OPTIMIZATION OF COMMUNITY BASED SMALL SCALE IRRIGATION SCHEME

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Abstract- One of the most important natural resources which are extremely crucial for our daily life is water. Maharashtra, the second largest state in India, both in area as well as in population, has very limited assured irrigation due to lack of water. Small-scale irrigation and its optimization an important aspect for to optimum use of water and energy. It involves individual or community participation based small groups of farms, organized and managed by farmers, usually independent of government resources. This type of development has often proved successful in places where arid areas, where the drought like situations occur frequently, the government funds not available. The several options are available for irrigation like surface, sprinkler and drip irrigation. So it is necessary to select proper system for optimum use of water and energy. The study area Palsunda is a village located in Mokhada Taluka, in the District of Palghar, Maharashtra state in the Konkan region. Agriculture is the main occupation of people in Palsunda. Agriculture is rain fed in summer or in rabi season there is no crops are grown because of non-availability of water to agriculture. To overcome this problem the people from village come together to construct minor lift irrigation scheme based on community participation. From study it is found that total energy consumption for rising main to lift water from source throughout base period of crop for drip irrigation scheme is 2648.8 Kw.H while for surface irrigation scheme 3889.6 Kw.H hence net saving of energy 1240.08 Kw.H hence the rising main with drip irrigation system is more energy efficient than surface irrigation system. The most appropriate pattern for study area is vegetable in summer ,which results in maximum net benefits of Rs. 562026 by irrigating of 2.83 hectares of land in summer.

Keywords- small-scale irrigation, optimization, community participation, rising main.

I. INTRODUCTION

One of the most important natural resources which are extremely crucial for our daily life is water. The rain-fed agriculture contributes 58 per cent to world’s food basket from 80 per cent agriculture lands [1]. There are the two types of sources of this essential resource viz. surface water and ground water. Maharashtra, the second largest state in India, both in area as well as in population, has very limited assured irrigation due to lack of water. The most of the agriculture in Maharashtra depends on the rainfall, due to lack of rain water harvesting structures in the summer people from watershed area faces lots of problem of water, The area is not possible to satisfy the basic need of drinking .Drought like situation occurred frequently in India. Water scarcity is a global problem, but it is most severe in arid and semi-arid regions. Often, increasing water demands due to population growth further aggravate the problem. At the global level, the agricultural sector is the largest consumer of water resources. Consequently, this sector is heavily impacted by water scarcity and yield reduction may result in a decline of food security worldwide. Hence, improvements in agricultural water management are needed. Optimization of irrigation systems and improvement of water resource allocations through appropriate crop pattern according to season which will give maximum benefits to the farmer and save excess use of water.

A. Small Scale Irrigation

Small-scale irrigation is an important aspect of irrigation development in many countries. It involves individual or small groups of farms, organized and managed by farmers, usually independent
of government resources. This type of development has often proved successful in places where arid areas, where the drought like situations occur frequently, the government funds not available. This is not to say that small-scale is therefore better than large-scale farming, or indeed that small-scale is simpler to develop. It is a different approach to irrigated farming, with its own challenges. Irrigation development requires careful design, construction and management to be successful. It is, perhaps, in the management element that the key difference lies. In a small system there are no tiers of management, as in the large-scale schemes. Farmers alone decide when to irrigate and how much water to apply; start and stop the pumps; and generally run the entire scheme with the help of the family or local community.

II. OBJECTIVES OF THE STUDY

The objectives of the current study as follows,

a) Identification of constraints in agricultural watershed.

b) To maximize the crop returns by optimum use of land and water.

c) To design of the small scale lift irrigation scheme for study area based on the community participation

III. STUDY AREA

Palsunda is a village located in Mokhada Taluka, in the District of Palghar, Maharashtra State in the Konkan region as shown in figure 1. Palsunda as is located 103 Kms north from old District Headquarters, Thane and 133 Kms from the State Capital of Mumbai. Palsunda was realigned with the district of Palghar in August 2014. Located at a latitude of 19.403636° and a longitude of 73.91483°.Palsunda is surrounded by Jawahar Taluka towards West, Triambak Taluka towards East, Vikramgadh Taluka towards North and Igatpuri Taluke towards South. Nashik, Silvassa, Amli and Ozar are the cities nearby to Palsunda. The Gram Panchayat to which it belongs is Saturly-Palsunde.

Following are the information collected during the baseline survey of the study area.

