Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July, 2021:1034 – 1039

Development of Android Application for Optimization of Irrigation System Capacity

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Abstract

This paper presents development of android application for optimization of irrigation pumps. Methodology for assessment of crop water requirement, hydraulic head assessment and power rating is defined. Further, the android application structure, development procedure and its working sequences are presented. Validation of the application is taken up through case studies in Bagalkot Dist. 10 case studies are conducted. Actual field data is collected from farmers and tested for validation in the proposed application. It is observed that, the results of application match exactly with analytical calculations carried for each case. Farmers and consultants can install application for their localized use and for consultancy. It is concluded that the proposed application will help farmers and consultants to optimally resize their existing irrigation pump systems..

Keywords: Irrigation Pump; Optimization; Blaney-Criddle method; Evapotranspiration; Android application.

1. Introduction

India's largest livelihood source is agriculture sector with 70% of the rural public primarily depending on agriculture and allied activities. Further, major percentages of farmers are at the level of small and marginal farming. It is revealed that around 30 million irrigation pumps are installed in India and about 70% are powered with grid electricity, only 0.4% are solar pumps and rest of the pumps are fed with diesel. In India electricity consumption by irrigation pumps accounts 20-25% of total electricity consumption [1]. Building generating units to meet the increasing load is expensive and hence the energy conservation opportunities are to be identified in the irrigation systems. One such option is optimizing the irrigation pump capacities according to exact need of the farmers. Optimization of irrigation system is an effective measure to realize reasonable, high efficient and sustainable use of water resources in irrigated area.

Optimization of irrigation system necessitates the assessment of crop water requirement of a specific agriculture land. Literatures presented many methods to assess crop water and among these methods assessment of the crop water through evapotranspiration is employed as an effective method. Reference crop evapotranspiration assessment is carried by many methods, viz, Hargreaves, Turc, Thornthwaite, BlaneyCriddle and Christiansen's method [7]. However, feasibility of each method depends on the meteorological data requirement. Blanney criddle method needs only temperature data and provides accurate crop water value during the normal conditions. However, in extreme weather conditions, this method will yield excessive or lesser values of crop water requirements. With the actual crop water values, irrigation pump capacity is calculated based on local hydraulic conditions. Literatures present many methodologies for optimization of irrigation system capacity. However, the requirement is to develop an android application for the efficient methodology. In the present work optimization methodology is developed and android application is built for the proposed methodology.

2. Methodology

Following sections present analytical methodology employed for optimizing the irrigation pump and procedure for development of the Android application.

1.1Analytical Calculation of Optimum Pump Rating

In the proposed method of optimizing the irrigation pump capacity, assessment of crop water, flow rate from pump and hydraulic head at the agricultural land are employed. Crop water is the evapotranspiration due to local climatic conditions. Actual water requirement of any particular site depends on net area of crop cultivation, type of the soil & its percolation properties, sunshine, temperature and the crops grown in agricultural land. Thus, total crop water is assessed by evapotranspiration, which will results in accurate water requirement in mm/day. The crop water requirement is given by (1) [1,6];

$$\mathrm{ET_{crop}} = K_C \times ET_o \quad mm/day \qquad (1)$$

Where,

$\mathrm{ET_{crop}}$ is the crop evapotranspiration

$\mathrm{ET_0}$ is the reference evapotranspiration

Kc is the crop coefficient

Reference crop evapotranspiration ($\mathrm{ET_0}$) depends on local climatic conditions. Many methods available in the literatures, however Blaney-Criddle method requires minimum data for assessment of evapotranspiration for selected site. Therefore Blaney-Criddle method is employed in the present work. Assessment of $\mathrm{ET_0}$ is given by (2);

$$\mathrm{ET_0} = p(0.46T_{mean} + 8) \quad mm/day \qquad (2)$$

Where,

T_{mean} is the mean daily temperature

p is the mean daily percentage of annual daytime hours

Mean daily percentage of annual day time hours (p) varies from 0.24 to 0.30 throughout year in southern part of India. Crop factor (Kc) presents water requirement of particular crop at varying growth stages. Values of crop factors for selected crops are listed in Table.1. Four growth stages of crops are distinguished as: initial stage, crop development stage, mid-season stage, late season stage. Major water consumption is during mid-season stage. However, length of different crop stages will vary according to climatic conditions. With known values of crop factors and growth period, water requirements are calculated for various crops. In the present methodology, employed in the Android application development, sizing of pumps is carried for maximum water requirement conditions i.e for mid-season stage of any crop. Thus, resulting pump will fit for all seasons and worst conditions.

