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Bringing degraded land to agricultural use

impact of soil and water conservation activities and integrated approach

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Bastar, situated in southern part of Chhattisgarh, occupies an area of 39.06 lakh ha which is even bigger than state like Kerala. More than 60% area is under forest and the tribal community dominates in this bio-diverse zone. There are seven administrative districts which have typical socio-economic problems. In spite of availability of precious natural resources and forest produces, the people are very poor and the livelihood depends on subsistence agriculture. The landscape is hummocky having five distinct farming situations on topo-sequence. Badi (Homestead garden) exists on top most situations followed by Marhan (unbunded sloppy uplands), Tikra (bunded sloppy uplands), Mal (midlands) and Gabhar (lowlands). The bare hummocky topography and high precipitation (1,200-1,400 mm out of which more than 50 % rainfall takes place within 15 -20 days) leads greater runoff and severe soil erosion and land degradation; moreover, crop faces moisture stress during remaining period due to dry spells. The uplands are at higher threat as they are not protected. Upland crops like maize, millets, niger and horse gram are major livelihood support crops.

Key words: Agriculture, Degraded land, Soil, Water conservation

A project area was considered by the AICRP on Dryland Agriculture, College of Agriculture, IGKV Campus Jagdalpur (Chhatisgarh) under Tribal sub-plan from the point of view of overall development particularly under rainfed farming system during 2012. In the village Tankapal, it was observed that the ridge lines of this village are prominent and most of the fields particularly near to ridge lines are severely affected by soil erosion. The runoff potential of the area is also high due to high intense rains and continuity of land slope. It was also observed that the fields on the ridge lines are owned by the farmers and they are trying to cultivate the area with the traditional crops. But due to low productivity and severity of soil erosion, few areas have been abandoned and the fields are no longer being cultivated by them despite having deep soil profile on the middle and lower reaches of the ridgelines. However, it has been observed that if suitable soil and water conservation measures are adopted, these degraded lands can be brought under cultivation. Similarly, it was also observed that despite having high runoff potential, the sufficient irrigation water is not available in the form of either surface or sub-surface water. Thus, it is also desirable that for trapping the sub-surface flow of water coming from the upper reaches, open wells need to be provided in these fields so that water will be made available for agricultural use. Thus in the initial year, six RCC open well were constructed in this 20 acre (8.08 ha) barren and abandoned fields.

Similarly, it is also assessed that to harvest the water flowing in the natural drainage lines in the lower and valley portion, provision of stop dams has to be made so that appreciable amount of water is to be collected so that it become almost a perennial source of water. Though few tanks are also available in the villages, but their capacity has to be increased by deepening and desilting process so that not only storage capacity is increased but also the lifted desilted soil will spread in degraded portion to improve its fertility. Provision of all the above may be useful in bringing the degraded portion in agricultural use for increasing crop productivity and farm income. Considering the above factors in view, the present study was carried out in the village (by considering a degraded portion of 20 acre (8.08 ha) area which was owned by 25 farmers earlier but no longer being used by them extensively for the crop production due to severe degradation) to assess the impact of various developmental activities and soil and water conservation measures on the productivity and increase in the water availability in this degraded portion.

Before the start of actual work, a team of the scientists visited the area several times to have close look into the topographical and ground reality of the area from the point of view of natural resource management. A reconnaissance survey was made and critical and hot spots (which were converted into gullied portion due to uncontrolled runoff and severe erosion) were located and demarcated. Detailed discussion with the farmers have been observed, as given here.

- The 20 acre (8.08 ha) cultivated area which is owned by 25 farmers was severely affected by soil erosion. Several prominent drainage lines were developed due to uncontrolled runoff.
- The upper portion above the existing stone and property bund is heavily degraded and stony, the runoff potential is high as the slope of the area is in the range of 15 to 25%.
- Though diversion drain and bund was constructed by the project last year, it was not possible to divert all the runoff water due to topographical condition. The heavy runoff coming from the upper portion enters into the cultivated fields from the several points after damaging diversion bund and develops deep gullies and caused severe erosion. Few loose boulder structures and gabion structures have been constructed by the project team last year but they are not sufficient enough to control and manage the runoff effectively.
- The entire 20 acre (8.08 ha) area is almost converted into sloppy and undulating fields and thus the area was found not suitable for cultivation. Though few farmers are growing seasonal crops but productivity was very low.
- Agro-horti system is being developed by the project by planting 1,000 fruit plants. Plants have been found grown satisfactorily. The plants are already being grown in this portion before the treatment by the project team.
- It was observed that the runoff water coming from the upper fields and within the fields need to be managed properly to reduce the amount of water running away from the fields and to reduce the development of further serpentine-shaped gullies due to uncontrolled runoff.
- It was also observed that few ring open wells have been developed by the project, but they are not recharging as it receive little sub-surface flow underneath the soil surface. Thus, by increasing the time of concentration of runoff water in the area for the longer time and it may aid to sub-surface flow entering into the open well.
- The prevailing continuity of slope in the entire area increases the velocity of runoff water entering into the area from upper reaches during monsoon season affected the area most and converted the area into degraded portion with multi-directional slopes. Similarly because of uncontrolled runoff and high runoff velocity, various prominent ridge lines are developed and increased the severity of soil erosion.
- Infestation of various weeds was also observed in this portion as most of the area was not being cultivated intensively by the farmers for many years.
- Since runoff entering into this portion from the upper area cannot be controlled very effectively despite the construction of diversion bunds, it was desirable that the runoff coming from the upper reaches and runoff generating in the portion is managed through various soil and water conservation measures to reduce its velocity, amount, increase the time of concentration, increasing the base flow and to increase the surface storage in the area itself.
- Further, it was observed that an area of 2 acre (0.808 ha) was converted into the depressed portion as the soil from the area was excavated by the farmers for other non-agricultural use. It was almost converted into kiln thus it was also decided that the portion is to be refilled with the excavated soil so that the continuity of farm area is maintained and chances of further development of gullies will be minimized by reclaiming it.

