

Index Catchment – A New Concept for Sustainable Integrated Development

N.S. Vangani¹, Surendra Singh¹ and R.P. Sharma²

¹ Central Arid Zone Research Institute, Jodhpur 342 003, India

² Watershed Development and Soil Conservation, Jodhpur 342 003, India

Abstract: The concept of index catchment development provides a holistic approach for optimizing the use of land and water, so as to prevent soil erosion, improve water availability and increase fuel, fodder and agricultural production on sustained basis. In the Osian index catchment, adoption of various development activities during a five-year period increased the cropping intensity by 31.4% and forage yield by 1.97 t ha⁻¹. Construction of water harvesting structures helped to increase the recharge to ground water, as indicated by rise in static water level. Sediment deposition against loose stone check dams was 3.68 m³ ha⁻¹ year⁻¹.

Key words: Index catchment, Osian, contour vegetative hedges, contour furrows, loose stone check dams, *khadin*.

In western Rajasthan, the area to the west of 350 mm isohyete does not have any integrated drainage system. This area is mostly covered by different types of landforms. In some areas, the drainage channels originating from higher lands do not flow for a long distance, but get disappeared/buried under aeolian and alluvial deposits. The runoff generated either in these drainage channels or from the peripheral ridges of the above landforms is collected in depressional areas. Under such situations, the crest lines of sand dunes or ridge lines of eroded rocky outcrops from the water divide between independent geohydrological units. The runoff is governed by the peripheral boundary lines. Such areas have been termed as "Index Catchments". This newly developed concept is somewhat different from watershed, but could be adopted as an ideal hydrological unit for sustainable integrated development.

In this paper, suitable techniques for sustainable integrated development of different landforms in Osian index catchment have been discussed.

Study Area

Osian index catchment (I.C.) is situated between 26°37' and 26°43'N latitudes and between 72°51'30" and 72°56'E longitudes in Jodhpur district. It covers an area of 4670 ha and is bounded by low ridges of stony wastelands in the east and sand dunes on the western fringe. The drainage channels originating from stony wasteland ultimately disappear in sandy terrain, but the runoff flows down to the depressional areas.

During the project implementation period from 1991-92, the rainfall was unevenly distributed with erratic pattern. From 1991 to 1996, the annual rainfall varied between

201 and 544 mm. The maximum rainfall received in 24 hrs varied from 53 to 93 mm. However, during the rainy seasons, the rainfall distribution and crop growth were not in harmonious balance. The long dry spells between two rainfall events were the most common features.

The hills, rocky/gravelly pediments, sandy undulating buried pediments, sandy hummocks and older alluvial plains are the major landforms of the study area. The slope varies from 1 to 4%. The area is dominantly covered by moderately deep to very deep fine sand to loamy sand soils underlain by a loose lime concretionary layer. However, in the eastern part, the soils are very shallow and eroded. These soils belong to landuse capability classes II to VIII. Trees and shrubs had a sparse cover during the study period and consisted of *Acacia tortilis*, *A. senegal*, *Prosopis juliflora*, *Prosopis cineraria*, *Tecomella undulata* and *Lycium barbarum*. The ground vegetation included the poor annual grasses. Moreover, the area had severe to very severe water erosion/wind erosion/deposition problem.

The inhabitants of the area were practically depending on meagre traditional surface water resources (*nadis*) for daily requirement of water. The seven village tanks (*nadis*; storage capacity 0.61 mcm) were widely scattered and used to remain intermittently dry for long periods (6-10 months) due to scanty and erratic rainfall and heavy pressure of animal population on available drinking water.

Materials and Methods

The index catchment boundary was delineated on the Survey of India topographic

sheets at 1:50,000 scale by considering the crest of sand dunes and ridges of rocky outcrops as the line of water divide. Due weightage was also given to the relative heights in the non-ridge areas and the boundary line was drawn through the highest elevated spots. The index catchment boundary was further refined from field checks.

Based on the different landforms and landuse systems, the developmental activities envisaged were: contour vegetative hedges (CVH), *Kana bandi* (cuttings of *Crotalaria burhia* buried in sand), contour furrows, loose stone check dams (LSCD), pasture development silvipastoral system, afforestation, development of water harvesting structures (*khadins*, ponds, farm ponds/*tankas* and renovation of *nadis*).

A relatively cheaper technology of contour vegetative hedges (CVH) was adopted to treat 1560 ha of arable land. The hedges were placed at 40 m interval to prevent soil erosion by runoff water and to conserve soil moisture. Additionally, these miniature earthen bunds were fortified with *Cenchrus ciliaris*/*Cenchrus setigerus* or *Lasiurus sindicus* grass species. For better establishment/planting of the grass species at an interval of 10 cm, a small 'V' ditch was provided. Moreover, to control wind erosion from arable lands, *kana bandi* with the help of *Crotalaria burhia* at a spacing of about 20 to 25 m across the wind direction was carried out.

Prior to the implementation of the developmental activities most of the non-arable lands (571 ha, including pasture lands and wastelands) were completely degraded and devoid of any kind of vegetation. The

pasture lands (260 ha) were treated with contour furrows at an interval of 8 to 10 m and seeding of perennial grass seeds. In rocky/gravelly wastelands (260 ha), afforestation was done in staggered trenches, mainly with *Acacia tortilis* species. Plantation of *Prosopis cineraria*, *Acacia senegal*, *Azadirachta indica*, *Parkinsonia* sp. and *Dalbergia sisso* was carried out in the agricultural farms and on field boundaries, which created more interest in the beneficiaries especially the farmers.

