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RESEARCH ARTICLE OPEN ACCESS

Watershed Management and Rainwater Harvesting using QGIS at Rajgoli (Bk), Chandgad. – Case Study

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ABSTRACT
M/S KWALITY ANIMAL FEEDS PVT. LTD. was established in 1983 and began its operations in 1985 with an objective of providing quality feed for poultry with a nutritionally balanced diet and an assured performance. Kwality house is into the business of animal Feed, live chicken and processed chicken and is presently, a well-known and well-accepted brand. Today, the company is one of the leading companies in North Karnataka.
As we know, to provide solution to any problem it is very important to have required data in hands. Thus, collection of data was done by discussion with the workers in the factory. Frequent visits to the site allowed me to gain the onsite practicality. After collection of data the further important thing is to know the problem, they where they facing the shortage of ground water and problems arising due to it from soil excavation purpose in nearby area.
Despite of Heavy Rains in monsoon season, the ground water level is decreased, which is due to lack of water conservation and storage techniques. The industry near this area M/S Kwality Animal Feeds also face the problem of water shortage as by reduction in ground water which ultimately caused them with 5 borewells out of 7 are empty. This study aims to cater the water scarcity and improvement in ground water level by implementing watershed management practices.
Our case study is based on area Rajgoli Budruk in taluka Chandgad, dist. Kolhapur where they face the shortage of ground water and problems arising due to it from soil excavation purpose in nearby area. Despite of Heavy Rains in monsoon season, the ground water level is decreased, which is due to lack of water conservation and storage techniques. The industry near this area M/S Kwality Animal Feeds also face the problem of water shortage as by reduction in ground water which ultimately caused them with 5 borewells out of 7 are empty. This study aims to cater the water scarcity and improvement in ground water level by implementing watershed management practices.

Index Terms— Rainwater Harvesting, Continuous Contour Trenches, Water scarcity, Watershed Management.

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I. INTRODUCTION

As the world faces an increasing critical need to address climate change, the impact that water conservation has on a sustainable environment in undeniable. Groundwater is the primary source of freshwater that caters to the demand of ever-growing domestic, agrarian and industrial sectors of the country. Over the years, it has been observed that the necessity for the exploitation of groundwater resources for various everyday needs, like toileting, bathing, cleaning, agriculture, and drinking water, industrial and ever-changing lifestyles with modernization is leading towards tremendous water wastage. Though many technological devices are being developed to minimize the water wastage, the impact will be greater if every individual contributes to water conservation by minimizing or optimizing groundwater usage for daily activities. Today, water conservation at individual level has become very critical. Our water resources are depleting each year. Additionally, we cannot generate artificial water and must depend on water sources available on our planet earth. Due to population boom and excessive need of water to suit our ever-expanding modern lifestyle, water scarcity is felt all over the world. This has given rise to major concerns over water conservation. Adopting rainwater harvesting and recharging groundwater is one of the simplest and best measures in conserving water globally. This practice can efficiently be implemented in lieu of traditional water supplies that are currently on the verge of tapping out. And these are the most efficient and low-cost techniques.

1.1 Introductions to kwality animals feeds

M/S Kwality Animal Feeds pvt. ltd. Pvt Ltd., was established in 1983 and began its operations in 1985 with an objective of providing quality feed for poultry with a nutritionally balanced diet and an assured performance. Kwality house is into the business of animal Feed, live chicken and processed chicken and is presently, a well-known and well-accepted brand. Today, the company is one of the leading companies in North Karnataka.

Figure No. 1- Total industry premises of kwality animal feeds

1.2 Rainwater harvesting

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops. It is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to runoff. Rainwater can be collected from surface runoffs or roofs. Rainwater harvesting technologies are simple to install and operate. Local people can be easily trained to implement such technologies, and construction materials are also readily available. Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device and the conveyance system. Rainwater harvesting is an important environment friendly approach. Its uses include water for domestic use, irrigation purpose, industrial uses etc. The harvested water can also be used as drinking water, longer-term storage and for other purposes such as groundwater recharge.

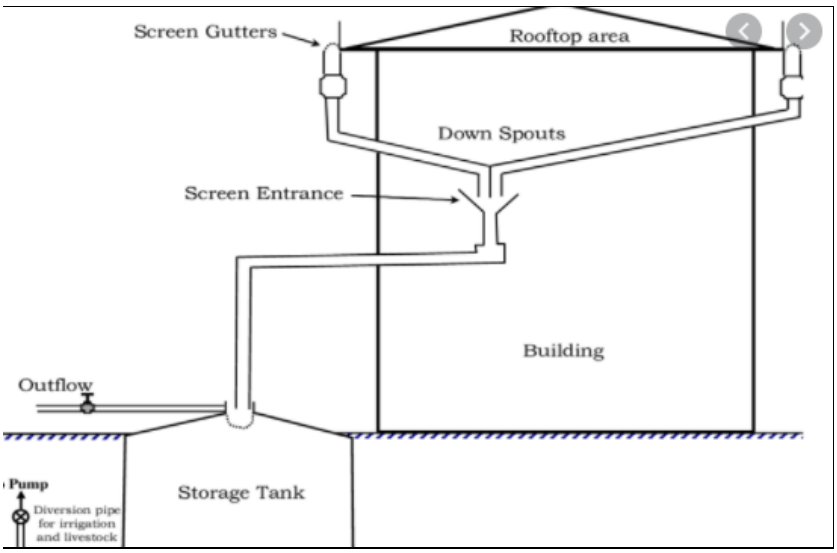


Figure No.2- Rainwater harvesting

1.3 Watershed

A watershed is an area of a land, such as mountain or valley which collects rainwater into common outlet such as river, lake or reservoir. It is an area where the water from rainfall is drained to a common point. A watershed is defined as any surface from a few hectares to several thousands of square kilometers in which rainfall is collected and conveyed to a common natural waterway. Watershed is geo-hydrological draining run-off

water at a common point and it could be demarcated based on ridge and gully lines. When rain falls on the mountains, it flows down through small streams. Many such streams join to form bigger streams, which turn join to form rivulets, which join to form rivers and so on. The entire area which supplies water to a stream or rivulet or a river at a particular point in its flow is called the watershed or catchment area or drainage basin of that particular point. The top of the watershed is called hill or ridge portion. The ridge-line partitions one watershed from another, or can be said to be the boundary of the watershed. All the droplets of rain within the watershed will flow from ridge portion through different drainage lines to the valley portion of the watershed and will be drained out of the watershed through a common exit point

1.4 Continuous contour trenches

A Continuous Contour Trench is dug at a right angle to the slope which helps in retaining soil moisture and water conservation. A structure that reduces soil erosion and implements good amount of recharge of ground water Continuous contour trenches are planned along contour lines so that water flowing downhill is stopped in its tracks by the trenches. The excavated soil after the digging is used to build contour bunds after trench. Plant some small plants on bunds which soak small amount of water, it will help trap the sediments that will overflow due to heavy rainfall. Contour bunds will stabilize the soil around trenches.

