6m. A minimum free board of 0.6m above full supply level and a parapet wall of minimum 0.6m height with top coping should be provided.

**4.4 Pump house**

Pump house for vertical turbine pumps for lift irrigation schemes where vertical turbine pumps are used it is preferable to provide circular pump house over a circular jackwell. A rectangular pump house above a circular jackwell is not desirable as it may be structurally unstable and uneconomical. The floor level of the pump house should be about 0.3m above ground level or 1.0m above high flood level whichever is higher. Although the floor can be of RCC slab with suitable openings for lowering of the pump assembly, it is desirable to construct it with wooden planks fixed with nuts and bolts on mild steel girders. This minimizes its cost and also reduces the possibility of electric leakage. The roof of the pump house should be of RCC slab of about 150 mm thickness. The height of the pump house should be kept at 5m. Gantry arrangements with chain pulley block can be provided at a height of 4m above the floor of the pump house. This is very convenient for handling equipment equipment during erection, dismantling and maintenance. The capacity of the gantry should be such that it may lift upto the maximum weight of a single unit which generally varies between 0.5 to 3.0 tons depending upon the size and HP of the pumpset. Two windows of size 1m x 1.2m each and one door of 1.5m x 2.1m, preferably with rolling shutter, should be provided in the pump house. A ventilator near the gantry level should also be provided. A lightening conductor should invariably be provided when the top of the pump house is more than 5m above ground level. Sometimes due typical site conditions particularly where the river banks are steep and deep, use of submersible pump is preferable compared to a vertical turbine pump. In such cases the jackwell can be omitted and a smaller diameter well can be provided to accommodate the submersible pumps. In such cases a smaller pumproom of size 4m x 3m x 3.25 can be constructed. The pumproom should be at ground level or at a suitable elevation above high flood level to keep the control panels safe.

Pump house for centrifugal pumps in lift irrigation schemes horizontal centrifugal, pumps are generally large units. For their installation the pump house does not have to house the pumpset alone but also the control panels and other electrical and mechanical fittings. For such units pump houses are generally constructed rectangular in shape. The size of pump house for centrifugal units for different discharge is given in table4.The pump house is required to house the pumps and giving them stable and sound foundation. Pump house is most conveniently located on the top of well where feasible. For jack well, pump house is used to house the vertical pumps, the starters and switch boards. As per S.E. lift irrigation circle notes it should be of rectangular shape in plane. It is formed by structural steel members as frame work and G.I. sheets used for walls. This provides good design against earthquake. This rectangular shape provides adequate space for accommodation of heavy switch gear panels of motors within the pump house itself. Thereby avoiding the necessity of separate gear room.The design of the pump house should be such that it can accommodate all the pumps with stand bye unit and having sufficient space in between them for repair etc. as pump sound is having revolving machinery parts, it must provide sound foundation. From the observation of existing jack-wells, it is found that due to working of heavy duty. Electric motors, the room temperature of pump house rises considerably. To avoid this good ventilation is provided by steel framed windows at two levels, one at pump level and other at top level. Exhaust fans are also provided for additional ventilation.

Table 4 Size of Pump houses for Centrifugal Pumpsets

| Sr. No | Discharge of each pump (lps) | Size of Pump house | | |
|---|---|---|---|---|
| | | Length (m) | Breadth (m) | Height (m) |
| 1 | 2 | 3 | 4 | 5 |
| 1 | 25 | 6.25 | 2.75 | 3.25 |
| 2 | 50 | 6.25 | 2.75 | 3.25 |
| 3 | 100 | 6.25 | 2.75 | 3.25 |
| 4 | 150 | 7.25 | 3.50 | 3.25 |
| 5 | 200 | 7.25 | 3.50 | 3.25 |
| 6 | 300 | 8.50 | 4.00 | 4.00 |
| 7 | 350 | 9.75 | 4.25 | 4.25 |
| 8 | 450 | 9.75 | 4.25 | 4.25 |
| 9 | 550 | 10.25 | 4.50 | 4.50 |
| 10 | 700 | 12.75 | 4.75 | 4.50 |

