Efficiency Improvement of Large LI Schemes: Mhaisal Project, Maharashtra

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Abstract

The Sahyadri hill ranges running in north south direction parallel to Arabian sea in Maharashtra, divides the region in two parts, 'Konkan' on western side and 'Deccan plateau' on Eastern side**.** This hill range divides the region meteorologically in heavy rainfall and scarce rainfall zones. The Konkan and Sahyadri are having heavy rainfall while, Deccan Plateau falls in rain shadow area. Rivers originating from Sahyadri and flowing towards east are having abundant water. If the sub basins form north to south [Godavari to Nira (all sub basins)], are studied in details, it is found that, all these rivers and tributaries flow perpendicular to Sahyadri. The gravity system (constructing dam and irrigation by gravity canals) mitigates the water demands in this drought prone area. There are about 25 Major dams constructed on eastward rivers and tributaries fulfilling the water demands of such rain shadow area.

The situation differs in southern part (Krishna, Koyna and Warna sub basins). The river Krishna flows nearly parallel to Sahyadri upto karad. Hence large area between Nira sub basin and Krishna sub basins cannot be irrigated by gravity system. These sub basins are Yerala, Agrani and Man. As per Maharashtra Irrigation Commission Report[1], these three sub basins are most arid sub basins in Maharashtra. This area is always drought prone and lies in Satara, Sangli and Solapur districts. The annual per capita water available is as small as 240 cum/year, and that to per ha is as small as 512 cum/year. This is quite less than threshold value as by UNO (per capita 1000 cum/year), which is going to reduce day by day with increase in population and standard of living.

This drought prone area lies 150 m to 250 m above the river bed of Krishna. Hence Government of Maharashtra has taken various large Lift Irrigation Schemes in hand utilising 1810.50 Mm^3 of water irrigating 313474 ha area. (These schemes are Kavathe kenjal, Jihe Kathapur, Tarali, Urmodi, Vasana, Wangana, Tembhu, Takari, Dhangarwadi, Hanbarwadi and Mhaisal etc). Obviously the cost of LIS is more than any gravity scheme, but Government of Maharashtra is not having any alternative to meet the water demands, give social justice to large area and to avoid migrations in search of water, employment and food. The works of almost all LIS are under progress.

Mhaisal LIS is one of the scheme benefits large drought prone area in Sangli and Solapur districts. This is huge a scheme having total lift of 255 m in 6 stages using 133 pumps consuming power of 114433 HP (85.52 MW) having irrigation potential 81697 ha from of drought prone 177 villages. Annual electrical consumption of the scheme is 384 Mu. The unit costs of the scheme are Rs.0.364 Million per hector and Rs 60.52 million per Mm3 of water utilization. The scheme is approved by Central Water Commission in 2009.

If the unit costs are seen, they are obviously more than any gravity schemes. The Government has to more precise on efficient use of water in this scheme for following reasons,

1. Constraint by KWDT on water utilisation.
2. Benefiting larger area and more population with limited water resource.
3. Energy saving and ultimately consuming carbon credits.
4. Efficient use of comparatively costly water.

In Mhaisal LIS the Government has successfully implemented following means of efficient water utilisation

1. Design techniques and lining of Jath main canal: Reduction in water loss by 25.94 % and cost saving by Rs.611.7 millions.
2. Topographical advantage in design and lining to distribution network: Saving in water loss by 37 to 43%, cost saving by Rs. 210.2 millions.
3. Topographical advantage in piped network in Bhose canal: Saving in water loss by 100%, cost saving by Rs. 78.5 millions.
4. Piped distribution network in proposed Devnal canal: Saving in transit loss by 100%, cost saving by Rs.111.5 millions.
5. Implementing drip and sprinkler irrigation systems.
6. Volumetric assessment and operation of LIS through Water Users Association under by MWSSIF act 2005.

In the paper above mentioned successful case studies from the Mhaisal LIS are elaborated.

1.0 Metrological and topographical necessity of lift irrigation scheme in Krishna basin

1.1 Rainfall Pattern

The Sahyadri hill ranges running in north south direction parallel to Arabian sea in Maharashtra, divides the region in two parts, 'Konkan' on western side and 'Deccan plateau' on Eastern side**.** This hill range divides the region meteorologically in heavy rainfall and scarce rainfall zones. The Konkan and Sahyadri are having heavy rainfall while, Deccan Plateau falls in rain shadow area. Rivers originating from Sahyadri and flowing towards east are having abundant water.