Figure No.3 - Continuous contour trenches

1.5 Contour bunds

From the Excavated soil of trench, construct a contour bund right below the trench. Bunds provide additional help to obstruct water and silt. Construct stone pitching on the either end of the bunds. Plant saplings, seeds, and grasses on the top face of the bund which requires less water, so that this will additionally help in catching water and silt. Contour bunds are bunds constructed along the contour lines. They are usually made of stones or soil (sometimes in variation with crop remains). They are constructed along a contour in order to best slow the water flowing down the slope, which increases the green water pool of the soil and prevents erosion.

Figure No.4 – Contour bunding

II. DISCUSSION

- The project has two main components which are: -

1. Rainwater harvesting
2. Watershed management

- Further we will discuss about these 2 points in detail: -

2) Rainwater harvesting: -

1. Definition: -

i) Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops.

ii) Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to runoff. Rainwater can be collected from surface runoffs or roofs.

iii) Rainwater harvesting technologies are simple to install and operate.

iv) Local people can be easily trained to implement such technologies, and construction materials are also readily available.

v) Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device and the conveyance system.

vi) Rainwater harvesting is an important environment friendly approach.

vii) Its uses include water for domestic use, irrigation purpose, industrial uses etc.

viii) The harvested water can also be used as drinking water, longer-term storage and for other purposes such as groundwater recharge.

2. Need for Rainwater Harvesting System: -

i) The rapid rise in human population has made optimum use of fresh water imperative.

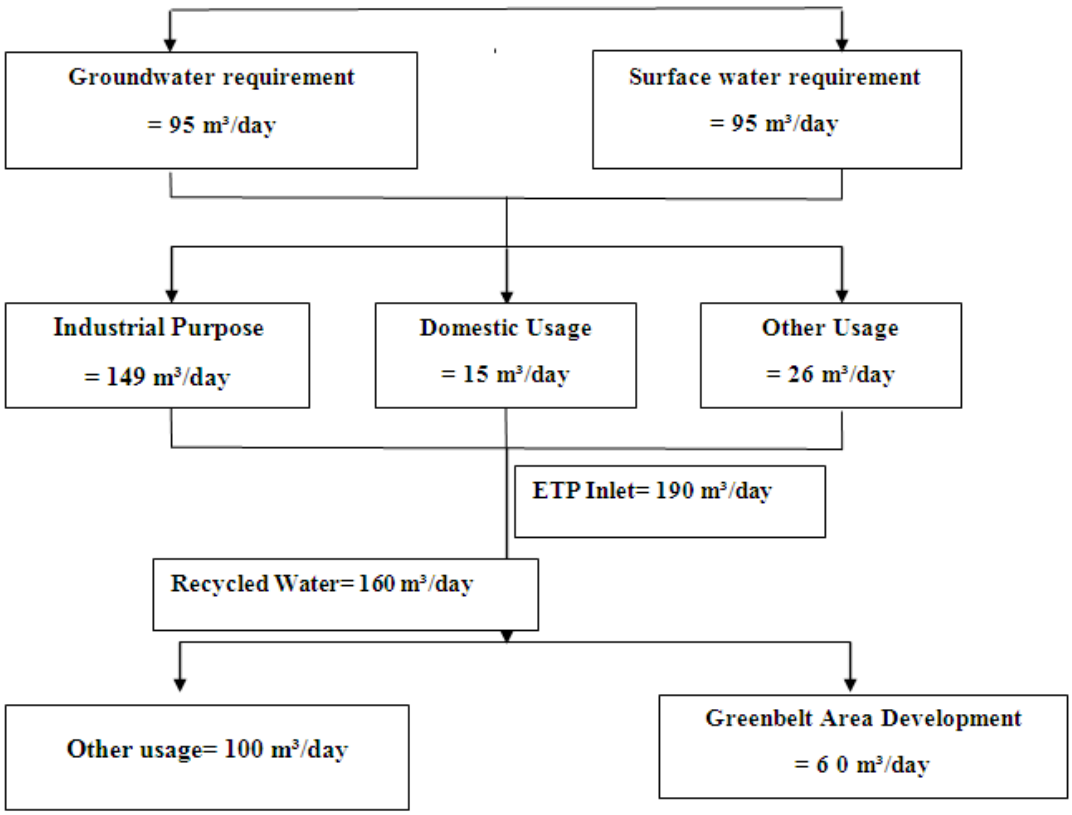
ii) Urban water supply systems in particular are under tremendous pressure to meet the needs of the population as well as industry and large-scale construction.

iii) The increased need for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail.

iv) Consumption of polluted water is beset with health hazards.

v) The use of rainwater is a useful alternative

3. Water Balance Diagram of 350m³/Day



4. Breakup of water requirement and usage: -

Activity	Existing requirement (m3/day)	Total requirement (m3/day)	No. of operational days in a year	Annual requirement (m3/year)
Industrial Purpose	149	149	300	44700
Domestic Purpose	15	15	300	4500
Green Area Development	60	60	300	18000
Other use	126	126	300	378000
Grand total	**350**	**350**	**300**	**105000**

5. Rooftop Rain Water Harvesting

Total Rooftop Area	**5924.22 m^2**
Average Rainfall	1400 mm = 1.4 m (Year 2020)
Catchment factor for Roof top	0.85 (as per CGWB)
Total Runoff from rooftop	5924.22 x 1.4 x 0.85 = 7049.82 m^3 /Annum

Figure No 8. Rainwater harvesting

3) **Watershed Management: -**

1. Watershed management system: -

i) A watershed is an area of a land, such as mountain or valley which collects rainwater into common outlet such as river, lake or reservoir.

ii) It is an area where the water from rainfall is drained to a common point.

iii) A watershed is defined as any surface from a few hectares to several thousands of square kilometers in which rainfall is collected and conveyed to a common natural waterway.

iv) Watershed is a geo-hydrological draining run-off water at a common point and it could be demarcated based on ridge and gully lines.

