Watershed Approach for Rainwater Management

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Abstract

Watershed an area having common drainage point is a planning unit for soil and water conservation, rainwater harvesting and overall development of rainfed areas within it. At present, well defined watershed maps of Karnataka are available for the above purpose. The important rainwater harvesting structures in watersheds are farm ponds, nala bunds and check dams. The paper describes these rainwater harvesting structures with respect to their types, design criteria, site selection and construction.

Farm ponds are small water harvesting structures generally dug of trapezoidal shape across water ways or gullies to harvest the unavoidable runoff. Normally the catchment area of each farm pond of 250 m^3 storage capacity is one hectare. It can potentially harvest and store runoff from 5-15 runoff causing rains per year. Nala bund is an earthen embankment constructed across the valley in arable or non-arable land to store runoff for percolation to recharge the groundwater. It is provided with suitable outlet/surplusing arrangement can be adopted in all areas. Check dam is masonry structure with a spill way constructed across the gully to serve as gully control and water harvesting structure. It is more stable than other structures since it is a concrete structure and the flow is not blocked. Among these structures, check dam constructed approximately on every 1 to 2.5 km of nala course is more effective in rainwater harvesting, ground water recharge and rejuvenation of defunct borewells.

The impact assessment of rainwater harvesting in Kuthangere micro watershed is highly convincing with long lasting benefits to the farmers even today. Watershed approach for rainwater harvesting increased the land use land coverof the area in a span of twenty six years. The close up view of the Kuthangere watershed before (1992) the watershed programme and after a lapse of 10 and 20 years shown the establishment of mango based agri-horticultural systems in class IV and VII lands. The improvement in land covers is clearly visible in ten years after the plantation. At present, there are sixteen farm ponds, eight nala bunds and two check dams in the micro watershed of 250 hectares. The harvested water is being used for protective irrigation besides groundwater recharge.

Introduction

Watershed is a defined geographical area with a specific drainage point. All the precipitation received in this area moves along the slope and finally drains through the common drainage point. Thus, there is a definite natural relationship between the precipitation, the topography and the runoff. Further, there is an intricate and intimate relationship among the natural resources like soil, water, vegetation and the human and animal population using the watershed. This relationship were more stable and sustainable a couple of generations ago, partially on account of low biotic pressure and mainly due to a reverence people had towards trees, forests and other natural assets. However, the status of these resources is worsening over the years, both because of the increasing human and animal population and the changing attitudes and lifestyles of the people. The consequent increasing demands and the reducing concerns about the environment and ecology among the general public has lead severe degradation of the natural resources. The ill effects are more clearly visible in the rain fed agro- ecosystems.

This calls for immediate measures to improve rain fed agriculture on watershed approach, in the country where a large part of the cultivated area is rainfed and a majority of the farming community depends on this land base.

Why the Concept of Watershed for Land Resource Management?

Soil, water and vegetation are so interdependent that one cannot be managed efficiently without the other two. Rainwater being the climatic parameter needs to be disciplined once it comes in contact with vegetation and soil. The unit of soil management can be a soil series, a phase or a type, while that of vegetation is forest type, plant genus, species or the crop variety. But, water can be conveniently and efficiently managed only if the hydrological unit vis-a vis watershed is taken as a whole. Since these three are interdependent resources, watershed is considered to be the ideal unit. Further, deforestation, soil degradation, sedimentation and the resultant floods, droughts, and poverty often require different kinds of solutions but are connected by the fact that they can best be understood and managed as physical units defined by the flow of water, that is watershed.

