Int.J.Curr.Microbiol.App.Sci (2023) *12*(12): 48-55

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 12 Number 12 (2023)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2023.1212.007

Runoff Potential Based Farm Pond Designs for Latur Division of Maharashtra under Changing Climatic Condition

Akshay Kulkarni*, Madan Pendke*, Papita Gourkhede and Bhaskar Bhuibhar

Vasantrao Naik Marathwada Agricultural University, Parbhani, M.S., India

**Corresponding author*

Keywords

Curve number, Farm pond, Micro-catchment, Rainfall, Runoff

Article Info

Received:
19 October 2023
Accepted:
22 November 2023
Available Online:
10 December 2023

A B S T R A C T

Latur division of Marathwada region of Maharashtra State is traditionally a drought-prone region. The region receives annual rainfall in the range of 500 to 800 mm. Rainfall in uncertain and erratic in this region and sometimes suffers from severe droughts. The productivity of all crops decreases with either deficiency of rainfall or its distribution which creates moisture stress in critical growth period due to occurrence of dryspells during July and August. Runoff is one of the important hydrologic variables used in most of the water resource planning. Rainfall duration, intensity and aerial distribution influence the rate and volume of runoff. Catchment characteristics such as slope, shape and size, cover of soil and duration of rainfall have a direct effect on the peak flow and volume of runoff from any area (Chandler and Walker, 1998). Estimation of runoff for designing of any water harvesting structure is very important. Therefore, rainwater harvesting and its storage is an important issue in this region. The harvested water with suitable rainwater harvesting structure can be utilized for sustainable crop production. The rainfall data was collected from the Agro-meteorological station. Runoff was estimated using SCS curve number method considering the all parameters like soil type, vegetation etc. The rainfall runoff relationship was worked out for further planning of small water harvesting structures like farm ponds. Rainfall and runoff are significant constitute the sources of water for recharge of ground water in the watershed. Estimation of runoff in a watershed is very important to manage the water resources efficiently. The runoff potential for Latur division was found to be 20.07 %, indicating a good scope for rainwater harvesting and thereby, many more rainwater harvesting structures can be constructed based on site specific conditions. A relation between rainfall and runoff for Latur was worked out as Y = 0.486X - 186.3 (R^2 value - 0.731).The derived linear rainfall-runoff relation may be used to determine the runoff associated with any rainfall that takes place in the region. The link between rainfall and runoff will be helpful in determining the possibility for collecting rainwater and reusing it to increase the yield of different types of crops that get rain. For the catchment area of 1 ha, 2 ha, and 3 ha, respectively, farm pond sizes with storage capacities of 417 m^3, 651 m^3, and 939 m^3 are specified for Latur station. Farm ponds of the square size, measuring 16 x 16 m, 19 x 19 m, and 22 x 22 m (top measurements), with a side slope of 1.5:1 and a depth of 3 m, in trapezoidal are recommended.

Introduction

The standardization of farm pond sizes in India takes into account the unique climatic conditions, agricultural practices, and socio-economic factors prevalent in different districts. This process involves the development of guidelines and recommendations based on scientific research, practical experiences, and lessons learned from successful implementations. The soil characteristics of different districts also play a significant role in determining the standardized farm pond sizes. Cropping patterns and water requirements specific to the agricultural practices in India are key considerations in the standardization process. The socio-economic factors of the districts, including the economic feasibility and affordability for farmers, are crucial in determining the standardized farm pond sizes.

The standardization of farm pond sizes for districts under changing climate in India is a critical approach to address the water management challenges in agriculture. By considering rainfall patterns, soil characteristics, cropping patterns, and socio-economic factors, this standardization process aims to optimize water resource utilization, enhance resilience to climate change, and promote sustainable agricultural practices. The guidelines and recommendations developed through scientific research and practical experiences support farmers in implementing appropriate farm pond sizes, ensuring the long-term sustainability of agricultural systems in the face of a changing climate. Catchment characteristics such as slope, shape and size, cover of soil and duration of rainfall have a direct effect on the peak flow and volume of runoff from any area (Chandler and Walker, 1998). Uneven distribution of rainfall and thus runoff during last decade due to climatic variations was observed.