2. Importance of watershed management: -

i) Management of the environment has been primarily focused on specific issues such as air, land, water

ii) Most efforts have resulted in decreasing pollutant emissions to air and water, improved landfills, remediation of waste sites, contaminated ground water, protection of rare and endangered species, design of best management practices to control water and contaminant runoff.

- Following is the method used for watershed management: -

3. Continuous Contour Trenches: -

i) A Continuous Contour Trench is dug at a right angle to the slope which helps in retaining soil moisture and water conservation.
ii) A structure that reduces soil erosion and implements good amount of recharge of ground water
iii) Continuous contour trenches are planned along contour lines so that water flowing downhill is stopped in its tracks by the trenches.
iv) The excavated soil after the digging is used to build contour bunds after trench.
v) Plant some small plants on bunds which soak small amount of water, it will help trap the sediments that will overflow due to heavy rainfall.
vi) Contour bunds will stabilize the soil around trenches
vii) Advantage
(a) Applicable to all soil and rainfall conditions.
(b) Prevents soil erosion and degradation.
(c) Enhances surface water infiltration and soil moisture.
(d) Simple structure, requiring only basic construction material.
viii) Disadvantage
(a) Regular maintenance is required.
4. Contour Bund
i) From the Excavated soil of trench, construct a contour bund right below the trench.
ii) Bunds provide additional help to obstruct water and silt.
iii) Construct stone pitching on the either end of the bunds.
iv) Plant saplings, seeds, grasses on the top face of the bund which requires less water, so that this will additionally help in catching water and silt

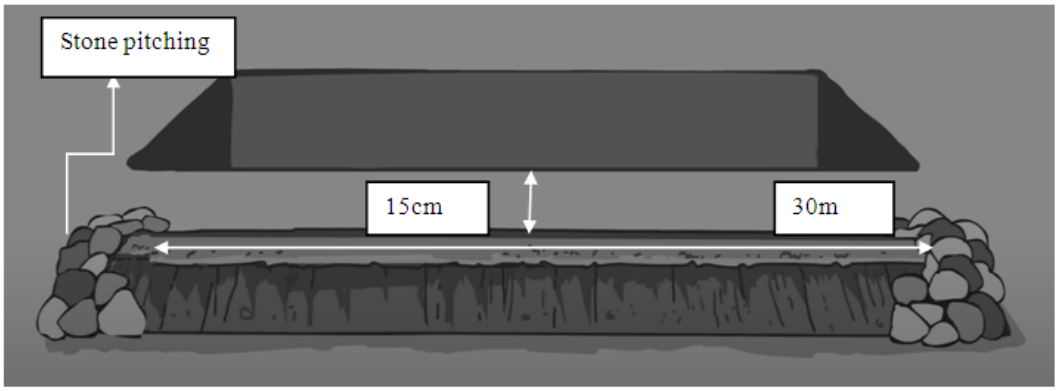


Figure No 9. Contour trenches with stone pitching

- Contour Bund Measurements: -

Distance between trench and bund(berm)- 15 cm
Length of Bund- 30 m (same as that of trench)

Scientific approach: -
These are the few methods we learned and implemented in our project
Methodology: -

- Rainwater harvesting:

1. Calculation of total runoff of the industry premises.
2. Construction of rainwater harvesting storage system.

- Watershed management:

1. Construction of watershed management practices by the technique Continuous Contour Trenches (CCT's).
2. Components used
(a) Google Earth Pro
(b) QGIS
(c) Rainfall calculation (hilly area)
(d) Continuous Contour Trenches

- Construction of rainwater harvesting tank:

i) We have done the proposal of rainwater harvesting tank (underground)as an environmental engineer.
ii) Total storage requirement :60m^3
iii) We have provided 4 tanks of 15m^3 and following are the calculations for tanks.
iv) EXCAVATION:
v) Total excavation = 4×3.1×2.3 = **28.52 cu.m.**
vi) Overall Excavation:

Concrete Quantity	No. of Walls	Length	Width	Height	Quantity
Long wall	2	3.6	0.3	2	4.33 cu.m
Short wall	2	2.5	0.3	2	3 cu.m
Slab	2	4	3.1	0.3	7.44 cu.m
Total Quantity					14.76 cu.m

- **STEEL Quantity:**

It is 1% of overall Qty. of concrete = 1100 × 14.76 = 0.1476 cu.m.
= 0.1476×78.59 (Quintal per cu.m)
= 11.58 Quintal
= 1158 Kg

Total Estimation:

FOR 1 RAINWATER TANK TOTAL ESTIMATION = 144080
WE PROVIDE SUCH 4 RANK SO TOTAJ EATIMTION = 576320

Description	Quantity	Rate	Cost
Excavation	28.52 cu.m	175	4991
Concrete	14.76 cu.m	5500	81180
Steel	1158 Kg	50	57900
Total Estimation:			144080

- Pipe Estimation: -

1. Following is the total pipe estimation required from building to tank.
2. Total Distance = 350 m
3. Pipe material: PVC
4. Diameter = 4 inch
5. Costing of 1 pipe (6 m) = 850
6. Total Pipe costing: Rs 46,700

Figure No 10. Pipeline System

- M/S Kwality Animal Feeds Pvt. ltd. is an industry, in Rajgoli, Taluka Chandgad, District Kolhapur.

