Development of a Decision Support System, DOMIS, for Designing Micro Irrigation Systems

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Abstract

A decision support system namely DOMIS (Design of Micro Irrigation Systems) was developed for standardizing the designs of Drip, Sprinkler and Micro Sprinkler irrigation systems. The decision support system was developed using standard formulae with richness of knowledge and expert opinions. Flexibility and simplicity of use make the DSS DOMIS a superior tool for designing micro irrigation systems. The DSS provides knowledge, expert opinion and necessary data on crops, soil, water and climate in the form of default options at different interactive stages of the software. The DSS also allows the user to make appropriate changes in the parameters provided by the DSS, if the user so desires. DSS-DOMIS suggests most optimal layout plan for main, sub-main and lateral pipes with appropriate sizes of different components including pipes, pumping system, filters and fertilizer application systems. The web based system has been hosted on the net with domain name http://domis.iari.res.in. Besides the design of micro irrigation systems, the DSS provides complete list of concerned State and district officials, approved micro irrigation system suppliers and the general information about the district, different Government schemes and their implementing agencies all over the country. The decision support system will be useful for industry, farmers, students, researchers and policy makers. The DSS is available for use or free on line and the author will appreciate the feedback and suggestions from the users for its further improvement.

Keywords:
Micro Irrigation System Design, Decision Support System, Micro irrigation software

Introduction

India has limited land and water resources with only 2.3 % land and 4% of water but with a population of over17% of the World. Immediately after independence in 1947, Government of India started investing rather heavily in increasing its water resources for irrigation from a mere 22.6 Mha to the present level of over 100 Mha out of a total potential of 140 Mha. Introduction of high yielding varieties of cereals combined with developed water resources and of course with the use of chemical fertilizers brought about a green revolution in the country. Government of India also initiated several National and State level organizations for developing package of practices appropriate for local agro climatic and socio economic situations. All these strategies resulted in quantum jump in food grains production from a mere 52 MT in 1952 to 295 MT in the year 2017. This quantum jump in production for food

sufficiency adversely affected the water resources availability, particularly ground water. To increase the production further to meet the requirement of growing population there is an urgent need to conserve the depleting water resources through policy, peoples' participation, capacity building, technological advancement and technology transfer pertaining to savings of each and every drop of water.

Agriculture is the major consumer of water (about 80 %) with very poor utilization. Initially very big dams were created for storing of water and then linked with canal water distribution network. Timely completion of big irrigation projects was all the time challenging and having several litigations. Irrigation experts then started realizing that instead of creating additional large dams/ irrigation projects which have long gestation periods and are no longer economically viable due to cost escalation (many fold) and low water-use-efficiency (as low as 38%) such projects have. This happened because of greater emphasis only on the development of water resources and little/ no emphasis on its efficient utilization. Since surface and underground water resources were made available to the farmers free of charge, these resources were exploited mercilessly. This has been reported by the experts that water would be the single most critical limiting factor for India's economical development requiring continuous promotion of micro irrigation for reducing water consumption in agriculture.

In the year 1985, the Government realized the urgent need to promote water saving technologies in agriculture to sustain against the increasing water demands of progressively developing urbanisation, industrialization and other sectors of the economy requiring water. In India land holdings are very small (more than 80% lad holdings are less than 1 ha) and the farmers are resource poor. Micro irrigation is the most efficient method of irrigation but is expensive too. It was understood that small and marginal farmers in India will not be able to benefit from microirrigation technology owing to its high cost and only a few rich farmers having large holdings only will be able to use the technology. Government after analysing the situation decided to offset the high cost of micro irrigation equipment through a subsidy scheme for small and marginal farmers (with land holdings less than 5 ha only). To address the problem of very poor and very small farmers provision of additional subsidy was kept in the scheme. The scheme also addressed the issue of regional inequity in agricultural development by keeping different levels of subsidies.

With the financial support schemes and other enabling initiatives of the Government including, funding of research for developing package of practices for growing different crops under different agro-climatic conditions under micro irrigated environment, the adoption of micro irrigation in the country started increasing. The Government started putting stringent conditions on the system suppliers to manufacture locally to be eligible to participate in the scheme partly funded by the Government. Government also established a National Committee in the Bureau of Indian Standards for developing and certifying irrigation equipments manufactured in India for their desired quality.

The author has had the privilege of being associated with the scheme since its inception in 1985 and has lead the largest Precision Farming Development Centre located at Water Technology Centre at Indian Agricultural Research Institute, New Delhi for over two

decades; He has been involved in different Guidelines Formation Committees and subsidy committees of the Government. He has had close interaction with industry. He has been a regular member for over two decades and continues to be a regular member of the Bureau of Indian Standards Committee for formulation of Indian Standards for Irrigation equipments. The author has been a researcher and has published more than two hundred research articles, ten books and twelve bulletins on micro irrigation. His contributions have earned him the top national recognitions and awards.

