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Hillocks are being greened as part of the watershed Kurnool IWMP project in Andhra Pradesh

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Abstract
Soil erosion was halted and carbon sinks were created by planting fodder, fruit, and drought-tolerant biomass species in highland steep areas and protecting natural regeneration. Enhanced vegetative cover is being developed as a horticulture block planting site and another side of the hilltop as fodder land, resulting in improved nutritional security for villagers and livestock, as well as increased money for GPs from fruit harvesting. Greening of hillocks was undertaken in Kurnool Batch-IV watershed projects, which is a severely drought-affected area. The average yearly precipitation is 550 millimetres. This activity resulted in an increase in vegetation cover on the hilltop region, with a survival rate of more than 80%. It was decided to combine NREGA in and IWMP greening hillock effort. Seedlings of neem, custard apple, and other woody plants are planted on the mounds of dug staggered trenches down the slope, following the ridge to valley concept. It is critical to comprehend the effects of vegetation before performing hilltop greening to increase water resources and soil erosion control. Upstream areas/ridges are given priority in watershed initiatives for water harvesting structures and vegetation. Planting trees has been linked to a higher rate of evapotranspiration, according to studies. While improving ground water and soil moisture, issues like drought resistance, economic value, and ecological impact must be addressed while selecting plants along trench bunds. Trenches run the length of the slope and serve as drainage lines and water gathering structures.

Keywords: Greening of hillocks, IWMP, NREGA, Slope, water harvesting structures, horticulture

Introduction

Deterioration of agricultural fields in India is enormous with factors like uneven climatic conditions, frequent failures in monsoon, and land use and land cover for different purposes. Over the last few years, India has encountered a sudden series of precipitation events across different states due to climate change. These led to severe crisis of environment, ecology, and financial which are linked to livelihoods of large sections of population.

Geographically, some areas are fertile and arable but other are not. So, the focus to bring back ecological balance so many efforts has been made from the respective governments since decades. Some of these efforts are focused on severe climatic condition zones like drought hit regions in India through watershed programmes which is a novel programme in making regions to be use for everyday living not only for the populations but also the animal and different species populations. This brings entire ecosystem working for all with balancing the ecology with the developments that are taking place in the landscape. Some of the drought prone regions have to prime focus to provide better life with minimum life support guarantees in a given area. Kurnool of Rayalaseema region is one of the severe drought prone areas which has been facing water related problems and had large migration to other places across the world.

Integrated Watershed Management Programme has taken the initiation in the region to bring back the ecological balance with various efforts such as soil and water conservation works, greening of hillocks, and livelihoods improvement programme.

Among these, greening of hillocks played a crucial role in improving the green cover especially at the hilly areas. Improved vegetative cover through productive use of hillocks is being developed as horticulture block plantation site and another side of hillock as fodder land leading to nutritional security of villagers as well as livestock along with improved revenue for Gram Panchyats as harvesting of the fruits. Planting the upland hilly areas with fodder, fruit and drought hardy biomass species and conserving natural regeneration resulted in arresting of soil erosion and serving as carbon sinks.

As part of IWMP, greening of hillocks activity in micro watersheds batch-I to Batch-IV in Kurnool district of Andhra Pradesh was taken up in approximately 10 Ha. which is severely drought-hit area. This action has resulted to increase in vegetation cover on the hillock areas in the district, with more than 80% survival rate. National Rural Employment Guarantee Programme in convergence with IWMP greening hillock activity has been taken up successfully.

The forest and local species like neem, custard apple and woody plant seedlings are planted on the mounds of dug staggered trenches along the slope following the principle of ridge to valley. Before implementing greening of hillocks to improve water resources and soil erosion control, it is important to understand the impact of vegetation.

In watershed programs upstream area/ridge is given priority for water harvesting structures and vegetation. Many studies have proven that planting trees often is associated with increased rate of evapotranspiration. While selecting plants along the trench bunds factors like drought resistivity, economic importance and ecological contribution must be considered while improving ground water and soil moisture. Trenches across the slope functions as drainage line treatment purpose and water harvesting structure.