Depending upon its length 2 or 3 windows can be provided on the suction side and 1 or 2 on delivery side of the pump house. For each pumpset the foundation block should be constructed in 1:3:6 cement concrete. Tobe safe against vibration effects the foundation blocks should be isolated from the floor by a layer of bitumen. For large size installations provision of suitable gantry to handle the equipment should invariably be made. The roof of the pump house should preferably be of RCC slab of 150mm thickness or of wooden rafts with G1/AC sheets or tiles, other guidelines that should be kept in view while designing a pump house are,

- The pump house foundation should be taken about 0.6m below the ground level in hard soils about 0.9m in other cases.
- Gantry crane of capacity 0.5 to 3.0 tons depending upon the weight of pumpset, should be provided.
- The pump house and sumpwell should be constructed separately and not one above the other. Wall of the pump house should be 0.45m thick and the exposed surface should be plastered with cement mortar (1:4).

These is a tendency to increase the size of pump house so that it may be used either as a store room or as an operator's quarter. Such a practice should be discouraged and the size of the pump house should be restricted to what is actually required for installation and for efficient and economic operation of the equipment. These design specifications of sumpwell and pump house can be followed both at off take point.When the total suction lift at river head is within the limits of centrifugal pump and at subsequent stages also.

**4.4 Piping System :**Piping System **f**rom manifold near the pump house upto delivery chamber is one of the important units of a lift irrigation scheme. The first and the foremost requirement of a piping system is to have the correct size of suction and delivery pipes. The diameter of suction and delivery pipes should be such that fraction head loss in them do not exceed to 10% of the equivalent pipe length. The lengthy of delivery pipe is considered upto manifold only which is fitted close to the pump house. Beyond that it is generally classified as pressure mains. In pressure mains beyond the manifold the permissible flow velocity is confined to a maximum of 1.37m/sec. As a general rule the suction and delivery pipes should be one size larger than the pumps suction/delivery flange size. With these larger diameter suction pipes a reducer would be necessary. This should be of eccentric type to avoid the possibility of developing air pockets. On the delivery side an enlarger would be necessary to connect the larger diameter delivery pipe to the pump flange. Only long radius bends should be used in the pipe assembly. In case of large size centrifugal pumps a separate vacuum or hand pump can be provided for easy priming of the pumps. In some cases a by-pass from delivery pipe beyond reflex valve is connected to suction side for facilitating priming. Table 5 gives the recommended diameter of suction and delivery pipe in the discharge range of 20 to 500 litres/sec. While using he pipe sizes given in Table care should be taken to keep the pipes as straight as possible by avoiding bends

Table 5 Recommended diameter of Suction and Delivery Pipes

| Sr No | Discharge | Pipe diameter (mm) | |
|---|---|---|---|
| | | Suction | Delivery |
| 1 | 2 | 3 | 4 |
| 1 | 20 | 125 | 100 |
| 2 | 30 | 150 | 125 |
| 3 | 50 | 200 | 150 |
| 4 | 100 | 300 | 250 |
| 5 | 150 | 350 | 300 |
| 6 | 200 | 400 | 350 |
| 7 | 250 | 450 | 400 |
| 8 | 300 | 500 | 450 |
| 9 | 350 | 550 | 500 |
| 10 | 400 | 600 | 550 |
| 11 | 450 | 600 | 550 |
| 12 | 500 | 650 | 600 |

The delivery outlets from the pumps are generally connected to the rising main through a manifold or Y-piece, except in cases where the main delivery chamber is very close to the pump house and the delivery pipe from each pump is directly taken upto the chamber. The manifolds are either of MS or CI fabrication. It is recommended that MS manifold be preferred owing to its easy fabrication and less damage during handling. While connecting pipe to the main pump it should be remembered that unless the foundation grout sets properly and bolts are tightened the pipe should not be connected to the pump.

