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*Research Article*

# Development of a web-based simulation application for efficient drip irrigation submain design

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**Abstract**
Drip simulation software is essential for accurately optimizing and maximizing the efficiency of drip irrigation systems, enabling precise water management and resource conservation. The present study developed a powerful web-based application to assist irrigation system designers in evaluating the effectiveness of the submain design on uniform or non-uniform slope conditions. The software facilitates the simulation and optimisation of submain design by incorporating modern drip design approaches and state-of-the-art software development methodologies. With its intuitive user interface, the software allows users to effortlessly enter important design parameters, including slope specifications, lateral discharge rates, submain length, lateral spacing and submain inlet pressure head. The software calculates to determine the pressure head values at each outlet and the relative variation in pressure head ($v_h$), allowing for comprehensive design evaluation. Extensive testing using various typical sample data ensured the high accuracy and reliability of the developed web application. It empowers users to explore multiple design alternatives and determine the most suitable option. Rigorous testing, employing various typical sample data, has further enhanced the accuracy and reliability of the developed application. Live demonstrations were conducted to evaluate its user-friendliness, yielding overwhelmingly positive feedback from designers. The software can be accessed conveniently via the website https://www.dripdesigncheck.in/telescopic/submain, ensuring easy availability to users.

**Keywords**: Darcy-Weisbach equation, Drip irrigation, Python, Simulation, Submain

## INTRODUCTION

As the global population is projected to exceed 9 billion by 2050, the demand for food production is expected to increase significantly, putting huge pressure on water resources (Chartres *et al*., 2015 and Grafton *et al*., 2015). In order to address this challenge, efficient irrigation methods are crucial. Drip irrigation is widely recognized as an effective and widely adopted technique that delivers water directly to the root zone of plants in a controlled and precise manner. This approach minimizes water wastage and enhances water-use efficiency, making it particularly suitable for water scarcity regions (Barragan *et al*., 2010). Moreover, drip irrigation offers additional benefits, such as reducing soil erosion, suppressing weed growth and improving crop quality (Kooij *et al*., 2013 and Sidhu *et al*., 2021). As a result, the adoption of drip irrigation systems has gained momentum worldwide, as they have the potential to increase water productivity and address water-related challenges in agricultural production (Ambomsa, 2020).

The design and simulation of submain in drip irrigation play a crucial role in optimizing the overall efficiency and effectiveness of the irrigation system. Proper submain design is of utmost importance in drip irrigation systems as it directly impacts the efficiency and effectiveness of water distribution to crops. The submain serves as the main conduit for transporting water from the water source to the lateral lines, which deliver water to individual plants (Keller and Bliesner, 1990). Uniformity ensures that each plant receives an adequate and consistent water supply, essential for optimal crop growth and yield (Christiansen, 1942 and Keller and Karmeli, 1974). On the other hand, inefficient submain design can result in uneven water distribution, leading to overwatering or underwatering of plants, both of which can negatively affect plant health and productivity (Pereira *et al*., 2002; Khan *et al*., 2006; Wang and Chen, 2020; Ame and Shouhua, 2022 and Ravikumar, 2022a).

A simulation is an effective tool that assesses a drip irrigation system's operational efficiency and safety. By creating a virtual model, simulations provide the capability to predict the impact of altering variables such as pressure, flow rate, and pipe characteristics (such as length and diameter) on the system's performance (Mirza, 2018 and Gallardo *et al*., 2020). Simulation tools enable irrigation professionals and farmers to assess various design alternatives, analyze system performance and identify potential issues before implementation. By simulating different scenarios and parameters, such as flow rates, pressure heads, and lateral spacing, designers can optimize the submain design to achieve the desired uniformity and efficiency. This helps in reducing water and energy consumption while ensuring adequate water supply to each plant (Ravikumar, 2022b).