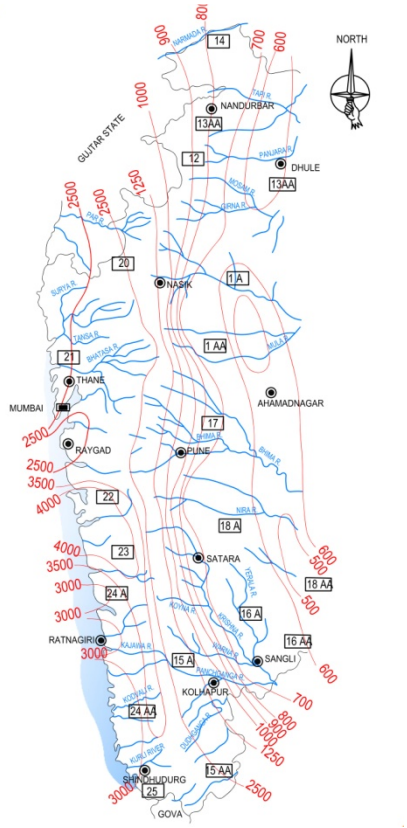

Figure 1: Isohytal map

1.2 Topography of Agrani, Yerala and Man sub basins

If the sub basins form north to south [Godawari to Nira (all sub basins)] is studied in details, it is found that, all these rivers and tributaries flow perpendicular Sahyadri. The gravity system (constructing dam and irrigation by gravity canals) mitigates the water demands in this drought prone area. There are 25 Major dams constructed on eastward rivers and tributaries fulfilling the water demands of such rain shadow area.

The situation differs in southern part (Krishna, Koyna and Warna sub basins). The river Krishna flows nearly parallel to Sahyadri. Hence large area between Nira sub basin and Krishna sub basins cannot be irrigated by gravity system. These sub basins are Yerala, Agrani and Man. Yerala and Agrani rivers flow parallel to Krishna upto certain portion in north south direction. These rivers originate in drought prone area and meets Krishna in drought prone area. As per Maharashtra Irrigation Commission Report[1], these three sub basins are most arid sub basins in Maharashtra. This area is always drought prone and lies in Satara, Sangli and Solapur districts. This drought prone area lies 150 m to 250m above the river bed of Krishna.

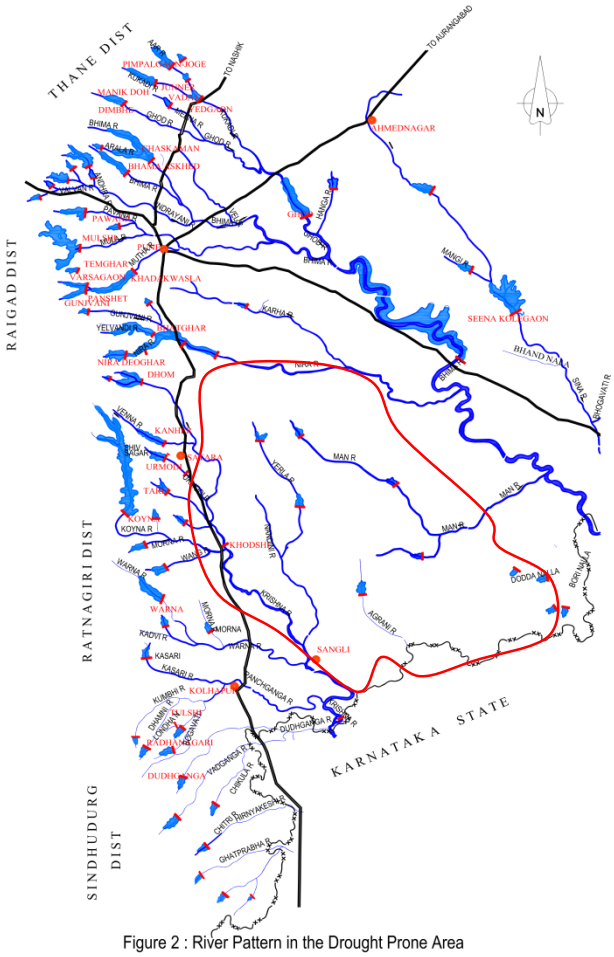

Figure 2 : River Pattern in the Drought Prone Area

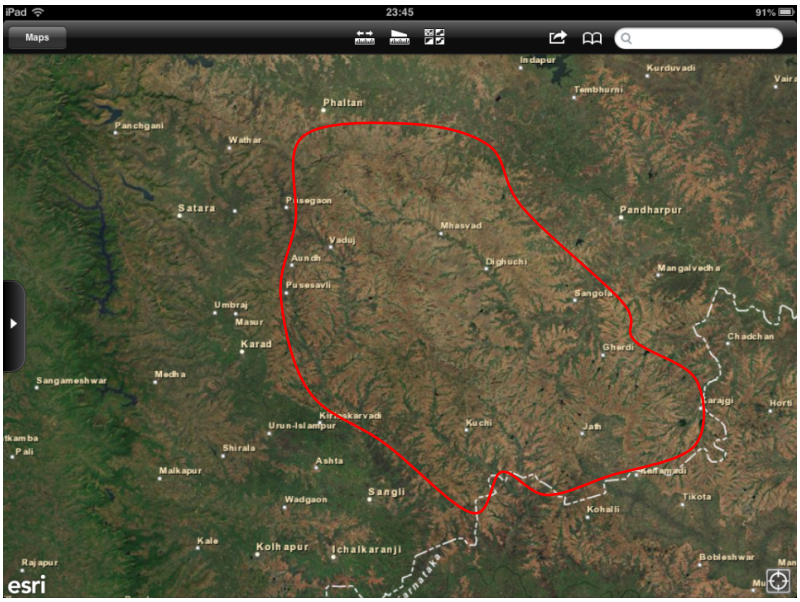

Figure 3: Satellite Image of the Drought prone area

The dry area seen in above image is the high rise drought prone area between Krishna and Bhima sub basins. The longitudinal section along the rising main and canal is plotted from source Mhaisal pump house to tail end of command (river Bhima near Pandharpur) is presented in Figure 3 below. The L section clearly shows the low lying river streams and the command area above the river streams, necessity of LIS.