Pumping or rising mains constitutes one of the important items of lift irrigation scheme. It is a conduit between the manifold and the distribution chamber. These are generally RCC pressure pipes of P1, P2, P3 or pre-stressed class but asbestos cement MS/CI, ERW OR PVC/HDPE pipes are also used. The type of pipe depend upon (i) its cost (ii) easy availability (iii) transport and handling problems and (iv) life. The pipe class P1, P2, or P3 defines the pressure or head it can withstand. P1 class pipes can be used for pressures upto 2kg/scqm or pressure head upto 20m and P3 class upto 3kg/scqm or pressure head upto 30m. The total head at any point can be calculated from the L-Section after finding the total hydrostatic head at that point and adding friction head to it for the length of pipe upto that point. As far as possible the rising main should be straight and should be laid about 1m below ground. Whenever the rising main crosses a mullah or a gully it should be supported on RCC blocks. The velocity of water in pumping mains of RCC pipes should be limited to 1.37 m/sec.

For smaller than required diameter rising mains the friction losses would be higher and thus the total pumping head would increase. This increases HP of the pumping units and results in its higher initial cost as well as greater running charges. On the other had for larger than required diameter rising mains, the friction losses and the total head are low. This reduce HP of the pumping units and results in lower cost of power consumption, but the initial cost of investment increases. A compromise between the two keeping in view the economics is therefore advantageous. Such an analysis is however, time consuming and the results may vary with cost escalation of pipes which is much steeper than rise in energy charges. Such an analysis is therefore, generally not practiced. We should select the rising main pipe diameter such that friction losses do not exceed 3m per 1000 m. length of the pipe. A pipe diameter which is larger of the two as given by velocity and friction head criteria should be adopted.

The friction losses in a piping main can be computed from any of the following equations.

1. Darcy- Weisbach Formula

$$h_f = flv^2/2gd$$

Where $h_f$=Loss of head due to friction in m

F =Coefficient of friction for the type of pipe (generally taken as0.003 to 0.01)

L = Length of pipe in m

D = Internal diameter of pipe in m

V = Velocity of water in m/sec and

g = Acceleration due to gravity (9.8 $m/s^2$)

2.William Hazen Formula

$$V=0.85\ CR^{2/3}\ S^{1/2}$$

Where V=Velocity of water in m/sec

C = Coefficient of friction for the pipe material taken as 130 for concrete pipes.

R = hydraulic mean depth of pipe in metre (d) for circular pipes flowing full

S = hydraulic gradient

3. Scobey's formula

$$V=1.26H^{1/2}\ D^{2/3}$$

Where V = Velocity of flow in m/sec

H=Loss of head due to friction in m per 1000m length of pipe

D=Diameter of pipe in m

Using friction losses as a guiding factor and keeping them below the permissible limit of 3m/1000m the diameter of RCC pipes for different discharges are worked out on the basis of above formulae and the higher of the these is recommended as given in Table 6

Table 6 Recommended Diameter of RCC Pipes for Rising Main

| Sr No | Discharge in litres/sec | Recommended Diameter |
|---|---|---|
| 1 | 2 | 3 |
| 1 | 20 | 250 |
| 2 | 30 | 250 |
| 3 | 50 | 300 |
| 4 | 100 | 400 |
| 5 | 150 | 450 |
| 6 | 200 | 450 |
| 7 | 250 | 500 |
| 8 | 300 | 600 |
| 9 | 350 | 600 |
| 10 | 400 | 600 |
| 11 | 450 | 700 |
| 12 | 500 | 700 |
| 13 | 550 | 700 |
| 14 | 700 | 800 |
| 15 | 800 | 800 |
| 16 | 900 | 900 |

| | | |
|---|---|---|
| 17 | 950 | 900 |
| 18 | 1000 | 900 |

Bifurcation of Pumping Mains for diverting part flow from the rising mains, the rising mains, the pipes are sometimes designed telescopically according to the lower discharge requirement beyond the bifurcation point. In such case if the bifurcated pipe is closed or partly operative, the increased discharge with higher flow velocity may endanger them in case of water hammer. Therefore, diverting part of the total flow at intermediate stages in the rising main should be avoided. The pipe for rising main should confirm to IS Standard IS : 458 and IS:784 according to which the pipes should be safe for twice the working pressure i.e. the factor of safety for pipes should be 2.Cast iron (CI) pipes are mostly used for water supply schemes because of their durability (approximate life 30 yrs), good strength and low cost maintenance. They, however, have the disadvantage of heavy weight, high transportation cost, higher cost, higher cost of laying and jointing, liability to develop defects such as pit holes, blow holes and higher roughness of internal surface. Because of the above and their high cost CI pipes are not commonly used in lift irrigation schemes