In drip irrigation systems, evaluating the pressure head variation along the submain is of utmost importance as it enables the assessment of the goodness of the irrigation system. This evaluation is commonly accomplished by calculating the pressure head at each outlet of the submain. This calculation incorporates factors such as frictional head losses and head loss/gain due to changes in elevation. Traditional analytical methods for determining the pressure head at each outlet can be time-consuming and tedious due to the large number of calculations involved. However, the use of software can streamline this process, significantly reducing time requirements and minimizing the potential for manual errors (Pedras *et al*., 2009; Patel *et al*., 2018; Palau *et al*., 2020 ; Wang *et al*., 2021). Based on the preceding studies, the primary aim of the present study was to develop a web-based simulation application specifically tailored for optimizing the design of submain in drip irrigation systems.

## MATERIALS AND METHODS

A comprehensive explanation of the methodology employed to simulate the pressure head variation along the submain is provided and demonstrated with numerical examples.

### Simulation of pressure head distribution along the submain

The design methodologies proposed by Ravikumar (2022b, c) serve as the foundation for the procedures employed in this study. When the submain is positioned on an upward slope, the pressure head experiences a gradual decline along the length of the pipe due to friction and elevation losses, as depicted in Fig. 1. Conversely, when the submain is installed on a downward slope, the pressure head at each location is determined by the elevation gain and friction losses, as illustrated in Fig. 2. These observations formed the basis for the design considerations and simulations conducted in this research.

The Darcy-Weisbach equation (Eq. 1), is commonly used in drip irrigation systems to calculate the friction loss occurring within the pipes. This equation is particularly recommended for systems with pipe diameters below 125 mm, as observed in the literature (Keller and Bliesner, 1990 and Ravikumar, 2022a). The equation takes into account factors such as the flow rate, pipe diameter and length, providing an accurate estimation of the frictional losses experienced in the system. By applying the Darcy-Weisbach equation, designers can assess and optimize the pipe sizing and layout to ensure efficient water flow and minimize energy losses.

$$\Delta h_L = 789000 \times \frac{Q^{1.75}}{D^{4.75}} \times L \qquad \text{Eq. 1}$$

Where $\Delta h_L$ is the total frictional head loss (m), Q is the discharge rate through the submain (l/s), D is the submain diameter (mm), and L is the total length of the submain (m).

In order to find out the friction loss at any lateral locations along the submain, 'l' measured from the submain inlet $(\Delta h_l)$, Eq. 2 is used (Ravikumar, 2022a).

$$\Delta h_l = \frac{789000}{2.75 \times D^{4.75} \times (\frac{q}{s})} (Q^{2.75} - (Q - \frac{ql}{s})^{2.75}) \qquad \text{Eq. 2}$$

Where

Q: Discharge rate through the submain, l/s

q: lateral discharge rate, l/s

s: spacing between laterals, m

D: Diameter of the submain, mm

l: length from submain inlet, m

When a submain is laid on any slope situation, the resultant pressure head is obtained as Eq. 3.

$$h_l = h_{start} - \Delta h_l + p\Delta Z_l \qquad \text{Eq. 3}$$

Where

$h_l$ : pressure head at any length l (m)

$h_{start}$ : pressure head at the submain inlet (m)

$\Delta h_l$ : Total friction loss till length l (m)

$\Delta Z_l$ : Elevation difference at l with reference to inlet (m)

p = 1 for downslope and -1 for upslope

In this study, the relative variation in pressure head ($v_h$) was adopted as a reliable indicator to assess the quality of drip irrigation pipe design due to its simplicity and robustness (Zhang *et al*., 2013 and Ravikumar, 2022d). The $v_h$ represents the ratio of the maximum variation in pressure head (Δh) to the average pressure head at each outlet position along the submain ($h_a$). To determine the Δh, the maximum ($h_{max}$) and minimum ($h_{min}$) pressure head values among all the submain outlets are considered. The difference between these two values provides the Δh value. By calculating the Δh and the average pressure head ($h_a$), the $v_h$ can be obtained using Eq. 4.

$$v_h = \frac{\Delta h}{h_a} \qquad \text{Eq. 4}$$

Maintaining the $v_h$ within specific allowable limits ( $v_h^a$ ) is vital to ensure a safe and effective design. The design is considered unsafe if $v_h$ is greater than the $v_h^a$ .