A. Population: The population of the area is collected from the census record (2011) published by the government of India. The number of household are 335. Total population of village is 1628 out of which male are 839, female are 789 and sex ratio 940 (Source: http://www.censusindia.gov.in)
B. Agriculture: Agriculture is the main occupation of people in Palsunda. People either own land and do agriculture or landless people work as agriculture labourers. They mainly grow Naagli (Raagi), Paddy, Varai, Toor, Khurasni, Uleeth and Kuleeth. Some farmers have started growing vegetables and few more have taken up horticulture (mainly mango and cashew). Agriculture is rain fed as there is no irrigation facility and no water scheme available in this village. For kharip season mostly the Rice are taken and Rabi Season Nagli, Khurasani, Toor, kuleeth and vegetable are taken by the farmers. From the month of January to June no crops are taken as there is no water is available for the irrigation most of the crops are taken in kharip season only.

C. Water source: Gram Panchayat of Saturly-Palsunde has two main sources of water – the rivers of Pinjal and Wagh. Palsunda is surrounded its three sides by Pinjal river and its tributaries and is the primary source of water for the irrigation and drinking. There is no government scheme for irrigation and also there is no pond or lake in the village.

D. Climate and Rainfall: Climate in this area is tropical. Summer here is very dry and hot and lasts for three months from April to June. The winter months are dry and cold and typically last for four months from November to February. Monsoon sets in during the month of June and lasts through mid-September. The village having the rainfall with fifty years average being 2585. (Source:- http://collectorpalghar.in).

E. Soil type: The village mainly has reddish soil, with shallow texture. Some traces of black soil are seen near river banks as well as places of siltation. It is rich in phosphorous and potassium. Texture of soil varies from gravelly to loam. The soil is readily permeable to water, therefore, the iron content of the soil is low due to over leaching and infiltration. Even though the rains are heavy in this region, due to soil erosion, rain water does not retain in soil. (Source:-http://collectorpalghar.in).

IV. METHODOLOGY

At the global level, the agricultural sector is the largest consumer of water resources. Consequently, this sector is heavily impacted by water scarcity and yield reduction may result in a decline of food security worldwide. Hence, improvements in agricultural water management are needed. Optimization of irrigation systems and improvement of water resource allocations through appropriate crop pattern according to season which will give maximum benefits to the farmer and save excess use of water. A summary of the main steps in the methodology are explained by following flow chart in figure.2

A. Identifying and the ranking of the problems in study area

The study area is rain fed the agriculture of the study area is depending on the monsoon. As the monsoon over there is no water is available for the irrigation purpose. At present there is no government schemes are executed in the study area for the irrigation purpose. After the monsoon over the entire agriculture activities stop up to next monsoon, there is no crops are grown in rabi season as lack of water. The problems identified in study area as, Lack of irrigation scheme, suitable site for storage reservoir, method of irrigation and cropping pattern.

B. Baseline survey of the study area

Baseline survey of the study area is carried out to know the present problems in the study area and its constraints. The information about study area like population, agriculture, water source, rainfall and soil type is collected as discussed in detail in study area .

To design the minor irrigation scheme based on community participation for that name of the farmers who interested to involve in this scheme, there location from storage reservoir, site for storage reservoir, availability of source of water (Pinjal river) and electricity that data are collected from farmers and by visual observation of the site.
C. Preparing the contour map of the study area

The contour map of the study area is prepared to know the suitable site for storage reservoir. The site is selected at higher elevation of reduce level 413 m. The water from the Pinjal river of reduce level 377 m is lifted and stored at storage reservoir (Farm pond) and from the storage reservoir the water is supplied to the farmers by under the action of gravity. For creating the contour map of the village the software used is Global Mapper. Global Mapper is a geographic information system (GIS) software package currently developed by Blue Marble Geographic’s that runs on Microsoft Windows. Global Mapper handles vector, raster, and elevation data, and provides viewing, conversion, and other general GIS features. (Source:-http://www.globalmapperforum.com). The NASA Shuttle Radar Topographic Mission (SRTM) has provided digital elevation data (DEMs) for over 80% of the globe[2]. This data is currently distributed free of charge by USGS (United States Geological Survey Department) and is available for download from the USGS ftp site. The SRTM data is available as 3 arc second (approx. 90m resolution) Dems. DEM data was downloaded from SRTM website (Source:-srtm.csi.cgiar.org). The downloaded DEM (digital elevation model) are processed in the global mapper software and the contour map of the study area of interval 0.5 m is prepared. The contour map of Palsunda village as shown in figure 3 as below.
D. Optimization and design of small scale (Minor) lift irrigation scheme