a) Latitude: 16.0103
b) Longitude: 74.4473
c) Average annual rainfall: 1400 mm (IN 2020)
d) Soil Type: Laterite soil
e) Color of Soil: Brownish to Reddish
f) Total Area: 3842013.82 m²
g) Greenbelt area: 3748843.86 m²
h) Open area (hilly area): 93169.96 m²

Figure No 11. Georeferenced image

- Google Earth Pro

1. Tracking the Location (for ex. Kwality Animals Feeds, Rajgoli (Bk), Chandgad, Kolhapur.)
2. Selection of required area.
3. Calculating the selected area.
4. Drawing Contour lines with tool **New Path.**

Figure No 12. Tracking and selection of Industry area

- QGIS

1. Transferring .kml file from Google earth pro to TCX convertor.
2. Importing .csv file to QGis Software.

3. Converting to DEM (Digital Elevation Model) file.
4. Generating contour intervals of 2m,4m.

Figure No 13. Contour Points

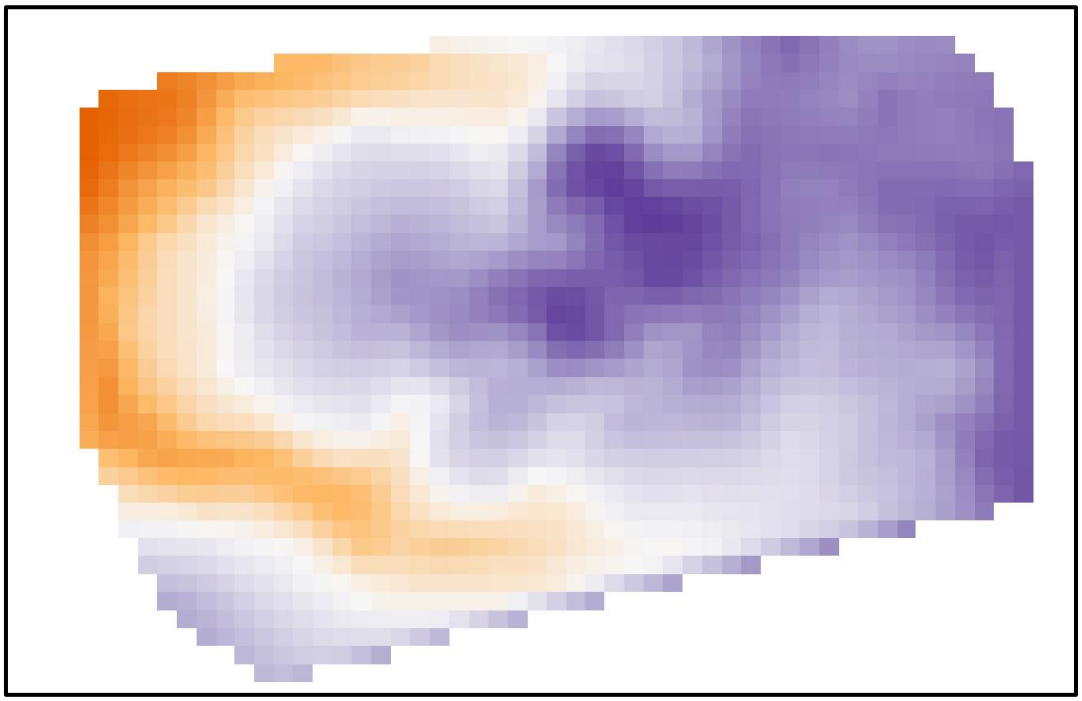


Figure No 14. 2D DEM file

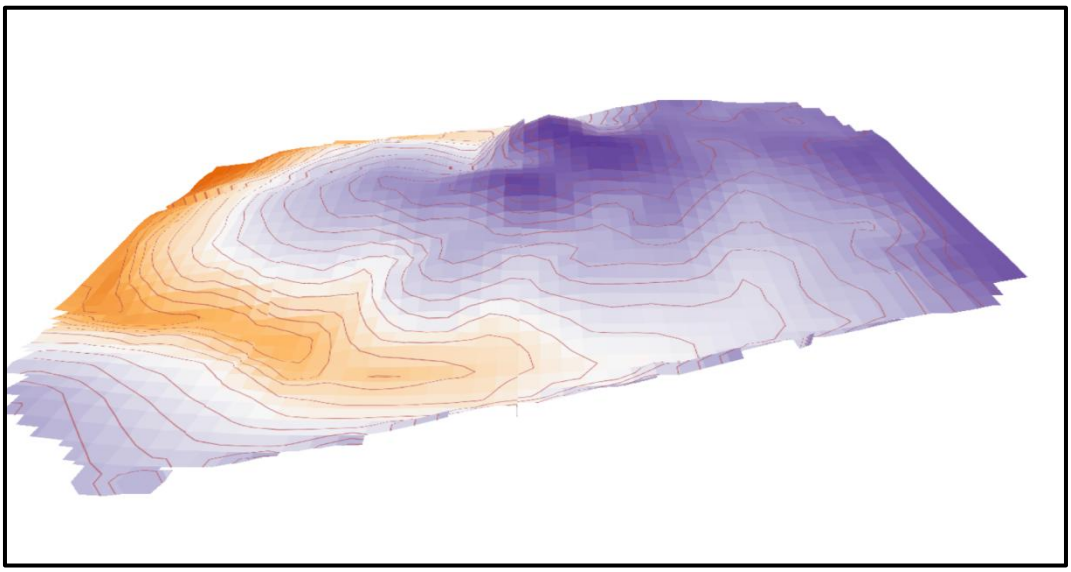
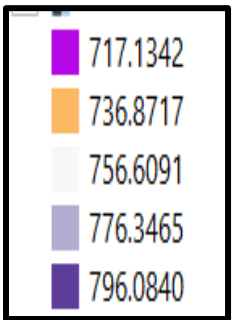