Methodology

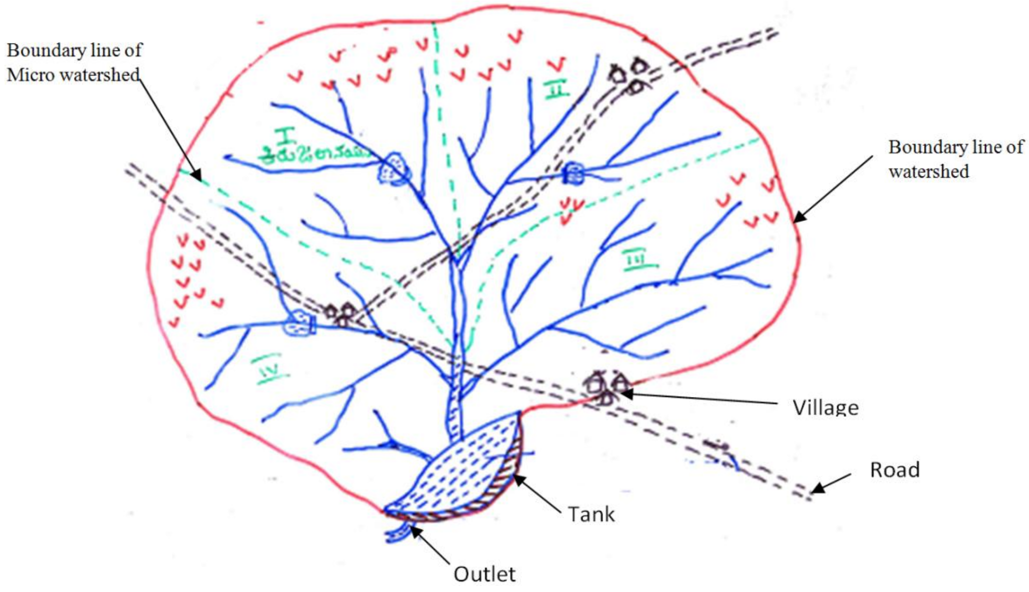
The selected watershed lies 60 km away from Bengaluru in Magadi taluk of Ramanagar district. The normal annual rainfall of the Kuthanagere watershed was 1028 mm in 50 rainy days. The major portion of it is received during April to November with peak during September (202 mm). The detailed soil survey of Kuthanagere watershed was carried out using cadastral map of 1:5000 as base map. The survey was carried out before (1995) and after 19 years (2014) of watershed development using the standard soil survey procedures as described in the Soil Survey Manual (IARI, 1971). While initiating the project, the watershed was delineated the treatment plan was prepared based on the survey and accordingly developed on ridge to valley concept.

Watershed Delineation

Since Watersheds are natural hydrological units, there are no standard maps indicating watershed boundaries for the state as in case of administrative boundaries viz., taluka, village etc. The non-availability of such maps for watersheds has resulted in different implementing agencies delineating the watershed boundaries in their own way and has led to the following ambiguities

- Duplication of efforts by different agencies in treating the same watershed
- Lack of information about which agency is treating which watershed
- Lack of spatial information about the area treated in the past and area to be covered in future.
- Difficulty in preparing new project proposals for large areas/number of watersheds.
- Delineation of watersheds in isolation may result in not adopting the ridge to valley concept
- Difficulty in coordination of developmental activities in watersheds, which are shared by two or more administrative units (Taluk/district).
- Wrong delineation of watershed boundaries by inexperienced agencies and staff.

To overcome these ambiguities, it is essential to delineate the watersheds up to micro watershed level for the entire state and then generate the watershed maps for any administrative unit. Although All India Soil and Land Use Survey (AIS&LUS, 1990) has developed a 5-stage delineation system demarcating Water Resources Region, Basin, Catchment, Sub-catchment and Watershed for entire India, it is very difficult to take up watershed as a unit for implementation, because watershed comprises huge area(0.2- 3 lakh ha). Keeping in view the hurdles in managing large areas (watershed-wise), Karnataka State Remote Sensing Applications Centre (KSRSAC 2005), Bangalore has further delineated the watersheds into sub-, mini- and micro-watersheds to facilitate the implementing agencies to choose a smaller unit.



Delineated Model Watershed map

Results

Rain Water Harvesting Structures

1. Sunken ponds/ Farm Ponds: are small storage structures made across waterways and/ or gullies to collect inevitable runoff for subsequent use as supplemental irrigation, to recharge ground water and for improving availability of water for agricultural and other uses, in cultivate areas where slope is less than 5 %. The most economical earthwork and desired water storage are the two guiding factors for locating the structure. The catchment should be large enough to yield sufficient runoff for filling the pond. They are preferably located in areas with impervious substratum. The details of dimensions for the farm ponds and re-charge ponds are given below.

