

User Manual for Surface Water Yield Model (SWYMOD) Ver. 1.0

**K. S. Reddy, R. Nagarjuna Kumar, K.V. Rao,
V. Maruthi, B.M.K. Reddy and B. Venkateswarlu**



National Initiative on Climate Resilient Agriculture
Central Research Institute for Dryland Agriculture
Santoshnagar, Saidabad, Hyderabad – 500 059, A.P., India
Web: www.crida.in

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CONTENTS

Sl.No.	TITLE	Page
	FOREWORD	
	PREFACE	
1.	Introduction	09
2.	Installation of Software	12
3.	Instructions to use Surface Water Yield model (SWYMOD)	13
4.	Conclusions	28
5.	References	28

FOREWORD



Land and water are the two natural resources, which have to be judiciously managed to increase crop production and productivity. The primary source to all water resources is rainfall. The rainfall in any given region is not uniformly distributed over space and time. Erratic distribution causes high rainfall events leading to surplus run-off and prolonged dry spells for standing crops. Surface runoff from a watershed is a result of interaction between the rainfall and watershed structures. The best alternative to manage the inevitable runoff is by storing in dug out ponds, popularly known as farm ponds. There have been many attempts in the past to predict runoff by using simple two variable regression approaches or by using complicated modeling procedures. Simpler approaches suffer from inaccuracy, while sophisticated and elaborate modeling approaches are advantageous but they require large amount of input information taking more time of computation and need good expertise. These models have been developed for climatic conditions outside the country. Thus, these models when applied to the Indian conditions with erratic distribution of rainfall and different land use patterns produce erroneous results. Considering these difficulties, there is necessity to develop a simpler model to be understood and used by a field staff with minimum input data requirement like daily rainfall and land use information which are generally available in the micro watersheds of the country. For that an iterative process/logic is developed by integrating the water balance of farm pond and the SCS (Soil Conservation Service) curve number method, for finding the appropriate curve number for different land uses in the catchments, by using the criteria of model efficiency of > 90 %. The Surface Water Yield Model (SWYMOD) is developed with Graphical User Interface (GUI).The software is very user friendly and is useful to soil and water conservation engineers, research scientists of SAU'S & ICAR, project personnel working in IWMP and MGNREGS, state agricultural departments etc.

I complement Dr. K.S.Reddy and his team for coming out with such a useful publication. The feedback from all stakeholders will be most welcome for improving the contents and bringing out a second edition.

B. Venkateswarlu

B.VENKATESWARLU
Director, CRIDA

FOREWORD

PREFACE

Simple model or procedure for estimating surface runoff / water yield from the catchments with readily available input data, is required for soil and water conservation engineers. Building Surface Water Yield Model (SWYMOD) integrating pond water balance and SCS curve number method, is an attempt to generate the curve numbers for existing land uses based on the observed and predicted pond water depths. The iterative process developed in the form of a model is very user friendly with minimum input data requirement. The dataset include daily rainfall, hydrologic soil group, land use distribution, observed pond depths, seepage, evaporation etc. We hope the model runoff will be useful to the practicing scientists, engineers of SWC and all other field functionaries of IWMP and MGNREGS.

The authors are grateful to Dr.A.K.Singh, DDG(NRM), ICAR, New Delhi for his guidance in the present work. We are indeed thankful to the field staff namely, Shri V.Sreeramulu, Farm Superintendent, B.Kurmaiah, T1, B.Rama Krishna, and Mr. Yariah, field staff of Gunegal Research farm for their help in recording the data for validation of model. The help and co-operation of CAO, SFAO and their staff are fully acknowledged for printing the bulletin. We invite comments and suggestions from all stakeholders in making improvements in feature edition of this bulletin.

- Authors

PREFACE



Introduction

Land and water are the two critical natural resources that influence the agricultural production and productivity in all production systems of the countores. The primary source to all water resources is rainfall which is stochastic in nature. The rainfall in any given region is not uniformly distributed over space and time. The high rainfall areas with annual rainfall > 1125 mm experience floods and erosion hazards in agricultural land which is of prime concern for agricultural production and environmental protection. It has been estimated that 50-60% of rainfall goes as run off carrying away 16 tha^{-1} of top soil annually. This results in reduction in water storage capacity of soils leading to soil moisture deficits affecting crop growth. It also causes siltation of reservoirs (Singh, 1990) reducing their storage capacity and active life.

In other areas receiving low to medium rainfall, erratic distribution causes high rainfall events leading to surplus run-off and prolonged dry spells for standing crops. All these factors call for control of surface run-off and water conservation. A combination of agronomic and engineering measures reduce the runoff and soil erosion, but complete control of runoff by absorption in to soil profile is not possible under tropical climate, in view of the tropical rainfall distribution. The next best alternative to manage the inevitable runoff by storing in dug out ponds, popularly known as farm ponds.

Since runoff is a natural stochastic event, development and use of hydrologic models have become important tools, as wide spread monitoring of rainfall-runoff phenomenon across the length and breadth of the country is laborious, expensive and time consuming. A major objective of using such models is to scientifically estimate the water yield of the watersheds so that an appropriate strategy is evolved to harness this water. The flow of any stream is determined by two different factors. One is climate, mainly precipitation and the other is the physical characteristics of the drainage basin. The rate and amount of water yield depends on amount of rainfall, its intensity, the physical properties of the soils and shape, size and drainage pattern of the watershed.





User Manual for SWYMOD

At present, there are several sophisticated and complicated models starting from continuous watershed models to event based watershed models and empirical relations. The most common problems faced while applying hydrologic models to Indian watersheds is their large input data requirement for calibration and their location specific use. Beside huge data requirement, these models are taking more time of computation and need good expertise.