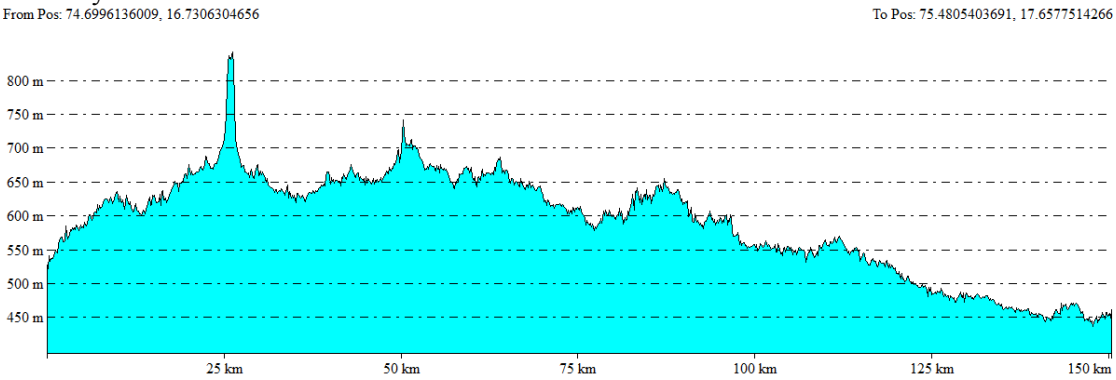

Figure 4: Typical L section of Mhaisal project Command from Krishna to Bhima

1.3 Diversity in Water Availability

The Maharashtra Irrigation Commission has classified the sub basins in Maharashtra. The comparative statement of annual water available for three representative catchments is shown below. These three representatives are one from Konkan, one from east flowing but originating from Sahyadri and one from study area. This comparison is for annual water available per capita and per hector of CCA.

Table 1: Comparative of Annual Water Available in Sub basins

Sub basin No	Sub basin Name	Water Available Per ha (of CCA)	Water Available Per ha (of CCA)	Remark
22	Central Konkan	48761	11809	Abundunt
15 A	Upper Krishan Wes	18317	4255	Abundunt
18 A	Remaining Bhima	512	240	Scarce

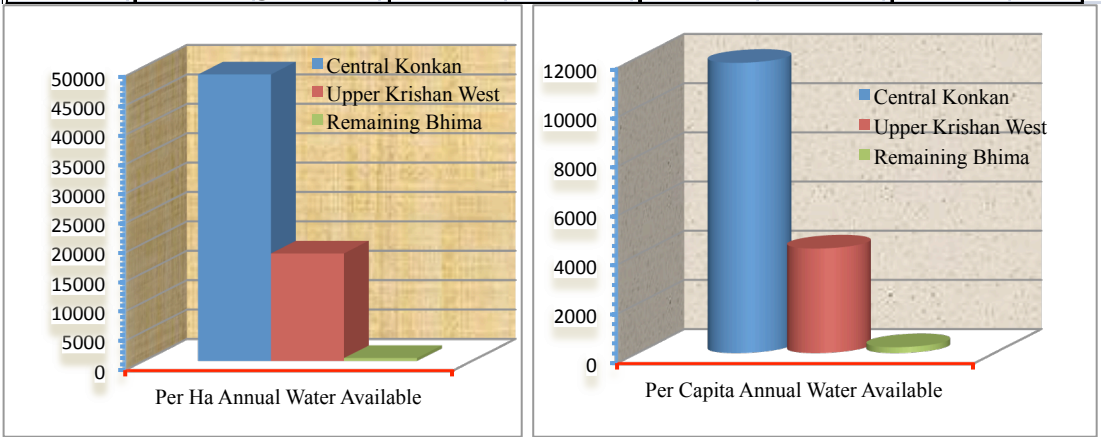

Figure 5: Per ha and per Capita Annual Water Available in various sub basins

It can be seen from above table and chart that per ha water available in remaining Bhima is only 10 % of Konkan and 27% of upper Krishna. Similarly per capita water available in remaining Bhima is only 2% of Konkan and 5.6 % of upper Krishna. Surprising thing is this diversity is within 100 km radius.

2.0 Study Area

In present study how the efficient use of scarce water is done in Mhaisal LIS is elaborated.