In lift irrigation schemes mild steel pipes (MS pipes) are used in special situations such as where the rising main is exposed, in trunk mains of an inverted siphon and on bridges or valleys where pressures are higher than 7kg/cm2 and strength with least weight are one of the main considerations. Mild steel pipes are seldom available in diameters below 600mm. These have high durability and strength and hence their wall thickness is small. This results in their low weight, easytransportation and easy laying and joints. However, direct tapping from them and repairs become difficult. MS Pipes are also liable to action of acids and alkalis present in water and presence of these produce incorrosion. The corrosion in MS pipes is greater compared to CI pipes and therefore the maintenance cost of MS pipe is comparatively high. Mild steel pipes are unable to withstand heavy external loads and partial vacuum caused by sudden emptying of a pipe may cause its collapse or distortion.

Coating on Steel Pipes buried steel pipes are subject to corrosion and damage unless these are properly protected by suitable coatings. These coatings should be resistant to scratching during transport and laying of the pipe, to moisture, chemical, biological attach, electrical current the temperature variation. These should be hard enough to prevent damage during handling and due to stones in the trench and yet sufficiently adhesive to adhere well to the pipe wall and flexible enough to withstand the flexing of the pipe wall. The most common coating for pipes is a thin adhesive coat followed by a coating reinforced with fibers and then possibly an auteur wrapping. The pipe surface is initially cleaned by wire brushing or sand blasting or acid prickling and the prime coat is then is then applied by spray, brush or dipping the pipe in a bath. Bitumen or coal tar enamel is preferred for prime coating. After the primary coat the pipe may be spirally wrapped with impregnated or woven glass fiber matting. This is sometimes followed by paper or asbestos felt impregnated with bitumen or coal tar. The pipe is then white-washed to assist in detecting damage and to shield the coating from the sum. The coating may be applied in the field after welding the pipe joints or in the factory, in which case the ends are left bare for jointing and coated in the field. The thickness of the coating should be at least 3 mm.

Other type of coating include an asbestos fiber bitumen mastic 3 to 5mm thick, coal tar pitch, epoxy paints, PVC or polythene tapes, resins or plastics, cement mortar and zinc applied by galvanizing. Exposed pipes can also be primed and painted with bitumen based aluminum or enamel.Finished coatings need to be checked for flaws, pin holes etc. by means of suitable detectors. Lining of steel pipes is used to resist internal corrosion and to minimize the friction losses. Unlined steel pipes may be oxidized by corrosive substances in flowing water.The most popular lining is bitumen (3 to 5mm thick) or coal tar enamel (2 to 3mm thick) Bitumen which is by-product of petroleum is the cheaper of the two. Before applying the lining the pipe wall is cleaned by sand blasting or other method and the lining is then applied by brush or spray or dipping or spinning to obtain smooth surface. Spun enamel in particular provides a smooth finish. Coal tar is also more resistant to moisture than bitumen, although it is more brittle and is consequently subject to damage by impact and flexing of the pipe. Plasticized coal tar enamels have however now been developed to overcome the problem of brittleness. Epoxy paints are also used successfully for lining, although their careful application is necessary to ensure that successive coats adhere to each other. The recommended thickness of lining varies with the type of paint but it is normally of the order of 0.3 mm applied in 2 to 4 layers is also used for large diameter pipes. The lining applied is usually 5 to 10 mm thick.In view of the costly treatment required to be given to mild steel pipes their use in irrigation schemes becomes uneconomical. Further when these pipes are laid over the ground they are often tampered with and damaged by local people particularly in sugarcane growing areas. Use of MS pipes is therefore, not recommended for rising mains in lift irrigation schemes.