**Demonstration using a sample scenario**

The methodology explained above is demonstrated using a sample scenario where a telescopic submain is installed on a non-uniform slope. The goodness of the submain design, which has a length of 50 m, is evaluated based on the $v_h^a$ of 0.1. The submain's diameter is 45.8 mm for the first 16 m, 36.4 mm for the next 8 m, and 28.8 mm for the remaining 26 m. The diameter and slope details are presented in Fig. 3. The lateral pipes are installed with an interval of 2 meters and the flow rate of each lateral is 300 l/h. The $h_{start}$ is 10 m.

As per the above-discussed procedure, we need to find out the friction loss and elevation gain (since the profile is downslope) to determine the pressure head distribution along the given submain of length 50 m.

The discharge rate of flow (Q) through each pipe segments are marked in Fig. 3.

Friction loss at 2 m from the closed end:

$$\Delta h_2 = \frac{789000}{2.75 \times 45.8^{4.75} \times \frac{0.0833}{2}} (2.08333^{2.75} - (2.08333 - \frac{0.0833 \times 2}{2})^{2.75})$$

= 0.07104 m

$$\Delta h_4 = \frac{789000}{2.75 \times 45.8^{4.75} \times \frac{0.0833}{2}} (2.08333^{2.75} - (2.08333 - \frac{0.0833 \times 4}{2})^{2.75})$$

= 0.13709m

A similar calculation is repeated until 16 m (for the first segment from the inlet with a diameter of 45.8 mm),

$$\Delta h_{16} = \frac{789000}{2.75 \times 45.8^{4.75} \times \frac{0.0833}{2}} (2.08333^{2.75} - \left(2.08333 - \frac{0.0833 \times 16}{2}\right)^{2.75}) = 0.43736 \text{ m}$$

For the second segment from 16 to 24 m (with a diameter of 36.4 mm), $\Delta h_l$ is calculated as:

$$\Delta h_{18} = 0.43736 + \frac{789000}{2.75 \times 36.4^{4.75} \times \frac{0.0833}{2}} (1.416667^{2.75} - \left(1.416667 - \frac{0.0833 \times (18-16)}{2}\right)^{2.75})$$

=0.54328 m

$$\Delta h_{24} = 0.43736 + \frac{789000}{2.75 \times 36.4^{4.75} \times \frac{0.0833}{2}} (1.416667^{2.75} - \left(1.416667 - \frac{0.0833 \times (24-16)}{2}\right)^{2.75})$$

= 0. 0.79728 m

We repeat the same calculation for the third segment from 24 to 50 m (with a diameter of 28.8 mm):

$$\Delta h_{50} = 0.79728 + \frac{789000}{2.75 \times 28.8^{4.75} \times \frac{0.0833}{2}} (1.08333^{2.75} - \left(1.08333 - \frac{0.0833 \times (50-24)}{2}\right)^{2.75})$$

=0.1.8006 m

For different values of l, the $\Delta h_l$ values are tabulated in Table 1.

Based on the $\Delta h_l$ and elevation difference with respect to the inlet of submain, the pressure head at each lateral location is calculated and tabulated in Table 1.

From the Table 1, $h_{min}$ = 9.0591 m; $h_{max}$ = 9.949 m and $h_a$= 9.441 m and $v_h$ = 0.094 Since the $v_h$ is less than $v_h^a$ , the design can be accepted. However, since this procedure involves a number of calculations, developing software is much more needed. Also, it will be more useful for the users to analyse the pressure head variation, if data could be represented as given in Fig. 1-2.

**Development of web-based simulation software**

In line with the above-mentioned procedure, a web-based application was developed specifically for submain pipe design. The back-end development utilized the Python programming language, known for its simplicity, power and extensive library support. To create user-friendly and responsive user interfaces, HTML and JavaScript were employed. Additionally, the integration of interactive table listings was achieved using the *DataTables* library, while the *Plotly* library was utilized for data visualization. The development process,