2.1 Mhaisal LIS

Mhaisal LIS is a lift irrigation scheme on river Krishna. The latitude and longitude are 16^0 14' 00" N and is 74^0 42' 00" E respectively. Weir is constructed near village Mhaisal. It lifts water from river Krishna and irrigates the command in above mentioned drought prone area. It can be treated as interlinking of rivers, because it links sub basin Krishna to Agrani and Man (sub basins of Krishna and Bhima respectively) in Krishna basin of Maharashtra. It connects the sub basin from abundant water to scarce water zone. It irrigates Miraj, Tasgaon, KavatheMahakal, Jat tahsils of Sangli district and Sangola and Mangalwedha tahsils of Solapur district in Maharashtra, which all falls under drought prone area. The water availability in command per ha and per capita is less than 1000 cum and 500 cum respectively.

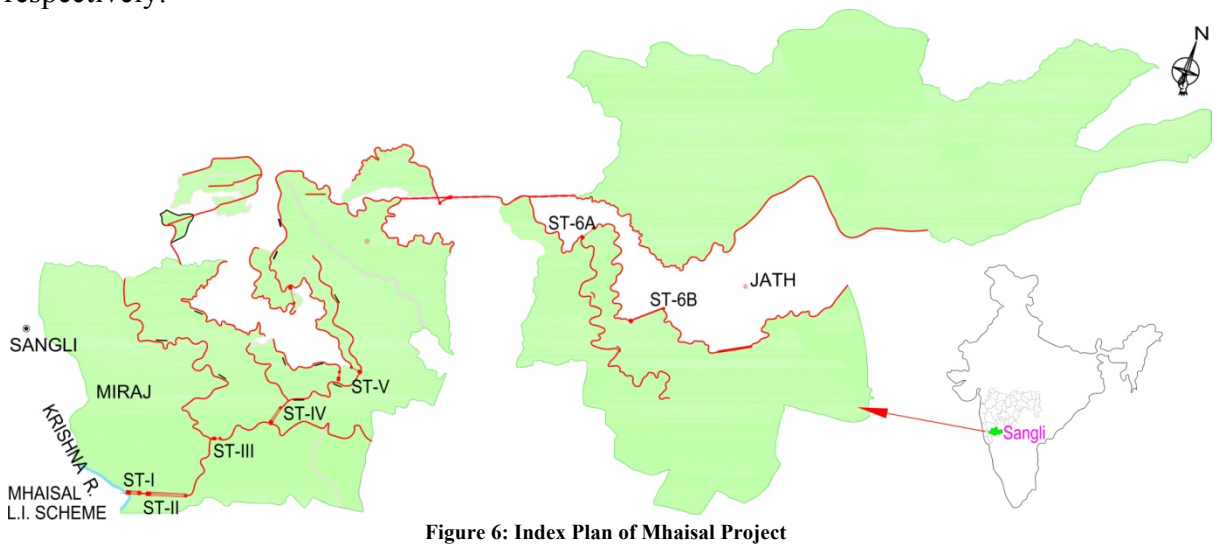

Figure 6: Index Plan of Mhaisal Project

2.2 Salient Features of Mhaisal LIS

1.	Irrigation potential	81697 ha
2.	Water utilisation	491.576 Mm3
3.	No of villages benefited in 5 tahsils and 2 district	177
4.	No of pumps	133
5.	Power required	114433 Hp (85.52 MW)
6.	Maximum lift	255 m
7.	No of stages	6
8.	Annual power consumption	384.56 Million Units
9.	NPV of project (2011-12 price level)	Rs 29752.076 million
10.	Unit cost of project	
	a. Cost per ha	Rs 0.364 million
	b. Cost per Mm^3(of utilized water)	Rs 60.524 million

The schematic diagram and L section of the scheme are as following.

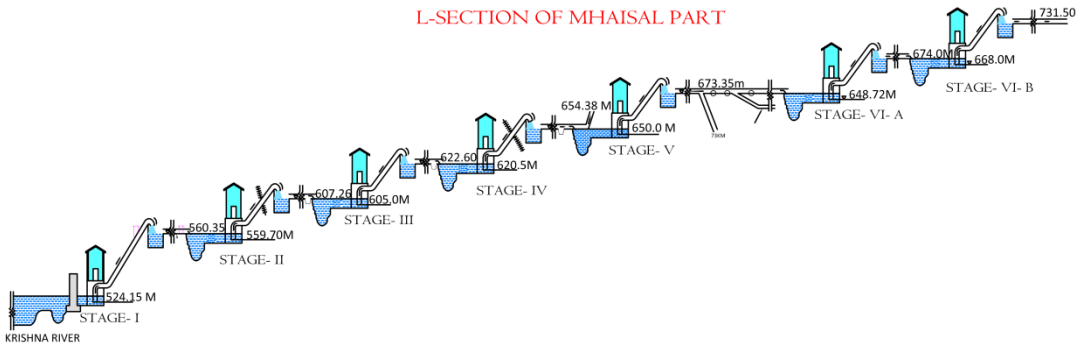

Figure 7: Schematic L Section of Mhaisal LIS

Most of the headwork components are completed and typical pump house photograph is shown below.