Importance and significance of greening of hillocks

The agriculture sector in India is severely deteriorated due to enormous factors like frequent failure of monsoon. The hills in rural areas formerly flourished with dense forest vegetation, wildlife and colorful birds. Age-old trees were used by local people to make their homes and agriculture equipment. They were contributing fruits, fodder, medicinal plants and firewood. Huge diversified birds existing in these forests were helping agriculture by eating insects in crops. Dense vegetation on these hills attracts clouds and timely rainfall was the regular scenario in this region. Large scale deforestation, urbanization and natural forest fires have resulted in the loss of plants which made the area barren and prone to soil erosion.

Apart from local reasons, climate change and global warming are making these areas low productive and low fertile. Deforestation and different anthropogenic activities will have significant impact on soil biota and biogeochemical cycles. As it is well known that horticultural plants are adaptable to the extreme agro-climate, in addition they can also supply products for sustained economic returns and nutritional security to the people.

A major reason for poverty among the rural individuals in India is the absence of access for both people and communities, to productive assets and financial assets. The greening project was a unique one and continuous or staggered contour trenches dug on ridge portions impound rainwater to improve moisture in upland areas, and promote natural regeneration of vegetation, besides recharging groundwater downstream side. Trenches across the slope are important to increase groundwater and rejuvenate the base flow during the summer season. The plantations raised with species like custard apple, neem and tamarind are yielding income to village panchayats. Soil fertility is the important factor of soil, and it reflects soil physical, chemical and biological characteristics. In ecology and ecological balance, soil fertility is an important driver as it plays a major role in the biosphere.

Concerning sustainable resource management, vegetation extension systems must incorporate the idea of strength and persistence. Resilience is the ability of the eco-system to withstand stress and natural disasters. Persistence means that the long run of the system should be ensured. Over exploitation of natural resources by increasing population and industries have made systems weak in terms of resistance towards any change in the climate. This aspect needs to be strengthened by encouraging various capacity building and resource management methods.

The persistence is an inherent component of the rural agro-forest system, which is manifested by human inputs. In the programmes like greening of hillocks, people's participation with effective implementation of governance is a needful tool. This can ensure the resource management in more sustainable manner.

Main objective of the greening of hillocks in watershed management

The main objectives are as follows for greening of hillocks through the integrated watershed management programme.

1. To bring changes in ecological variables such as land use, vegetative cover, soil moisture, augmenting groundwater and overall economics
2. To ensure the ecological balance to be continuous and sustainable in the long run even after the government support is withdrawn
3. To improve vegetation and soil through appropriate water conservation measures in cultivated and degraded lands
4. To bring maximum utilization of waste/unused land into productive, using technical/non- technical measures.
5. To establish the process of development through long term works implementation and its maintenance

Technical aspects of Greening of hillocks

Contour trenches are suitable in areas with 10-20% slope along the hillocks and hills. Moderate to less rainfall areas with maximum depth of the soils are best suited for construction of trenches. Detailed methodology was shown in Fig.1, Fig.2 and Fig.3.

