Int.J.Curr.Microbiol.App.Sci (2021) *10*(02): 281-297

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 10 Number 02 (2021)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2021.1002.034

Investigation on Variability of Potential Runoff on Planning of Conservation Measures under Semi-Arid Tracts of North-Eastern Karnataka

W. Kaisara* and U. Satishkumar

Department of Soil and Water Engineering, College of Agricultural Engineering, Raichur, University of Agricultural Sciences, Raichur, Karnataka, India

**Corresponding author*

A B S T R A C T

Keywords

Land resource inventorization, Potential runoff, Intensity-Infiltration method, Soil phase unit, Conservation measures and/or structures

Article Info

Accepted:
12 January 2021
Available Online:
10 February 2021

The detailed land resource inventorization of Chhatra II micro-watershed was carried out to a scale of 1:8000 using IRS imagery and cadastral map of the area as base map aided by ground truth delineation. The contiguous surface soil sampling was done from the grid, each of the size of 6 ha and profile sampling was done at identified sites considering the factors of slope, topography, physiography and land forms. The results depicted variability as well as distribution of the aforesaid physical factors within the micro watershed revealed that slope is (gently sloping), depth (shallow), texture (sandy loam) and gravelliness (gravelly), hence resulting in 23 soil phase units. The probable average runoff excess estimated based on Intensity-Infiltration method with aid of input data on rainfall events established that the average annual runoff was115.1 mm alongside average runoff producing rainfall of 388.5 mm. The Environmental flow has been accounted for from the available runoff excess with maximum (42.4 mm). Contour bunding system and graded bunding system were proposed for the arable land. Contour trenching system was proposed for non-arable land and diversion drains were proposed for Rock outcrop. Conservation structures like check dam, farm pond were proposed for drainage line treatment.

Introduction

Water being one of the most essential natural resources for life next to land is likely to become a critical scarce resource in many regions of the world and India in particular. India faces an increasingly urgent situation with its limited and insubstantial water resources already stressed out and dropping while various sectoral demands are growing hastily. Given the availability of water resources in India displaying a great deal of spatial and temporal variability, the rise in population and the growth of economic activities without doubt result in increased demands for water to be used for various purposes.

The arid and semi-arid regions are characterized by a climate with no or insufficient rainfall to sustain agricultural production (Ali *et al.*, 2017). During a rainfall event, water reaches to the surface of the earth out of which it goes through a run of processes. Most of the rainfall water through torrential downpours is lost as runoff, eroding significant quantities of precious top soil (Kalpana, 2006). Runoff from a watershed depends on rainfall, infiltration, and watershed characteristics and it can be measured daily, monthly, or annually as well on rainfall intensity and typically it varies seasonally (Adham *et al.*, 2014). It is essential to know the runoff volume for a watershed as runoff is the most important hydrological component for a design of any hydrologic structure and especially in the area of water scarcity (Ibrahim Kaleel *et al.*, 2018). In carrying out water availability studies, it is always appropriate to use the observed runoff data.

Materials and Methods

Chhatra II micro-watershed (4D3A7I1f) is part of Kalarhatti sub-watershed, Lingasuguru taluk of Raichur district, Karnataka State and it lies between 76˚23´ to 76˚26´ East longitudes and 15˚52´ to 15˚54´ North latitudes (North Eastern Karnataka)covering a total area of 648.43 hectares bounded by Hegapur, Hadagalli and Todki villages (Fig. 1). Chhatra II micro watershed forms part of the North-Eastern dry zone of agro-climatic region of Karnataka hence "fairly" displaying conditions of a Subtropical climate. Geology of the study area is solely contributed to by granite rocks.

The long term average annual rainfall for Chhatra II is 584.80 mm most of which is experienced during *Kharif* (June to October) about 81.4 per cent. December is the coldest month with the mean daily maximum and minimum temperatures of 29.3˚C and 17.7˚C respectively, while May is the hottest month with a mean daily maximum temperature of 39.8˚C.

Land resource inventory

The detailed land resource study of Chhatra II micro-watershed was carried out to a scale of 1:8000 using IRS imagery and cadastral map of the area as base map aided by ground truth delineation. The survey was carried out by the standard soil survey procedures as described in the soil survey manual (IARI, 1971). At first instance, the traversing of the study area was done to have a resource inventory of physiography, streamlines, geology, vegetation, and land use. Based on soil surface heterogeneity locations were fixed to study pedons. Pedons were studied in the field out of several mapping units for their morphological features. A soil sample from identified horizons of each pedon was collected for analysis of Physico-chemical properties. The contiguous surface soil sampling was done from the grid, each of the size of 6 ha and profile sampling was done at identified sites considering the factors of slope, topography, physiography and land forms. The horizons were identified and designated according to revisions in Soil Taxonomy. Horizon wise soil samples were collected from pedons. The derived soil phase units are referred from Sujala-III project (Satishkumar and Rajesh, 2018) as given in Table 1.

Estimation of Potential runoff

In the present study, for estimation of runoff generated, Intensity-Infiltration Method was employed. The method is a model derived based on primary data namely; soil phase units, rainfall events characterized in terms of average intensity, depth and duration (with minimum duration of 15 minutes), responses of the land in terms of infiltration and extent of "opportunity time" provided by the extent of slope and vegetation coverage. The infiltration rate and intensity of rainfall during an event is a characteristic and would be "instantaneous" and each soil phase unit may have infiltration rates of the soil characteristically different from other mapping units. Model is derived into integral components namely; rainfall-intensity process, infiltration process, runoff process, runoff process, runoff conservation/ intervention process and runoff excess. This processes are explained in detail in the following subdivisions.

Rainfall-Intensity process

Among all forms of precipitation, rainfall is the common one. Total runoff producing rainfall was estimated in view of rainfall characteristics such as magnitude of intensity, distribution according to time and space and its variability. Rainfall events are recorded by gauges at specific locations. Point precipitation data are used collectively to estimate aerial variability of rain. The volume of rainfall is expressed as depth in centimetres (or millimetres) which falls on a level surface. To compute Effective rainfall received in each class, several intensity classes were grouped according to various ranges, all having the difference of 10 mm h^{-1} i.e. (10-20 mm, 21-30 mm, 31-40 mm, 41-50 mm, 51-60 mm, 61-70 mm), as much of rainfall fall within this ranges, then taking mid-class interval intensity averages and multiplying with average duration for each event and number of events in the class. Finally Effective rainfall excess across each mapping unit was calculated. The rainfall process which includes intensity class, were estimated for the period (2010-2018).

Infiltration process

Infiltration is the process of water penetrating from the ground surface into the soil. The maximum rate at which water can enter the soil is called the infiltration capacity. When water is ponded on a homogeneous soil, characteristics zones of saturation, water transmission and soil wetting develop as the wetting front propagates downward. The factors affecting infiltration are rainfall, soil type, water contents in the soil, vegetation cover and ground slope. The values of the infiltration rates (9 mm h^{-1}) for clay textured soils and (18 mm h^{-1}) for sand textured soils were adopted based on studies conducted elsewhere, where the similar studies have been conducted pertaining to similar soil textures (Neelambika *et al.,* 2016; Shwetha *et al.,* 2015).