Figure 8: Photograph of completed Mhaisal Pumphouse

3.0 Necessity of Efficient Use of water in LIS

Every irrigation scheme needs efficient use of water, but particularly when it is LIS, efficient use of every drop is essential. The Government has no alternative to take large LIS in the peculiar drought prone area where gravity schemes are not physible.
These schemes are taken to maintain socio economic balance and avoid the migration of population in search of food, water and employment.
If the unit costs are seen, they are obviously more than any gravity schemes. The Government has to more precise on efficient use of water in this scheme for following reasons,

1. Constraint by KWDT on water utilisation.
2. Benefiting larger area and more population with limited water resource.
3. Energy saving and ultimately reducing carbon credits.
4. Efficient use of comparatively costly water.

If the unit costs are compared in same region for gravity and LIS schemes, it is observed that the unit costs for LIS are quite high as compared to gravity. For example the unit costs for Nira Deoghar project[3] and Mhaisal LIS are compared here. The costs are NPV at 2011-12 price level. (Balance costs are as per 2011-12 schedule of rates and the year wise expenditure since commencement of project is projected to the 2011-12 price by wholesale price indices).

Unit Cost Comparison of gravity and LIS

Table 2: Unit cost Comparison of Gravity and LIS

Unit Cost	Gravity project (Nira Deoghar)	LIS (Mhaisal)
Cost per Ha in Rs	325000	364000
Cost Rs million per Mm^3	58.40	60.52

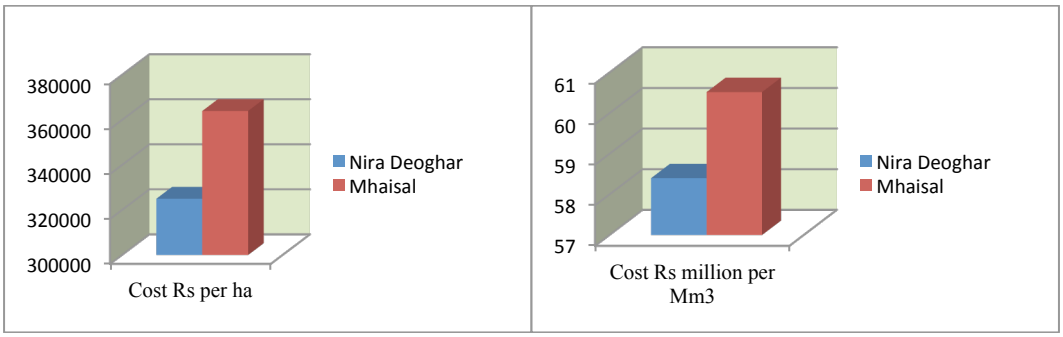

Figure 9: Unit cost Comparison of Gravity and LIS

Also, the operation and maintenance costs of LIS are quite higher than gravity projects. The O&M is higher because of,

- Large quantum of energy is required to lift the water
- Depreciation value of pumps and other mechanical and electrical components which is not there in gravity schemes

As LIS water is costly both in capital cost and O&M, hence it is essential to improve water use efficiency.

4.0 Efficiency Improvement in Mhaisal project:

As explained earlier the project consists of LIS on Krishna River. Main components are pump houses and switchyards, rising mains, main canals and distribution networks.
In Mhaisal Lift Irrigation Scheme following methodologies are successfully implemented to improve water use efficiency.

4.1. Using Improved Design Techniques and Lining to Jath Main Canal

Main canals of any LIS are neither contour canals nor ridge canals. So that it does not have any specific pattern of alignments and it crosses so many ridges, valleys and have many deep cuts.

Jath Main Canal of the project originates from km 56 of Kavathe Mahankal canal after fifth stage of lift. This canal has length 83 km with initial 20 km length of tunnel. Open gravity

canal is from km 21 to 83.Total irrigation potential on this canal is 34460 ha. As said earlier, the canal crosses so many ridges and valleys. It was decided by Government of Maharashtra[4] to go for lined canal section. It surprise that, lined canal is economical than unlined canal. For unlined canal has bottom width of 9.20 m which reduces to 2.60 m in lined canal. This is because in lined section, velocity of flow increased due to reduction in rugosity coefficient. This increased velocity reduced the cross section and ultimately the wetted perimeter. The loss of water is reduced lining itself, by reduction in wetted perimeter and reduction in flow period and the. Total saving of water per rotation is 3.23 Mm^3 in 12.45 Mm^3, which comes to 25.94 % saving. The work of main canal is in progress as above.