Considering the above factors and critical aspects, it was decided that the area should be provided with the following various soil and water conservation measures in the April-June 2014, so that the desired objectives shall be achieved within a short duration of time in following monsoon season.

- Construction of series of sunken ponds in all the prominent ridge lines from top to lower portion so that the runoff is retained in these ponds and total amount of runoff water leaving the field is appreciably reduced. The storage of the runoff water in these ponds will also reduce the runoff velocity and thus retard/control the process of soil erosion and further development of gullies.
- Since, land terracing has to be adopted to break the continuity of slope so that time of concentration, amount and velocity of runoff is reduced and thus bunds at vertical regular interval were constructed by dividing the entire area into four portions.
- Each sunken pond is provided with the loose boulder structure each on upstream and downstream side so that the silt is trapped and soil is retained for the stabilization of drainage lines.
- The excavated soil for the creation of sunken ponds was spread in the depressed and undulating and irregular shaped area to bring them into a leveled portion by using dumper and tractor trolleys.
- Tractor drawn leveler was also used to level the fields after the deep ploughing in the entire area by tractor drawn MB plough and spreading the excavated soil.
- In the left side of lower portion of the area, a water storage tanks was constructed so that a concept of Zing's terracing is also introduced while developing the area.
- Planting of *stylo hamata* grass to control the soil erosion at the upper portion of the land.

Construction of sunken ponds: The major activity undertaken for the development of this portion was the construction of series of sunken

Interventions

Interventions details	No. of units/Area (ha)
Construction of trench having size 1,000 m × 4 m × 1.5 m to catch the rain water of upper side hillock	6,000 m^3
Construction of contour trenches across the slop at an interval of 10 m for effective in situ soil and water conservation size 1 m ×1.5 m × 1,000 m.	1,500 m^3
Construction of Cattle Protection Trench around the site size 1.5-0.75/2 × 1 × 1,000 m.	1,125 m^3
Construction of gabion structure to control the soil erosion as per the requirement	800 m^3
Construction of sunken ponds of different dimensions	16 Nos.
Construction of zing terraces of different dimensions	2 Nos.
Plantation of mango (var. Dashehri) along with contour trench	1,000
Plantation of *chiku* (var. cricket ball) along with contour trench	700
Intercropping of maize, cowpea, small milletes and upland rice.	20
Construction of in situ RCC tank of size 50 m ×20m × 3 m	3,000 m^3
To develop gravitational device for water supply.	8 Unit

ponds to act as surface water storage bodies and for arresting the runoff water coming down the slope through drainage lines already developed naturally to reduce its erosive velocity.

The sunken pond comprises an excavated portion (rectangle shaped) of variable depth (as per soil depth) and variable length and width as per stream section or drainage line. The excavated material is deposited along the side banks with a view to prevent siltation from surrounding areas. An upstream slope and downstream slope is also provided to facilitate movement of silt along with flow thus reducing siltation. A silt trap of loose boulders is provided on upstream side. The structures are generally constructed in series to trap maximum runoff, however, bends in the stream were avoided as these are susceptible to bank erosion. The technology is used in conjunction with shallow wells adjoining the stream, which enable farmers to harvest the increased sub-surface flow for irrigation.

The sunken pond is a structural measure constructed in a defined gully portion with a view to conserve water for better runoff management along with reduction in land degradation of adjoining fields. The problem of water conservation and gully erosion is generally addressed by the sunken pond. It is a means of controlling concentrated runoff to increase its infiltration and to harvest the runoff water. Thus, it is a technology intended to recharge the wells located downstream or in the adjoining fields as a result of increase in ground water levels.