Infiltration rate was modified based on slope and vegetation and to end subtracted from average intensity to devise instantaneous runoff rate in each intensity class. The instantaneous runoff rate is the difference between average intensity in each class and effective infiltration rate. The infiltration rates of each mapping unit and subsequently modifications in the infiltration rate due to influence of opportunity time were considered. The process of estimating the effective infiltration rate after due consideration of land use and slope or of typical mapping units based on experimentation in field of similar soil phase units (Tables 2 and 3) is given in Table 4.

Runoff process

Runoff means the draining or flowing off of rainfall from a watershed area through a surface channel hence representing the output from the watershed in a given unit of time. In the present study, runoff which resulted from intensity classes as well as their corresponding infiltration rates were considered. Potential runoff means maximum runoff that get generated in an area from a given rainfall event. Potential runoff was estimated from several rainfall intensities reaching to the ground surface hence surface runoff being generated. Potential runoff was also affected by prolonged rainfall events which resulted in saturation of the soil thus no more water could be held in soil and as a result, excess runoff water released from the soil into the river channels. Potential runoff rate for each intensity class was computed as product of instantaneous runoff rate (mm h^{-1}), number of events in each class as well as average duration for each event and the same were calculated for the period (2010-2018).

Runoff Conservation/Intervention process

This portion describes methods where surface runoff is collected and stored in dams, tanks, or cisterns for later use. In the present study, existing conditions in the form of bunding as one of the runoff conservation measures was employed. Design runoff retained which was assumed the same across each intensity class was computed from the product of minimum length of bund, cross-section of the water spread area, which can store surface runoff. It is observed that a minimum length 50 m ha^{-1} of the bund is prevailing as the length required in retaining the runoff from a square plot (1.0 ha) of size 100 x 100 m. Further, the anticipated water spread area across bunding implemented would be 1.2 m^2 (½ x 10 m x 0.24 m). The permissible length of water spread perpendicular to length is taken as 10 m and effective depth of water impounding is 0.3 m. Finally the runoff retained across bunding system in each mapping unit was calculated and the same were estimated for the period (2010-2018). The formula for anticipated waterspread area would be:

$$A = \frac{1}{2} \times L \times D \quad (1)$$

Where, A = Anticipated water spread area (m^2)

L = minimum length of the lateral bund (m), considered 10 m based on physical observations and interpretations

D = depth of water impounding (m), considered 0.24 m based on physical observations and interpretations and for runoff retained would be:

$$Rr = B_L \times A \times I \quad (2)$$

Where, Rr = runoff retained (mm)
B_L= minimum bund length (m ha^{-1}), 50 m
A= Anticipated waterspread area (m^2)
I= Impact factor i.e. bunding due to longitudinal slope

Runoff excess generation

The runoff excess which indicate the runoff (mm) that goes beyond the conservation capacity implemented and joining the immediate nala/ stream and reaches to outlet. The depth of runoff excess was taken as difference between potential runoff depth and design runoff retained across the bunding system. The above concept allowed for estimation of probable runoff excess generation originating from infiltration and saturation excesses beyond the existing bunding system. The formula for runoff excess would be:

$$R_E = R_d - R_r \quad (3)$$

Where,

R_E = Runoff excess, mm
R_d = Potential runoff, mm
R_r = Runoff retained, mm

Estimation of Environmental flow

Environmental flow is the water allowed to flow towards the watercourse such as river, lakes so as to aid sustain ecosystem. The model has been taken advantage of and used to estimate environmental flow by apportioning the quantity of runoff excess during each year. From the perspective water policing, it is proposed by deducting 20 percent of runoff excess.

Preparation of Development plan for sustainable usage of land natural resource

The study carried out in respect of physiography, soil loss estimation, soil texture, soil depth, land slope, type of land use within the micro-watershed was used in modeling the plan of developmental actions. Soil and water conservation measures are broadly classified under two types, firstly the agronomical and vegetative measures. Biological/vegetative measures are effective only up to 2 per cent of land slope and where the problem of erosion is not severe. Secondly is the engineering/mechanical structures which can be constructed either in-situ such as contour bunding, contour trenches, contour terracing or ex-situ such as percolation tanks, nala bunding, etc.

Soil and water conservation plan may be established by providing engineering measures/structures along with the recommended agronomical/vegetative practices viz., contour cultivation, strip cropping, inter-cropping, crop rotations, contour vegetative bunds, etc.

Results and Discussion

Land resource inventorization

The land resource inventorization is an important process which takes into account soil characteristics, topographical upheavals and delineation of extensivity of similar characteristics of soil as a unit. The increase in slope (2.5-15.2 %) has been observed to have some ramifications in decreasing infiltration rate also at the same time the agricultural cropping situation during *Kharif* season has enhanced "opportunity time" for infiltration rate. The texture with sizeable clay proportion (10 units with 265 ha) and with less clay (13 units with 346 ha) will have a clear influence on two dominant groups with infiltration rate.

The gravelliness which generally largely occupies with (15-35%) indicating moderate susceptibility for erosion. Out of total area of 648.43 ha, (369 ha) has a depth limitation (less than 25-50 cm) indicating careful selection of crop and in developing better strategy of soil and water conservation through appropriate measures and/or structures.

Estimation of runoff

From Fig. 2. showing variation in average runoff excess (mm) during the period (2010-2018), it can be observed that mapping unit and/or land use wise, maximum capacity of flow is in Rockout crop (348.6 mm), followed by BHGhF3g2S2R1 with (285.9 mm) then (268.7 mm) for Habitation and least value of about (28.7 mm) is observed in both THDcB2 and CHRcB2g1S1 mapping units.

From Table 5, the calculated average runoff depth for 9 years was found to be 115.1 mm. From Table 6 and Fig. 3, it is revealed that the maximum runoff excess of the watershed was observed during 2013 which was about 26.9 percent of the total rainfall and minimum runoff excess of about 16.1 percent was found in 2018. Still on (Table 6) which has calculated the Environmental flow allowed at an outlet at 20% of runoff excess generated in micro-watershed, it can be observed that 2013 recorded the highest quantity of 42.4 mm which was about 5.4 percent of the total rainfall followed by 36.8 mm registered in 2017, which is about 5.3 percent of the total rainfall. Results further show that the maximum runoff excess of 169.6 mm recorded in 2013 is available for harvesting through conservation structures.