Annual runoff estimation is generally by developing regression equations to different watershed parameters. This annual runoff estimation does not help much in design of water storage structures because water is needed at some critical stages of crop. Annual runoff coefficients and rainfall-runoff relation do not give any idea of runoff availability during the relatively short period of cropping season. There is some scope of using monthly rainfall-runoff relationship for the designing purpose, but multivariate regression models are very location specific and cannot be used for other watersheds. Moreover, the models have been developed for climatic conditions outside the country. Thus, these models when applied to the Indian conditions with quite erratic distribution of rainfall and different land use patterns produce erroneous results.

Unfortunately, small watershed hydrology has mostly been neglected field in the country and proper small stream gauging data are extremely scanty. This indicates the necessity to develop a simpler model to be understood and used by a field staff with minimum input data requirement like daily rainfall data and land use information which are generally available in the micro watersheds of the country.

Daily water yield models are better suited for the design of storage structure and to study the availability of stored water for proper crop planning in the rainfed farming. Though, there are some water balance and regression models based on daily rainfall, they require detailed measured data for calibration of model parameters and have limited applicability over other watersheds. The most commonly used method is Soil Conservation Service curve number (SCS) method for estimation of runoff from small watersheds because of its simplicity. The SCS curve number method was first developed by SCS, USDA. The SCS curve





number method requires daily rainfall data which is available at most of the regions. Design estimates of CN based on soil, cover, and land use are given in Hand book of hydrology (Anonymous, 1972) for Indian conditions. Curve number is dimensionless and its value varies from 0 to 100. Several researchers have studied the runoff potential of watersheds by generating appropriate CN values for different land uses. However, the hydrology of micro catchments or mini catchments having area < 100 ha is different from the larger watersheds, particularly in rainfed conditions. Therefore use of CN values developed for larger watersheds in runoff estimation may result in over or under estimation as runoff characteristics of mini catchments are different. Accordingly, the design of the SWC structures will be affected.

Farm pond technology is well recognized in the country for storing ex-situ runoff from the mini farm catchments. An iterative process/logic is developed by integrating the water balance of farm pond and the SCS method, for finding the appropriate curve number for different land uses in the catchments. The criterion of model efficiency is taken to compare the observed and predicted pond water depths on daily basis. If model efficiency is > 90 %, the set of CN values entered in the model can be accepted.

Using the developed iterative process/logic, the Surface Water Yield Model (SWYMOD) is developed with MS Excel as a back end and a user friendly front end using .Net based on SCS curve number method. The model uses daily rainfall data, distribution of land use cover within micro watershed, information on hydrologic group of soil, curve number, the AMC(Antecedent Moisture Content) condition of micro watershed and observed reservoir water depths. Users can retrieve and view the information in the form of graphs and data tables. The model is useful for soil & water conservation engineers, and all field staff designing farm ponds in IWMP and MGNREGS schemes. The modeling approach allows a realistic assessment of the worth of stored water and enables its scientific allocation among competitive crop activities in the command of the farm ponds. This software is easy to operate even by beginners. **CD with SWYMOD software is available inside the back cover of the user manual.**





Installation of Software

System Requirements

In order to run Surface Water Yield Model, the following Hardware and Software are required:

1. Windows Operating System: MS Windows XP.
2. RAM: 512 MB or More
3. Hard Disk: 500 MB or more
4. MS Office: 2007 version.
5. Processor with 32 bit

Procedure for Installation

Zipped files containing the executable program for installing Surface Water Yield Model available in the CD

1. Copy the zipped files from CD to the PC.
2. Unzip the folder

Pre-Installation

There are a couple of pre-install checks that users are encouraged to address to ensure successful installation and execution of Surface Water Yield Model software. First in order to run the Model GUI, installation of a current version of .Net Framework is required (at least the .Net Framework version 3.5 or later). Second Microsoft Office Excel of 2007 is required. If the version number of Excel is older than 2007, GUI is not guaranteed to work. In this case, installing MS Office Excel 2007 and Access Database Engine software which is available in the given CD folder is recommended.

3. After Pre installation Checks, Run SETUP.EXE.



When running the installation file, a series of windows will pop up. By selecting 'Next >' in each of the windows, Surface Water Yield Model will be installed.





Instructions to use SWYMOD

Before going to execute SWYMOD, user has to prepare the input file for the Model in MS Excel as shown in Fig 1. The column headings in the input Excel file should not be interchanged.

For Module 1, the input MS Excel file should contain following data type fields. Columns: Day (Integer), Date (mm-dd-yyyy) , Rainfall (mm) and Runoff (mm).

For Module 2, the input MS Excel file should contain following data type fields. Columns: Day, Date, Water deposit (m), Water depth (mm), Water loss (mm/day) Seepage (mm), Rainfall (mm), Evaporation (mm).