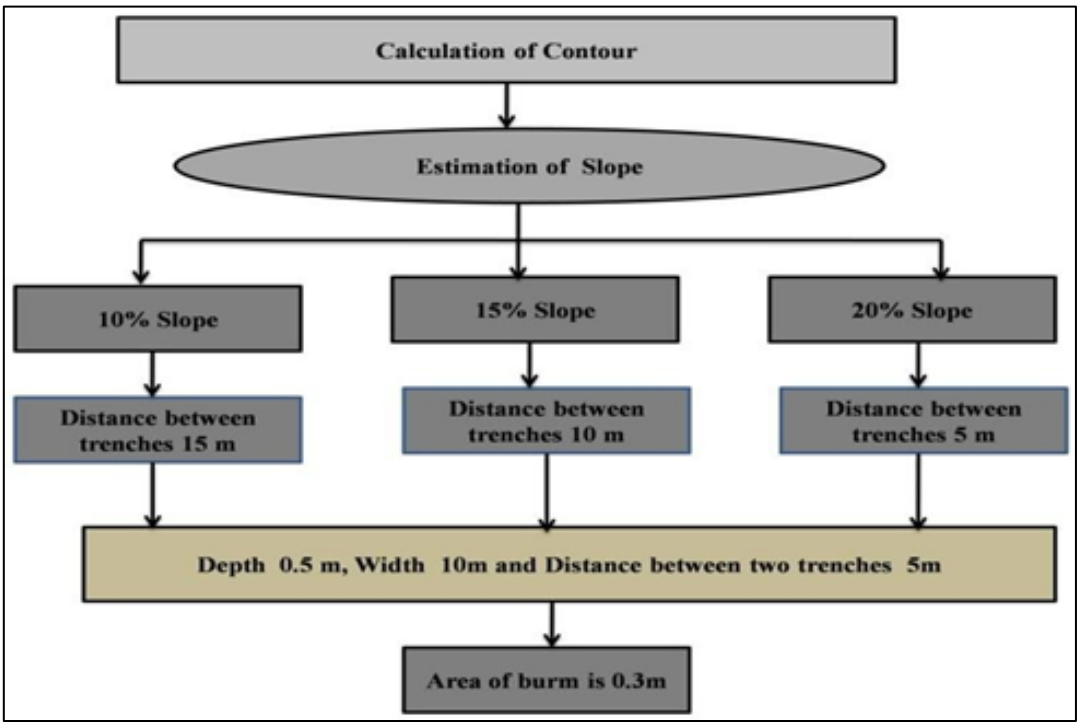

Fig 1: Show the depth of 0.5m, and 10m distance between two trenches

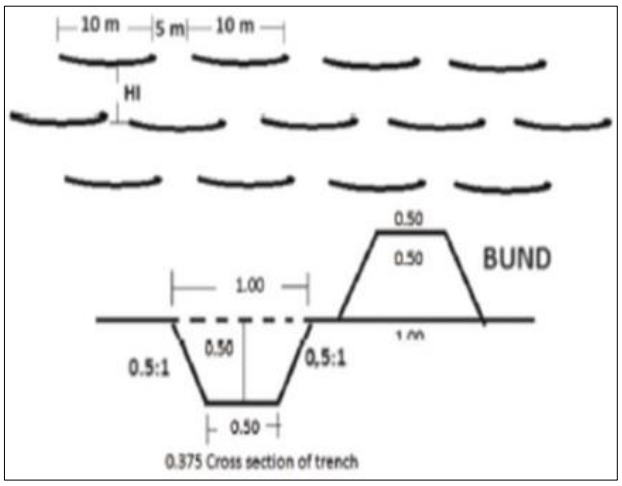

Fig 2: Trench with 0.5m Depth

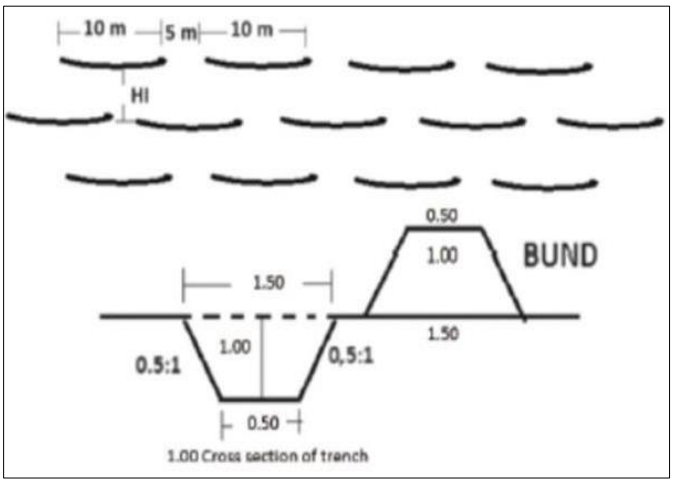

Fig.3: Trench with 1.0m Depth

Study Area

In the district, greening of hillocks activity is very innovative and implemented since Batch-II and the main objective is to improve vegetation and soil through appropriate water conservation measures in cultivated and degraded lands. During the period from Batch-II to Batch-V, totally 36 greening of hillocks were covered in 19 projects of 28 micro watersheds in an extent of 239.89 ha of land and spent an amount of Rs. 111.96 (Lakhs). Considering all the activities watershed program has initiated greening of hillocks in the district for batch-II to Batch IV projects.

Material and Methods

The entire data related to greening of hillocks collected from the DWMA –Kurnool and analyzed and presented batch wise in Table-1.

Results and Discussions

It is evident that the details of the works carried out during the study period for the greening of hillocks at WCC of Alur, Dhone and Nandyal of Kurnool district. Details of works are included as WCC, project site, micro-watershed area, sanctioned works in area extent (ha.), pitting and planting works implemented, total expenditure for hillock greening.

The total works approved for 12 hills covering 6 projects under 8 micro watersheds and the area covered by plantation was 135 ha. Subsequently, works such as pitting and planting were done in 12 hills covering 116.68 ha. out of 135 ha with an amount of Rs.67.84 Lakhs.