Asbestos Cement Pipes (AC) pipes are sometimes used in lift irrigation schemes. However, the constraints on their large scale use are (a) limited availability due to limited manufacturing capacity and (b) availability in lower diameter ranges only (c) high cost. Following guidelines should be kept in view for use of A.C. Pipes

(i) The diameter of pipe should be such that frictional head loss do not exceed 3m/100m
(ii) The class of pipe should be selected according to the hydraulic head.
(ii) AC pipes of required class and diameter confirming to IS: 1592 should only be used.
(iii) Only full length pipes after proper testing should be used.

It is also desirable that the bank satisfy itself about the test pressure reports given by the manufacturer and satisfactory performance of these pipes in test nuns.

Plastic Pipes with the technological advance in plastic industry, rigid polyvinyl chloride (PVC) and high density poly-ethylene (HDPE) pipes are becoming more and more popular in the agricultural field. Advantages of these pipes are:-

(i) These pipes neither corrode nor get incrusted and their life span is reported to be about 50 years which is comparable to the life of conventional pipes.
(ii) These pipes have a smooth internal surface hence water with higher velocity can flow through them. The friction head loss is low compared to other pipes of the same diameter. With lesser friction head, the HP of the pumpset is smaller resulting in saving in initial and operational cost.
(iii) These pipes are 6 to 8 times lighter in weight compared to concrete pipes this facilitates their safe and cheap transport and handling.
(iv) Laying and jointing of these pipes is much easier and can be attended to even by farmers. The time required for their laying and jointing is short compared to CC or CI pipes.
(v) These pipes are tough the non- brittle. They can withstand working pressure 10kg/cm$^2$.

Owing to these advantages these pipes are now being used to a greater extent in lift irrigation schemes. However, care has to be exercised during their laying and jointing. No sharp edge should come in contact with the pipe surface otherwise high point pressure may result in damage and consequent leakage. There is a fear amongst farmers that these pipes are damaged by burrowing animals but this can be avoided with proper maintenance. Another limitation in large scale use of these pipes is their present availability with B.I.S. mark upto 600 mm diameters only. It has been observed in field that when these pipes are connected to metal valves or fittings, the joints often give way due to water hammer this disrupting the entire system. It is, therefore, necessary to pressure use water hammer control devices when these pipes are used in pumping mains. PVC pipes confirming to IS:4985 (1981) should only be used. Before using any particular types of pipe for pumping main it is necessary to keep in view their availability and compare their cost economics with other types of pipes readily available. At times use of a particular type of pipe may be more economical but it may be in short supply which may delay completion of the scheme and deprive the farmers of benefits of irrigation which in not desirable. In such cases a slightly costlier pipe may prove more advantageous. Therefore, it should be remembered that while selecting any type of pipe for pumping mains, its cost economics should be considered in view its availability in the market.

Multistage Pumping Mainsbefore taking a decision on this aspect, an economic analysis of the entire system should be worked out and examined in each individuals use. Further where the command area is undulating and proper topographic slope is available over a considerable length it is preferable to provide gravity mains if necessary with multi state pumping. The economics with single stage and multiple stagepumping has to be examined on merits in each case.

Distribution cistern of Delivery Chamber the rising main is let into and ends in a masonry chamber called the distribution cistern or delivery chamber. This chamber receives water from the pumping main and distributes it to various channels or distribution pipes take of from the distribution cistern. It is desirable to provide distribution system at all intermediate points where valves are provided to take off water from the rising main. The size of the delivery chamber is governed by the rate of flow of water the pumping main into the chamber and the number and diameter of pumping main leading into it. This chamber can be circular square or rectangular in shape. Normally the size of the cistern is so fixed that it may have about 2 minutes retention time for the designed discharge. Arrangements should be made to draw surplus water in case the chamber overflows particularly if only one outlet is provided from the delivery chamber. A maximum of 3 off takes can be provided in the cistern. If water to be released in the channel is to be measured, the off takes can be provided with sill and gates or notches. When a notch is to be fixed, the size of cistern should be designed considering the following factors:

(i) The depth of cistern should be at least 3 times the maximum depth of flow over the notch.