A	B	C	D	E	F	G	H
Day	Date	Water Deposit(m)	Depth (mm)	water loss, mm/day	Seepage (mm)	Rainfall (mm)	Evaporation (mm)
1	7/29/2008	0	0	0	0	1.8	0
2	7/30/2008	0	0	0	0	0.6	0
3	7/31/2008	0	0	0	0	0	0
4	8/1/2008	0	0	0	0	0	0
5	8/2/2008	0	0	0	0	18.6	0
6	8/3/2008	0.10	100	0	0	29.3	7.8
7	8/4/2008	0.10	100	0	0	5.7	2.6
8	8/5/2008	0.20	200	0	0	1.5	3.8
9	8/6/2008	0.40	400	0	0	14.5	7.0
10	8/7/2008	0.50	500	0	0	9.5	4.0
11	8/8/2008	0.60	600	0	0	8.0	3.0
12	8/9/2008	1.20	1200	0	0	60.5	2.5
13	8/10/2008	2.66	2660	0	0	55.5	2.2
14	8/11/2008	2.64	2640	20	12.0	6.0	8.0
15	8/12/2008	2.58	2580	60	58	0.0	2.0
16	8/13/2008	2.56	2560	20	15	0.0	5.0
17	8/14/2008	2.54	2540	20	15	0.0	5.0
18	8/15/2008	2.50	2500	40	36	0.0	4.0
19	8/16/2008	2.46	2460	40	35.5	0.0	4.5
20	8/17/2008	2.40	2400	60	56.5	15.2	3.5
21	8/18/2008	2.38	2380	20	15	0.0	5.0
22	8/19/2008	2.34	2340	40	34.5	0.0	5.5
23	8/20/2008	2.32	2320	20	11	16.0	9.0
24	8/21/2008	2.28	2280	40	36.5	2.0	3.5
25	8/22/2008	2.24	2240	40	34.4	0.0	5.6
26	8/23/2008	2.20	2200	40	32.2	0.0	7.8

Fig. 1. The input file for model in MS Excel





User Manual for SWYMOD

To execute the Surface Water Yield model go to Start button in windows → Programs → Surface Water Yield model, then Home page of model is displayed as shown in Fig2. This page gives you the brief information on how to proceed based on your requirement.

Surface Water Yield Model

Objective: Fixing Curve Number for different landuses in a Watershed Using SCS Curve Number Method.

Module 1

This Module deals with generating the curve numbers for the different landuses in a watershed with the available dataset of observed rainfall, direct runoff and distribution of landuse.

Module 2

This Module deals with generating the curve numbers for the different Landuses in a watershed with the farm pond or any other water storage structure with the dataset of observed rainfall, water depth, observed seepage, and observed evaporation along with rated curves for Depth vs Waterspread Area and Depth vs Storage Volume

On Farm Surface Water Hydrology

Go to Module 1 Go to Module 2

Developed by
K.S. Reddy, R.Nagarjuna Kumar, K.V.Rao, V.Maruthi and B.Venkateswarlu
Central Research Institute for Dryland Agriculture (CRIDA)
Santhoshnagar, Saidabad (P.O), Hyderabad-500 059
Andhra Pradesh

Fig. 2. Home page of Surface Water Yield Model

If you wish to generate the curve numbers for the different land uses in a watershed with the available dataset of observed rainfall, direct runoff and distribution of landuse, then select Module 1.





Alternatively, if you wish to generate the curve numbers for the different landuses in a watershed with the farm pond or any other water storage structure with the dataset of observed rainfall, water depth, observed seepage, and observed evaporation along with rated curves for depth vs water spread area and depth vs storage volume then select Module 2.

After selecting Module1 or Module 2, user will get next screen shown in Fig 3. In this page user need to select the number of different land use cover types and then click on submit.

Number of Landuse Form

Surface Water Yield Model - Landuse cover

Please enter the number of different Landuse cover Types

submit

Fig. 3. Screen to select number of landuse cover types



User Manual for SWYMOD

After submitting, user will proceed to input module as shown in Fig 4. Here, user needs to enter the details of the watershed area like landuse cover type, hydrologic soil condition, hydrologic soil group, curve number and the area. For user reference USDA table is provided in the left side of the screen. This table acts as guidance for the user in selecting the CN values for different land configurations and land users. These values will vary for Indian conditions with mini catchments, considered for design of farm ponds. After entering the details user has to click on submit.

Watershed Details

USDA Table
Runoff curve numbers for hydrologic soil cover complex

Land use cover	Treatment or practice	Hydrologic condition	Hydrologic soil group			
			A	B	C	D
Fallow	Straight row	--	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
	Contoured and terraced	Good	62	71	78	81
Small Grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
	Contoured and terraced	Good	59	70	78	81
Closed seeded legumes or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
	Contoured and terraced	Good	51	67	76	80
Pasture orange		Poor	68	79	86	89
		Fair	49	69	79	84

Surface Water Yield Model

Input Module

Landuse Cover Type:

Hydrologic Soil Condition:

Hydrologic Soil Group:

Curve Number:

Area (Hectares):

NOTE : Please refer the USDA table on the left for reference

Fig. 4. Input module screen to enter landuse cover information and Curve Numbers





After submitting the details user will get new screen as shown in Fig 5. Here, user has to click on the button “Verify input Data” to check the entered data. User can modify the data here if required by pressing “back” button. After verifying the data user can click on the button “Calculate WCN (Weighted Curve Nmber) value” to generate the WCN value for AMC II. If user wants to save the input data to the excel file click on the button “Save the Input Data to the file” and give the name to the file. To proceed to next screen press Next.

	Landuse Cover type	Hydrologic Soil Condition	Hydrologic Soil Group	Curve Number	Area (Hectares)
▶	Agriculture (Fallo..	Good	A	67	7
	Forest (Woodland)	Good	B	58	7
	Roads(dirt, hard)	Fair	C	73	0.5
*					

Calculated WCN value = 62.862

Fig. 5. Input data table and output of WCN value

Here user gets screen as shown in the Fig 6 to specify the input file. User can select stored rainfall data Excel input file by clicking on “Browse” button. After selecting browse button, the output is shown in the Fig 7.