Among these, Gudipadu micro-watershed under WCC Dhone recorded the highest level of pitting implemented as per the sanctioned works in 3 hillocks in an area of 33.01 ha plantations with an amount of Rs 14.76 Lakhs including planting to an extent of 32.87 ha followed by Sarparajapuram micro-watershed in Dhone where the 3 hillocks were approved and 28.39 ha implemented. It is observed both pitting and plantation in 3 hill works were carried out to the extent of 23.03 ha. with the gross outlay of Rs 12.73 (lakhs). Overall, it shows successful implementation of works for works approved at the ground level in all the watersheds

Table 1: Greening of Hillocks works in Kurnool District during 2010-11- Batch-II

S. No	WCC	Project	Micro Watershed	Admin Sanctioned		Pitting		Planting		Expenditure
				Physical	Extent (Ha)	Physical	Extent (Ha)	Physic al	Extent (Ha)	In lakhs
1	Alur	Hathibelagal	Hattibelagal	1	15	1	12.49	1	12.45	8.4
2	Dhone	Gudipadu	Gudipadu	3	35	3	33.01	3	32.87	14.76
3		Laxmipuram	Bastipadu	1	10	1	10.01	1	9.82	4.54
4		Sarparajapuram	Sarparajapuram	3	30	3	28.39	3	23.03	12.73
5		Gorantla	Anugonda	1	10	1	8.01	1	8	6.61
6			Laddagiri	1	15	1	10.5	1	10.5	10.06
7	Nandyal	Bramhanakotkur	Allur	1	10	1	10.28	1	10.01	6.02
8			Damagatla	1	10	1	10	1	10	4.72
	Total			12	135	12	122.69	12	116.68	67.84

Table 2: Greening of Hillocks works in Kurnool District during 2011-12- Batch-III

S. No	WCC	Project	Micro Watershed	Admin Sanctioned		Pitting		Planting		Exp.
				Physical	Extent (Ha)	Physical	Extent (Ha)	Physical	Extent (Ha)	
1	Alur	H. Muravani	H.Muravani	1	10	1	4.45	1	4.45	1.71
2			Hanumapuram	1	10	1	8.02	1	8.02	4.08
3		Kadimetla	Kadimetla	2	20	2	16.66	2	15.91	4.89
4		Nagarur	Chigeli	1	10	1	4.3	1	4.29	1.78
5			Nagarur	1	10	1	4.04	1	3.98	1.21
6		Nerniki	Yellarthy	1	10	1	0.19	1	0.19	0.06
7	Dhone	Kambalapadu	Kambalapadu	1	10	1	8.18	1	4.55	2.62
8		Kappatrala	P.Kotakonda	1	10	1	8.63	1	8.63	4.75
9		Ulindakonda	Ulindakonda	2	25	1	6.91	1	6.91	1.29
10	Kolimi gundla (RAID S)	Thollamadugu	Abdullapuram	1	10	1	4.98	1	2.31	1.31
11			Chintalayapalle	1	10	1	8.12	1	5.83	2.3
12			Korumanupalli	2	20	2	14.03	2	11.4	4.93
13			Thollamadugu	2	20	2	11.03	2	11.03	4
	Total			17	175	16	99.54	16	87.5	34.93

The table-2 above shows the details of works implemented for greening of hillocks in WCCs at Alur, Dhone and Kolimigundla (RAIDS) of Kurnool district during the period of Batch-III. Details of works are comprised as WCC, project site, micro-watershed area, sanctioned works in the extent of area (ha.), pitting and planting works implemented, total expenditure for greening of hillocks. Totally 13 micro watersheds covered under 8 projects of Batch-III (H. Muravani, Kadimetla, Nagarur, Nerniki, Kambalapadu, Kappatrala, Ulindakonda and Thollamadugu).

The total works approved for 17 hillocks, in an area of 175 ha. for total pitting and planting activities with the overall expenditure of Rs. 34.93 (lakhs).

The next highest among these is the Thollamadugu micro-watershed of Kolimigundla, where 2 hillocks approved and planting and pittings were undertaken in an area of 11.03 ha each by spending around Rs 4 Lakhs. Overall, it shows successful implementation of all the sanctioned works for which it was approved in the district.