Six prominent drainage lines and gullied portion developed due to uncontrolled runoff rushing down the slope from the upper reaches were identified and selected. In an entire drainage line, six sunken ponds were developed and constructed using JCB machines. The dimension of each sunken pond was 12 m × 6 m × 3 m. On the downstream and upstream side, a slope of 2:1 was provided in each sunken pond so that the runoff water enters into the tank without causing any splash erosion and further development of gully head advancement. Further, it also ensured that the runoff water leaves the sunken pond without damaging the downstream portion as it moves upward in the pond with side slope of 2:1. On both upstream and downstream side, loose boulder structures were constructed so that silt free runoff enters into each sunken pond. Thus, 18 sunken ponds have been constructed in the area to retain runoff water of 6,000 cu.m. and allows it to percolate deeper into the soil profile to increase the sub-surface flow in the open well constructed in the area.

Sunken ponds constructed in the treated area

ID No.	Length (m)	Width (m)	Depth (m)	Volume (m^3)
S1	12.4	5.7	2.8	197.9
S2	24.3	7.9	2.7	518.3
S3	16.7	6.8	3.1	352.0
S4	19.3	5.7	3.1	341.0
S5	22.7	6.4	3.1	450.4
S6	14.9	5.4	2.9	233.3
S7	31.6	5.4	3.0	511.9
S8	31.6	4.8	3.0	455.0
S9	26.9	5.7	2.9	444.7
S10	7.6	4.4	3.0	100.3
S11	22.8	4.9	3.2	357.5
S12	28.8	4.6	2.9	65.4
S13	26.9	5.7	2.9	52.9
S14	19.5	5.6	2.8	305.8
S15	31.9	5.3	2.8	473.4
S16	39.9	5.4	2.7	581.7
Z1	15.6	4.9	2.9	221.7
Z2	22.9	5.5	2.7	340.1
Total				6,003.3

Construction of terraced land: The act of terracing specifies an agricultural method of cultivating on steeply graded land. This form of conservation tillage breaks a hill into a series of steps like benches. These individual flat structures prevent rainwater from taking arable top soil down hill with it. The entire area was divided into four portions width-wise as per the actual and prevailing field conditions along the slope. At the end of each portion, an earthen bund was formed by using JCB machine and by excavating a channel on both upstream and downstream side of the bund. It has provided these four portions as sort of terraced land. This activity not only reduced the continuity of the slope but also allowed the runoff water move slowly through the entire terraced portion due to its relatively flat topography. At the junction of each bund and prominent drainage line, a wire mesh structure with boulder was provided to allow the movement of runoff from the upper portion into lower portion with slow and controlled velocity.

Construction of trenches and bunds: In these four terraced portions, trenches have been excavated at the end of each terraced portion and an earthen bund is also constructed all along the trenches so that the runoff water is diverted from each portion and guided with the retarded velocity towards the natural drainage lines where sunken ponds are constructed in series. The earthen bund also acts as property bund for each terraced portion. On the two sides of these degraded portion, a diversion bund has been also constructed to carry excess runoff coming from the upper

Dimensions and details of trenches and bunds

Details	Dimensions
Trench I	330 m × 0.7 m × 1.0 m
Trench II	350 m × 0.7 m × 1.0 m
Trench III	170 m × 0.7 m × 1.0m
Total length of bunds/trech	850 m
Total length of diversion trench	1.8 km.

reaches and the runoff leaving the treated area for its safe disposal.

Deep ploughing: In the entire area, deep ploughing operation was carried out simultaneously using tractor drawn MB plough so that the weed infestation and its spread are controlled. This also allowed the minor leveling of the terraced portion.

Spreading of the excavated soil: The excavated soil was spread in the lower and depression in the entire area using tractor trolleys and tractor drawn leveler was used to level the terraced portion. Similarly an area of 1 acre (0.404 ha) was also leveled by spreading the excavated soil and by leveling it in this portion.

Construction of tanks: Zing's terracing: Three excavated tanks were constructed at the lowest portion where topography becomes little flatter to collect the runoff water so that a concept of Zing's terracing is adopted which is a special type of bench terrace designed for dryland moisture conservation. It typically employs an earthen embankment similar to the ridge terrace; a part of the terrace interval immediately above the ridge is bench-leveled. Runoff water from the sloping area is retained on the leveled/excavated area and absorbed/retained by the soil. The stored water would be utilized for irrigating the donor areas during the stress period. The stored water in these tanks will also reduce the amount of runoff leaving the fields without aiding to soil moisture profile. Thus, zing terracing is the practice of developing conservation bench terrace which is another type of rainfall multiplier, using part of land as a catchment to provide additional runoff onto level terrace on which crops are grown.