User Manual for SWYMOD

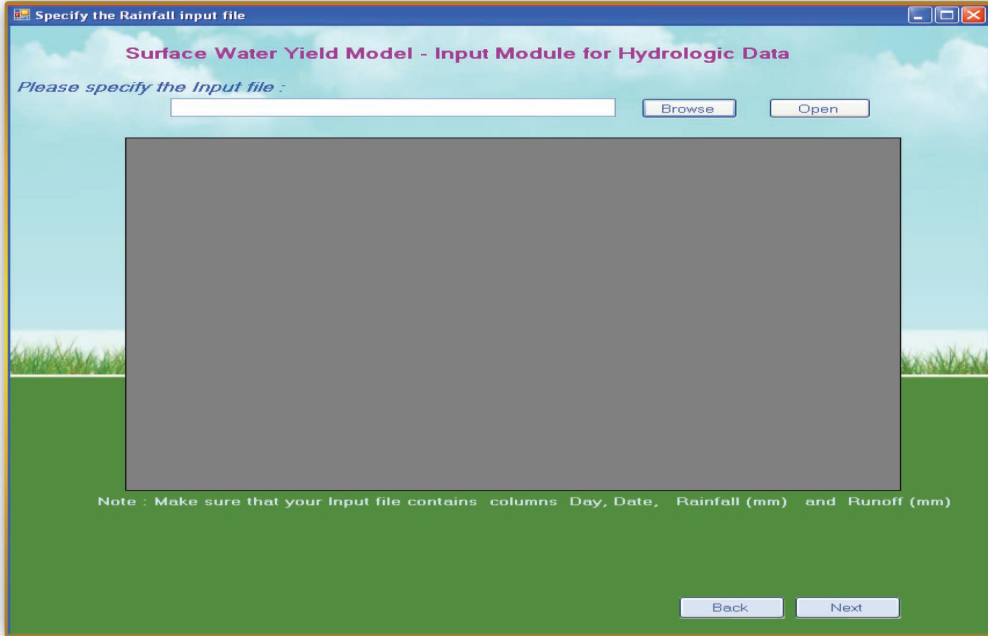


Fig. 6. Screen to browse the rainfall data Excel input file for the model

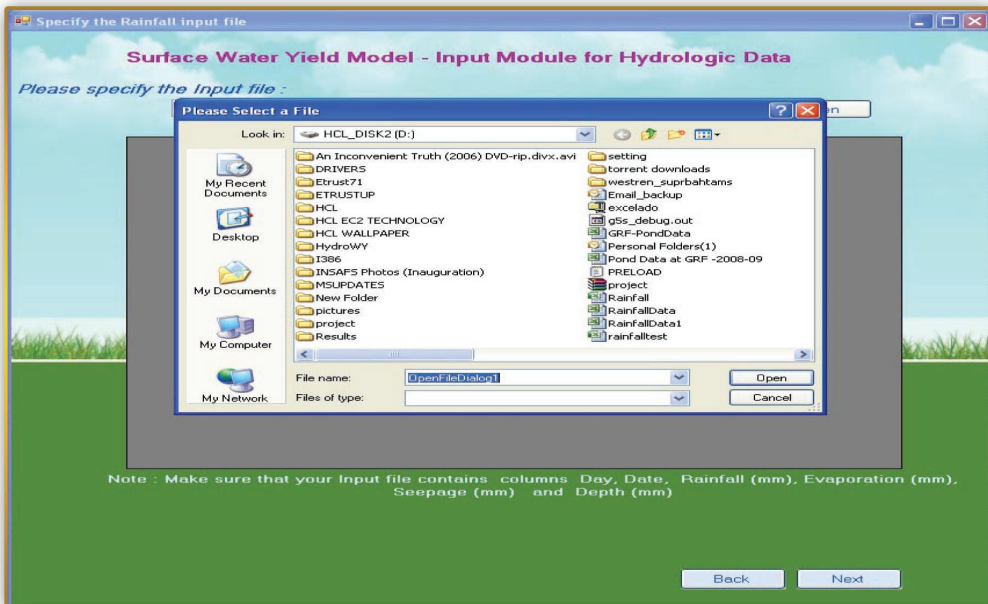


Fig. 7. Selecting the rainfall data Excel file for the model





After user selected the input file, click on “Open” button to open the input file. The selected input file is displayed as shown in the Fig 8. If user want to modify select “Back” button or to proceed further press “Next”.

Specify the Rainfall input file

Surface Water Yield Model - Input Module for Hydrologic Data

Please specify the Input file :

D:\sample input file.xls

Day	Date	Rainfall (mm)	Water Deposit(m)	Depth (mm)	Evaporation (mm)
1	7/29/2008	1.8	0	0	0
2	7/30/2008	0.6	0	0	0
3	7/31/2008	0	0	0	0
4	8/1/2008	0	0	0	0
5	8/2/2008	18.6	0	0	0
6	8/3/2008	29.3	0.1	100	7.8
7	8/4/2008	5.7	0.1	100	2.6
8	8/5/2008	1.5	0.2	200	3.8
9	8/6/2008	14.5	0.4	400	7
10	8/7/2008	9.5	0.5	500	4
11	8/8/2008	8	0.6	800	3
12	8/9/2008	60.5	1.2	1200	2.5
13	8/10/2008	55.5	2.66	2660	2.2
14	8/11/2008	6	2.64	2640	8
15	8/12/2008	0	2.58	2580	2
16	8/13/2008	0	2.56	2560	5
17	8/14/2008	0	2.54	2540	5

Note : Make sure that your Input file contains columns Day, Date, Rainfall (mm) and Runoff (mm)

Fig. 8. Selected input file for SWYMOD





User Manual for SWYMOD

Here user will get screen for Calibration for Initial Abstraction and AMC 5 days total rainfall shown in the Fig 9. After specifying the values for initial abstraction and AMC 5 days total rainfall click on “Next” to proceed. If any modifications required click on “Back” button. As recommended, initial abstraction of 0.2 is selected for black soils and 0.3 is selected for red soils. Provision is made for calibration for local conditions.