Around 20 per cent area of the Latur division of Marathwada region comes under moderate to high rainfall zone. Two to 3 prolonged dry spells during crop growth period which resulted in variations in crop production and productivity and overall socioeconomic condition of farmers. The average productivity of all *kharif* crops varies depending of monsoon behavior. Therefore, rainwater harvesting and its storage is an important issue in this region. The harvested water with suitable rainwater harvesting structure can be utilized for sustainable crop production. Accurate size of farm pond based on runoff potential needs to be designed for efficient storage and its effective utilization for sustainable crop production.

Materials and Methods

For estimation of runoff potential, the daily rainfall data for moderate to high rainfall zone i.e. for Nanded station for the period of 2011-2021 have been collected from Meteorological Observatory, All India Coordinated Research Project on Agro-Meteorology, VNMKV, Parbhani. The daily runoff for the each runoff producing rainfall event was estimated using SCS curve number method. The rainfall and runoff data was analyzed and grouped in as fortnightly manner.

The SCS curve number techniques is based on recharge capacity of the watershed. The recharge capacity was determined by antecedent moisture condition and by physical characteristics of the watershed. Antecedent moisture condition (AMC) was used as an index of watershed wetness. (Ponce and Hawkins, 1996). Hydrological Soil Group (HSG) plays an important role in runoff production from a particular land surface of watershed. For the study area, the hydrological soil group was considered as “D’.

The selection of curve numbers is based on various hydrologic soil cover, land use, treatment or cultivation practices, hydrological condition of the area and hydrological soil group. The standard sets of equations for estimation of runoff potential from black soil region were used using SCS curve number technique. Considering the available maps of land use/ land cover and hydrological soil group, the area of each class of land was worked out. Assigning the suitable curve numbers for respective land use and HSG to each area, the weighted curve number was

determined and used in estimation of runoff potential. Amutha and Porchelvan (2009); Bansode and Patil (2014); Bhura *et al.*, (2015) and Mishra *et al.*, (2005) used SCS curve number method for runoff estimation. Similar technique was used in this study for estimation of runoff potential.

Based on the runoff potential from the standard catchment area, the fortnightly runoff volume was estimated and considering the pan evaporation and seepage rate from the soil strata, the cumulative runoff potential to be harvested in the farm pond was estimated. Accordingly, the sizes of farm pond as per catchment area were worked out.

Results and Discussion

Estimation of Cure Numbers

CN values were estimated based on hydrologic soil group, average slope of land and land use pattern of the area for moderate to high rainfall zone of Marathwada region. The weighted values of curve numbers for three AMC condition were calculated as per USDA SCS-CN method. The hydrologic soil group for the region was observed as 'D' with slope range of 0.5 to 3.0 %. The weighted curve numbers were calculated as 76, 88 and 91 for AMC-I, AMC-II and AMC-III respectively.

Estimation of runoff volume

The daily surface runoff was estimated and thereby, the yearly runoff data for Latur division of Marathwada region is presented in table 1. The average runoff was calculated and also noticed the maximum runoff year.

Rainfall-runoff depth relation

The rainfall-runoff relationship is graphically represented in Fig.1.

The relation obtained can be used for finding out runoff corresponding to any rainfall occurring in the area. For the study area, the relation was found to be linear. The relation obtained was Y = 0.486X – 186.3 and the R^2 value was 0.731.

Vinithra and Yeshodha (2013) used rainfall-runoff modelling using SCS-CN method as a case study of Krishnagiri district, Tami Nadu.

Satheeshkumar *et al.*, (2017) conducted study on rainfall–runoff estimation using SCS–CN and GIS approach in the Pappiredipatti watershed of the Vaniyar sub basin, South India.

Designs of farm pond for various average catchments of Latur station

Farm ponds are designed based on rainfall runoff relationship and expected evaporation and seepage losses during the monsoon season and also according to catchment area of 1 ha, 2 ha and 3 ha based on the average size of land holding of the farmers of the region. Farm ponds are designed related to size of pond and the storage capacity based on expected runoff from the corresponding catchment area.

