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Runoff Potential of *Nadis* in Different Landforms in the Guhiya Catchment, Western Rajasthan

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Abstract Small earthen embankment/dug out ponds called *nadis* are the principal drinking water sources in the Indian desert. The structure and functioning of this ancient practice is studied in relation with geomorphic units to design for greater storage and better utilization of runoff water. The interrelationship between runoff volume and catchment area in different landforms have been explained by regression equations. It is revealed, that in buried pediments, the *nadis* should be constructed under catchment slopes of less than 1%.

Key words Runoff potential, Landforms, *Nadis.*

Surface storage of water is one of the sources for human and livestock consumption in the arid zone of Rajasthan. The inhabitant of this region, harness the meagre runoff in dugout/embankment ponds, locally known as *nadis*. This source although relatively meagre, undependable due to erratic rainfall and often implies problems with respect to suitable site for storage, heavy sedimentation, high rate of evaporation (2473 mm year^{-1}) and seepage losses (1577 mm year^{-1}) (Anonymous 1988), yet it is a vital drinking water source in this region. In this paper an attempt has been made to design the *nadis* for expected runoff volume in relation to catchment characteristics in different landforms encountered in this region. This will facilitate to have maximum runoff storage with least waste of water.

The study area

A case study was conducted in Guhiya catchment, which forms an important constituent of the upper Luni basin. It lies between 72°56' to 74°05' E and 25°44' to 26°11' N and covers an area of 3051 km^2. The mean annual rainfall is 431 mm, varying from 69 to 722 mm with 90% concentrated during the monsoon period i.e. July to September. The elevation ranges from 171 m to 560 m.

The area possesses a variety of landforms viz. hills and intermountain uplands, buried pediments along the foot hills of Aravallis, rocky/gravelly pediments, older alluvial and younger alluvial plains. The older alluvial plains covers the maximum 60.2% of the total area, whereas the younger alluvial plains occupy the least (4.7%) of the total area (Amal Kar 1982).

Materials and Methods

While conducting the water resources survey regarding the present water potential and their management, observations such as water spread area, depth of *nadis*, catchment characteristics, and duration of water availability were recorded in the field. The observation points (*nadis*) were 137 located in five different landforms and five rainfall zones; less than 300 mm, 300-350, 350-400, 400-450 and more than 450 mm. The catchment areas and density of *nadis* were taken from 1:50,000 survey of India maps.

Results and Discussion

The characteristics of *nadis* situated in different landforms and rainfall zones are presented in Table 1. By a perusal of Table 1, it would be found that the depth of these structures varies from 1.2 to 7.0 m. However, there is hardly any difference in an average depth of 2.9 to 3.3 m irrespective of their ocurrence in different landforms and rainfall zones. In hills and intermountain uplands and in younger alluvial plains, *nadis* were located in more than 450 mm rainfall zone. Whereas in other landforms these ocurred in less than 300 to more than 450 mm rainfall zones. In hills and intermountain uplands *nadis* are larger in capacity with respect to average

Table 1 *Characteristics of nadis in Guhiya catchment*

Landform unit/ Rainfall zone	No. of observations	*Nadi* depth (m)	*Nadi* volume ($X 10^3 m^3$)	Catchment area (ha)	Average annual runoff m^3ha^{-1}	*Nadi* density	Duration of water use (months)
Hills and inter–mountain uplands/ more than 450 mm	22	2.0–5.0 (3.2)	3.96–610.5 (174.9)	22.5–617.5 (217.5)	882.0	1	7–9 (8.0)
Rocky/gravelly pediments/350 to more than 450 mm	8	2.4–4.0 (3.2)	5.00–212.8 (62.7)	16.3–155.0 (65.8)	953.3	75	6–8 (6.8)
Buried pediments/ 400 to more than 450 mm	22	2.0–4.6 (2.9)	2.00–99.4 (27.7)	25.5–309.3 (72.9)	414.3	19	4–12 (7.1)
Younger alluvial plains/more than 450 mm	5	2.0–4.9 (3.0)	9.00–92.2 (39.7)	15.0–634.5 (147.6)	927.0	21	7–12 (9.0)
Older alluvial pl–ains/less than 300 to more than 450 mm	80	1.2–7.0 (3.3)	1.30–630.0 (55.2)	20.0–1179.3 (94.8)	734.3	15	2–12 (7.3)

Table 2 *Effect of catchment slope in nadi volume per catchment area under different landform units*