Table.1 Soil Phase units and their characteristics in Chhatra II micro watershed

Soil Phase	Soil Series*	Texture	Slope (%)	Erosion	Gravelliness (%)	Stoniness (%)	Rockiness (%)	Depth (cm)
BHGhF3g2S2R1	BHG	h (Sandy clay loam)	F(15.2)	3 (Severe)	g2 (Very gravelly);35-60	S2 (Very strong stony);0.1-3	R1 (Fairly rocky);2-10	(Very shallow); <25
CHRbC2g1S1	CHR	b (Loamy sand)	C(4.0)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony);0.01-0.1		(Shallow); 25-50
CHRcB2g1S1	CHR	c (Sandy loam)	B(3.0)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRcC2g1S1	CHR	c (Sandy loam)	C(3.5)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRcC3g1S1	CHR	c (Sandy loam)	C(2.5)	3 (Severe)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRhB2g1S1	CHR	h (Sandy clay loam)	B(3.3)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRhC2g1S1	CHR	h (Sandy clay loam)	C(2.6)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRhD3g1S1	CHR	h (Sandy clay loam)	D(5.0)	3 (Severe)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
CHRiC2g1S1	CHR	I (Sandy clay)	C(3.6)	2 (Moderate)	g1 (Gravelly); 15-35	S1 (Strong stony); 0.01-0.1		(Shallow); 25-50
HEGmC2	HEG	m (Clay)	C(3.4)	2 (Moderate)	(Non-gravelly); <15			(Moderately shallow); 50-75
KALbC2g1	KAL	b (Loamy sand)	C(3.6)	2 (Moderate)	g1 (Gravelly); 15-35			(Very shallow); <25
KALcC2g1	KAL	c (Sandy loam)	C(2.6)	2 (Moderate)	g1 (Gravelly); 15-35			(Very shallow); <25
KMTcD3g1	KMT	c (Sandy loam)	D(6.0)	3 (Severe)	g1 (Gravelly); 15-35			(Shallow); 25-50
THDcB2	THD	c (Sandy loam)	B(3.1)	2 (Moderate)	(Non-gravelly); <15			(Moderately shallow); 50-75
THDcC2	THD	c (Sandy loam)	C(3.8)	2 (Moderate)	(Non-gravelly); <15			(Moderately shallow); 50-75
THDhB2	THD	h (Sandy clay loam)	B(3.2)	2 (Moderate)	(Non-gravelly); <15			(Moderately shallow); 50-75
THDiC2	THD	I (Sandy clay)	C(4.1)	2 (Moderate)	(Non-gravelly); <15			(Moderately shallow); 50-75
VKRbC3g2S2	VKR	b (Loamy sand)	C(3.4)	2 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3		(Shallow); 25-50
VKRcC3g2S2R1	VKR	c (Sandy loam)	C(4.1)	3 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3	R1 (Fairly rocky);2-10	(Shallow); 25-50
VKRcD3g2S2	VKR	c (Sandy loam)	D(8.8)	3 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3		(Shallow); 25-50
VKRcD3g2S2R1	VKR	c (Sandy loam)	D(3.6)	3 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3	R1 (Fairly rocky);2-10	(Shallow); 25-50
VKRhC3g2S2R1	VKR	h (Sandy clay loam)	C(2.9)	3 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3	R1 (Fairly rocky);2-10	(Shallow); 25-50
VKRhD3g2S2R2	VKR	h (Sandy clay loam)	D(5.1)	3 (Severe)	g2 (Very gravelly); 35-60	S2 (Very strong stony); 0.1-3	R2 (Rocky)10-25	(Shallow); 25-50

* -BHG (Bhogapur), CHR (Chhatra), HEG (Hegapur), KAL (Kalmali), KMT (Kamarkhed tanda), THD (Thodki) and VKR (Vyakarnal), *Source*: Sujala-III Project

Table.2 Derived values of Infiltration rate for Clay (m) textured soils (≤ 9 mm h^{-1})

Modified Infiltration rate based on Slope and Vegetation							
Vegetation (%)	**Slope (%)**	**mA**	**mB**	**mC**	**mD**	**mE**	**mF**
		0-1	**1-3**	**3-5**	**5-10**	**10-15**	**15-25**
	MF*	0	0.85	0.75	0.5	0.45	0.4
0-20	0	9.0	7.65	6.75	4.5	4.05	3.6
21 - 40	1.20	10.8	9.18	8.1	5.4	4.86	4.32
41 - 60	1.50	13.5	11.47	10.12	6.75	6.07	4.32
61 - 80	1.75	15.7	13.38	11.81	7.87	7.08	4.32
81 - 95	1.90	17.1	14.53	12.82	8.55	7.69	4.32

* - Multiplication Factor, *Source*: (Neelambika *et al.*, 2016; Shwetha *et al.*, 2015)
NB: values of Clay considered for: f, g, h, i, k textures

Table3 Derived values of Infiltration rate for Sand (c) textured soils (≤ 18 mm h^{-1})

Modified Infiltration rate based on Slope and Vegetation							
Vegetation (%)	**Slope (%)**	**cA**	**cB**	**cC**	**cD**	**cE**	**cF**
		0-1	**1-3**	**3-5**	**5-10**	**10-15**	**15-25**
	MF*	0	0.85	0.75	0.5	0.45	0.4
0-20	0	18.0	15.30	13.5	9	8.1	7.2
21 - 40	1.20	21.6	18.36	16.2	10.8	9.72	7.2
41 - 60	1.50	27.0	22.95	20.25	13.5	12.15	7.2
61 - 80	1.75	31.5	26.77	23.62	15.75	14.17	7.2
81 - 95	1.90	34.2	29.07	25.65	17.1	15.39	7.2

* - Multiplication Factor, *Source*: (Neelambika *et al.*, 2016; Shwetha *et al.*, 2015)
NB: values of Sand considered for: b texture

Table.4 Estimation of Effective infiltration rate

Soil Phase	**Texture**	**Constant Infiltration rate (mm h^{-1})**	**Vegetation**		**Slope**		**Effective infiltration rate (mm h^{-1})**
(1)	(2)	(3)	(4)		(5)		(3)* (4)* (5)
BHGhF3g2S2R1	Sandy clay loam	9	(%)	MF	(%)	MF	4.32
			41-60	1.5	F (15-25 %)	0.4	
CHRbC2g1S1	Loamy sand	18	41-60	1.5	C (3-5 %)	0.75	20.25
CHRcB2g1S1	Sandy loam	18	41-60	1.5	B (1-3 %)	0.85	22.95

NB:It must be noted that at (F) slope, (MF) factor for vegetation is considered the same since it is assumed that with such slope, vegetation is likely to be fewers

Table.5 Yearly runoff excess (mm) for Chhatra II micro-watershed (2010-2018)