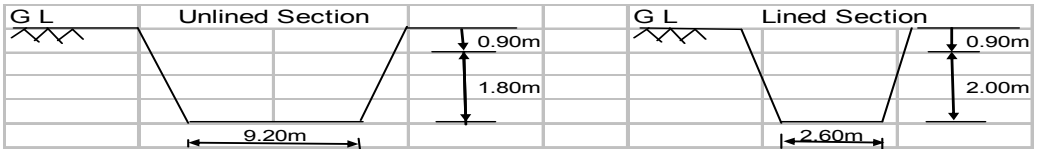

Figure 10: Lined and Lined Cross sections of Jath Main Canal

The advantages of the lined section over unlined of Jath canal are as following

- Cost saving by Rs. 611.7 million
- Increase in velocity 0.60 m/s to 0.90 m/s
- Water saved by 3.23 Mm^3 (25.94 %)
- Reduction in initial time to each tail reaches by 9.45 hrs. Ultimately saving in power consumption.
- Saving in excavation quantity, ultimately the time period of construction.
- Saving in land width, less oppose for land acquisition.
- Increased velocity reduced chances of silting of canal and finally reduction in maintenance cost.

4.2. Topographical Advantage in Design of Distribution System and Lining to Distribution System on Jath Canal

The Jath canal of the project has peculiarity that, the main canal to tail end of distribution network is having drop of 50 m to 80 m. Due to scouring velocity constraint one can increase bed gradient of unlined canal. But if lined canal is proposed one can go upto 2 m/s velocity. If lined distribution is designed for such bed gradients it gives triple benefit. Reduction in cross section (ultimately cost), reduction in cost of construction of falls, and O&M cost. The GOM has taken decision to go for lined disnet work[5].

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For unlined Distributory has bottom width of 6.00 m which reduces to 1.45 m in lined canal. This is because in lined section, velocity of flow increased due to reduction in rugosity coefficient and advantage of steeper gradient. This increased velocity reduced the cross section and ultimately the wetted perimeter. The loss of water is reduced lining itself, by reduction in wetted perimeter and reduction in flow period. Total saving in water is to 37 to 43%. The work of distribution system is in progress as above.

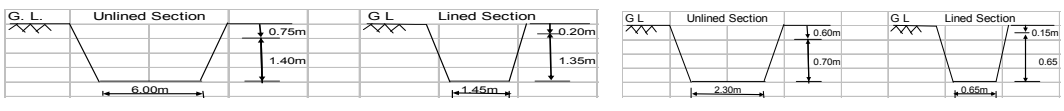


Figure 9: Typical Unlined and Lined Cross sections of Jath Distribution System.

The advantages of the lined section over unlined section of Jath distribution system are as follows

- Cost saving by Rs. 210.206 million
- Increase in velocity from 0.58 m/s to 0.82 m/s which comes out to be about 40%
- Water saved by 37 to 43 % which goes in losses
- Reduction in initial time to each tail reaches. Ultimately saving in power consumption.
- Saving in excavation quantity, ultimately the time period of construction.
- Saving in land width, less oppose for land acquisition.
- Reduction in Barrel length of structure, ultimately saves the cost and time period of construction.
- Increased velocity reduced chances of silting of canal and finally reduction in maintenance cost.

4.3 Adopting Pipe Network System

In three locations of the project, it was found that the command is in hilly terrain, having undulations it was very cumbersome to construct gravity canal. The difference in head is up to 80 m. It is found beneficial to go for piped network in technical as well as financial point of view. Obviously the losses are zero percent. These are Bhose, Gavan and Devnal canal and their distribution. The features of these are discussed in details in following paragraphs.

4.3.1 Extended Gavan Pipe Network

The Extended Gavan LIS is a small LIS under Mhaisal project, originating from km 39 of Kavathe Mahankal canal after Fifth stage of Mhaisal LIS. A weir is constructed on Agrani river which is feed by Kavathe Mahankal canal. From this weir water is lifted by 4 pumps of 425 HP each, irrigating 1700 ha area. Piped Network is of diameter 350 mm to 1200 having total length of 39.605 km. It is a completed scheme. It has designed and executed as piped network up to outlet level. It is successfully running since last 3 years. Since it is a piped network, there are no seepage or transit losses.

Irrigation is proposed by drip only and for this required head (minimum 15 m) is maintained at each outlet of gravity main.

4.3.2. Bhose Pipe Network System

After Fourth stage of Mhaisal LIS, Salgare canal is started, in KM 2 of Salgare canal Khanderajuri branch canal is started. Bhose canal of the project starts from km 8 of Khanderajuri branch canal having irrigation potential of 4581 ha and total network is 93.35 km. The topography of command area is hilly, lots of local humps and undulations are on the alignment. A level difference of 15 m on main canal and 22 to 25m on the distribution system is available. The ICA is to be irrigated through 319 outlets.

In Bhose network, initially system is designed as unlined canal system then it is decided to go for pipe network[6]. It is found that piped networks are economical than open gravity canal. The loss of water is reduced to nil by pipe network itself, reduction in flow period.

The advantages of the piped network of Bhose canal are as following

- Cost saving by Rs. 78.52 million
- Increase in velocity from 0.45 m/s to 0.90 m/s.
- Water saved by 3.025 Mm^3 (100%) which goes in losses.
- Reduction in initial time to each tail reaches by 9.89 hrs. Ultimately saving in power consumption.
- As no land acquisition is required no oppose for work by farmers, ultimately saved the time period of construction.
- Maintenance cost of pipe network system is very less.
- Management of irrigation in this system is easier than open canal system.