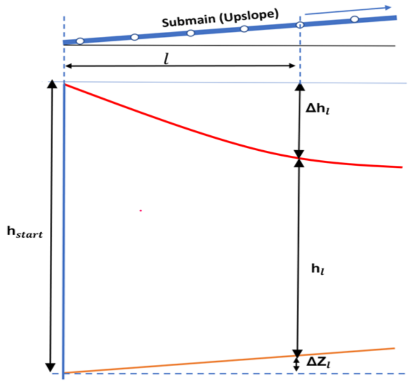


**Fig. 1.** *Pressure head variation along submain laid on Upslope*

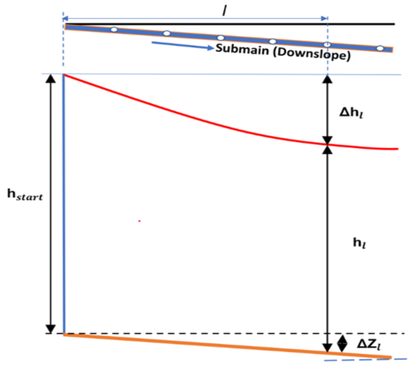


**Fig. 2.** *Pressure head variation along submain laid on downslope*

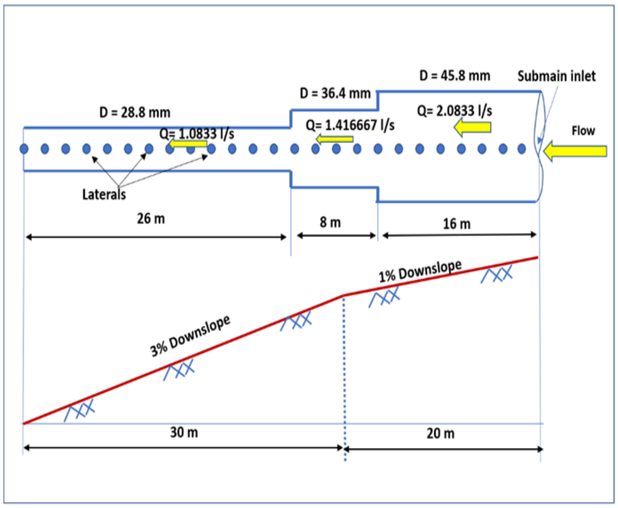


**Fig. 3.** *Telescopic submain laid on non-uniform slope*

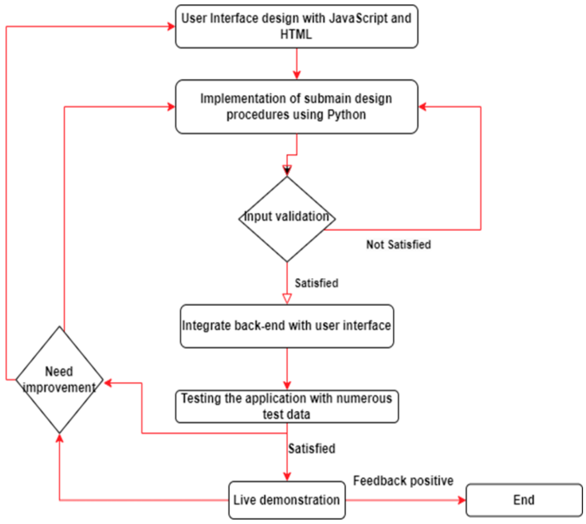


**Fig. 4.** *Technical flow chart of Web-application*

including the various steps involved, is summarized in Fig. 4.

Input validation is a pivotal aspect of software development as it plays a critical role in ensuring user input accuracy, comprehensiveness, and consistency. In this study, JavaScript was employed to implement robust input validation mechanisms, enabling the software to provide users with prompt feedback through warning and error messages whenever improper values or texts were entered. To guarantee the effectiveness of the developed web application, extensive testing was carried out using diverse test data. This rigorous testing process aimed to identify any potential error related to input validation and to ensure the software's ability to handle various scenarios accurately and reliably. Furthermore, live demonstrations were conducted with designers, and their feedback was collected.

## RESULTS

The user interface of the developed web application is shown in Fig. 5.

### User interface and working

The user must first enter the length of the field up to which the submain is to be laid. Once the submain length is entered, they can click on the "add details" button to enter the submain diameter data (Fig. 6). The user must then enter the number of diameter segments, diameter values, and the length up to which each diameter segment is intended to be laid. After entering the details of each segment, the user needs to add the details to the table using the "add" option. If any errors are encountered, there is an option to remove any added details (Fig. 6). The number of segments entered will determine whether the submain is telescopic or not. If there is only one segment, it means that the size is uniform throughout the length. Otherwise, it is telescopic.