Figure No 15.3D DEM file



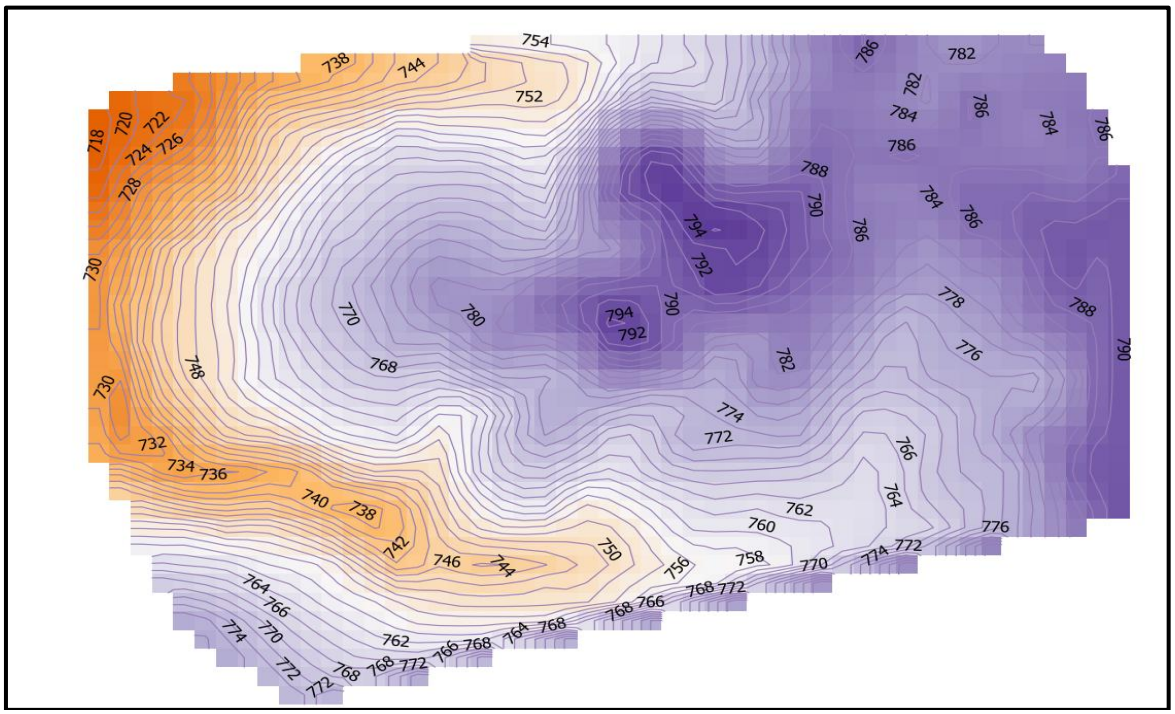


Figure No 16 Contour Interval: 2m

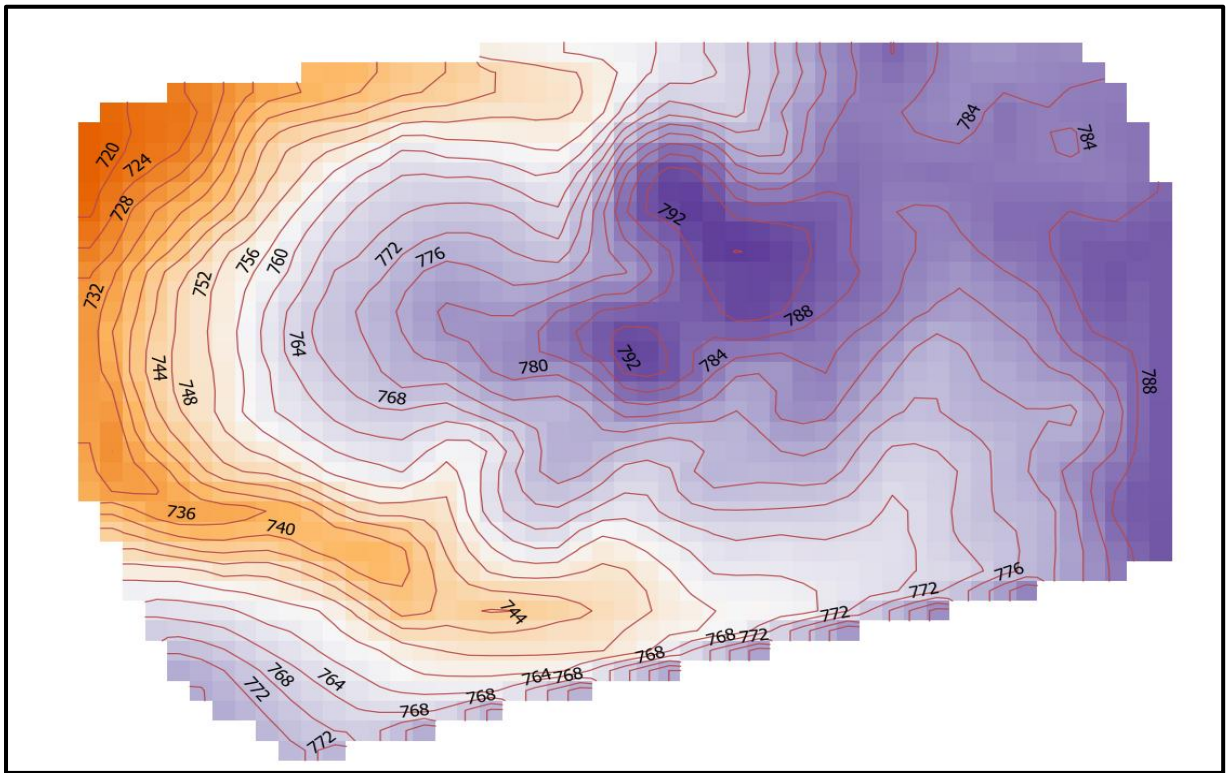


Figure No 17. Contour Interval: 4m

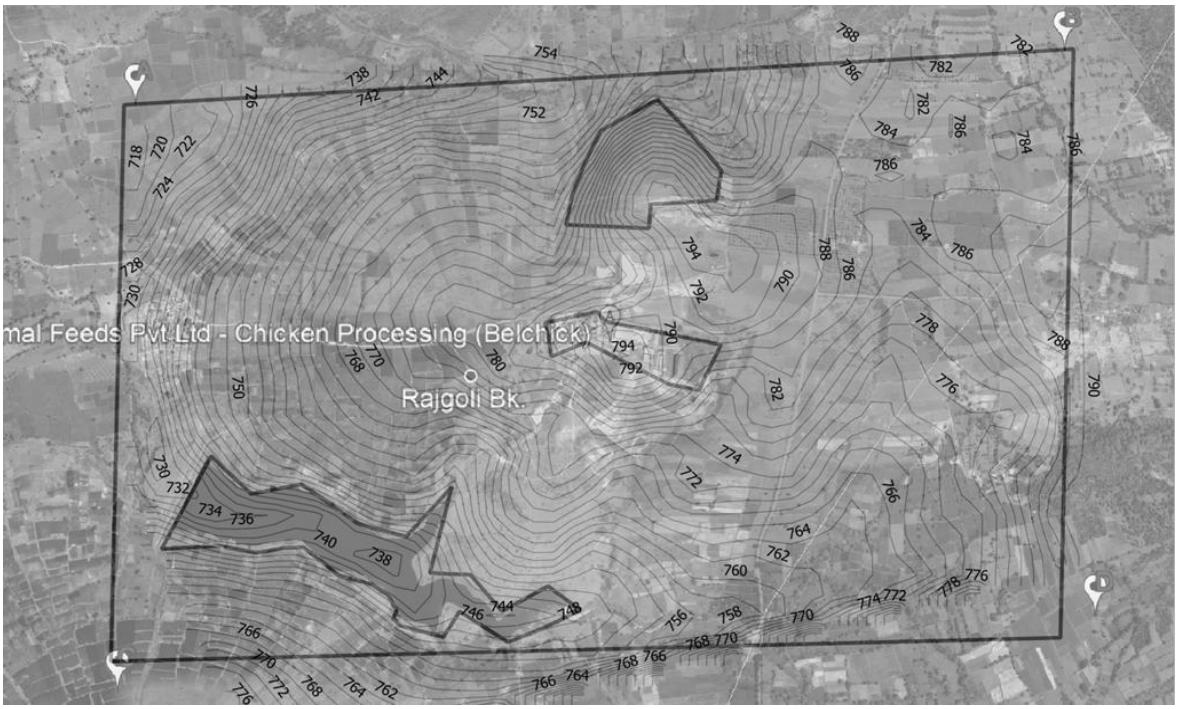


Figure No 18. Geo reference image overlapped with contour points

Results/observations/work experiences: -

1. Runoff Calculation (Hilly area): -

i) Rainfall intensity (Rajgoli bk, Chandgad)- 1.4m=1400mm

ii) Runoff (Hill area) = Area (in m²) * Rainfall(m) *(1-Runoff coefficient)
= 93169.96 * 1.4 * (1-0.20)

=104350.35 m^3/yr.
= 869.58 m^3/day
or
= 8,69,586.29 lit/day

Figure No 19. Catchment Area (hilly area)