Calibration for Initial Abstraction and AMC 5 days total Rainfall

Initial abstraction coefficient 0.2

Rainfall limits for estimating antecedent moisture conditions

5 days total antecedent rainfall (mm) for the Growing season.

Standard AMC values for Growing season

AMC 1 = less than 35 mm

AMC 2 = 35 mm to 52.5 mm

AMC 3 = greater than 52.5 mm

AMC 1 less than 35 mm

AMC 2 35 mm to 52.5 mm

AMC 3 greater than 52.5 mm

Back Next

Fig. 9. Screen for selection and calibration of initial abstraction and AMC 5 days total rainfall





After Calibration for Initial Abstraction, user will get the model efficiency along with the graph shown in the Fig 10, if the user has selected the Module 1 in the home page of the model.

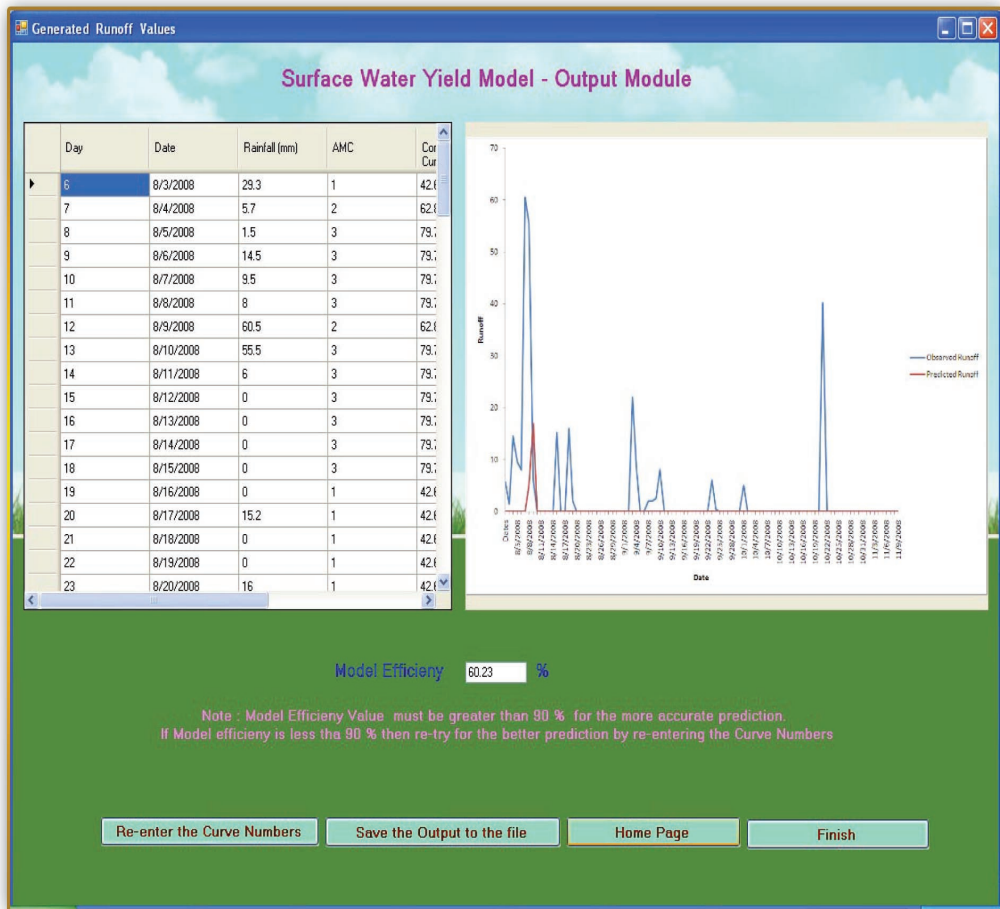


Fig. 10. Model efficiency of the module 1

Model efficiency value obtained must be greater than 90 % for more accurate prediction. If Model efficiency is less than 90 % then re-try for better prediction by re-entering the curve numbers.





User Manual for SWYMOD

If user wants to re-enter the curve numbers click on “Re-enter the curve numbers”. If user wishes to save the output to the file click on “Save the output to the File”. To go back to the home page click on “Home Page”. After completing the model execution user can exit by selecting “Finish” button.

If the user has selected the Module 2 in the home page of the model , user will get the screens as shown in Fig 3 to Fig 9. After Calibration for Initial Abstraction user will get screen shown in Fig 11. Here user has to select the type of the Cross section of the Pond, to proceed further select “Next”.

The screenshot shows a window titled "Generated Curve Numbers" with a sub-header "Calculated Curve Numbers". It contains a table with the following data:

Day	Date	Rainfall (mm)	AMC	Corresponding Curve Number
6	8/3/2008	29.3	1	74.627
7	8/4/2008	5.7	2	87
8	8/5/2008	1.5	3	93.963
9	8/6/2008	14.5	3	93.963
10	8/7/2008	9.5	3	93.963
11	8/8/2008	8	3	93.963
12	8/9/2008	60.5	2	87
13	8/10/2008	55.5	3	93.963
14	8/11/2008	6	3	93.963
15	8/12/2008	0	3	93.963
16	8/13/2008	0	3	93.963
17	8/14/2008	0	3	93.963
18	8/15/2008	0	3	93.963
19	8/16/2008	0	1	74.627
20	8/17/2008	15.2	1	74.627

Below the table, there is a section titled "Select the type of Cross Section of the POND :". It contains two radio buttons: "Trapezoidal" (selected) and "Rectangular / Square". At the bottom right, there are "Back" and "Next" buttons.