Following are the design steps are adopted for the design,
1. Identification of source for lift Irrigation.
2. Selection of site for storage reservoir.
3. Identification of the reduce level of source and storage reservoir for calculation of head.
4. Selection of cropping pattern for which scheme to be designed.
5. Area of the crop to be irrigated.
6. Demand calculation for the selected cropping pattern.
7. Design of scheme for calculated demand.

a) Agricultural demand calculation

The agricultural water demand calculation is based on the, Manual on “Irrigation water management” by Food and Agriculture organization (FAO) of United States. This manual provides the specific information for calculation of the agricultural water demand.

b) Optimization of Rising Main

Energy and hydraulic efficiency are more important goal for sustainable development of an irrigation system. Saving of energy have become ones world’s main concerns over the last years and will grow to be more and more important in near future. Long distances pumping mains has greater head loss hence it is necessary to select the proper diameter to save the energy and cost of pumping [3]. For the optimization of the rising main, following are the steps are adopted,
1. The total demand of water for irrigation (daily scheme demand) is calculated from Eq.[6],
2. Considering the availability of electricity and electricity shutdown periods the time of pumping is decided and it is 10 hour.
3. The discharge through system is calculated by knowing the value of volume and time of pumping.
4. For the trial and error basis the different diameters of pipes are considered and velocity of water through system for different diameter is calculated.
5. The total head loss i.e. Head loss due to friction (major loss= \( flv^2/2gD \)) plus the minor loss considering 10% of major loss plus elevation head is calculated [4].
6. The total cost of the system is determined by adding the cost of electricity, pump, and pipe.
7. Optimal diameter selection: The graph of the diameter on (X- axis) and Total cost on (Y- axis) is plotted graphically, from the plotted line the point is selected in such way that which provides the minimum cost for the system and also satisfies the design requirements.
8. Check for velocity in the system: The graph of velocity of the water in rising main versus the diameter of rising main is plotted graphically. The velocity should be greater than 0.6m/s and lies between 1-2 m/s [5].
V. RESULT AND DISCUSSION

The minor irrigation scheme is designed for the following parameter,
1. Head = R.L of Hill - R.L of Bank of river + Depth of river
   = 413-377+15m.
   Total design head = 51 meter.
2. Crop area to be irrigated = 7 acre, or 2.83 Hectare.
3. Crop type = Vegetable.
4. Average base period of crop = 110 days.
5. Delta for crop = 0.450 m. [6]
6. Length of rising main = 366 m.

a) Agriculture Water demand calculation,[7]
1. Seasonal crop water requirement = Delta × Area under crop in Hectare………………… [1]
   = 0.450 m × 2.83 Hectare
   = 0.450m × 2.83 × 10,000 m²
   = 12,735 m³ / Season.
2. Average crop water requirement = Seasonal crop water requirement / Base period…………. [2]
   = 12,735/110
   = 115.77 m³ / day.
3. Peak crop water requirement = 2 × Average crop water requirement………………………… [3]
   = 2 × 115.77 m³ / day.
   = 231.54 m³ / day.
4. Irrigation efficiency = Field application efficiency × Distribution efficiency × 100…………………[4]
   For drip irrigation,
   Field application efficiency = 95%
   Distribution efficiency = 90%
   = 0.95 × 0.90 × 100
   = 85.5 %…………………………….For drip irrigation
   For surface irrigation,
   Field application efficiency = 60%
   Distribution efficiency = 95%
   = 0.95 × 0.60 × 100
   = 57 %…………………………….For surface irrigation
5. Seasonal scheme water demand = \( \frac{\text{Crop Water requirement (m}^3\text{/hect}) \times \text{Cropped Area (hect)}}{\text{Irrigation efficiency}} \)…………[5]
   = (4500 × 2.83) / 85.5
   = 14,894m³ / Season……………………for drip irrigation
   Seasonal scheme water demand = \( \frac{\text{Crop Water requirement (m}^3\text{/hect}) \times \text{Cropped Area (hect)}}{\text{Irrigation efficiency}} \)
   = (4500 × 2.83) / 57%
   = 22,342m³ / Season……………………for surface irrigation
6. Daily scheme water demand = Seasonal scheme water demand / Base period…………………. [6]
   = 14,894 / 110 m³ / day.
   =135.40 m³ / day. ………………………………For drip irrigation.
   Daily scheme water demand = Seasonal scheme water demand / Base period.
   = 22342 /110 m³ / day.
b) Optimization of Rising main

Following are the Table no.1 and Table no.2 shows the detailed calculation and result of optimization of rising main for drip and surface irrigation system.