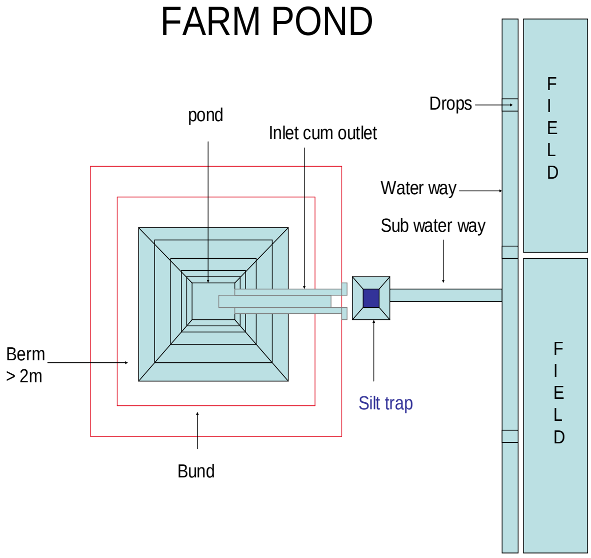
Farm ponds	Recharge ponds				
Catchment area (Ha)	Dimension (m)	Capacity (cum)	Catchmen t area (Ha)	Hard soil	Dimension(m) Loose soil
1	9X9X3	250	Up to 25	12X6X3	11X13X2
2.7	15 X15X 3	409	25 to 50	15X8X3	15X17X2-3
4.3	18X18X3	642	50 to 100	18X10X3-4	18X20X2-3
6.2	21X21X3	928	100to 250	21X10X3-4	21X23X2-3

Trapezoidal formulae of farm pond

To find volume: v= d/3 (A1+A2+A1+A2);   V = d/6 (A1+A2+4Am)

Where v= volume, d =depth, A1= Top segment area, A2 = Bottom segment area, Am = Mid segment

Design of a Farm pond



Farm ponds in the watershed area

2.Nala bunds : consists of homogeneous earthen embankment –inner core bund and the outer main bund- constructed across the nalas/ valleys which have distinct banks with width of about 5 to 15 m and depth of about 1 to 3 m. and the slope of the nala bed should be 1 to 3 %. A cut outlet is also provided at one end of the nalabund where bank strata are hard and non-erosive. This structure is taken up with the objective of controlling runoff water, reducing sedimentation of tanks/reservoirs, providing protective irrigation, drinking water for the cattle and wild life, increase moisture regime and recharge underground water table. The catchment area of a nalabund would be 80 to 500 ha, where rainfall is below 750mm per year and 40 to 250 ha, where rainfall is more than 750 mm per year.

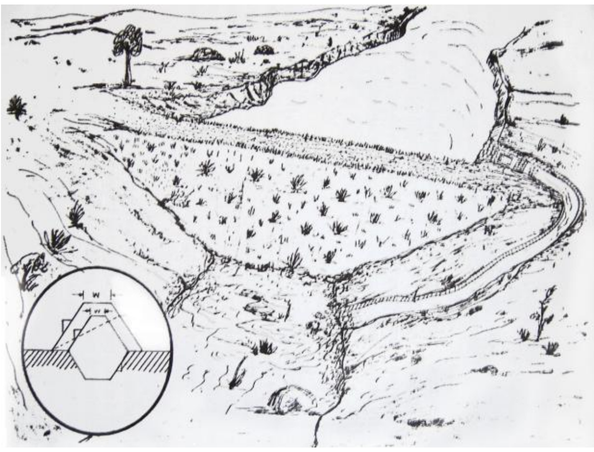


Fig: Line diagram and constructed Nala bunds in the watershed area

Site Selection and Components

Gully sites having restricted width, more depth but greater length are identified for locating such structures to minimize earthwork. The site should also have a provision for location of surplus sing arrangement, 2 – 3 m away from the structure. The banks of the gully should be strong enough to withstand the pressure of the impounded water. The major structural components consist of core wall (core trench, blanket/gorge wherever necessary and core bund), foundation/bund seating embankment and surplus weir.

3. Check dams: Check dams are constructed across gullies to reduce the velocity of runoff, heal the gully, store water for use by livestock and recharge groundwater in wells lower down. Depending on the size of the gully, the check dam may be constructed with earth, rocks, boulders, masonry or concrete. A series of check dams should be constructed from top towards bottom. The dams should be so spaced so that the crest level of one coincides with the base level of the next dam upstream. Generally, a grade of 0.1 to 0.5% is provided.