Fig. 11. Calculated Curve Numbers for module 2





If user selected the Trapezoidal Cross Section the next screen will be displayed as shown in the Fig 12. Now user has to specify the Side Slope, Bottom width, L/W (length/width) ratio and the maximum depth and then user has to click on “Next” to proceed.

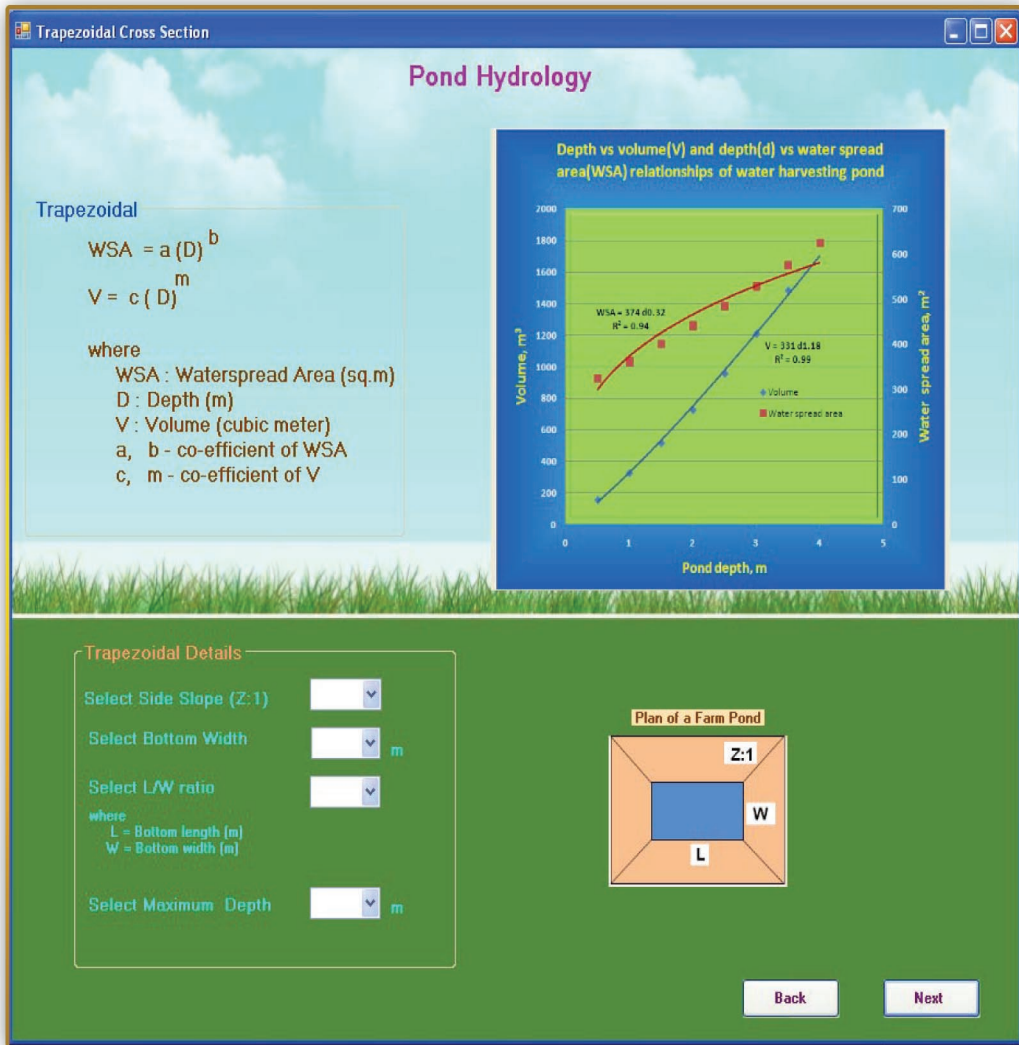


Fig. 12. Input screen for pond hydrology details for trapezoidal cross section of farm pond





User Manual for SWYMOD

After specifying the pond hydrology details in the previous screen the user will get next screen as shown in Fig 13.



Fig. 13. Screen to generate pond water balance

If the user Click on “Generation of pond water balance“ user will get the screen with pond water balance components and the graph between observed and predicted pond water depths. Model efficiency is also calculated and displayed in the screen as shown in Fig 14.