(ii) Side walls beyond the notch should not be less than 2.5 times the maximum depth of flow over the notch

(iii) Sill of all the notches should be kept at the same levels. Other points that may serve as guide while designing the delivery cistern are as follows:-

(a) Minimum thickness of foundation concrete should be 150mm for stiff blackcotton soil and 100mm for other soils. Foundation should be in 1:4:8 cement concrete.

(b) The minimum top width of masonry steining should be 225mm in case of brick masonry and 375 mm in or RR stone masonry.

(c) Plastering of exposed faces of cistern should be with CM (1:4) 20mm thick for RRmasonry and 12 mm thick for brick masonry.

(d) Canals taking off from the chamber should be preferably lined.

(e) The distance between the successive rows of pumping mains within the cistern should be 1 m.

Pipe line distribution system in left irrigation scheme the water is lifted from jackwell to highest point (deposition point), say to the main distribution camber. This water is then distributed in command area by the network of pipe-line or using channels, lined or unlined. This network of pipe line or channel which takes water from main distribution chamber and carries it in command area under gravity is called “Distribution system”. Distribution system must be well planned, efficient in order that each field or plot gets required amount of discharge. This efficiency of lift irrigation scheme mainly depends upon d distribution system.The last point of distribution system is an outlet from which water is supplied to each field in the territory of that outlet by means of field channel or water course. The work up to outlet falls under the jurisdiction of engineering and from outlet the further conveyance of water falls under the jurisdiction of farmers.Distribution system may consist of network of pipe line or network of channel. The economic analysis of these two alternatives should be carried out before coming to the final decision. As a general rule, when discharge is smaller, the pipe line distribution system is efficient and discharge is large, the channel distribution proves efficient. The main objectives of distribution system are,to divide the command area into number of parts (zones) so that water from the outlet allotted for that part can easily irrigate it and to distribute the quantum of water required to an individual part of command area.

Requirements of good distribution system are;

(a) It should be so planned and designed that its initial cost is minimum. The distribution system should utilize the maximum length of non-pressure pipes as far as possible.

(b)It should be provided with valves and subsidiary distribution chamber whenever necessary.

(c) The distribution line should be so laid that it can be maintained properly.

(d) The distribution line should be laid over the ridges and the zoning should be such that the crossing of drainage structure, roads, railways, nallas etc. minimum.

Pipe line distribution system has been popularized in the recent lift irrigation scheme pipe line distribution system have the following merits and demerits;

Merits:

(1) For the smaller discharges, say upto 2 to 3 cusecs by the distributaries pipes of 150 mm, 230mm, 254mm, 300mm, are economical than channel distributaries.
(2) The pipe distributaries are buried at about 1 m to 1.5 m below the ground level. This prevents the loss of area and the cultivation. Mulching operation are almost unobstructed.
(3) Controlling devices like value etc. can be easily provided which facilitate the smooth functioning of the scheme.
(4) There is no loss of water due to seepage and evaporation.
(5) Construction of pipe line system is easy.

Demerits:

(1) The pipes either pressure or non-pressure are costlier than channel construction. However, small diameter pipes compensate this factor upto certain extent.
(2) The repairs are rather difficult & leakage in the pipe lines cannot be found out to be verified easily.
(3) For small command areas between 10 hect. to 24 hect. pipe distribution may not be economical.
(4) Transportation & handling of pipes requires additional expense.
(5) The sluice valves, air valves & accessories are costly & have to be fitted by a skilled person.

Channels of trapezoidal shapes are generally constructed in channel distribution. The channels may be lined or unlined depending upon the soil conditions. The channel distribution is cheapest mode of distribution, especially for large discharge in flat terrains. The main channels are arranged at the centers& outlets are taken from the main channel from the ridges. The channel distribution system requires to fulfill certain hydraulic requirements like bed slope, velocity etc. The channel should be provided with the balancing depth. The bed slope may be 1:4000 for the discharge of 1.9 cumec to 1:800 for 32 cumecs discharge.

The channels may be lined or unlined for the soils with the poor drainage characteristics. For permeable soils, channel lining though costlier, entails in certain advantages like high velocity of flow, reduction in seepage flow, anti-waterlogging measure, non-silting characteristics, less maintenance etc.