- Method: Continuous Contour Trenches: -

CCT's are provided across the slope so that maximum water is recharged

Slope	Distance
0-4%	10m
4-8%	8m
8-15%	6m
15-33%	4m

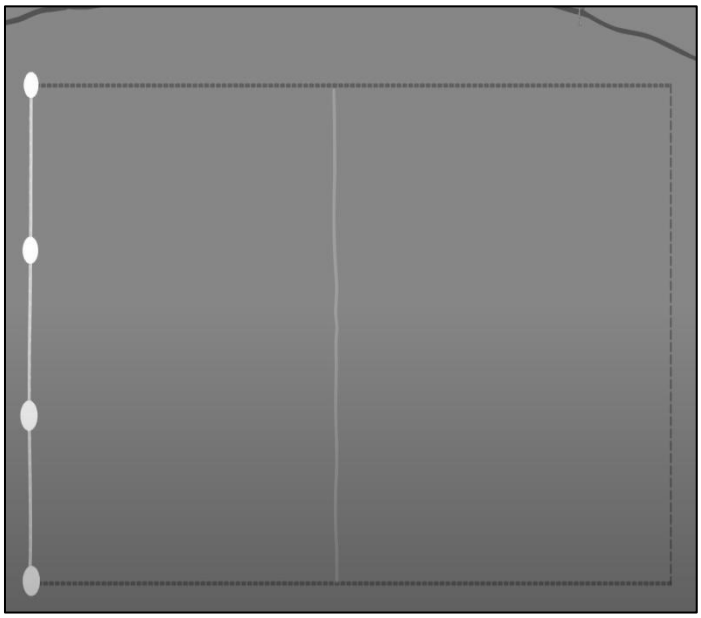


Figure No 20. Contour Points as per slope

- Area Marking

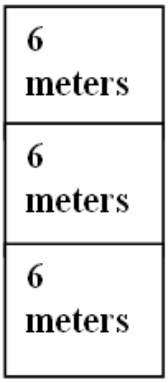


Figure No 21. Area marking

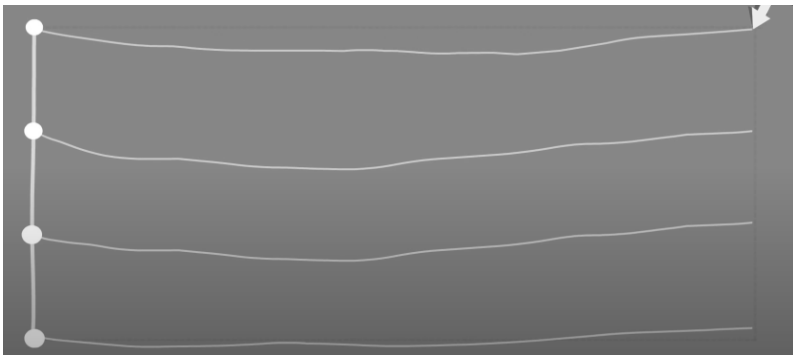


Figure No 22. Contour Lines with 6 m distance

- Construction of the trenches

Slope	Distance
0-4%	100m
4-8%	50m
8-15%	30m
15-33%	20m

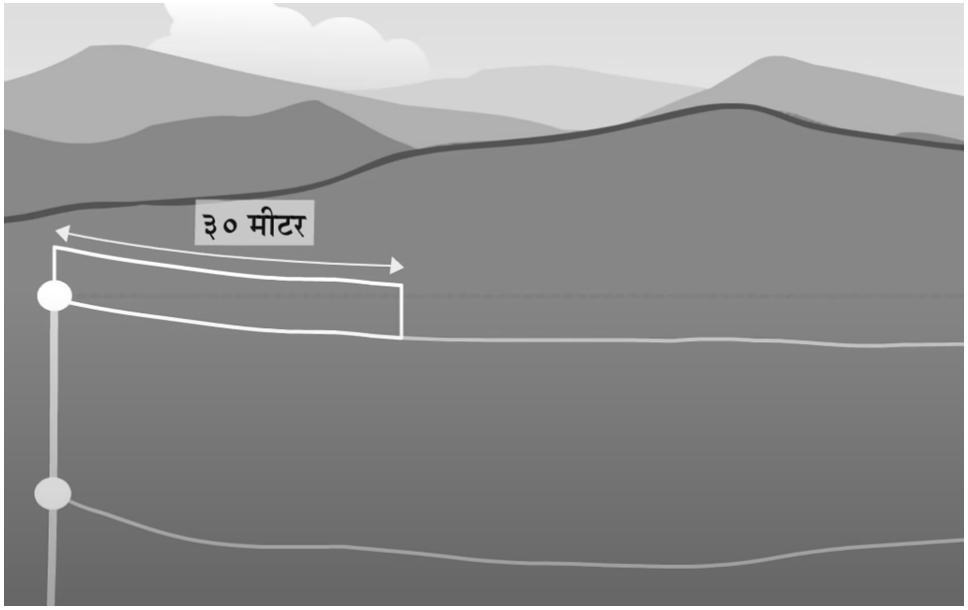


Figure No 23. Length of Trench

- The Structure

a) Trenches: Length- 30 m (As the slope is between 8 to 15%)
Width- 60 cm
Depth- 45 cm
Distance between each trench- 3 m

b) NOTE: In the 2nd contour line and so on alternatively, the initial trench should be of 15 m.