1. Graph Total cost Versus Diameter

The graph of the diameter on (X-axis) and cost on (Y-axis) is plotted graphically as shown in figure 4. From the graphically plotted line the point is selected in such way that which provides the minimum cost for the system. Hence the economical diameter for drip irrigation system is 2.5 inch which gives the optimal cost in Rs. 55055.35. While for surface irrigation system optimal diameter is 3 inch and gives the total cost of Rs. 66198.

2. Graph of Velocity in system versus Diameter of system

The graph of diameter versus velocity of the water in rising main for different irrigation system is plotted graphically as shown in figure 6. A good guide to selecting the right pipe diameter is to keep the velocity below 1.6 m/s. This is good engineering practice. It ensures that head losses are low and it will help to avoid the surge and water hammer (sudden oscillations in water pressure) problems which can cause pipes to burst. The velocity of water goes on increasing as the diameter of the pipe reduced hence the more head loss is take place. The selected optimum diameter satisfies the all the design parameters, the velocity of the flow in rising main for drip irrigation system is 1.20 m/sec. While the velocity in rising main for surface irrigation system is 1.30 m/sec. The velocity is greater than 0.6m/s and lies in the range of 1-2m/s as per the guideline given in CPHEEO, (1999) manual.

3. Graph of Energy consumption in system with change in diameter

The graph of Energy consumption in system with respect to change in diameter is plotted graphically as shown in figure 5. The graph shows that as decreasing the diameter of system the energy consumption is increases hence it is necessary to select the optimal diameter in order to which it will consume less energy during pumping. The selected optimal diameter for drip irrigation system consumes the energy 24.08 Kw.H per day. While selected optimal diameter for surface irrigation system consumes the energy 35.36 Kw.H per day.

Figure 4. Optimization of Rising main for drip and surface irrigation system.
Figure 5. Energy consumption per day with change in diameter for drip irrigation system.

Figure 6. Graph of diameter versus Velocity for different irrigation system.