Based on runoff potential, the farm pond of capacity 417 cum., 651 cum. and 939 cum. were designed for 1 ha, 2 ha and 3 ha catchment area respectively.

The details of farm pond sizes, storage capacity, area under protective / supplemental irrigation and area under pond construction is presented in table 2.

In Conclusion, rainfall-runoff relationship proved to be the most valuable information for designing of farm pond as rainwater harvesting structure. Following conclusions were drawn from the study.

1. The runoff potential for Latur division of Marathwada region is found to be 21.18 %. A linear relationship of rainfall and runoff was observed representing a good scope for rainwater harvesting.
2. Farm pond sizes of storage capacity of 417 cum., 651 cum. and 939 cum. are standardized for catchment area of 1 ha, 2 ha and 3 ha respectively for Latur division of Marathwada region.

Table.1 Year-wise rainfall, runoff and % runoff for Latur station

Year	Annual Rainfall, mm	Total Rainfall which contributes runoff, mm	Runoff, mm	% Runoff	Runoff coefficient
2012	760.5	760.5	174	22.87	0.2287
2013	821.4	702.6	79	11.24	0.1124
2014	496	431.8	87	20.14	0.2014
2015	490.7	401.9	36	8.95	0.0895
2016	1142.3	1100.1	444	40.35	0.4035
2017	780.2	766.9	192	25.03	0.2503
2018	604.6	543.2	149	27.43	0.2743
2019	764.1	715.9	81	11.31	0.1131
2020	950.4	900.3	168	18.66	0.1866
2021	1137.2	998.5	273	27.34	0.2734
2022	889.4	886.9	175	19.73	0.1973
Average	803.34	746.23	168.9	21.18	0.2118
Maximum	1142.3	1100.1	444	40.35	0.4035

Table.2 Farm Pond sizes for Latur station

Catchment Area, ha	Top Size of pond mxm	Bottom Size of pond mxm	Side slope	Depth of farm pond, m	Capacity of farm pond Cum	Area under 2 irrigation of 5 cm depth (ha)	Area irrigated % of catchment area	%Catchment Area under pond construction
1.0	16 x 16	7 x 7	1.5: 1	3	417	0.75	75	2.56
2.0	19 x 19	10 x 10	1.5: 1	3	651	1.2	60	1.80
3.0	22 x 22	13 x 13	1.5: 1	3	939	1.8	60	1.61