To add slope details, the user must click on the "add details" option corresponding to the slope details in the window. Clicking on this option will display a dialog box (Fig. 7). The user must enter the number of slope segments, which will determine whether the field topography is uniform or not. Next, the user can enter the de-

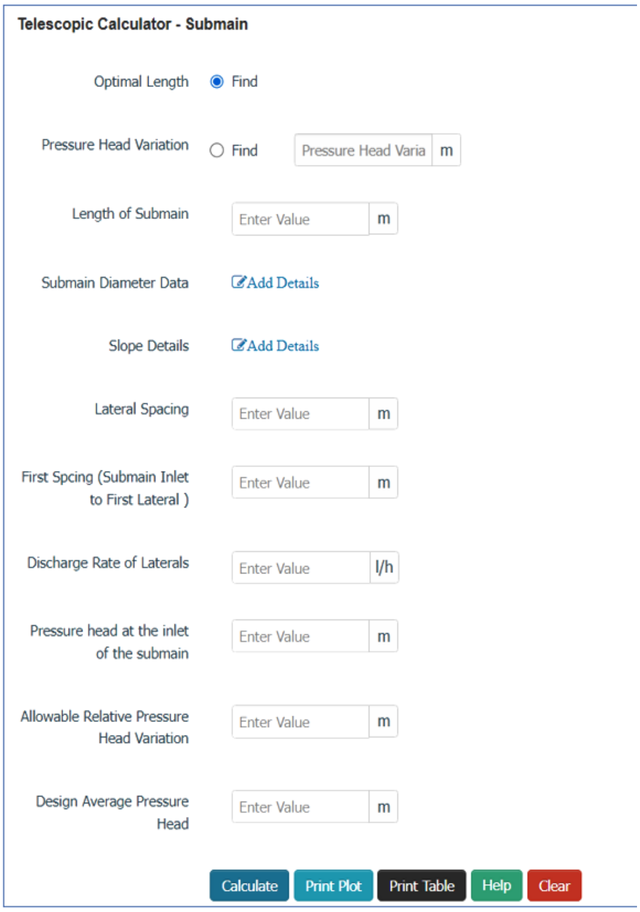


**Fig. 5.** *User interface of the developed web application*

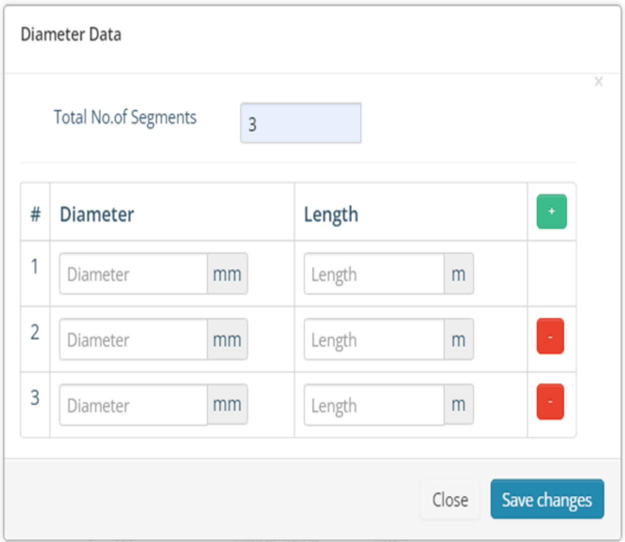


**Fig. 6.** *Diameter data dialog box for entering diameter details of submain*

tails for each segment, including the slope percentage, slope type (upslope, downslope, or horizontal), and the length of each segment. The total length of each segment should be equal to the length of the submain entered. If the total length is not equal, an alert message will appear, prompting the user to enter data for the entire length of the submain. Furthermore, the user is required to input the values corresponding to lateral spacing, the discharge rate of laterals, and $v_h^a$ into the respective text boxes.

**Output:** Once the user inputs the required values and clicks on the "calculate" button, the software will begin calculating the variation in pressure head and relative pressure head. Moreover, the software will generate a design note that will provide information on whether the design is acceptable or not based on $v_h^a$ . The design note helps users make informed decisions about the submain system's design.