Year	Total Rainfall (mm)	Rainfall-Runoff Relationship						
		Intensity classes (mm/h)	**No. of events in each class**	**Effective rainfall (mm)**	**Potential runoff (mm)**	**Runoff retained (mm)**	**Runoff excess (mm)**	**Volumetric runoff excess (cum)**
2010	503.5	10-20	31	263.6	98.2	19.7	78.5	508433
		21-30	8					
		31-40	3					
		41-50	1					
		51-60	3					
2011	420.0	10-20	24	323.2	144.6	25.1	119.5	757574
		21-30	9					
		31-40	5					
		41-50	4					
		51-60	1					
		61-70	1					
2012	414.0	10-20	17	329.1	77.0	10.3	66.7	432002
		21-30	2					
		31-40	1					
2013	788.5	10-20	24	674.4	227.4	15.3	212.1	1373808
		21-30	5					
		31-40	4					
		41-50	1					
2014	560.0	10-20	17	480.4	172.7	14.8	157.9	1023330
		21-30	6					
		31-40	1					
		41-50	2					
2015	446.0	10-20	16	381.9	109.4	6.7	102.8	665918
		21-30	6					
2016	274.5	10-20	7	210.6	72.8	10.8	62.0	401460
		21-30	2					
		31-40	2					
2017	698.0	10-20	21	648.4	194.8	11.0	183.8	1190924
		21-30	8					
		41-50	1					
2018	323.5	10-20	8	185.2	58.9	6.7	52.2	338558
		31-40	2					
Total								**6692007**
Average				**388.5**	**128.4**	**13.4**	**115.1**	-

Table.6 Estimated Environmental flow during the period (2010-2018)

Runoff excess (mm)							
Year	**Total rainfall (mm)**	**Available**		**That can be harvested through conservation structures**		**Environmental flow allowed at an outlet (@20% runoff excess)**	
		mm	**%**	**mm**	**%**	**mm**	**%**
2010	503.0	78.5	15.6	62.8	12.5	15.7	3.1
2011	420.0	119.5	28.5	95.6	22.8	23.9	5.7
2012	414.0	66.7	16.1	53.4	12.9	13.3	3.2
2013	788.5	212.0	26.9	169.6	21.5	42.4	5.4
2014	560.0	157.9	28.2	126.3	22.6	31.6	5.6
2015	446.0	102.8	23.0	82.2	18.4	20.6	4.6
2016	274.5	62.0	22.6	49.6	18.1	12.4	4.5
2017	698.0	183.8	26.3	147.0	21.1	36.8	5.3
2018	323.5	52.2	16.1	41.8	12.9	10.4	3.2

Table.7 Yearly partitioning of processes occurring during rainfall event through period (2010-2018)

Year	**Total rainfall (mm)**	**Effective rainfall out of Total rainfall that contributes to runoff**		**Potential runoff out of Total Rainfall**		**Runoff retained and Runoff excess out of Potential runoff**			
						Runoff retained		**Runoff excess**	
		mm	**%**	**mm**	**%**	**mm**	**%**	**mm**	**%**
2010	503.0	263.6	52.4	98.2	19.5	19.7	20.1	78.5	79.9
2011	420.0	323.2	77.0	144.6	34.4	25.1	17.4	119.5	82.6
2012	414.0	329.1	79.5	77.0	18.6	10.3	13.4	66.7	86.6
2013	788.5	674.4	85.5	227.4	28.8	15.3	6.7	212.0	93.2
2014	560.0	480.4	85.8	172.7	30.8	14.8	8.6	157.9	91.4
2015	446.0	381.9	85.6	109.4	24.5	6.7	6.1	102.8	94.0
2016	274.5	210.6	76.7	72.8	26.5	10.8	14.8	62.0	85.2
2017	698.0	648.4	92.9	194.8	27.9	11.0	5.6	183.8	94.4
2018	323.5	185.2	57.2	58.9	18.2	6.7	11.4	52.2	88.6

Table.8 Proposed Contour Bunding System for Soil Phase Units having texture with clay (≤ 25 %)

Sl. No	Soil Phase Unit	Area	Slope (%)	Texture	Clay (%)	Silt (%)	Sand (%)	Proposed specifications of contour bunding			Runoff conserved at present (mm)	Expected with intervention (mm)	Average rainfall (2010-2018), (mm)
								Section (m^2)	Length (per ha)				
									Straight	Lateral			
1	CHRbC2g1S1	1	4.0	Loamy sand	5	15	80	0.79	150	50	4.6	13.8	492
2	CHRcB2g1S1	39	3.0	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
3	CHRcC2g1S1	36	3.5	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
4	CHRcC3g1S1	9	2.5	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
5	KALbC2g1	25	3.6	Loamy sand	5	15	80	0.79	150	50	4.6	13.8	492
6	KALcC2g1	5	2.6	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
7	KMTcD3g1	5	6.0	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
8	THDcB2	100	3.1	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
9	THDcC2	42	3.8	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
10	VKRbC3g2S2	8	3.4	Loamy sand	5	15	80	0.79	150	50	4.6	13.8	492
11	VKRcC3g2S2R1	23	4.1	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
12	VKRcD3g2S2R1	43	3.6	Sandy loam	10	30	60	0.79	150	50	4.6	13.8	492
13	**Total**	**336**	-	-	-	-	-	-	-	-	-	-	-

Table.9 Proposed Graded Bunding System for Soil Phase Units with clay (≥ 25 %)

Sl. No.	Soil Phase Unit	Area	Slope (%)	Texture	Clay (%)	Silt (%)	Sand (%)	Proposed specifications of contour bunding			Grade (%)	Runoff conserved at present (mm)	Expected with intervention (mm)	Average rainfall (2010-2018), (mm)
								Section (m^2)	Length (per ha)					
									Straight	Lateral				
1	CHRhB2g1S1	17	3.3	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
2	CHRhC2g1S1	81	2.6	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
3	CHRhD3g1S1	28	5.0	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
4	CHRiC2g1S1	10	3.6	Sandy clay	43	7	50	1.09	200	50	0.2	4.6	18.5	492
5	HEGmC2	13	3.4	Clay	67	18	15	1.09	200	50	0.2	4.6	18.5	492
6	THDhB2	18	3.2	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
7	THDiC2	22	4.1	Sandy clay	43	7	50	1.09	200	50	0.2	4.6	18.5	492
8	VKRhC3g2S2R1	19	2.9	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
9	VKRhD3g2S2R2	40	5.1	Sandy clay loam	25	15	60	1.09	200	50	0.2	4.6	18.5	492
10	**Total**	**248**	-	-	-	-	-	-	-	-	-	-	-	-

Table.10 Proposed Contour Trenching System for Non-Arable land use (Social Forest and Wasteland)