## 5. Practical Steps in Design Of Lift Irrigation

Lift irrigation is practiced when the water-supply is at too low level to run by gravitation on to the land. In such circumstances water is lifted up by mechanical means. Irrigation from wells is an example of the lift irrigation, in which sub-soil water is lifted up to the surface and then is conveyed to the agricultural fields.

The lift irrigation system can be designed by following methods:-

a) Engineering method
b) Customers method

The water rights of a river or a natural stream rest with the state government. Lifting water from rivers or streams requires prior approval of state govt. in the concerned department, generally Irrigation dept. The sponsor of lis should ensure that before a scheme is submitted to any bank necessary long duration permission for lifting the desired quantity of water from the stream is obtained from state govt. and is enclosed with the scheme proposal. While acreage of crops to be sown in the command of the scheme or the discharge to be lifted. In such cases the scheme should be framed accordingly. The cropping pattern under the scheme should be designed keeping in view the relevant factors and should be finalized in consultation with the district agricultural/irrigation officers.

The cropping Pattern depend upon the agro-climatic conditions of an area and availability of water. Perennial crops are possible only if the source of water if the river is perennial otherwise the scheme is to be designed for one or two seasonal crops. The cropping pattern generally change when irrigation facilities become available. With the introduction of irrigation cropping pattern does not radically change during kharif as the crops do not entirely depend on irrigation although their yield improves.An important point which often escapes attention is the nature of soil and its suitability for crops envisaged. To a good and experienced farmer it is the nature and composition of soil that matters more in determining the fertilizer dose and identification of areas under each crop. It is therefore, desirable to know and built in the scheme the nature and characteristics of soil and their suitability for the cropping pattern proposed.

The cropping pattern for 75 acres

1. Kharif 50 % of total land

2. Rabbi 50 % of total land

3. Hot weather 25 % of total land

4. Exceptional case: Sugarcane 25 % because it comes in all seasons

Table 7 Cropping pattern

| Sr. No | Crop | Kharif | Rabbi | Hot weather | Duty |
|---|---|---|---|---|---|
| 1. | Sugarcane | 20 | 20 | 20 | 40 |
| 2. | Sunflower | | 7 | | 45 |
| 3. | Vegetable | 7 | | | 50 |
| 4. | Cotton | 10 | | | 45 |
| 5. | Onion | | 10 | | 30 |

The irrigation Water Requirements of crops depend upon many factors. The important among these are the crop type, soil type, temperature, rainfall, humidity, wind velocity, sunshine hours and quantity of water. It would be thus seen that irrigation water requirement vary from place to place and depend upon the extent of area under different crops at the same place. The two common terms used in this connection are net irrigation requirement (NIR) and the gross irrigation requirement ( GIR ). The net irrigation requirement refers to the quantity of water required to be applied for successful growth of crop during its life period excusive of effective of rainfall during that period. The term irrigation requirement and water requirement is not synonymous. Water requirement is the quantity of water required for consumptive use and other economically unavoidable losses and that applied for special operations like land preparation, transplantation etc.The Gross irrigation requirement ( GIR ) is the total amount of water required for irrigation including conveyance and the field application losses. It can be referred to in many ways such as the gross requirement of water either at field level or at an outlet level or in canal. For lift irrigation schemes the gross irrigation requirement refers to the amount of requirement of crops within the command are met with at field level. It would thus include conveyance losses and losses in water application is cent percent efficient. These are losses in conveyance as also in the field by way of percolation below the root zone and surface runoff at borders and furrows. For design purposes the irrigation efficiency is taken as70% for lined or piped distribution system.

- Water Requirement $\propto 1/duty$
- Duty changes depends on
  1. Season
  2. Type of land (black cotton soil at field )

$$\frac{Acrage}{Duty} = \text{water requirement in cusecs}$$

- For 16 hours design

But electricity is available only for 12 hours in almost whole Maharashtra.

So, for 16 hours –

For 12 hours – x

- Total water requirement
  1. Sugarcane $= \frac{20}{40} = 0.5$ cusecs
  2. Vegetable $= \frac{7}{50} = 0.14$ cusecs
  3. Cotton $= \frac{10}{45} = 0.23$ cusecs
  4. Sunflower $= \frac{7}{45} = 0.16$ cusecs
  5. Onion $= \frac{10}{45} = 0.33$ cusecs

  Total = 1.35 cusecs for 16 hours.