Additionally, the software will present tabulated details for each outlet position, which the user can review on the interface. Furthermore, if the user wishes to have a copy of the details in .xlsx/pdf format, they can download it using the provided download button. This feature will allow users to have an organized and easily accessible copy of the calculations and results for future reference.

### Data visualization

Data visualization refers to using graphical representations to present complex information and data easily and interpretably. The aim of data visualization was to create visual displays that enable users to comprehend information quickly and efficiently. In this study, the developed web application can create visual representations of various aspects related to ground profiles, frictional head loss, and pressure head available at different locations, as discussed in Fig. 1-2. The application also included features such as saving, zooming in, zooming out, and hovering over the graphical results obtained.

### Examining the reliability and functionality of the developed Application

Extensive testing was conducted on the application using various datasets comprising valid and invalid, consistent and inconsistent data. A primary objective of these tests was to enhance the quality of the application by identifying and resolving any potential errors. A comparison was made between the outputs obtained by the developed application and those calculated manually to determine whether the simulation performed by the application was accurate and reliable. Table 2 presents a representative sample of software testing data based on a variety of simulation scenarios.

The web-application can be used to test different sets of sample data for designing the diameter of the submain. For example, consider the case where the submain has a length of 50 m and runs on an upslope of 1% for the first 15 m and 2% for the remaining 35 m. Lateral pipes are placed at 2.5 m intervals with a discharge rate of 300 l/h. The $h_{start}$ of the submain is 10 m, and the $v_h^a$ is 0.1. Four different design choices were tested. In the first two cases, a uniform diameter of 45.8 and 57.6 mm was used, and the software returned the values of Δh, $v_h$ and acceptability of the design (Table 2). Similarly, a telescopic pipe design was used in the third and fourth cases, and the results were recorded (Table 2). The output results generated by the software were precisely aligned with the expected outcomes. Users can make a well-informed conclusion based on the results obtained from these four example cases. Specifically, for the given field conditions, opting for the telescopic design rather than the uniform diameter of 45.8 or 57.6 mm is recommended.

Table 2 provides a set of sample test cases for submain pipe placement under upslope and downslope conditions. Each test case considered different design requirements and involved pipes of various sizes based on field conditions. The results revealed that Option 1 and Option 4 from Sample Case 1 offered satisfactory designs, with Option 4 being more cost-effective than Option 1. Recording the output from the web-application and calculating the pipe cost for each design option can provide users with valuable information to enhance their drip irrigation design. By analysing the results obtained from the software, users can assess the performance and efficiency of different design alternatives. Additionally, considering the cost implications of each option allows users to make informed decisions that optimize both the design effectiveness and economic feasibility of the drip irrigation system. This iterative process of recording outputs, evaluating costs, and refining the design can lead to improved water distribution, increased crop yield, and enhanced resource utilization in drip irrigation systems.

## DISCUSSION

The development of software tools, such as the web-based simulation application for submain design, addresses the increasing need for efficient and accurate irrigation system design and optimization. Traditional manual methods for designing drip irrigation systems can be time-consuming and prone to errors. The use of software applications streamlines the design process, improves accuracy, and allows for quick evaluation of multiple design alternatives. The web application developed in this study can be accessed via the website https://www.dripdesigncheck.in/telescopic/submain, ensuring easy availability to users.