Landform unit	Average *nadi* volume (m^3) per ha of the catchment area/slope group (%)			
	0.5–1	1–2	2–3	3–5
Hills and inter–mountain uplands	–	498.4	493.6	1908.9
Rocky/gravelly pediments	961.7	968.3	–	–
Buried pediments	477.0	402.0	266.7	–
Older alluvial plains	515.3	1008.5	1271.3	–
Younger alluvial plains	831.9	990.5	–	–

surface area ($70.2x10^3m^2$) and volume $174.9x10^3m^3$ and also larger catchment areas (217.5 ha) as compared to other landforms. The catchment areas were mainly hill slopes with medium density vegetative cover, generating runoff of 822.0 m^3ha^{-1}. An average runoff from hills and intermountain uplands, rocky/gravelly pediments, younger alluvial plains, older alluvial plains and buried pediments with sparsely vegetative covered was 882.0, 953.3, 927.0, 734.3 and 414.3 m^3ha^{-1}, respectively (Table 1). An average runoff volume per hectare from younger alluvial and older plains is significantly higher than the minimum *nadi* volume. As such, based on minimum catchment area available for *nadis* in younger alluvial and older alluvial plains, the storage capacity could be increased from $9.00x10^3$ to $13.4x10^3m^3$ and $1.3x10^3$ to $14.91.x10^3m^3$ by deep excavation. To minimise the evaporative and seepage losses, the optimised depth could be 5.0 m and 3.0 m in younger and older alluvial plains (Sharma & Joshi 1983). In buried pediments, average runoff was comparatively less than from other landforms. Moreover, amongst all the landforms in the study area, *nadis* in this landform though provided with sufficient catchment areas were generally less in depth, surface area and volume (Table 1), because the soils are deep to very deep with high infiltration rate.

The least density of *nadis* (no. per 100 km^2) has been recorded in the hills and intermountain upland unit. This is because of unfavourable physical conditions for village settlement and surface water need. The highest density of 75 100 km^{-2} have been recorded in the rocky/gravelly pediments. This indicates that rocky/gravelly pediments are an

Table 3 *Analysis of variance*

Landform unit	Source of deviation	Sum of squares	Degrees of freedom	Variance	F-test
Hills and inter mountain uplands	Regression	555793.3	1	555793.3	13.1*
	Deviation	851698.8	20	42584.9	
	Total variation	14074.9	21		
Rocky/gravelly pediments	Regression	34401.7	1	34401.7	28.5*
	Deviation	7252.9	6	1208.8	
	Total variation	41654.6	7		
Buried pediments	Regression	6753.6	1	6753.6	24.5*
	Deviation	5523.3	20	276.2	
	Total variation	12277.0	21		
Younger alluvial plains	Regression	3465.1	1	3465.1	14.1**
	Deviation	739.2	3	264.4	
	Total variation	4204.3	4		
Older alluvial plains	Regression	287538.8	1	287538.8	73.7*
	Deviation	304123.9	78	3899.0	
	Total variation	591662.8	79		

* $P > 0.01$

** $P > 0.05$

ideal landform for water harvesting which is mainly due to the shallow soil depth in the catchment areas, generating high runoff potential. However, *nadi* density in younger alluvial plains, buried pediments and older alluvial plains varies from 15 to 21.

Runoff volume in relation with catchment slope indicated the highest volume (1908.9 m^3 ha^{-1}) from hills and intermountain uplands with slope of 3-5% (Table 2) due to negligible percolation and least surface hinderances. In rocky/gravelly pediments, younger alluvial plains and older alluvial plains, *nadi* volume per unit catchment is increasing as the percentage of slope increases. But in the case of buried pediments, volume per unit catchment area is decreasing as the percentage of slope increases. It is mainly due to undulating topography in the higher elevated areas causing hinderance to runoff and high infiltration rate in deep sandy loam soils. From this it is inferred that in buried pediments, nadi should be constructed where the catchment have slope ranging from 0.5-1.0%.

The inter-relationship between volume of water and catchment area have been found to be significant at 1% level of probability in all the landforms units except in case of the younger alluvial plains significant at 5% level (Table 3). Runoff volume could be predicted by the regression equations described in Table 4

Table 4 *Regresion equations*

Landform unit	No. of obser-vations	Regression equations	Correla-tion coeffi-cient (r)
Hills and inter-mountain uplands	22	$Y = -14.2962 + 0.9465x$	0.6235
Rocky/gravelly pediments	8	$Y = -18.5307 + 1.2354x$	0.9087
Buried pediments	22	$Y = -7.0325 + 0.2839x$	0.7561
Younger alluvial plains	5	$Y = 27.3409 + 0.1027x$	0.9427
Older alluvial plains	80	$Y = 18.8866 + 0.3829x$	0.6971

Where Y = *nadi* volume in 10^3 m^3

x = catchment area in ha

Based on equations derived above for landforms in study area, runoff 100 ha^{-1} catchment area varies in buried pediments from $35.42x10^3 m^3$ to rocky/gravelly pediments; $105.00x10^3$ m^3 and equations are valid for minimum catchmet areas ranging from 15.0 to 22.5 ha.

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