Sl. No.	Soil Phase Unit	Area	Slope (%)	Texture	Land use	Proposed specifications of contour trenching		Remarks
						Length (m)	Section (m^2)	
1	BHGhF3g2S2R1	17	15.2	Sandy clay loam	Forest	15	0.27	Staggered
2	CHRiC2g1S1	10	3.6	Sandy clay	Forest	15	0.27	Staggered
3	KALbC2g1	25	3.6	Loamy sand	Forest	15	0.27	Staggered
4	KALcC2g1	5	2.6	Sandy loam	Wasteland	15	0.27	Staggered
5	KMTcD3g1	5	6.0	Sandy loam	Wasteland	15	0.27	Staggered
6	VKRbC3g2S2	8	3.4	Loamy sand	Forest	15	0.27	Staggered
7	VKRcD3g2S2	10	8.8	Sandy loam	Forest	15	0.27	Staggered
8	VKRcD3g2S2R1	43	3.6	Sandy loam	Forest	15	0.27	Staggered
9	VKRhD3g2S2R2	40	5.1	Sandy clay loam	Forest	15	0.27	Staggered
10	**Total**	**163**	-	-	-	-	-	-

Table.11 Proposed farm pond size (m^3 ha^{-1}) as applicable to mapping units considering maximum annual rainfall (2013) under existing interventions/conditions

Soil phase unit	Area (ha)	Slope (%)	Effective rainfall (mm)	Potential runoff (mm)	Runoff retained (mm)	Runoff excess (mm) (5)-(6)	Environmental flow @20 % of runoff excess (mm) (7)*0.2	Net runoff excess (mm) (7)-(8)	Capacity of Farm Pond (m^3 ha^{-1}) (9)*10
(1)	(2)	(3)	(4)	(5)	6)	(7)	(8)	(9)	(10)
CHRbC2g1S1	1	4.0	674.4	103.7	13.8	89.9	18.0	71.9	719.2
CHRcB2g1S1	39	3.0	674.4	74.7	13.9	60.8	12.2	48.6	486.4
CHRcC2g1S1	36	3.5	674.4	103.7	13.8	89.9	18.0	71.9	719.2
CHRcC3g1S1	9	2.5	674.4	103.7	13.8	89.9	18.0	71.9	719.2
CHRhB2g1S1	17	3.3	674.4	281.0	18.4	262.6	52.5	210.1	2100.8
CHRhC2g1S1	81	2.6	674.4	327.3	18.4	308.9	61.8	247.1	2471.2
CHRhD3g1S1	28	5.0	674.4	443.0	18.5	424.5	84.9	339.6	3396
CHRiC2g1S1	10	3.6	674.4	327.3	18.4	308.9	61.8	247.1	2471.2
HEGmC2	13	3.4	674.4	327.3	18.4	308.9	61.8	247.1	2471.2
KALbC2g1	25	3.6	674.4	103.7	13.8	89.9	18.0	71.9	719.2
KALcC2g1	5	2.6	674.4	103.7	13.8	89.9	18.0	71.9	719.2
KMTcD3g1	5	6.0	674.4	211.6	18.4	193.2	38.6	154.6	1545.6
THDcB2	100	3.1	674.4	74.7	13.9	60.8	12.2	48.6	486.4
THDcC2	42	3.8	674.4	103.7	13.8	89.9	18.0	71.9	719.2
THDhB2	18	3.2	674.4	281.0	18.4	262.6	52.5	210.1	2100.8
THDiC2	22	4.1	674.4	327.3	18.4	308.9	61.8	247.1	2471.2
VKRbC3g2S2	8	3.4	674.4	107.3	13.8	93.5	18.7	74.8	748
VKRcC3g2S2R1	23	4.1	674.4	103.7	13.8	89.9	18.0	71.9	719.2
VKRcD3g2S2R1	43	3.6	674.4	211.6	18.4	193.2	38.6	154.6	1545.6
VKRhC3g2S2R1	19	2.9	674.4	327.3	18.4	308.9	61.8	247.1	2471.2
VKRhD3g2S2R2	40	5.1	674.4	443.0	18.5	424.5	84.9	339.6	3396
Total	**584**	-	-	-	-	-	-	-	-

Fig.1 Location map of Chhatra II micro watershed

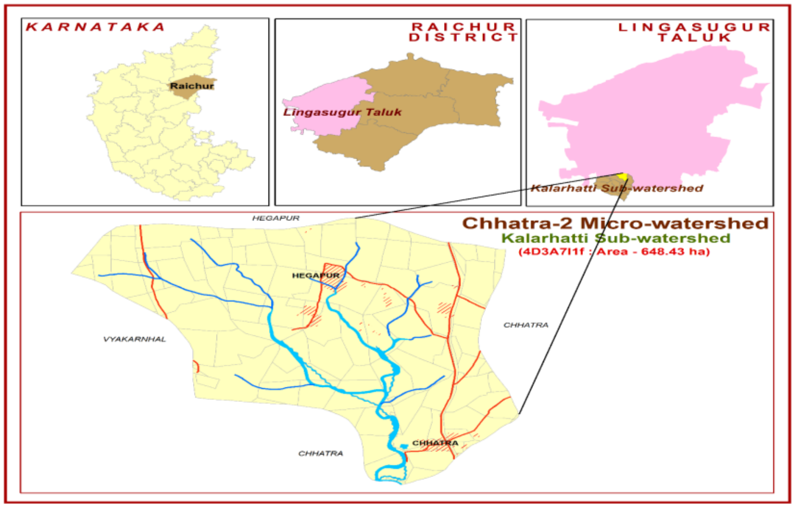


Fig.2 Averaged variability of runoff excess across different soil phase units and/or land use