**Table 1.** Pressure head distribution for the telescopic non-uniform slope situation

| Distance l (m) | Friction loss (m) | Elevation gain (m) | Pressure Head (m) |
|---|---|---|---|
| 0 | 0.0000 | 0 | 10 |
| 2 | 0.0710 | 0.02 | 9.9490 |
| 4 | 0.1371 | 0.04 | 9.9029 |
| 6 | 0.1983 | 0.06 | 9.8617 |
| 8 | 0.2548 | 0.08 | 9.8252 |
| 10 | 0.3068 | 0.1 | 9.7932 |
| 12 | 0.3545 | 0.12 | 9.7655 |
| 14 | 0.3979 | 0.14 | 9.7421 |
| 16 | 0.4374 | 0.16 | 9.7226 |
| 18 | 0.5433 | 0.18 | 9.6367 |
| 20 | 0.6382 | 0.2 | 9.5618 |
| 22 | 0.7227 | 0.26 | 9.5373 |
| 24 | 0.7973 | 0.32 | 9.5227 |
| 26 | 0.9955 | 0.38 | 9.3845 |
| 28 | 1.1668 | 0.44 | 9.2732 |
| 30 | 1.3130 | 0.5 | 9.1870 |
| 32 | 1.4356 | 0.56 | 9.1244 |
| 34 | 1.5366 | 0.62 | 9.0834 |
| 36 | 1.6177 | 0.68 | 9.0623 |
| 38 | 1.6809 | 0.74 | 9.0591 |
| 40 | 1.7281 | 0.8 | 9.0719 |
| 42 | 1.7614 | 0.86 | 9.0986 |
| 44 | 1.7828 | 0.92 | 9.1372 |
| 46 | 1.7948 | 0.98 | 9.1852 |
| 48 | 1.7997 | 1.04 | 9.2403 |
| 50 | 1.8006 | 1.1 | 9.2994 |

**Table 2**. A set of sample data used for simulating submain laid on different slope types

| Inputs to software | | Output from Software | | |
|---|---|---|---|---|
| **S. No.** | **D, mm** | **Δh, m** | **$v_h$** | **Safety Note** |
| **Sample case 1**: L= 50 m, Slope = 1% (Upslope) for the first 15 m and 2% (Upslope) for the remaining 35 m, s = 2.5 m, q =300 l/h, $h_{start}$= 10 m, $v_h^a$ = 0.1 | | | | |
| 1 | 57.6 | 0.957 | 0.10 | Safe |
| 2 | 45.8 | 1.218 | 0.131 | Not Safe |
| 3 | 57.6: 17.5 m; 45.8: 12.5 m; 36.4: 15 m; 28.8: 5 m | 1.1 | 0.12 | Not Safe |
| 4 | 68.8: 15 m; 57.6: 15 m; 45.8: 15m; 28.8: 5m | 0.945 | 0.099 | Safe |
| **Sample case 2:** L= 50 m, slope = 1% for the first 20 m (Downslope) and 3% (Downslope) for the remaining 30 m, s = 2 m, q = 300 l/h, $h_{start}$= 10 m, $v_h^a$ = 0.1 | | | | |
| 1 | 45.8 | 0.736 | 0.074 | Safe |
| 2 | 36.4 | 1.16 | 0.13 | Not Safe |
| 3 | 28.8: 26 m; 36.4: 10; 45.8: 14 | 0.968 | 0.103 | Not safe (boundary) |
| 4 | 28.8: 26 m; 36.4: 8; 45.8: 16 | 0.89 | 0.094 | Safe |

**Table 3**. Participant feedback on a developed software

| Participants | Number of participants | Feedback |
|---|---|---|
| Scientists (from CWRDM, Calicut) | 3 | Found the application useful and attractive |
| Agricultural Officers (from Various Krishi Bhavans, Kerala) | 10 | User-friendly and useful application<br>Add unit conversion option<br>Recommended developing a mobile application with similar functionality |
| Assistant Engineers (Irrigation Department, Kerala) | 5 | Useful, saving time and manual effort<br>Add unit conversion option |
| Assistant Executive Engineers (Minor Irrigation Section, Kerala) | 2 | Useful application<br>Easy to understand and navigate |
| Research Scholars (from TNAU, Coimbatore and Kerala Agricultural University, Thrissur) | 25 | Useful, saving time and manual effort<br>Add a detailed help window<br>(incorporated after the demonstration) |

Web-based simulation software offers several advantages over traditional desktop applications. Firstly, being web-based allows for easy accessibility, as users can access the application from any device with an internet connection. This enables a wider range of users, including irrigation system designers, engineers, and farmers, to utilize the software without the need for complex installations or specific hardware requirements. The web-based nature of the software enhances its accessibility, allowing a diverse user base to easily utilize its functionalities and benefits. The availability of the developed web application for submain design at https://www.dripdesigncheck.in/telescopic/submain further enhances its accessibility.