Table 1. Crop Factor for different crops

Crop Type	$\mathbf{K_c}$
Sugar cane	1.15
Cotton	1.15
Sorghum	1.10
Tomato	1.15
Onion	1.00
Maize	1.15
Sunflower	1.10
Groundnut	1.10

Irrigation pump capacity directly relies on output flow-rate of pump. Water requirement of crops per day is to be supplied within the stipulated period. Thus, based on electricity supply hours the water flow-rate is evaluated. For sustained operation with preventing water hammer effect in PVC pipes, water velocity is refereed as 1.5 m/s. Further, flow-rate in lit/minute and optimal diameter of pipe network in inches is assessed by respectively (3) and (4);

$$Q = (ET_c * A * 4.047) \div (N * 3600L) \quad lit/\min \tag{3}$$

Where,

Q is the water discharge in lit/min

A is the area in acres

N is the number of hours electricity is available

$$D = \{(Q*4) \div (v*Pi)\}^{1/2} * 39.38 \quad inch. \tag{4}$$

Where,

D is the diameter of the pipe in inches

v is the velocity of water flow in m/s, and is assumed to be constant with a value of 1.5 m/s

Water flowing in PVC pipe experiences friction and opposing resistance, which leads to energy loss. This loss develop on motor along with elevation of water level to be lifted, bends, valves, friction, change in diameter and length of pipe network. Major loss of head is due to friction. Other losses are minor, as compared to friction and elevation. Major and minor losses together referred as dynamic head. Elevations at suction and discharge sides are termed as static head. Static head at suction side is variable in small reservoirs. Thus, total head offered to pump is sum of dynamic and static heads and is given by (5);

$$H = H_{static} + H_{dynamic} \quad m \tag{5}$$

Where,

H_{static} is the static friction head loss in m

$H_{dynamic}$ is the dynamic friction head loss in m

H is the total friction head loss in m

In the present work friction losses are assessed by percentage friction loss coefficient (f_0) with reference to diameter of PVC pipe. Friction coefficient data are presented by manufacturer's data sheets and are listed in Table.2. Further, friction head loss is assessed by (6);

$$H_{dynamic} = (X * f_0 * 0.1) \quad m \tag{6}$$

Where,

X is the distance between water source and agricultural field in km

f_0 is the percentage friction head loss

Table 2. Percentage friction head loss corresponding to pipe diameter

Pipe Diameter (Inch)	**Percentage of Friction head loss (f_0)**
2	3
3	2
4	1.5
5	1.25
6	1
7	0.75

HP rating of pump is power required to lift water with required flow-rate with total head offered. This power rating in HP is calculated using (7).

$$Pout = p * g * Q * H * 10^{-3} * 0.746 \quad HP \tag{7}$$

Where,

Q is the water discharge in m^3/s

H is the total friction head loss in m

p is the water density

g is the acceleration due to gravity

1.2 Development of Android Application - AGRIPUMP

In the proposed android application the proposed android application Java is used as back end coding language and eXtensible Markup Language (XML) is used as front end coding. The codes run in android studio and simulated to check the correctness of working of android application. Further, an Android Application Package file (APK file) is generated. The application is entitled as “AgriPump”. Developed Android Application has six Activities; viz. Splash Activity, Login Activity, Verify OTP Activity, Main Activity, Main 2 Activity and Finish Activity. For all six activities java and XML codes are developed separately. In Splash Activity an initial defined screen will appear for specified definite time. That is the screen will stay for 3 seconds. Login Activity asks user to enter the existing mobile number for registration purpose and a message carrying One Time Password (OTP) will be sent to the entered number. Once the message is sent, session manager takes part in execution and countdown starts leading to the Verify OTP Activity. During Verify OTP Activity, within the session manager goes to zero, the user need to enter OTP through enrolled number. If the user unable to get the OTP or unable to enter the OTP within specified time can ask for resending the OTP. Once the OTP is entered this activity verifies and registers for further processing. At this point, process is handed over the Main Activity.

The screenshots of different activities in android application, are presented by Fig.1 (a), (b) & (c), Fig.2 (a), (b) & (c) respectively.

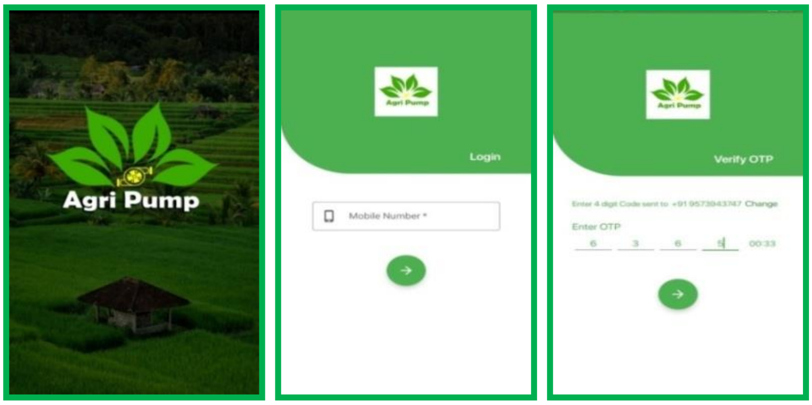

Figure 1. Splash Activity (a), Login Activity (b) and Verify OTP Activity (c)