The current Government has launched a very ambitious irrigation scheme in the country on June 2016 namely, PMKSY (Prime Minister Krishi *Sinchai Yojna* i.e. Prime Minister's Agriculture Irrigation Scheme). Under the scheme incomplete 99 irrigation projects lingering for long period will be taken up on priority for time bound completion which will increase estimated irrigation potential by 2 Mha. Under the scheme micro irrigation has been given another thrust as under the scheme it has been made mandatory (1) to bring at least 10% canal command areas under micro irrigation particularly in the tail end reaches of canal commands to address the problem of lesser water availability at the tail end of the canal owing to excess withdrawals on head reaches/ inadequate canal supplies. (2) to use harvested rain water under all watershed projects through micro irrigation only and (3) include at least 25% non horticultural crops too under micro irrigation scheme. It can be concluded that these Government policies not only have brought India to number one position in micro irrigated area coverage but will also attain a height which will not be easy for any other country to surpass in near future.

All these developments resulted in adoption of micro irrigation systems in very large number of fields (mainly small fields) across the country for different crops under different agro-ecological situations. Standardization of design of micro irrigation systems and the quality control on the type of systems became critical parameters for successful adoption of micro irrigation technologies. It was almost impossible to train all the persons involved in designing the micro irigation systems in the country therefore a need was felt to develop a technological tool for designing micro irrigation systems efficiently for different crops under different agro climatic conditions.

Design of microirrigation systems requires the data of crop, soil, climate and the hardware of the system. All the data may not be readily available to multitudes of the persons engaged in micro irrigation design at field level across the country. Therefore a Decision Support system equipped with complete data set of all the parameters needed for designing efficient micro irrigation systems was considered as the need of the hour for the success of micro irrigation scheme in the country.

Development of DSS

A DSS is a computerized system for helping in any decision-making process, which integrates multidisciplinary databases, modelling tools and multi criteria analysis methodologies that are useful to analyse and rank a set of alternatives. Supporting a decision means helping decision makers to generate alternatives, rank them and make choices, which

is particularly useful for design. Design of micro irrigation systems is an appropriate field for application of DSS as it requires in depth knowledge, a large number of data relating to soil, crop, climate water resource and its quality. Since the user may or may not have ready access to all these data his designs may be suboptimal and inefficient and uneconomical too. Therefore a DSS namely, DOMIS was developed for designing efficient micro irrigation systems even when the basic data required on soil, crop, climate and water source is not readily available with the user.

DOMIS- Design of Micro Irrigation Systems:

DOMIS was developed to design different micro irrigation systems including drip, sprinkler and micro sprinkler systems. The DSS provides help and guidance to the users about how to design appropriate micro irrigation systems for efficient water utilization under any given agro-climatic conditions. DOMIS with its huge data bank enables the user to design micro irrigation systems efficiently even without having the required data on soil, crop, climate and water source. The DOMIS is a web based DSS and can be accessed from any internet enabled device including desktop, laptop, mobiles etc. In the DSS the open source programming languages PHP and DHTML are used for front end design but for back end data connectivity MySQL is used.

DSS architecture

The DSS DOMIS has been developed in a simple architecture with five sequential building blocks as follows (Table 1).

Table 1. Building blocks of DOMIS architecture

SN	Name of block	Functions performed
1	Presentation block	web based interface, tools and applets are embedded
2	Data block	different data cache on crops, soil, climate and system hardware data are arranged
3	Information block	the option for the user to change / modify different data are provided
4	Algorithm block	All the logics and computations are done under this block
5	Final/ Report block	The fifth and final block presents the report of system design and the cost estimates.

Computational procedure in DOMIS

The following procedure of computation is followed in the DOMIS in its algorithm/ logic block. At each stage the user is provided with a default option with an option for the user to chose and use his input, if he so desires.

i. Division of the field into blocks (of desired dimensions, based on the field size and the selected system)
ii. Determination of appropriate system layout plan (for network of main, sub main and lateral pipes, based on the location of source and to minimize system cost)
iii. Estimation of water requirements (based on reference crop evapo-transpiration and dynamic crop coefficient and canopy factors)
iv. Determination of suitable water application rate (based on soil type, crop and water source)
v. Determination of sizes of different components of system network (sizes of main, sub main and lateral pipes on the basis of crop water requirements and by optimally balancing the cost and frictional losses within the pipes in limit)
vi. Estimation of size & type of accessories (filters & fertigation equipment, based on water quality and fertigation needs)
vii. Determination of total head requirement (suction, delivery heads and friction losses)
viii. Determination of size of motor pumping unit (based on flow requirements and the total head requirement)
ix. Estimation of the cost of the designed system (Based on the costs of different components of the designed system)

Data embedded in DOMIS and its source

The data embedded in the DSS were collected mainly from different Government authorized sources including historical daily agro-climatic data i.e. potential evapotranspiration (ET0 mm/day), soil properties, ground water table situation, wind velocity information of all the 718 districts of 29 States and 7 UT's in India. The crop database includes all crop parameters of different crops grown across the country. The crop parameters include effective rooting depths, crop coefficients (Kc) and crop spacing. Many crops data were taken from open source FAO publications Number 24 and 56 namely, Crop water needs. The DOMIS provides the user with stored data as default option but with flexibility to the user to modify the default data as per best of their knowledge.