During the construction of all these soil and water conservation measures, Vice Chancellor IGKV, Raipur, suggested that this area be converted as a model unit for further adoption and improvement in such types of area in other parts of the state.

BENEFITS

Within three months of its construction, it has been observed that the treated portion has been planted with various *kharif* crops and terraced portion provides favourable condition for satisfactory crop growth. Before the adoption of this technology farmers only cultivated single crop in the otherwise degraded land during monsoon. After conservation, additional crops taken during monsoon are soybean, vegetables. Second crop during *rabi* would be cultivated as sufficient irrigation water is available in the sunken ponds and the wells are receiving recharge from dugouts.

The runoff water is stored in the series of sunken ponds and excess water is being drained safely with reduced velocity and volume, thus reduces the problem of severe soil erosion. Since the percolation rate is high in the soil of the area, these ponds work as percolation tank, the retained runoff water moves laterally and downward to charge the soil profile. These tanks actually collect much more runoff than their storage capacity. It has been estimated that these tanks retained more than 10,000 m^3 water in the area which was otherwise moving out of the area with higher velocity. It has tremendously reduced the runoff velocity and stopped further soil erosion and degradation of the area.

Construction of various soil and water conservation measures has increased the total soil moisture conservation as evident from the surface storage in the sunken pond, leveled fields, due to diversion bunds and drains and increased ground water recharge. It has been observed that due to increased recharge the open well constructed in this portion are fully recharged and retaining water upto within 1 m from the soil surface which is otherwise not possible in the untreated area. This has increased its utilization by crops leading to satisfactory growth of crops and plants grown on the reclaimed portion.

Ecological benefits include soil cover improvement green cover observed 8 months of the year; increase in soil moisture, second crop now possible; efficiency of excess water drainage; soil erosion controlled increased subsurface seepage; and soil loss reduction because of treatment of catchment.

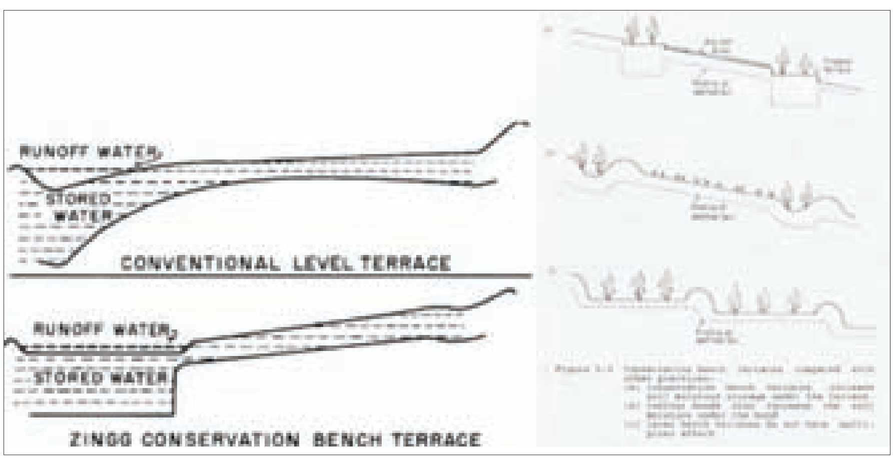

Fig.1. Zingg conservation bench terrace

Other benefits

Drinking water for humans and cattle, open well provides water for longer time.

Off-site benefits:

- The construction of terraced portion and sunken ponds has reduced the runoff movement and soil erosion process in the fields in the valley portion tremendously.
- The lower fields are getting sufficient moisture as the runoff water retained in the treated area gets percolate and recharge the

Open well in the terraced field getting recharged at higher rate due to increased runoff retention in the terraced portion and thus allowing more ground water recharge

Recharging of the open well at faster rate during rainy season 2014

soil moisture profile and moves downward to be retained and available in the soil profile for longer time in the fields located in the valley portions.

- Reduced downstream flash flood due to *in-situ* water conservation.
- Increased stream flow in dry season,
- Reduced downstream siltation.

It is a simple technology which only requires de-silting of the sunken ponds after few seasons. Major strengths/ advantages of the technology are: increased percolation; reduced evaporation due to subsurface storage; low risk of breaching/ damage in heavy rain; the natural drainage line is not disturbed and further development of washes, gullies stopped due to controlled runoff movement; low cost as compared to check dam; and simple technology easily understood by farmers.

SUMMARY

It can be confidently suggested that the land developmental activities carried out in abandoned cultivated field not only brought almost all area under cultivation but also ensured the safe disposal of the runoff water and retention of maximum possible runoff for groundwater recharge and surface storage for its utilization for irrigation the crops. The activities increases the crop productivity by many times on sustainable basis through efficient natural resource management in tribal belt of Jagdalpur district of Chhatisgarh.

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