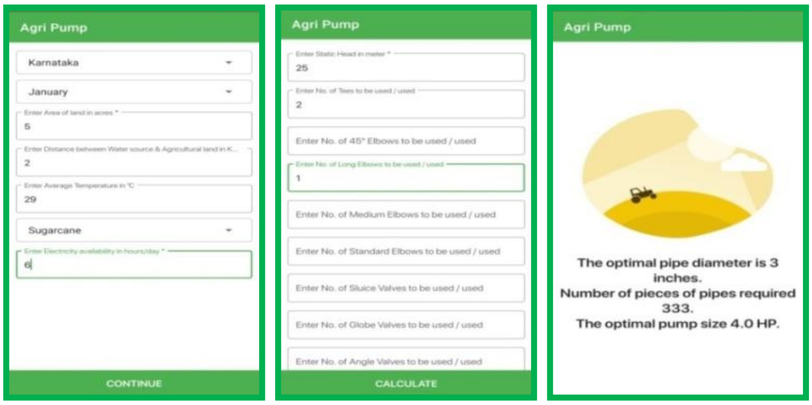

Figure 2. Main Activity (a), Main 2 Activity (b) and Finish Activity (c)

In Main Activity, data is collected and entire calculations are taken up. The data collected here are;

- State in which the field is located(only for Indian Union)
- Month of sowing seeds

- Land area in acres
- Distance between Water resource & Discharge point
- Average temperature at the field
- Crop being sown
- Electricity Supply Hours

Further in Main 2 Activity, all the corresponding calculations for optimal sizing for irrigation pump are taken up. In Finish Activity, final output display is presented, i.e final output of pump rating in HP, Diameter of PVC pipe in inches and number of pieces of PVC pipes required for the pipe network are displayed. The screenshots of android applications, i.e Splash Activity & Login Activity, Verify OTP Activity & Main Activity and Main 2 Activity & Finish Activity are presented by Fig.1,2, and 3 respectively.

The flowchart shown in Fig.4, presents the methodology employed in the android application AGRIPUMP.

3. Results and Comparison

Proposed methodology for optimal sizing of pumps and the android application are tested for validation. 10 case studies are taken up in Bagalkot. Farmers with different crops cultivation are employed for the study. Based on the actual field conditions, optimum sizes of the irrigation pump capacities were suggested. It is observed that most of the irrigation pumps are installed with excess capacities. Further, same assessments are carried out with developed android application. The results of analytical method and data displayed in application are compared. The comparison revealed that both results are matching each other approximately and the developed application works satisfactorily. The results of case studies and the comparison is presented in the Table.3.

Table 3. Results of case studies taken up for validation

Sl. Of Case Study	Total Water Requirement in l/d	Size of the Land in Hectares	Discharge rate in l/m	Length of the Pipeline in m	Suction Head in m	Total Head in m	Existing Pump Rating in HP	Optimum Pump Rating Analytical Calc.	Optimum Pump Rating Application Results
1	148304	2.08	411	1051	4.54	34.14	10.0	4.41	4.41
2	292330	4.10	812	600	6.00	16.48	10.0	4.20	4.20
3	267375	3.75	742	1090	4.50	23.72	10.0	5.52	5.52
4	237429	3.33	659	1111	5.45	27.98	10.0	5.79	5.79
5	296608	4.16	823	1201	6.00	23.18	10.0	5.99	5.99
6	296608	4.16	823	1202	6.00	25.31	10.0	6.53	6.53
7	207483	2.91	576	1501	4.54	36.16	10.0	6.53	6.53
8	178250	2.50	495	1090	6.00	42.49	10.0	6.60	6.60
9	326767	4.58	907	1261	4.54	23.90	10.0	6.80	6.80
10	292330	4.10	812	1515	6.00	31.06	10.0	7.91	7.91

4. Conclusions

An android application for optimally sizing the irrigation pumps is presented in the paper. Methodology employed for the assessment of crop water requirement, hydraulic head assessment and power rating is presented. Further, the development procedure for android application is described. The working sequence of the application is presented. Results of case studies are presented. The comparison of analytical results and application displayed results are tabulated and compared. The comparison indicated that, the android application works efficiently. Case studies are conducted for the different location in the Bagalkot dist. India. It is concluded that the proposed application will help farmers and consultants to optimally resize their existing irrigation pump systems.

Acknowledgment

Authors wish to thank Anand Traders, Bagalkot for the kind support in providing the technical details of Irrigation pumps and data for the case studies. Further, authors wish to thank a progressive farmer, Mr. Basavaraj Hunagundi, Bagalkot for helping in the process of survey.

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