- Trench Measurements

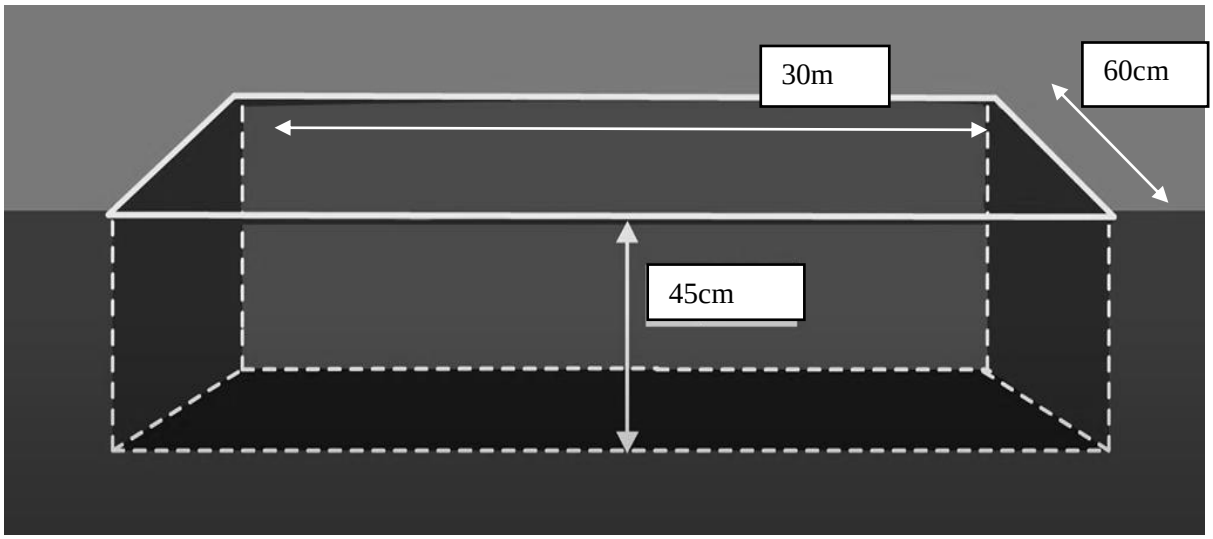


Figure No 24. Trench measurements

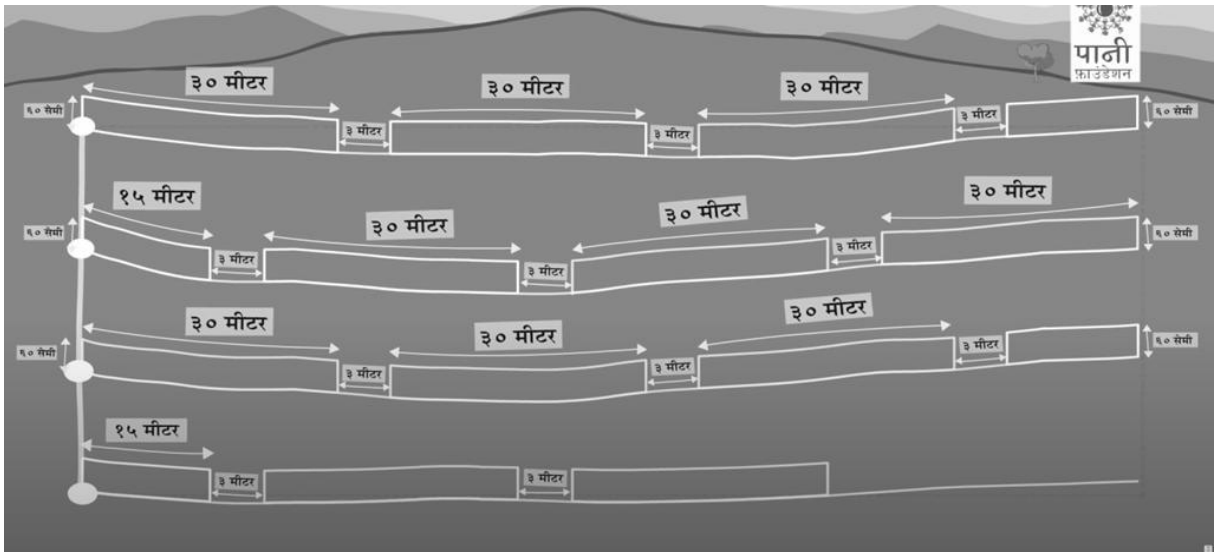


Figure No 25. Arrangement of CCT's

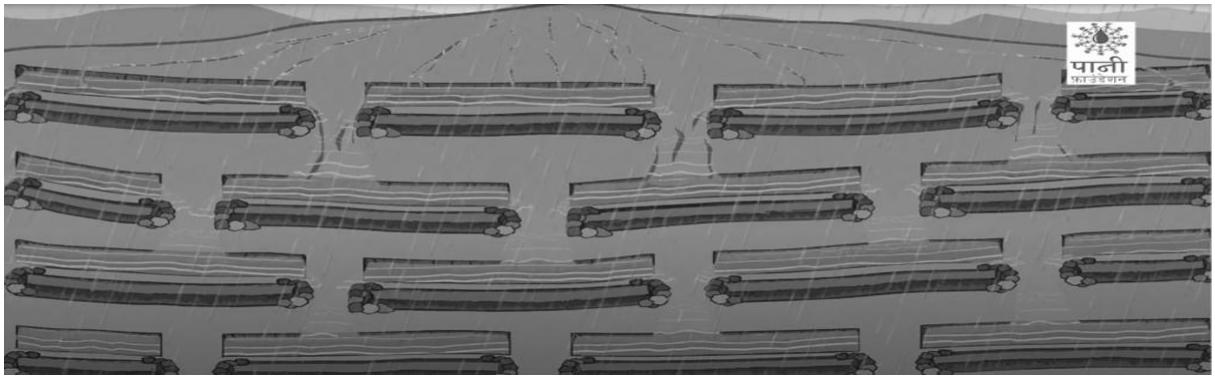


Figure No.26 The structure of trenches

- Contour Bund

(a) Catchment Area: -
(b) Total catchment area- 93169.96 m²
(c) Sub catchment 1 area- 24480 m²
(d) Slope of Sub catchment 1 area- 11.7%
(e) Sub catchment 2 area- 14596 m²
(f) Slope of Sub catchment 2 area- 9.5%

- Sub catchment 1: -

i) Area- 24480 m²
ii) Slope - 11.7%
iii) Size- L- 30m
W- 60 cm
D- 45cm

Calculations:
1 trench- 30 m with 3 m gap
Total horizontal length – 272 m
Total vertical length – 90 m
Total trenches in horizontal contour line = 272/33
= **8** (approximately)
∴ Total trenches required = 8*15 = 120

- Sub catchment 2: -

i) Area- 14596 m²
ii) Slope – 9.5 %
iii) Size- L- 30m
W- 60 cm
D- 45cm

Calculations:
1 trench- 30 m with 3 m gap
Total horizontal length – 178 m
Total vertical length – 82 m
Total trenches in horizontal contour line = 178/33
= 6 (approximately)

∴ Total trenches required = 6*13 = 78

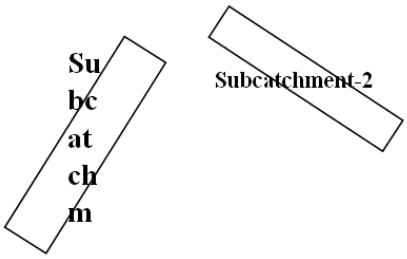


Figure No 27. Total Catchment Area

- Storage and Recharge capacity: -

i) The storage capacity of One Trench is approximately up to 8,100 lit in about 1 rain.
ii) Total water storage in 198 trenches (120+78) (sub catchment 1 + 2) Is approximately up to 16 lakh and 3 thousand lit in about 1 rain.

- Costing: -

i) Total no. of Labors required- 20 persons
ii) Working- 8hrs a day
iii) 1 trench requires up to approximately 2 hrs.
iv) 1 labor will construct 3 trenches a day
v) 20 labors will construct 60 trenches a day
vi) For 198 trenches: It requires 4 days with 20 labors in 8 hrs. per day
vii) Cost of a labor per day- Rs-500
Total cost for 4 days of 198 trenches = Rs 40,000/- (approximately).

Challenges faced: -
Factors affecting watershed management
- Watershed Characteristic