Fig.1 Rainfall-runoff relationship for Latur division of Marathwada region

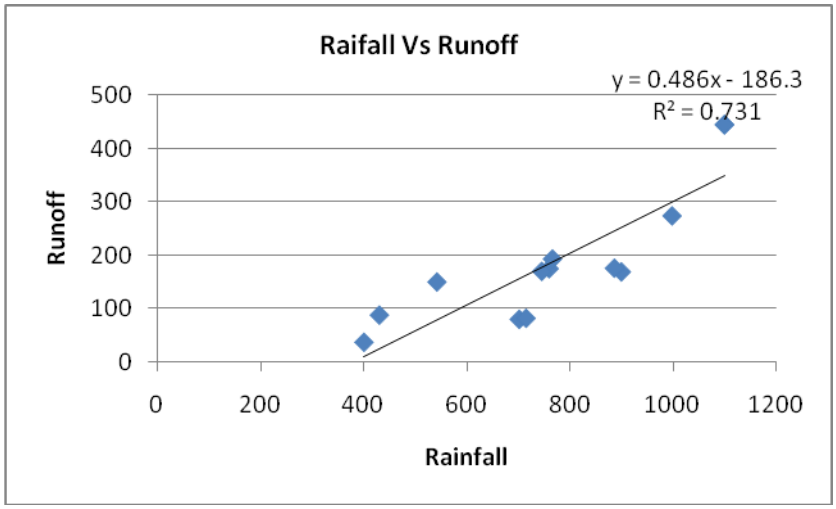

Table.3 Farm Pond design for 1 ha catchment area for Latur station

Month	Duration	Rainfall (mm)	Runoff (mm)	Runoff volume (m^3)for 1 ha area)	Dependable runoff volume (80%) (m^3)	Rainfall In pond (m^3)	Total (m^3)	Expected Evaporation from Pond (m^3)	Expected Seepage Losses from pond (m^3)	Expected Run. Volume (m^3)	Expected Cumulative Runoff volume (m^3)	Remark
June	1-15	75.11	11.27	112.7	90.16	30.04	120.20	31.46	21.78	66.96	66.96	
	16-30	69.48	7.81	78.1	62.48	27.79	90.27	46.85	31.70	11.72	78.68	1st filling of farm pond
July	1-15	73.15	16.27	162.7	130.16	29.26	159.42	36.48	28.20	94.74	173.42	
	16-31	88.54	17.18	171.8	137.44	35.41	172.85	34.87	31.00	106.98	280.4	
Aug.	1-15	46.11	3.45	34.5	27.6	18.44	46.04	32.13	26.70	-12.79	267.61	
	16-31	99.7	25.09	250.9	200.72	39.88	240.6	33.83	32.40	174.37	441.98	2nd filling of farm pond
Sept.	1-15	100.9	31.27	312.7	250.16	40.36	290.52	32.09	29.60	228.83	670.81	
	16-31	88.38	28.27	282.7	226.16	35.35	261.51	30.86	37.50	193.15	863.96	
Oct.	1-15	77.45	21.72	217.2	173.76	30.98	204.74	36.28	46.70	121.76	985.72	3rd filling of farm pond
	16-31	27.91	6.18	61.8	49.44	11.16	60.6	41.11	52.0	-32.51	953.21	

Size of farm pond
Top – 16m x 16m
Bottom – 7mx7m
Depth – 3 m
Side slope – 1.5:1
Volume of storage: 417 Cum.

Area irrigated = 0.75 ha
No. of irrigation = 2
Depth of irrigation = 5cm

Table.4 Farm Pond design for 2 ha catchment area for Latur station

Month	Duration	Rainfall (mm)	Runoff (mm)	Runoff volume (m^3)for 2ha area)	Dependable runoff volume (80%) (m^3)	Rainfall In pond (m^3)	Total (m^3)	Expected Evaporation from Pond (m^3)	Expected Seepage Losses from pond (m^3)	Run. Volume At the end of runoff (m^3)	Cumulative Runoff volume (m^3)	Remark
June	1-15	75.11	11.27	225.4	180.32	46.94	227.26	47.56	26.52	153.18	153.18	1st filling of farm pond
	16-30	69.48	7.81	156.2	124.96	43.42	168.38	70.56	35.50	62.32	215.5	
July	1-15	73.15	16.27	325.4	260.32	45.71	306.03	54.95	32.80	218.28	433.78	
	16-31	88.54	17.18	343.4	274.72	55.33	330.05	56.17	36.00	237.88	671.66	
Aug.	1-15	46.11	3.45	69	55.2	28.81	84.01	48.40	31.75	3.86	675.52	
	16-31	99.7	25.09	501.8	401.44	62.31	463.75	50.95	36.80	376	1051.52	2nd filling of farm pond
Sept.	1-15	100.9	31.27	625.4	500.32	63.06	563.38	48.33	32.80	482.25	1533.77	
	16-31	88.38	28.27	565.4	452.32	55.23	507.55	46.49	39.80	421.26	1955.03	
Oct.	1-15	77.45	21.72	434.4	347.52	48.40	395.92	54.64	49.50	291.78	2246.81	3rd filling of farm pond
	16-31	27.91	6.18	123.6	98.88	17.44	116.32	61.92	56.60	-2.2	2244.61	

Size of farm pond
Top – 19m x 19m
Bottom – 10mx10m
Depth – 3 m
Side slope – 1.5:1
Volume of storage: 651 Cum.