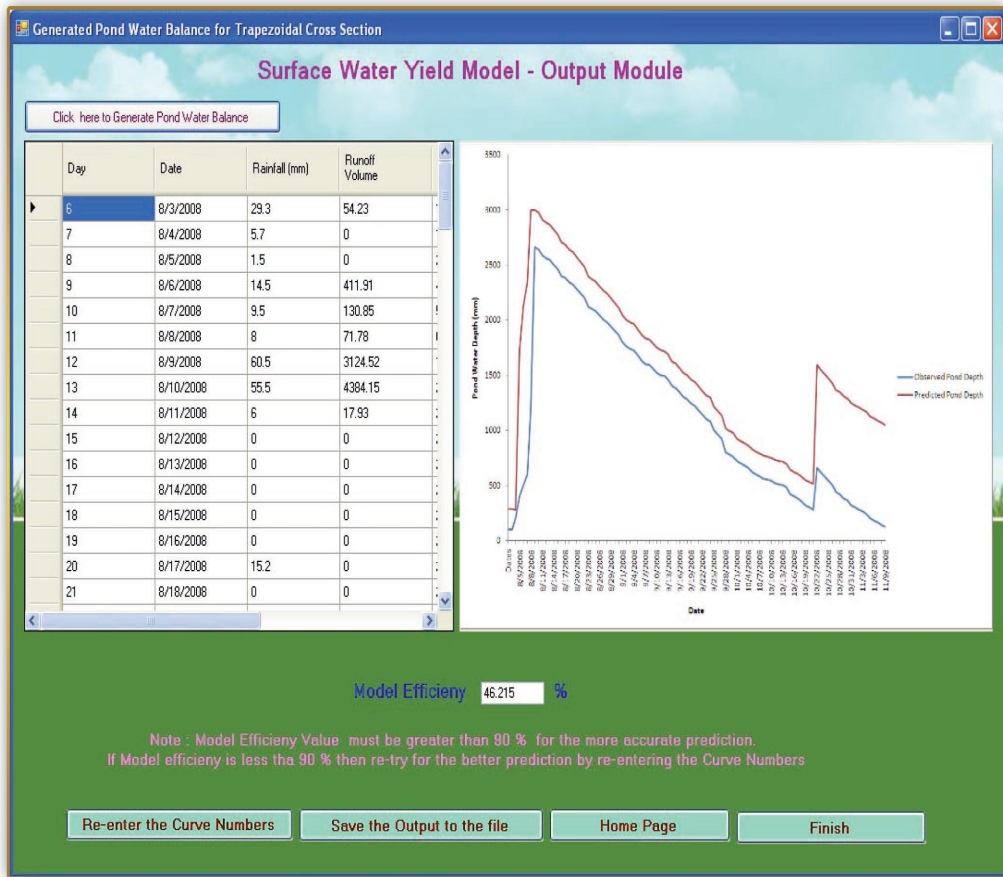


Fig. 14. Model efficiency of the module 2 for trapezoidal cross section of farm pond

Model efficiency value obtained must be greater than 90 % for the more accurate prediction. If Model efficiency is less than 90 % then retry for the better prediction by re-entering the Curve Numbers .To re-enter the curve numbers, user has to select “Re-enter the Curve numbers “. If user wants to save the output to the file click on “Save the output to the File”. If user wants to run the model from the beginning select the button “Home Page”. After completion of the execution of model user can exit from the model by selecting “Finish” button.





User Manual for SWYMOD

If the user selected the Rectangular/Square Cross Section of farm pond in Fig 11, user will get the next screen shown in the Fig 15. Now user has to specify the bottom length, width and depth of the cross section and Click on “Generate Pond Water Balance”.

Fig. 15. Input screen for pond dimensions in module2 for rectangular/ square cross section of farm pond

After generating pond water balance in the previous screen (Fig15), user can generate the graph by selecting “Display Graph” button. User will get Model efficiency along with graph for Module 2 of Rectangular/Square Cross Section of farm pond shown in Fig 16.



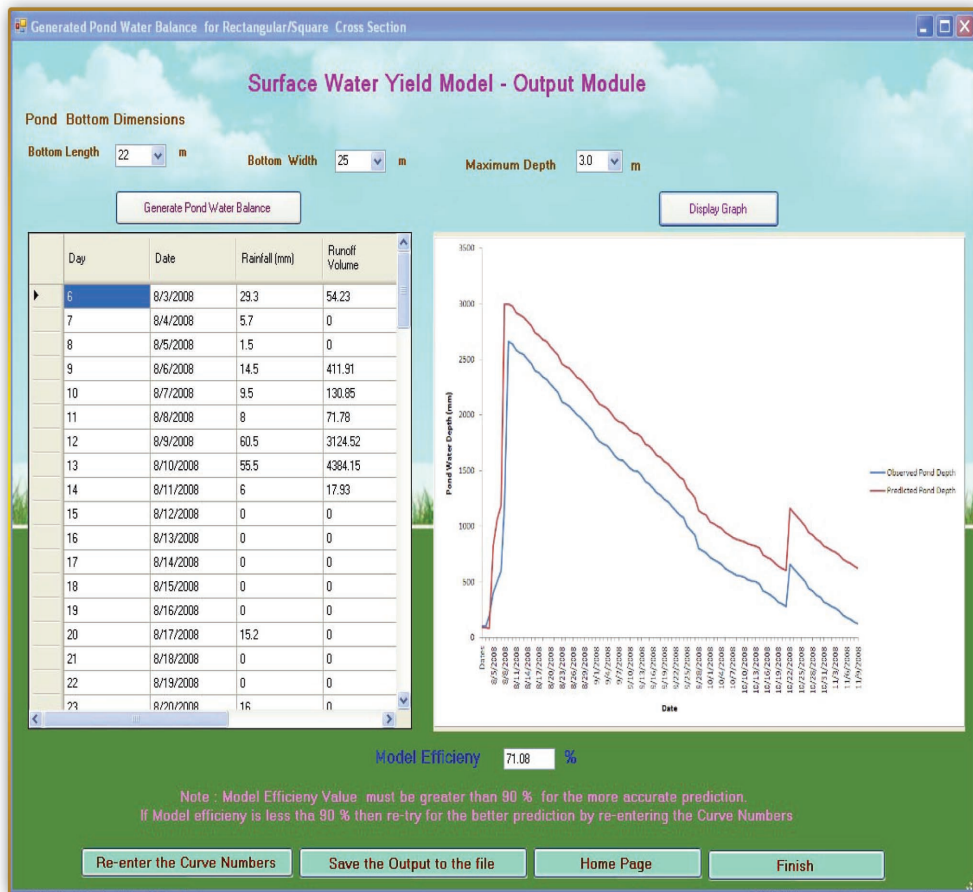


Fig. 16. Model efficiency of module2 for rectangular/square cross section of farm pond