1. Size and shape
2. Topography
3. Soils
- Climatic Characteristic
1. Precipitation
2. Amount and intensity of rainfall
- Watershed operation
- Social status of inability
- Water resource and their capabilities.
- Watershed management practices
1. Interns of purpose
2. To increase infiltration
3. To increase water holding capacity
4. To prevent soil erosion
- In brief various control measures are
1. Vegetative Measures (Agronomical measures)
(i) Grass land farming
(ii) Wood lands.
2. Engineering Measures (Structural practices)
(i) Contour bunding
(ii) Construction of diversion
(iii) Establishment of permanent grass and vegetation
(iv) Providing vegetative and stone barriers
Influence of soil conservation measures and vegetation cover on erosion, Runoff and Nutrient loss.

III. CONCLUSION

From this project following points can be drawn: -
1. Due to construction of rainwater harvesting system,50% rebate on abstraction charges from CGWA.
2. The management of watershed management provides a means to achieve sustainable land and water management.
3. Rajgoli (Bk), Chandgad area consists annual rainfall of 1400mm, which is a good amount of rainfall, still there is scarcity of water due to lack of water storage and recharging.
4. As the water level is below due to soil excavation, it is necessary to develop a watershed management.
5. Implementing of watershed management by the technique of Continuous Contour Trenches (CCT's) will lead to huge amount of water storage and recharge.
6. The total storage capacity of 198 CCT's is 16,03,000 lit in about 1 rain.
7. As per standards, the ground water recharge will show its impact within 1 year.
8. Regular maintenance of the CCT's is necessary.
9. Permission was granted for the NOC of groundwater abstraction from Central Ground Water Authority (CGWA).

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[4]. YouTube video on Contour Bunds by IIT Kharagpur. (https://youtu.be/d_Xe42J9BFk)