4.3.3 Proposed Devnal Pipe Network System

Devnal canal in the project originates after stage VI B. It irrigates 4120 ha command area and length of network 120 Km. The topography of command area is hilly, lots of local humps and undulations are on the alignment. A level difference of 22 m on main canal and 25 to 30m on the distribution system is available. It was very cumbersome to go for canal system with number of falls. Taking advantage it is proposed to go for pipe network. It is found that piped network is economical than open gravity canal. Obviously the losses are zero.

The advantages of the piped network in Devnal canal are as following

- Cost saving by Rs. 111.55 million
- Increase in velocity from 0.60 m/s to 1.50 m/s.
- Water saved by 0.334 Mm^3 (100%) which goes in losses.
- Reduction in initial time to each tail reaches by hrs. Ultimately saving in power consumption.
- As no land acquisition is required no oppose for work by farmers, ultimately saved the time period of construction.
- Maintenance cost of pipe network system is very less.
- Management of irrigation in this system is easier than open canal system.

4.4 Implementing Drip and Sprinkler Systems

Mhaisal project command is a drought, dry and with light drainable soil. It is best suited for horticulture. Particularly the crops grown are grapes, pomegranate. These two crops have good yield if they are on drip. The farmers are also habitual to use drip system. The farmers go for drip on their own. In the command of Gavan LIS 75 % farmers had done drip irrigation system below outlet level. The trend is to save water and go for additional land under irrigation with this saved water.

As the stakeholders are well known about scarcity and importance of water, same pattern will be followed for remaining command of the project.

It is well known that, water use efficiencies are more in drip and sprinkler irrigation system. As per the WALMI Maharashtra, the water use efficiencies are 90, 80, 70 and 60 percentage respectively for drip, sprinkler, lined canal and unlined canal[7]

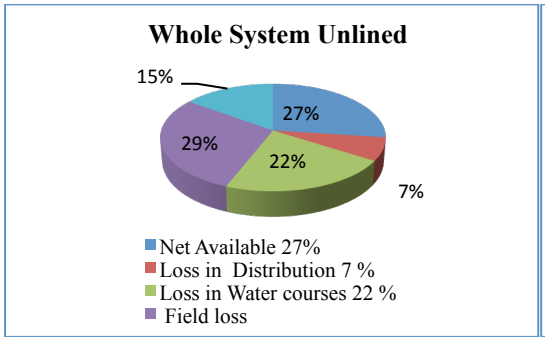
It is observed that the water use efficiencies and crop yields are increased by the use of sprinkler and drip irrigation system. As per the report of Planning Commission Govt of India May 2009[8] it is stated that in sprinkler irrigation system water saving in various crops ranges from 16% to 69% over the traditional method and increase in crop yield from 3% to 57%.
Drip irrigation method is well suited for wide spaced high value crops. The required quantity of water is provided to plant at the root zone through a network of piping system. Hence there is no loss of water either in conveyance or in the distribution. Details of increased yield and water saving under drip irrigation with various crops are given below.

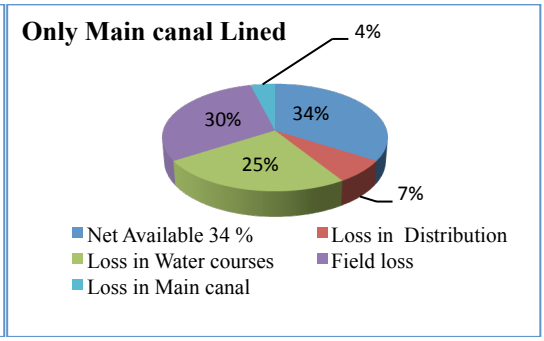
Table 3: Water saving and increment in yield due to drip

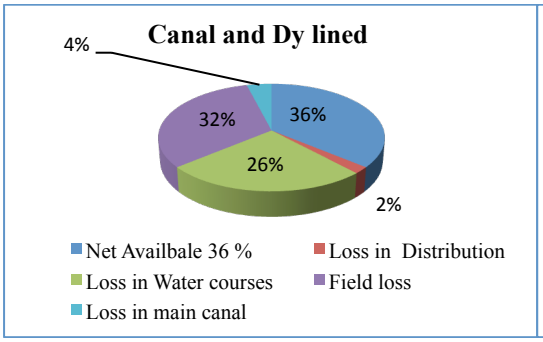
Sr No	Name of Crop	% increase in Yield	% Water Saving
1	Banana	30-40	9-60
2	Chili	10	68
3	Cotton	40-47	5-33
4	Pomegranate	21	51
5	Potato	20	49
6	Rose	20	40
7	Sugarcane	50	35
8	Tomato	25	40

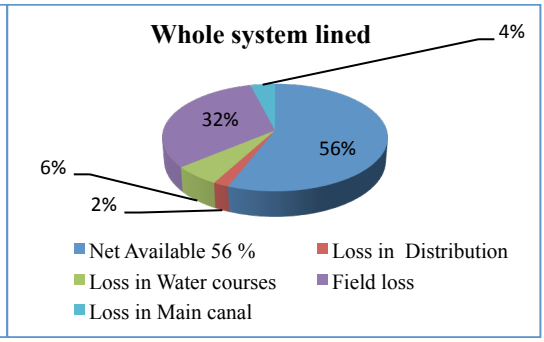
From above table it is observed that in Drip irrigation system water saving in various crops about 40% over the traditional method and increase in crop yield ranges from 10% to 50%.
In Mhaisal LIS, it is proposed to make compulsory to all beneficiaries to use drip or sprinkler irrigation system where pipe line distribution system is executed.