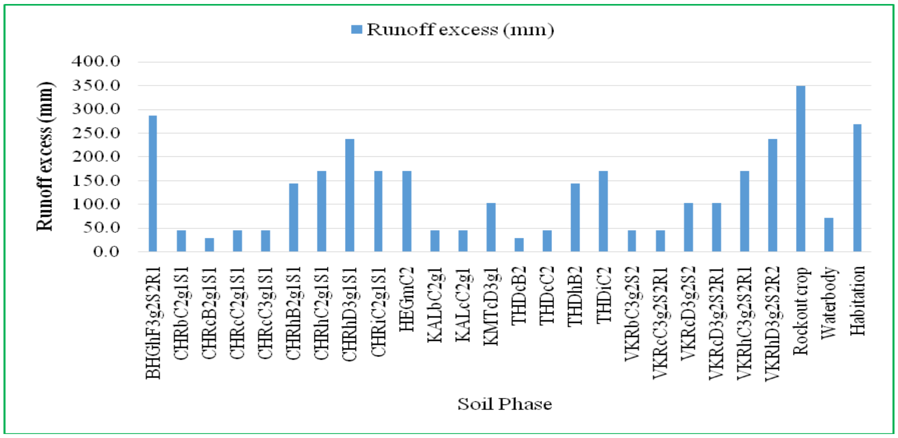


Fig.3 Yearly runoff excess (mm) from Chhatra II micro-watershed

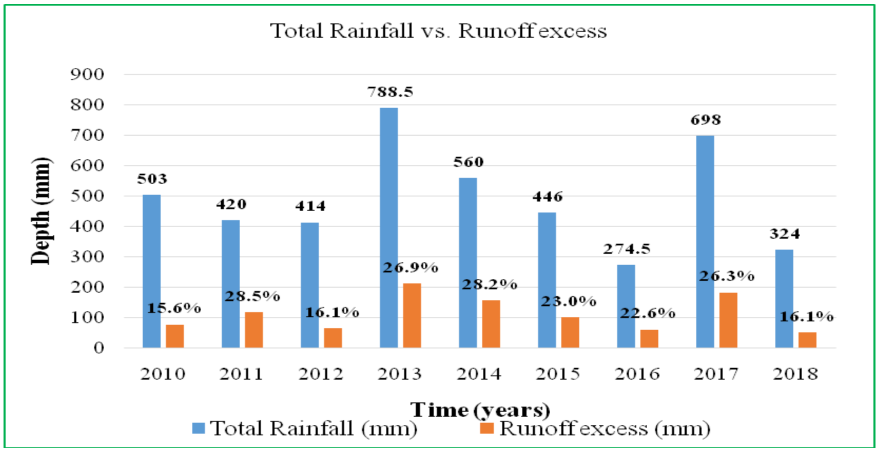


Fig.4 Distribution of runoff excess (mm) from each soil phase unit in year 2010

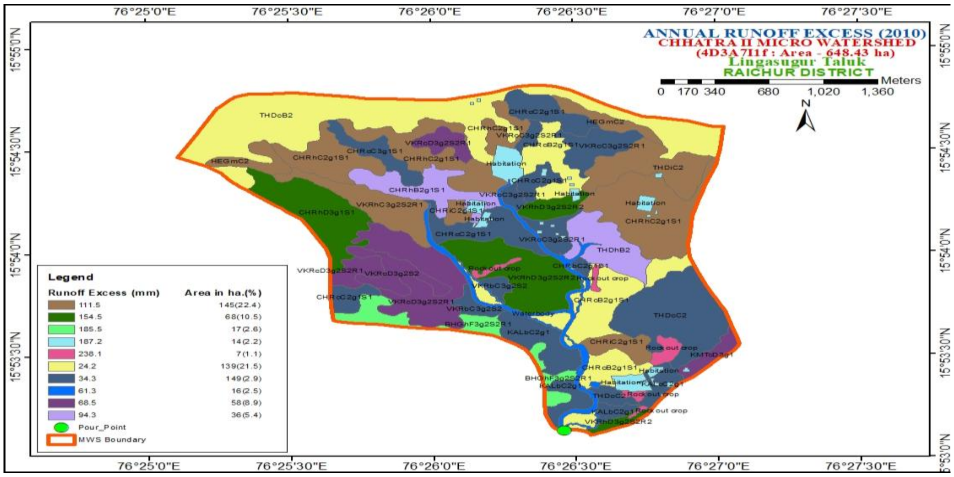


Fig.5 Distribution of runoff excess (mm) from each Soil Phase unit in year 2011

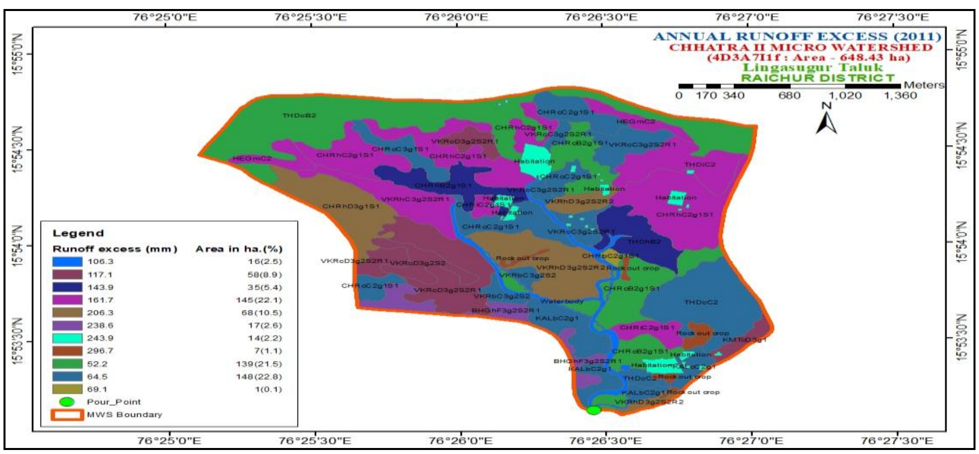


Fig.6 Distribution of runoff excess (mm) from each Soil Phase unit in year 2012

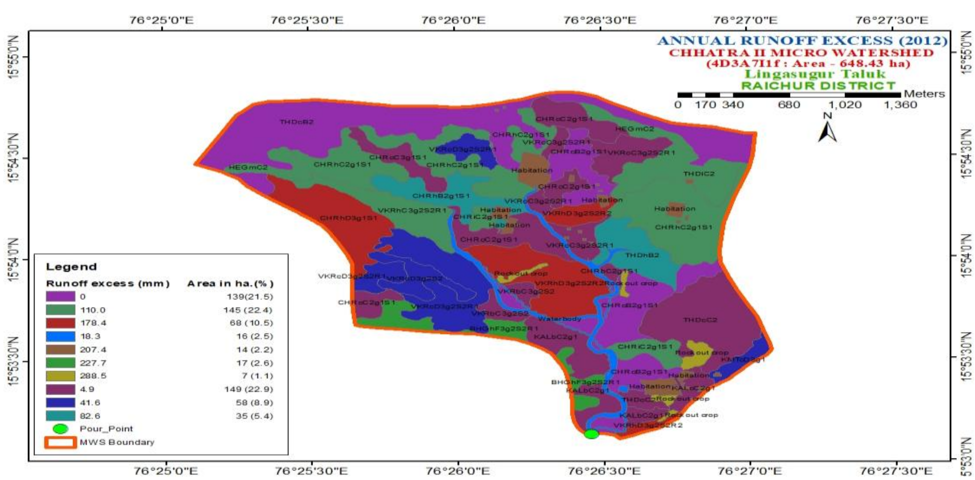


Fig.7 Distribution of runoff excess (mm) from each Soil Phase unit in year 2013

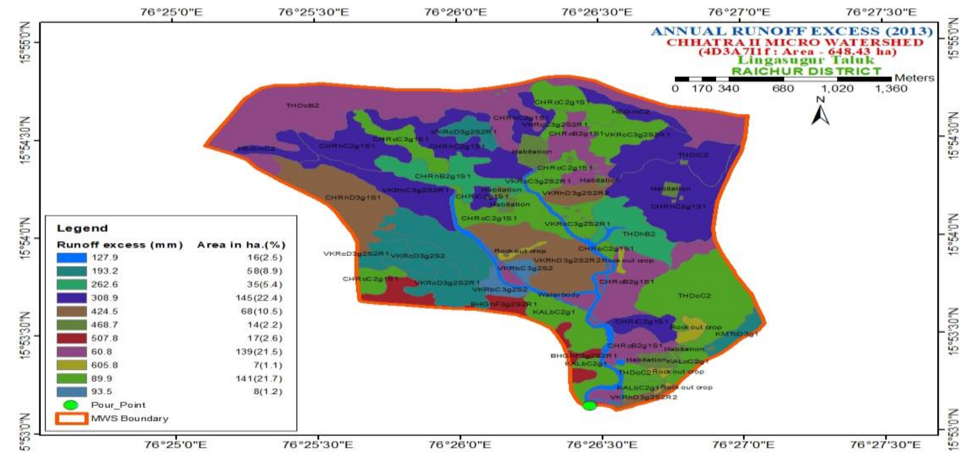


Fig.8 Distribution of runoff excess (mm) from each Soil Phase unit in year 2014

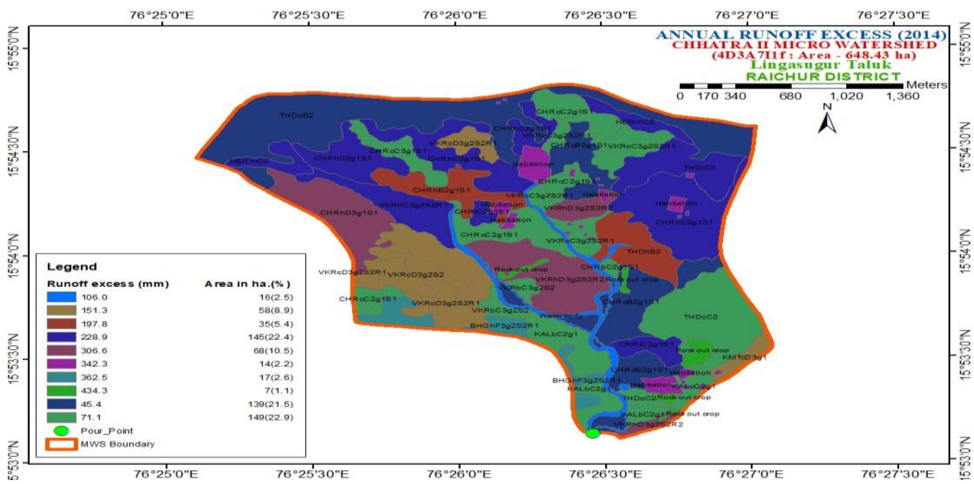


Fig.9 Distribution of runoff excess (mm) from each Soil Phase unit in year 2015

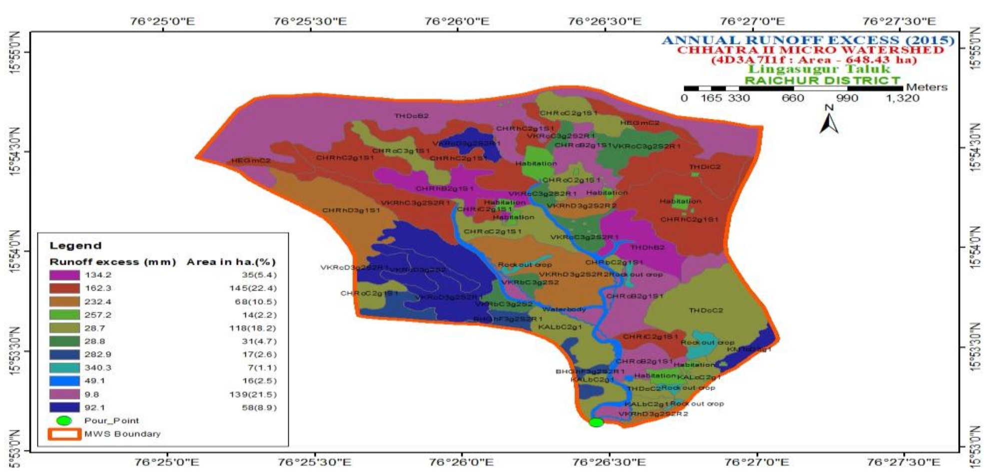


Fig.10 Distribution of runoff excess (mm) from each Soil Phase unit in year 2016

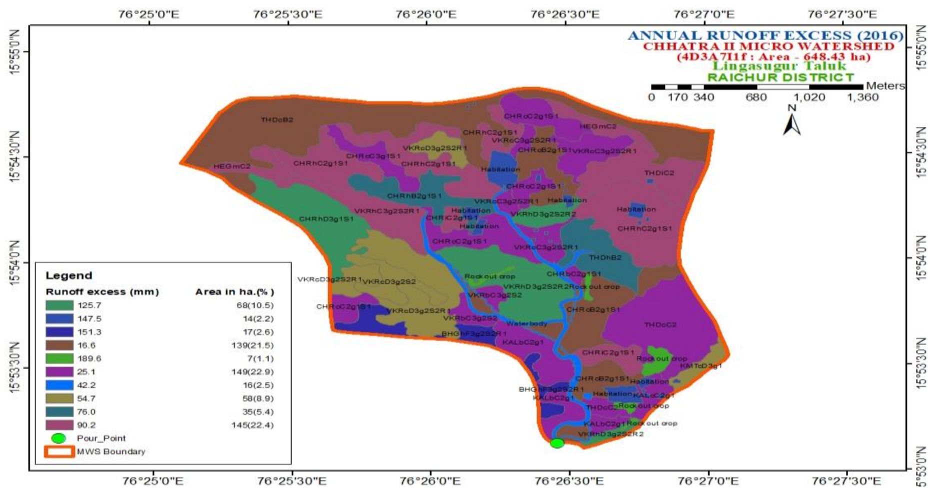


Fig.11 Distribution of runoff excess (mm) from each Soil Phase unit in year 2017

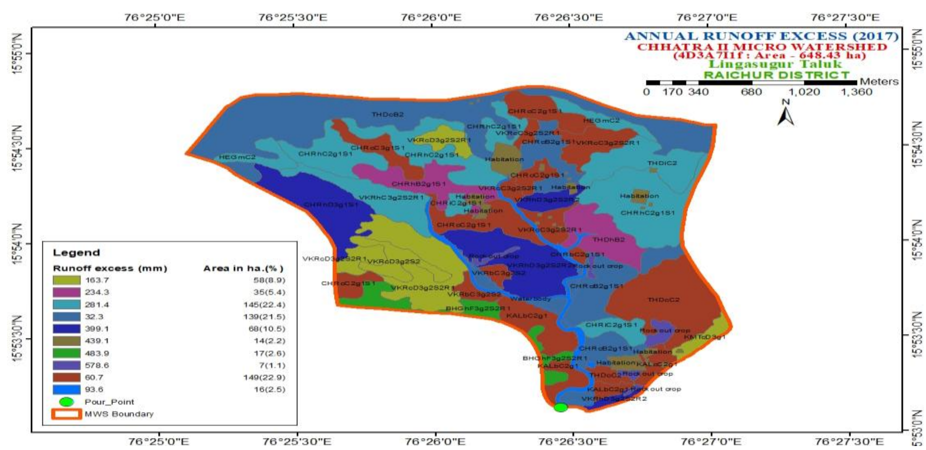
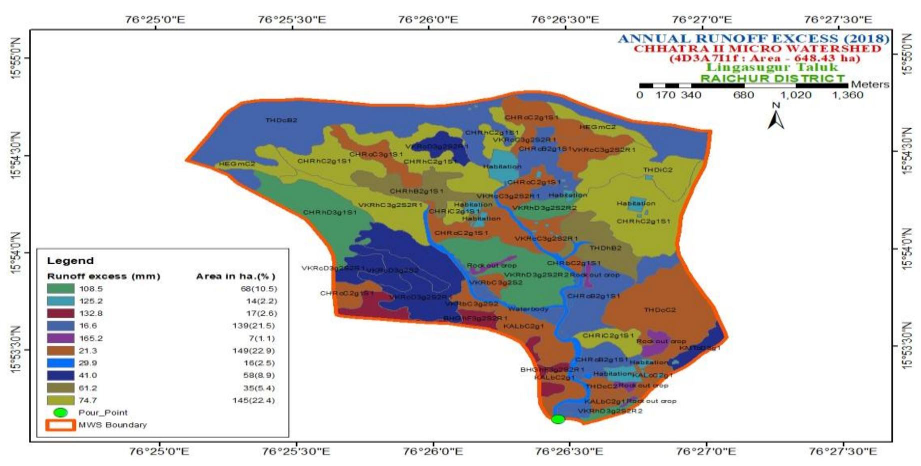


Fig.12 Distribution of runoff excess (mm) from each Soil Phase unit in year 2018



Preparation of Development plan for sustainable usage of land and water resources

The appropriate soil and water conservation measures for the Chhatra II micro watershed were designed based on soil, rainfall, land use and topography of the area. It is expected that after the implementation of these measures, the rainwater will be efficiently utilized and productivity will be increased. Conservation in this prospect means allowing dissipation of water flow energy by constructing contour or graded bund depending upon type of soil.In case of soil phase units, (12 numbers) with texture consisting clay quantity less than 25% would have more infiltration rate hence, contour bunds are proposed at the rate of (150 m ha-1) along with (50 m ha-1) of lateral bunding. Due to the contour bunding, there intend to be an increase in runoff harvested from (4.6- 13.8 mm). In case of soil phase units (9 units) with clay texture (≥ 25%), there would have less infiltration rate (≤ 