Model efficiency value obtained must be greater than 90 % for the more accurate prediction. If Model efficiency is less than 90 % then, user can re-try for the better prediction by re-entering the Curve Numbers. To re-enter the Curve numbers, user can click on “Re-enter the Curve numbers”. If user wants to save the output to the file click on “Save the output to the File” If user wants to run the model from the beginning user has to select the button “Home Page”. After completion of the execution of model user can exit from the model by selecting “Finish” button.





Conclusions

1. A Surface Water Yield Model (SWYMOD) is developed by integrating SCS curve number method and farm pond water balance for generating the curve numbers for different land uses. The model uses the testing criterion of model efficiency of more than 90 % for accepting the curve numbers.
2. The model is user friendly and CN values of different catchments with varying land uses can be fixed for estimating the runoff.
3. The model is constructed in two modules namely 1. With direct runoff measurement at the outlet of selected catchments and 2. With farm pond structure at outlet of catchment.
4. The model is very useful in accessing the runoff potential for the design of farm ponds, particularly implemented by IWMP, SAU'S, MGNRES, state line department of agriculture and central rural development.

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User Manual for Surface Water Yield Model (SWYMOD)

Ver. 1.0



**K. S. Reddy, R. Nagarjuna Kumar, K.V. Rao,
V. Maruthi, B.M.K. Reddy and B. Venkateswarlu**



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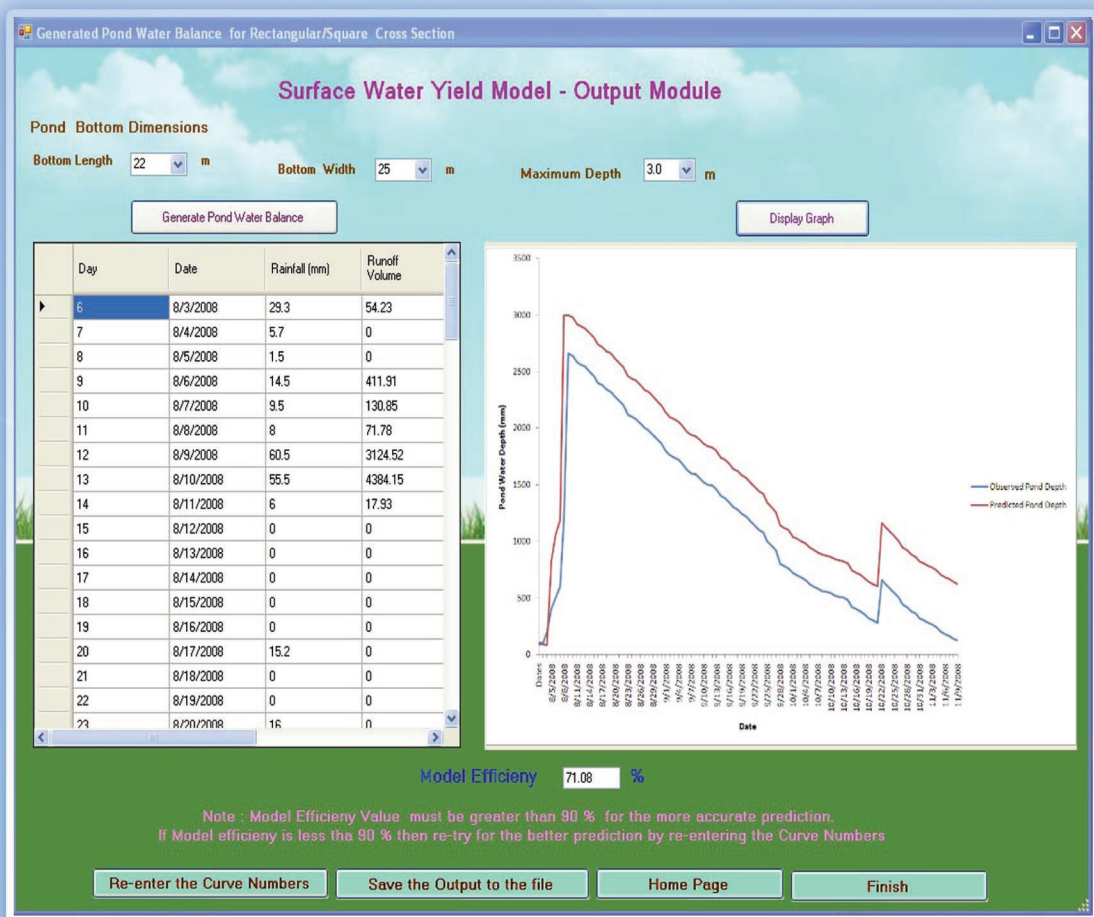
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**National Initiative on Climate Resilient Agriculture
Central Research Institute for Dryland Agriculture**

Santoshnagar, Saidabad, Hyderabad – 500 059, A.P., India

Web: www.crida.in



For further details or information, please contact :

The Director

Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad - 500 059, Andhra Pradesh, India.

Ph : 040-24530177 Fax : 040-24531802

website : <http://www.crida.in> E-mail : director@crida.in