Efficiency and water loss comparison of various systems









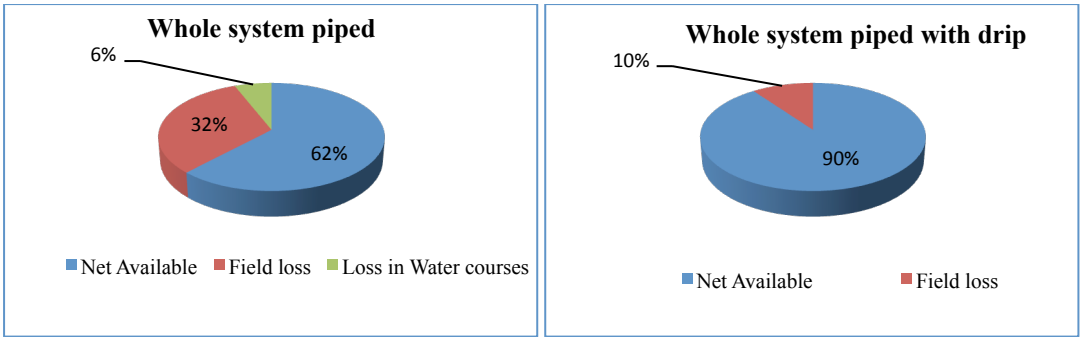


Figure 12: Water losses in various irrigation systems

4.4 Impelling farmers to grow cash crops

In the command area of Mhaisal Lift Irrigation Scheme are proposed to grow the cash crops such as Grapes and Pomegranate which requires lesser water than the sugarcane.
In the area of Miraj, Kavathe Mahankal and Tasgaon talukas there was drought in last two years. The rainfall was less than 250 mm. There is no other source of water in the region. The drinking water supply was through tankers in this region in uncommand of Mhaisal. Besides this, the farmers grew grapes of more than Rs. 7000 millions in year 2011-12 (as per APMC Sangli report[9]). This is example of most efficient use of partially completed Mhaisal LIS.

It is observed that cash crops like grapes, pomegranate requires less water, time and gives more yield and helps to improve economic and social level of farmers.

4.5 Volumetric Distribution of Water

In Maharashtra, after formation of Maharashtra Water Resources Regulating Authority (MWRRA), the act named, Maharashtra Management of Irrigation Sector by Farmer (MMISF)[10] has been passed. The act imposes to form Water Users Association (WUA) and volumetric assessment of irrigation water.

In this act it is considered that involvement of farmers in water management will facilitate equitable and judicious allocation of irrigation waters among farmers of head, middle and tail reaches and improves collection of water charges from users.

In Mhaisal project, it is proposed to have compulsory to deliver water only by volumetric basis and after formation of WUA. For this the water users associations (WUA) are to be formed on each minor having culturable command area in between 500 to 1000 Ha and water is delivered to WUA, they should made their internal distribution of water and maintenance of the system, collection of water charges and submit to WRD. Also by this act beneficiaries have choice to grow any type of crop in command area and quota of water of each farmer is reserved.

The formation of WUA is in progress and command is notified under section 1 and 2 of the act. The notification under section 3 and elections of representatives is balance. The efficiency of the project will definitely improve after formation of WUA and volumetric assessment.

5.0 Conclusion and results

- It is essential to have large LIS in drought prone area like Mhaisal LIS where, other gravity schemes are not possible, for justice and avoid migration of population in search of food, water and employment.

- In large LIS like Mhaisal, irrigating to drought prone area with limited water resources due to constraint of KWDT, it is essential to have efficient water use. Every drop saved is like, every drop generated, because water is costly in per view of capital and O&M cost; water is priceless if availability is considered; and water is life for those whom water is supplied additionally with saved water.

- As the unit costs of large LIS are higher than gravity schemes, they should be designed with precision and efficient use of water, with efficient use of water the schemes become economically physible.

- It is proved in Mhaisal project that lining of canals, piped network system are economical than conventional system. It is not always true that, lining of canals and pipe networks are costly. Taking into advantages of topography and design techniques these costly means found to be cheaper. These efficiency improvement techniques are cheaper in cost and saved water from 30 to 50 % in Mhaisal Project.

- Use of drip or sprinkler system should be made compulsory for large LIS.

- Public private partnership is essential for efficient use of water.

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