9 mm h^{-1}) hence, graded bund are proposed with section of (1.09 m^2) and length of (200 m ha^{-1}) as a straight bund and (50 m ha^{-1}) as a lateral length. There shall be longitudinal grade of (0.2%) to dispose off runoff accumulated behind the bunding that may continue to lodge beyond 24 hours since many times, continuous water logging in water spread area beyond 24 hours may be detrimental for crop growth.

Due to the graded bunding intervention, runoff conserved would be rising from (4.6-18.5 mm). In case of non-arable land (social forest and wasteland) that occur partially in some soil phase units (9 numbers) with total area (163 ha), contour trenches are proposed with staggered trenching having section of (0.27 m^2) and length of (15 m). As a part of water harvesting process, farm ponds are proposed with varied capacities depending upon different soil phase units which ranges from (486.4 – 3396 m3 ha^{-1}). The study has also taken care of earmarking environmental flow at a rate of 20 % of the runoff excess whose contribution from each mapping unit would be varying in the range of (12.2 – 84.9 mm). The total contribution towards environmental flow out of runoff excess during the study period would be varying from (10.4 – 42.4 mm). Diversion drains are also recommended for Rockout crop which covers about (7 ha) area.

From the study, it can be noted that the runoff estimation through Intensity, Infiltration provides a platform to analyse rainfall-runoff relations by categorising both in terms of soil phase units and 15 minutes interval rainfall duration. It also provides a scope for rather intensive primary data on influencing characters on infiltration, rainfall characteristics, then partitioning of runoff into potential, retained through conservation process and possible runoff excess available for harvesting. The model also provides scope for apportioning runoff excess as an environmental flow which essentially is required to help sustain the requirements other than agriculture of the greater catchment within which Chhatra II is a part of as a micro watershed. The average potential runoff, retained runoff, runoff excess and environmental flow are 136.1 mm, 19.9 mm, 122.5 mm and 24.5 mm correspondingly.