16 hours - 1.35 cusecs
4 hours - x

Hence, x = 0.34 cusecs for 4 hours

For 12 hours ,
1.35 + 0.34 = 1.69 cusecs

1.69 × 28.98 = 48.98 lit/sec

- For design purpose it is taken as ,

Additional 10 % = 48.98+4.898
= 53.88 ≈ 54 lps
Hence , discharge = 54 lit/sec
Capacity of motor ,

$$Hp = \frac{discharge \times head}{75 \times efficiency\ of\ motor}$$

Where efficiency of motor = 0.6 and 75 = constant

$$Hp = \frac{54 \times 79.5}{75 \times 0.6} = 95.4hp \approx 100\ hp$$

- Total head :-

Frictional losses = 5m per 1000 m

This value of frictional losses are taken from the graph attached herewith based on the IS specification.

For 7 m,

Frictional losses = 7 × 5 = 35 m ( G.L. = 35 m )

- Accessories head,

10 % of total frictional head,

10 % of 35 = 0.1 × 35
= 3.5 m

- Suction head = 6 m

Total head = ground level difference + frictional losses
+ accessories head + suction head

= 35 + 35 + 3.5 + 6

= 79.5 m

Hence, height of water at reservoir is 79.5 m

## 6. MODEL

This model has been prepared on the principle similar to that of Lift Irrigation & Drip Irrigation scheme. Some elevation difference is kept between the canal & the tray (farm) so as to achieve practical condition. Model consists of:

- 4 * 4 tray (farm)
- Submersible pump – 3m head
- NRV
- PVC pipe – 180mm
- Lateral pipe – 12mm
- Online Drippers
- End stoppers

Model is working as

1. Firstly, submersible pump is dipped into the canal water for 10 minutes to allow the water fill in it.

2. After 10 minutes switch is put on so that water is lifted up to the well situated in the farm through the main pipeline.

3. The non-return valve is attached to the main pipeline so that waterwill not go back in source.

4. Air valves are attached on the main pipeline according to the requirement to reduce the water hammer effects.

5. After that the water is passed to the main pipeline of distribution system through the screen filter from well. The screen filter isprovided to reduce the silting in the distribution pipeline so that Pipe line would not choke-up.

6. The water possess path of traveling as main pipeline followed by sub main pipeline followed by lateral pipeline & finally to the crops through the drippers.

Difficulties faced to run model is due to Excess water was coming through the drippers due to high pressure of motor. To overcome this problem we have increased the elevation difference & made the bypass way to the main pipeline so that pressure of water will be decreased & excess water will again fall in the canal.

**7. CONCLUSIONS**

The location of site is at Solapur district, Moholtaluka, village Angar. This region falls under dry zone of Maharashtra, hence face a lot of problem of scarcity of water. The precipitation observed is also very low. Electricity available for pumping water is around 10 hours instead of 16 hours specified by NABARD. In such a situation, optimum use of resources like water, electricity should be achieved. Also the design has to be economical. The total head between the source and actual site is 75m. Hence water has to be lifted from the source to the site. In order to achieve these objectives we proposed a lift irrigation scheme which would help to make optimum use of these resources. The scheme is so designed to irrigate a total area of 75 acres using the motor of total capacity of 90 HP.

TABLE 8 Net benefit- Economical Suggested Cropping Pattern

| Sn | Name of the crop | Area in acre | Income per acre | Total income |
|---|---|---|---|---|
| 1 | Cotton | 2.00 | 12000.00 | 24000.00 |
| 2 | Vegetable | 3.00 | 18000.00 | 54000.00 |
| 3 | Onion | 4.00 | 22000.00 | 88000.00 |
| 4 | Tomato | 3.00 | 41500.00 | 124500.00 |
| 5 | Sun flower | 4.00 | 19800.00 | 79200.00 |
| | **Total** | **16.00** | **-** | **369700.00** |

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