Operation and use of DOMIS

The web based DSS DOMIS has been hosted on the internet with the domain name as http://domis.iari.res.in. In the DSS an interactive Graphical User Interface (GUI) and responsive home page was designed (Fig 1). Besides helping in designing different micro

Fig. 1. Opening screen of DSS DOMIS

irrigation systems, DOMIS also provides general information about Government schemes, different micro irrigation systems, details about districts, implementing agencies in different States of India, approved system suppliers in different States and other general information about micro irrigation.

The DSS presents a little introduction, its scope and capabilities in in its opening screen (Fig 1). Interactively the user is guided in stepwise data inputting either by accepting default option or feeding his data. For example, on the crops data screen, the user is asked to identify a crop from the available list and its photograph and all other parameters, crop evapotranspiration, crop factor, canopy factor and plant to plant and row to row spacing are presented by default (Fig 2.). These may be accepted by the user as such or he can make appropriate changes as per his knowledge. Similarly the user is presented with the concerned appropriate data on different parameters dealt on different screen for the benefit and help of the user of the DSS. Using the input data and the standard design procedures the DSS helps the user in finalizing the layout plan for main, sub main and lateral pipes, dripper discharge and spacing, size and types of filters, fertigation unit and the motor and pumping units for the selected micro irrigation system. It also provides the estimated cost of the designed micro irrigation system based on the prices of different micro irrigation system components at the price index of 2017 (Fig. 3).

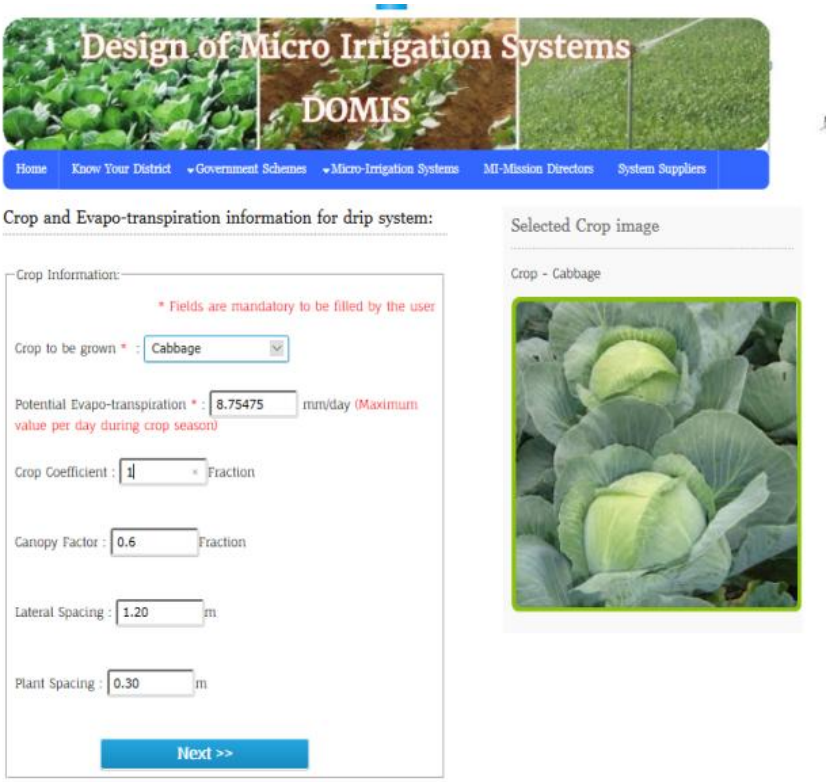

Fig. 2. Crop and its evaporation data sheet

Fig. 3. Design specifications and estimated costs of the different components of the designed drip irrigation system

Conclusion:

The developed decision support system for Design of Micro Irrigation Systems (DOMIS) will provide all the information related to design of system as well as cost estimation for drip, sprinkler, micro sprinkler. It will evaluate the economic feasibility with details cost calculation of the suggested layout in given agro-climate details. The tool will prove to be very useful in optimizing the designs of micro irrigation systems designs under different soil, crop and climatic conditions by multitudes of the personnel involved across the country. The web based system was hosted on the internet with domain name http://domis.iari.res.in on December 15, 2017 and has already touched over 4000 hits which is indicative of its use and acceptance across the country. International Commission on Irrigation and Drainage has also hosted the DSS on their website for use of everybody.

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