Acknowledgement

The study is part of the Sujala-III project funded by World Bank through Government of Karnataka. The authors duly acknowledge the support.

References

Adham, M. I., Shirazi, S. M., Othman, F., Rahman, S., Yusop, Z. and Ismail, Z., 2014, Runoff Potentiality of a

Watershed through SCS and Functional Data Analysis Technique. *The Scientific World Journal*. 10.1155/2014/379763.

Ali, RV., Morvarid, A., Artemi, CARV., Morvarid, A. and Artemi C., 2017, Contribution of raindrop impact to the change of soil physical properties and water erosion under semi-arid rainfalls. *Science of the Total Environment*. 13: 651-658.

IARI, 1971, Soil Survey Manual. Indian Agricultural Research Institute, New Delhi.

Ibrahim Kaleel, Satishkumar, U., Premanand, B. D., Polisgowsar, B. S., Rajesh,N. L., Shanwad, U. K. and Balakrishnan, P., 2018, Runoff and soil erosion modelling for sustained development of land and water resources under watershed concept. *Journal ofPharmacognosy and Phytochemistry*. 7 (1): 87-101.

Kalpana, O. B., 2006, Soil erosion risk modeling and current erosion damage assessment using remote sensing and GIS techniques. *M. Tech Thesis*,Andhra University. Visakhapatnam. (India).

Neelambika, Satishkumar, U., Balakrishnan, P., Polisgowdar, B. S. and Basavaraj, K., 2016, Evaluation of hydrologic response of flat land watershed under semi-arid climatic conditions. *M. Tech Thesis*, University of Agricultural Sciences. Raichur. (India).

Satishkumar, U. and Rajesh, N. L., 2018, Land Resource Assessment of Chhatra – 2 of Lingasuguru Taluk of Raichur District for Integrated Development under Sujala-III Project.

Shwetha, G., Maheshwara Babu, B., Polisgowdar, B. S., Shanwad, U. K. and Srinivasa Reddy, G. V., 2015, Soil loss estimation through mathematical models using RS and GIS in Timmapur watershed of Raichur District. *M. Tech Thesis*, University of Agricultural Sciences. Raichur. (India).

How to cite this article:

Kaisara, W. and Satishkumar, U. 2021. Investigation on Variability of Potential Runoff on Planning of Conservation Measures under Semi-Arid Tracts of North-Eastern Karnataka. *Int.J.Curr.Microbiol.App.Sci.* 10(02): 281-297. doi: https://doi.org/10.20546/ijcmas.2021.1002.034