Table No.1 Optimization of Rising main for drip irrigation system

| Sr. no | Volume (m³) | Head in m (m) | Discharge Cum. sec | Dia. (inch) | Dia. (m) | Area (m²) | Velocity (m/sec) | Head loss (h) | Total Head (H)=h+10hf in (m) | Power in (KW) | Power (Hp) | Energy (KWH) | Energy Cost | Pump cost | Pipe Cost per m | Pipe Cost | Total Cost |
|--------|-------------|---------------|-------------------|-------------|----------|-----------|-----------------|---------------|-----------------------------|---------------|------------|-------------|-------------|-----------|-----------------|-----------|-----------|
| 1      | 135.4       | 51            | 0.004             | 0.500       | 0.013    | 0.000     | 30.206          | 0.000         | 40541.111                   | 48968.552     | 16473.302  | 2246.330    | 16473.015   | 47442.28  | 4993.60         | 28        | 10268      | 16543       |
| 2      | 135.4       | 51            | 0.004             | 0.750       | 0.019    | 0.000     | 31.423          | 0.000         | 5338.787                    | 5923.645     | 2185.632   | 297.245     | 2185.625    | 6294.60   | 6924.58         | 28        | 10268      | 16543       |
| 3      | 135.4       | 51            | 0.004             | 1.000       | 0.025    | 0.000     | 7.551           | 0.000         | 1266.919                    | 1444.611     | 53.301     | 7.249        | 533.011     | 1535.67   | 16104.10       | 44        | 16104      | 17639       |
| 4      | 135.4       | 51            | 0.004             | 1.250       | 0.031    | 0.001     | 4.033           | 0.001         | 415.144                     | 907.658      | 18.731     | 75.474       | 187.308     | 539.476   | 57600.13       | 46        | 16836      | 92975       |
| 5      | 135.4       | 51            | 0.004             | 1.500       | 0.038    | 0.001     | 3.356           | 0.001         | 166.837                     | 234.521      | 8.653      | 11.706       | 86.539      | 249.266   | 41700.20       | 69        | 53254      | 67203       |
| 6      | 135.4       | 51            | 0.004             | 2.000       | 0.050    | 0.002     | 1.888           | 0.002         | 39.591                      | 64.550       | 3.410      | 4.744        | 34.886      | 100.471   | 27300.76       | 76        | 27816      | 55216       |
| 7      | 135.4       | 51            | 0.004             | 2.500       | 0.063    | 0.003     | 1.208           | 0.003         | 12.973                      | 65.271       | 2.408      | 3.275        | 24.083      | 69.3377   | 19800.00       | 96        | 55136      | 55000       |
| 8      | 135.4       | 51            | 0.004             | 3.000       | 0.076    | 0.004     | 0.839           | 0.004         | 5.214                       | 56.725       | 2.093      | 2.847        | 20.933      | 60.2877   | 100000.00      | 106       | 108796     | 58656       |
| 9      | 135.4       | 51            | 0.004             | 4.000       | 0.101    | 0.008     | 0.472           | 0.008         | 1.231                       | 52.361       | 1.932      | 2.627        | 19.319      | 55.6397   | 160000.00      | 142       | 52338      | 69194       |
| 10     | 135.4       | 51            | 0.004             | 5.000       | 0.126    | 0.012     | 0.302           | 0.012         | 4.045                       | 51.446       | 1.890      | 2.502        | 18.562      | 54.6647   | 160000.00      | 228       | 53448      | 100303      |
| 11     | 135.4       | 51            | 0.004             | 6.000       | 0.151    | 0.018     | 0.210           | 0.018         | 7.179                       | 51.179       | 1.883      | 2.588        | 18.883      | 54.3802   | 160000.00      | 298       | 168908     | 122922      |
| 12     | 135.4       | 51            | 0.004             | 7.500       | 0.189    | 0.028     | 0.124           | 0.028         | 2.053                       | 51.659       | 1.894      | 2.562        | 18.859      | 54.25598  | 160000.00      | 382       | 149176     | 157022      |
| 13     | 135.4       | 51            | 0.004             | 8.000       | 0.202    | 0.032     | 0.118           | 0.032         | 2.561                       | 51.643       | 1.883      | 2.561        | 18.833      | 54.25877  | 160000.00      | 472       | 172752     | 189606      |
| 14     | 135.4       | 51            | 0.004             | 9.000       | 0.227    | 0.040     | 0.093           | 0.040         | 2.560                       | 51.024       | 1.883      | 2.560        | 18.826      | 54.21866  | 160000.00      | 626       | 229316     | 245970      |

Table No.2 Optimization of Rising main for surface irrigation system

| Sr. no | Volume (m³) | Head in m (m) | Discharge Cum. sec | Dia. (inch) | Dia. (m) | Area (m²) | Velocity (m/sec) | Head loss (h) | Total Head (H)=h+10hf in (m) | Power in (KW) | Power (Hp) | Energy (KWH) | Energy Cost | Pump cost | Pipe Cost per m | Pipe Cost | Total Cost |
|--------|-------------|---------------|-------------------|-------------|----------|-----------|-----------------|---------------|-----------------------------|---------------|------------|-------------|-------------|-----------|-----------------|-----------|-----------|
| 1      | 203.1       | 51            | 0.006             | 3.000       | 0.076    | 0.004     | 1.239           | 11.731        | 65904.044                   | 3.537         | 4.110      | 10.257       | 101.8301    | 17700    | 20675.00         | 106       | 28796      | 66198       |
VI. CONCLUSION

As a result of this study, the following conclusions can be drawn:

- When the water resource are scare and agriculture is rain fed, a much highly targeted root zone can be watered with drip irrigation system than covering the whole field with water by surface irrigation.
- Drip irrigation system has high water application efficiency has minimal loss of water in distribution, during application, and watered zone is shadowed by plant itself hence evaporation losses is reduced.
- The total cost for rising main in small scale lift irrigation system for drip irrigation is Rs.55005 while for surface irrigation it is Rs.66198 hence saving of cost Rs.11193.
- Drip irrigation system has high water application efficiency hence the net saving of water throughout the base period of the crop is 8030 m³ for 2.83 hectares of land.
- The total energy consumption for rising main to lift water from source throughout base period of crop, for drip irrigation scheme is 2648.8KwH while for surface irrigation scheme 3889.6KwH hence net saving of energy 1240.08Kw.H, hence the rising main with drip irrigation system is more energy efficient than surface irrigation system.
- The most appropriate pattern for study area is vegetable in summer, which results in maximum net benefits of Rs. 562026 by irrigating of 2.83 hectares of land in summer.

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