Table 3: Greening of Hillocks works in Kurnool District during 2012-13- Batch-IV

S. No	WCC	Project	Micro Watershed	Admin Sanctioned		Pitting		Planting		Exp.
				Physical	Extent (Ha)	Physical	Extent (Ha)	Physical	Extent (Ha)	Lakhs
1	Dhone	Chityala	Chityala	1	10	1	7.07	1	6.29	3.37
2		Itikala	Kolimigundla	1	10	1	10	1	10	2.67
3	Nallacheli mila(CYA)	Nallachelimila	Kukatikonda	1	10	1	10	1	10	5.47
4			Nelathalamarri	1	10	1	0.69	1	0.69	0.21
	Total			4	40	4	27.76	4	26.98	11.72

The table-3 explained the details of works implemented for greening of hillocks in WCCs Dhone and Nallachalimilla of Kurnool district for the batch –IV 2012-2013 comprised as WCC, project site, micro-watershed area, sanctioned works in the extent of area (ha.), pitting and planting works implemented, total expenditure for greening of hillocks. Totally 4 micro watershed covered 3 projects under Batch-IV (Chityala, Itikyala, Nallachelimila).

The total works have allowed 4 hillocks to cover the field in 40 ha with plantation. Total pitting works carried out over an area of 27.76 ha in 4 hillocks. The plantation operates in an area of 26.98 ha. with the total expenditure of Rs. 11.72 (lakhs).

Table 4: Greening of Hillocks works in Kurnool District During 2013-14 Batch-V

S. No	Project	Micro Watershed	Admin Sanctioned		Pitting		Planting		Staggered Trenches Extent (Ha)	Exp. in Lakhs
			Physical	Extent (Ha)	Physical	Extent (Ha)	Physical	Exte (Ha)		
1	Jaladurgam	Jaladurgam	1	10	1	2.95	0	0	10	0.3
2		Utakonda	1	20	1	0.57	0	0	30	0.05
3	Kommemarri	Kommemarri	1	20	1	5.37	1	3	9	0.85
4		Nereducherla	1	25	1	6.77	1	5.53	10	1.27
	Total		4	75	4	15.66	2	8.53	59	2.47

The table-4 indicates the details of works implemented for greening of hillocks for Batch-V (2013014), which have 4 micro watersheds covered for greening of hillocks from 2 projects (Jaladurgam and Kommemarri) for Pitting (15.66 ha), planting (8.53ha) and staggered trenching works in 59 ha. to a total expenditure of Rs 2.47 (lakhs). All the greening works have been completed or near completion in the study area with the help of the staff of WCC and PIA for which the farmer have expressed their satisfaction for the works carried out.

Overall Abstract of Greening of Hillock work in Kurnool district

During the period of from Batch-II to Batch-V, totally 36 greening of hillocks were covered in 19 projects belonging to 28 micro watersheds in an area of 239.89 ha of land and spent an amount of Rs. 111.96 (Lakhs).

Table 5: Overall Abstract of Greening of Hillock work in Kurnool District

Name of the Batch	Projects	MWS	Total hillocks	Total Ha covered	Expenditure
2010-11 (Batch-II)	6	8	12	116.68	67.84
2011-12 (Batch-III)	8	12	16	87.7	35.93
2012-13(Batch-IV)	3	4	4	26.98	11.72
2013-14(Batch-V)	2	4	4	8.53	2.47
Total	19	28	36	239.89	117.96

Impact of the Greening of Hillocks

Since greening of hills has been implemented, good results such as soil improvement, soil water improvement, controlled soil erosion and land cover change etc. are observed and reported, the results are discussed here under.

Soil Improvement

Moderately shallow dark yellowish-brown gravelly sandy loam soils. Well-drained, that gives information about soil porosity and high permeability. These soils are severely subjected to soil erosion and neutral pH. Sandy loam soils contain 60% sand, 10% clay and 30% silt particles.

They have high draining water ability but cannot with hold enough amounts of water and nutrients for plants. The vegetation grown in such soils needs a frequent supply of water and fertilizers. They often show macronutrient deficiency hence require additional organic fertilization to support healthy growth.

Ground Water Improvement

Trenches have helped to retain water and allow percolation into deeper layers. Before project (2012-13) groundwater near the bottom of the hillock was 420 to 450 feet. After project (2016-17) GW is available at level 90 to 150 feet. 8 gabion structures were developed to store runoff water, which helped new bore wells to bring rock bearing soils into cultivable land.