Masonry and concrete check dams are permanent structures constructed across large gullies to store rainwater for recharging ground water in wells lower down. It is reported that there is increase. Check dams are stone masonry structures constructed across deep nala with the objective of controlling runoff water, reducing sedimentation of tanks/reservoirs, providing protection irrigation, drinking water for the cattle and wild life, increase moisture regime recharge underground water table. It consists of Body wall, Apron, Toe wall and flank walls on either side. They are constructed in nalas with depth of 2 to 3 m, width 10 to 20 m., and catchment area of 25 to 200 ha.

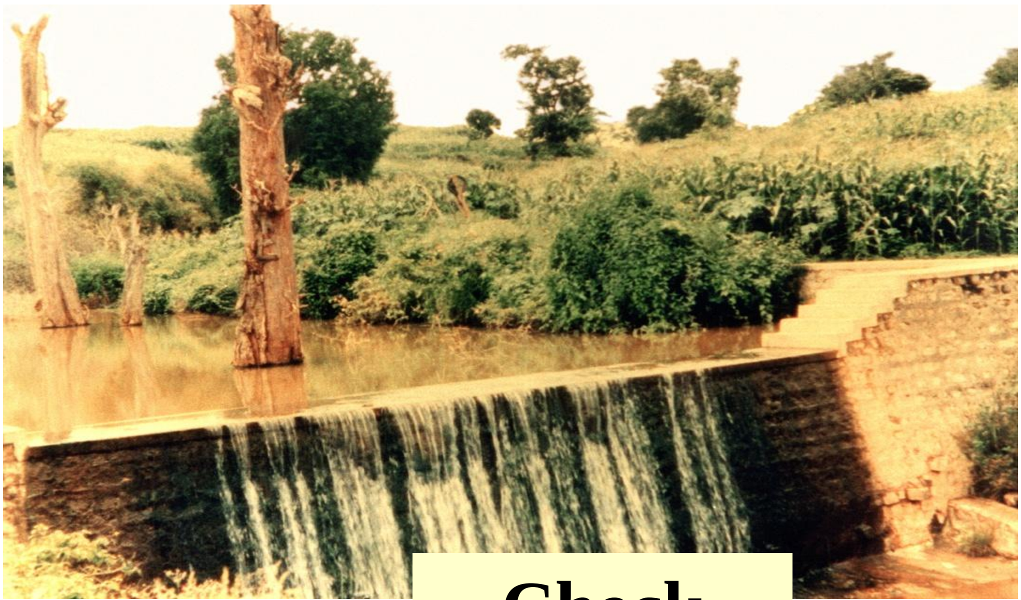
Water harvesting of run off by RRS, CD/NB

= ¼(crest length x impounding height x water spread length)

Where water spread length = impounding height x 100/percent slope

Site Selection and Specification

The site selected should be across the *nala*on a straight patch having a stable foundation stratum and banks. These structures are constructed in medium and deep gullies in all areas. The major components of the drop structures are head wall/body wall, head-wall extension (keying), side (wing) walls/flank wall, toe wall, end-wall/header line, apron, apron extension/ rough stone pitching and cutoff walls. The head-wall height (*h*) and weir height (d+f) together should not exceed the maximum depth of the gully. The dimensions of weir required are arrived at using the Rational, Ryve's and weir formulae (Krishnappa*etal.* 2006).



Check dam with solid apron in the watershed area.

Check dam with slope apron in the watershed area.

Summary

1) There were sixteen farm ponds dug in the watershed for harvesting and recycling of surplus rainwater, besides 8nala bunds/check dams. This harvested water was used efficiently for watering of the planted horticultural saplings particularly in the initial two years of their establishment. The stored rainwater was also used as protective irrigation to crops and to raise vegetables near the water bodies. The benefit cost ratio of harvested rainwater was worked out to be 3.33 for agriculture.

2) The exposed barren, gullied lands and scrap slopes of hillock which were subjected to severe erosion before, were covered with a thick mat of lush green vegetation by 1998 due to the developed silvi-pasture systems along with suitable *in-situ* soil and water conservation measures

3) The results of monitoring the water table level and the water drawn from 3 wells each in the treated and untreated neighboring watersheds have indicated as increased groundwater recharge in the treated watershed areas by 43 per cent.

4) Mango plantation in the established agri-horticulture system has given an additional income of Rs.3000 per acre of an average with only 15 trees per acre. The land use- land cover map of the watershed studied before and after the project showed remarkable increase in the area under agr-horticultural system from 5 per cent (in 1993) to 73 per cent (in 2017)

The close up view of change of land use land cover due to rainwater harvesting on watershed approach

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