The developed software has numerous advantages over existing software, such as IRRICAD, AquaFlow (Philipova, 2012 and TORO, 2014), HydroCalc (Halbac-Cotoara-Zamfir, 2009 and Mansour and Aljughaiman, 2020) and DSSP (Krishnan and Ravikumar, 2002 and Ravikumar 2022b). These software programs vary in complexity, pricing, and availability, among other factors. IRRICAD (Lincoln Agritech Limited, 2013) is an advanced, paid software offering more functionality than the developed one. However, the web-application developed in this study is simpler and more powerful in simulating the drip system submain, providing results based on the user's intuition. In addition, since the software is free to download, users can optimize their de-

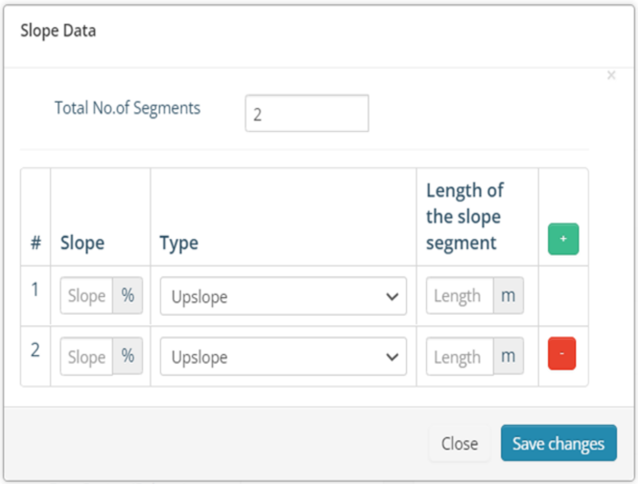


**Fig. 7** *Dialog box for entering slope details*

sign without incurring any cost.

The web-based simulation application was compared to other widely used software programs in the field. For instance, HydroCalc, a popular software developed by Netafim (Darwish *et al.*, 2022) was evaluated. The developed application presented detailed information in a tabular format, including friction loss, elevation gain/loss, and pressure head at each outlet location, offering enhanced insights compared to HydroCalc.

AquaFlow software offered various product options and models for users, providing details on different dripper characteristics (TORO, 2014). However, AquaFlow was found to be less user-friendly compared to the web application in this study. The developed application was also compared with another standalone simulation software called DSSP (Krishnan and Ravikumar, 2002). The pressure head values at each multi-outlet location provided by both the software were consistent. Although, the developed application offers more comprehensive results and insights than DSSP, as it lacks graphical representations and information regarding pressure gain/loss at each location.

The evaluation of software performance through feedback and recommendations from designers is highly valuable for any software development project. Therefore, a live demonstration of the application was conducted to facilitate this process. The demonstrations were conducted at two locations, namely Centre for Water Resources Development and Management (CWRDM) in Calicut and Tamil Nadu Agricultural University (TNAU) in Coimbatore. Table 3 presents feedback from participants who attended the demonstrations of the developed software. The participants included scientists, agricultural officers, assistant engineers, assistant executive engineers, and research scholars.

The overall feedback from the participants was positive, emphasizing the software's user-friendly interface and its ability to cater to their specific needs.

## Conclusion

A web-based application was developed to simulate and optimise drip irrigation submain designs. This application allows users to enter input details related to their irrigation system and then conducts simulations to evaluate the effectiveness of the design. The software considers various slope conditions, including uniform, non-uniform, and mixed slopes (upslope and downslope), comprehensively analysing the system's performance. One of the application's key features is its ability to compare multiple alternative designs based on the input data set. Users can evaluate different design options and select the most satisfactory one based on the simulated results. This feature thoroughly examines the system's performance and enables users to make informed decisions regarding their submain design. During the live demonstration of the software, valuable feedback was obtained from users. The feedback was overwhelmingly positive, with users highlighting the ease of use and the software's ability to cater to their specific needs. To make the software easily accessible, it is hosted on the website http://www.dripdesigncheck.in/telescopic/submain. Users can visit the website and utilize the web-based application to optimize their drip irrigation submain design, benefiting from its user-friendly interface and powerful simulation capabilities.

## Conflict of interest

The authors declare that they have no conflict of interest.

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