Area irrigated = 1.2 ha
No. of irrigation = 2
Depth of irrigation = 5cm

Table.5 Farm Pond design for 3 ha catchment area for Latur station

Month	Duration	Rainfall (mm)	Runoff (mm)	Runoff volume (m^3)for 3ha area)	Dependable runoff volume (80%) (m^3)	Rainfall In pond (m^3)	Total (m^3)	Expected Evaporation from Pond (m^3)	Expected Seepage Losses from pond (m^3)	Run. Volume At the end of runoff (m^3)	Cumulative Runoff volume (m^3)	Remark
June	1-15	75.11	11.27	338.1	270.48	67.59	338.07	71.05	45.23	221.79	221.79	
	16-30	69.48	7.81	234.3	187.44	62.53	249.97	105.4	46.50	98.07	319.86	1st filling of farm pond
July	1-15	73.15	16.27	488.1	390.48	65.83	456.31	82.08	49.50	324.73	644.59	
	16-31	88.54	17.18	515.4	412.32	79.68	492	78.47	46.00	367.53	1012.12	
Aug.	1-15	46.11	3.45	103.5	82.8	41.49	124.29	72.30	39.40	12.59	1024.71	2nd filling of farm pond
	16-31	99.7	25.09	752.7	602.16	89.73	691.89	76.12	43.20	572.57	1597.28	
Sept.	1-15	100.9	31.27	938.1	750.48	90.81	841.29	72.21	46.50	722.58	2319.86	
	16-31	88.38	28.27	848.1	678.48	79.54	758.02	69.45	49.65	638.92	2958.78	3rd filling of farm pond
Oct.	1-15	77.45	21.72	651.6	521.28	69.70	590.98	81.63	58.60	450.75	3409.53	
	16-31	27.91	6.18	185.4	148.32	25.11	173.43	97.95	69.55	5.93	3415.46	

Size of farm pond
Top – 22 m x 22 m
Bottom – 13 mx13 m
Depth – 3 m
Side slope – 1.5:1
Volume of storage: 939 Cum.

Area irrigated = 1.8 ha
No. of irrigation = 2
Depth of irrigation =5cm

References

Amutha R. and Porchelvan P. 2009. Estimation of surface runoff in Malattar sub-watershed using SCS-CN method. Journal of the Indian Society of Remote Sensing., 37(2):291- 304. https://doi.org/10.1007/s12524-009-0017-7

Bansode A. and Patil K. A., 2014 Estimation of runoff by using SCS curve number method and arc GIS. Int. J. Sci. Eng. Res., 5(7):1283–1287.

Bhura C. S., Singh N. P., Mori P. R., Prakash I. and Mehmood K. 2015. Estimation of surface runoff for Ahmedabad urban area using SCS-CN method and GIS. International Journal of Science Technology & Engineering.,1(11):411-416.

Chandler D. G., and Walker, 1998. Runoff responses among common land uses in the upland of Matalom, Leyte, Philippians. Transaction of ASAE.,41: 1635-1641.

Mishra S. K., Jain M. K., Bhunya P. K. and Singh V. P. 2005. Field applicability of the SCS-CN based Mishra–Singh general model and its variants. Water Resources Management.,19(1):37-62. https://doi.org/10.1007/s11269-005-1076-3

Ponce V. M. and Hawkins R. H. 1996. Runoff Curve Number: Has It Reached Maturity. Journal of Hydrol.Engg. 1(1):11–19. https://doi.org/10.1061/(ASCE)1084-0699(1996)1:1(11)

Satheeshkumar S., Venkateswaran S. and Kannan R. 2017. Rainfall–runoff estimation using SCS–CN and GIS approach in the Pappiredipatti watershed of the Vaniyar sub basin, South India. Modeling Earth Systems and Environment.,3(1):24. https://doi.org/10.1007/s40808-017-0301-4

Vinithra R. and Yeshodha L. 2013.. Rainfall-runoff modelling using SCS-CN method: A case study of Krishnagiri district, Tami Nadu. International Journal of Science and Research.,6:35-39. https://doi.org/10.21275/v5i3.nov162365

How to cite this article:

Akshay Kulkarni, Madan Pendke, Papita Gourkhede and Bhaskar Bhuibhar. 2023. Runoff Potential Based Farm Pond Designs for Latur Division of Maharashtra under Changing Climatic Condition. *Int.J.Curr.Microbiol.App.Sci.* 12(12): 48-55. **doi:** https://doi.org/10.20546/ijcmas.2023.1212.007