Soil Erosion Control

Soil erosion is one of the most predominant problems in this area because of over-exploitation of vegetation over this hillock. The local native species and highly elevated plants with dense root system have been eliminated in the past due to improper management. Non-local plants which have come from another place i.e. invasive plants have been occupied this area. These plants don't have a significant impact on soil, water and environment and have little ecological and economic importance. All these factors together, have resulted in depletion of water holding capacity, soil moisture, groundwater recharge and a higher rate of runoff volumes.

After project initiation, trenches on hillocks accompanied by drought-resistant and fruit bearing plants on the soil bunds have improved water percolation into the ground. Groundwater levels near that area have shown great improvement. Before the project, higher volumes of runoff was the common phenomena with soil thoroughly mixed with water until the bottom of the hillock and forming a layer of sand/soil on the existing land. As water (surface and subsurface) has improved, the local landowners have removed the existing boulders, rocks and sediment from the top layer to begin cultivation. The runoff water is also diverted into trenches, to farm ponds and percolation tanks which were built along the drainage line.

Land Cover Change

Lands near study area were filled with gravel/big rocks and wastelands occupied with shrub plants. Using machines this hard soil was removed and levelled into farmland. To increase fruit orchards and drought-prone plants, maintenance of soil moisture has immense impact. Sixty acres of barren area has brought under cultivation with groundnut, tomato, chilly, cucumber, sweet lemon, mango plantation. Another 35 acres of land is now being cultivated with maize, groundnut, castor, lentils and horse gram. Lentils are grown as an intercrop between mango plants during Kharif season. Mango plantation was taken in another 15 acres due to water resource availability.

Increased Number of Crops

Barren hillocks have been treated through plantation techniques and soil moisture conservation measures. Multiple activities such as constructing trenches, tree plantation, creation of watershed development infrastructure etc were carried out. Most of the newly developed cultivated area is now used for one or two crops and horticulture cultivation. Table.5. Fruiting begins after 3- 4 years after planting trees in horticulture. As a source of economy inter cropping with pulses and lentils is carried out two to three times a year.

Results and Conclusion

Natural resource management is achieved by improving unused/barren land into the green cover through the convergence of IWMP and NREGA in the present study area.

Technical knowledge was provided by IWMP and funding was sponsored by NREGA. After the hillock was greened, the ground water levels in the zone of influence were increased. Better plant growth can be ensured with uniform availability and distribution of soil moisture around the active root zone. On the hillock fruit plants like custard apple and fodder plantation for animals was planted. Trenches and greening helped to recharge ground water depth in the lower areas. This has helped some of the land owners to grow mango plantation and groundnut crop along with lentil as intercrop.

Post plantation care was being taken by Vanamitra, appointed by the watershed committee. Towards water supply an amount of Rs. 3,00,000 was released. Water was supplied 26 times in a year. Natural vermi-compost was supplied as bio manure which acts as a nutrient supplement. Twice a year mulching and weed removal was practiced to make sure that proper intake of nutrients by the plants. In spite of, all efforts a few plants die because of hard conditions of the soil. These plants should be replaced by new plants thus maintaining a maximum number of plants. Around this area, fencing is arranged to protect plants from grazing of animals. Generally, animals graze upon small bushes, shrubs, and the grass grows in this area. After taking care of the greening program, fodder/grass is grown in another half part of the hillock where animals can go for grazing.

During rainy season sufficient water is stored in trenches, keeping the soil moisture accessible to the plants. High temperatures are another familiar problem during the summer season. Fire tracing is accomplished by removing dry plants and leaves. The improvement in land covers is visible in five years after the plantation. It generated employment and income.

The Kurnool IWMP programme has been implemented greening of hillocks programme in batch-II to Batch V projects and totally implemented 19 projects 28 micro watersheds which covered 239.89.area of Ha of land after spending an anount of Rs. 111.96. The greening of hillocks activity resulted in increase vegetation cover on the hillock area with more than 80% survival of the plants. The selection of local species of the plants such as neem, custard apple and woody plant seedlings are planted on the mounds of dug staggered trenches along the slope following the principle of ridge to valley. It is also found that soil erosion controlled, ground water level increased subsequently helped in the increase of crop yield which helped the farmers to gain the more income through the crops. Overall, the farmers and watershed community were pleased with the greening of hillocks that brought back the village's former glory.



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