In the gullied non-arable lands, 297 loose stone check dams (LSCD) were constructed for soil and water conservation. The LSCD were supported with *Agave*, *Euphorbia caducifolia* and *Impomoea carnea*.

The surface water harvesting structures were developed in the form of *khadins*, sunken ponds, *nadi* renovation and tankas to harvest about 5% of the annual runoff.

Results and Discussion

The investigation revealed that due to construction of contour vegetative hedges as soil and water conservation and wind control (*kana bandi*) measures, the crop yield was increased manifold. Besides, an additional area of 115 ha was brought under cultivation. Cropping intensity, which was 64.9% during the base year, increased to 96.3% after implementation of the project. Due to the use of high yielding variety of seeds and proper soils and water conservation measures, crop yield was almost double. Among the *kharij* crops the maximum increase (129%) was recorded in the yield of pearl millet (HHB-60 and HHB-67), followed by moth bean (83%; Jadiya Jwala variety), sesame (77%), mung bean (66%;

K-851) and clusterbean (40%; Durgapura Maru).

In afforestation and silvipastoral programmes, different tree species were planted. The tree plantation was carried out every year from 1992-93 to 1995-96, and in three months of monsoon period. The planted tree species were: *Acacia tortilis* (79,150), *Prosopis cineraria* (8100), *Acacia senegal* (9150), *Azadirachta indica* (500), *Parkinsonia* (4200), *Dalbergia sisso* (4800) and *Prosopis juliflora* (5500). Kaul (1964) found no significant difference in survival of plants planted any time during the monsoon season. In our case, however, the overall survival of tree sapling was 58%, irrespective of planting time in monsoon season. The maximum survival of 65.16% was of *Acacia tortilis*, followed by *Prosopis juliflora* (56%), *Azadirachta indica* (50.9%), *Acacia senegal* (44.84%), *Parkinsonia* (42.23%), *Dalbergia sisso* (30.83%) and *Prosopis cineraria* (28.34%). These trees reduce the problems of fuel, fodder and land degradation.

The denuded pasture lands were treated with contour furrows and reseeded with perennial grass species. Such practices increase the forage production significantly (Ahuja *et al.*, 1973). Due to construction of contour furrows and conservation of moisture in sandy loam soils, the average increase in dry forage yield in the area was 1.97 t ha⁻¹. It was mainly due to the discouraging of open grazing in the treated area but also due to practising the cut and carry system. The availability of forage significantly increased milk production.

The construction of *khadins* and sunken ponds and renovation of *nadis* helped in recharging the ground water, its exploitation

also increased manifold. Prior to the construction of water harvesting structures, there were four wells in the index catchment area. The number increased to 13 wells in 1996. Consequently, the irrigated area increased from 25 to 148 ha for growing wheat, mustard, chillies and green fodder.

Monitoring of SWL (pre and post-monsoon) revealed that out of the four key wells, three key wells had increased recharge of 0.10 to 1.60 m. The net rise in SWL in the above three wells was between 0.75 and 1.65 m during 1991 to 1996 period.

The fourth observation key well was situated at a higher elevation than the water harvesting structures, and hence there was no appreciable recharge to ground water. The SWL declined here by 0.50 to 1.10 m every year.

Loose stone check dams (LSCD) is a commonly adopted practice which consists of a series of dry stone wall barriers of check dams constructed in the bed of gullies. In the project area, 297 LSCD of variable lengths were constructed according to the size of gully, but the height of each check dam was around 0.75 m. Observations on sediment deposition at 25 LSCD sites revealed deposition of 2.06 to 106.28 m³ at each site during the 5 year period. The total sediment deposition was 958.98 m³ per year (3.68 m³ ha⁻¹ year⁻¹) in the treated area.

The construction of *khadin* bunds across the slope/small valleys provided facility for collection and spread of runoff water received from a catchment area on the farmland for crop production, mainly during the *rabi* season. This system of water harvesting assured atleast one crop, whether

rabi or *kharif*, depending on amount of runoff water collected in the *khadin* area (Anonymous, 1981). The *khadin* system of water harvesting is best suited for arid region where rainfall is scanty.

Based on the runoff availability, renovation of 7 *nadis* (desilting), and construction of 13 sunken ponds and 21 farm ponds and 21 farm ponds/community *tankas* (Vangani *et al.*, 1988) were undertaken to mitigate the drinking water problem. The design and capacity were based on the availability of runoff from rocky/gravelly pediments. During the years 1992 to 1996, the harvested runoff potential was 16.58, 22.44, 25.44, 25.74 and 25.74 ha m, respectively.

The study indicates that the concept of index catchment can be adopted for sustainable integrated development in the arid region. This geohydrological unit may or may not have any drainage line, but it forms a impeded micro-catchment where runoff is not being utilized properly. The land treatments are almost the same as in a watershed. Almost all the farmers in the index catchment area were benefited in terms of increased crop yield due to water and wind management programmes. The cropping intensity increased from 64.7% to 96.3%, milk production increased by 1.33 times than in the base year, and perennial grass production to the tune of 1.97 t ha⁻¹. Deposition of sediments in gullied areas and augmentation of recharge to the ground water due to water harvesting structures, are the other major benefits.

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