

Watershed Management for Ingrul village in Sangli District, Maharashtra by using GIS



Snehal S. Patil, Deepali R. Kulkarni, Padmasinh D. Patil.

Abstract: Watershed is land surface bounded by a divide which contributes runoff to a common point. Watershed management basically involves management of land surface and vegetation so as to conserve and utilize maximum water that falls on the area of watershed and also conserve the soil for long term benefits to the farmer and his society. Watershed management implies the wise use of soil and water resources so as to provide clean, uniform water supply for beneficial use and to control damaging overflow. Study area for this project work is Ingrul village, which is comes in Shirala tehsil, Sangli district of Maharashtra state. This area lies between Latitude 16.9550N, Longitude 74.1585E and Elevation 587 m. In Ingrul village in pre-monsoon period lack of water availability for drinking, agricultural purpose. Due to the water scarcity the agricultural production is reduced. To reduce the problem of water, watershed management is necessary in the Ingrul village. Watershed studies conducted employing a GIS platform have incontestable that the special analysis capabilities of GIS hold the key to improved watershed modeling techniques. The GIS-based watershed modeling method begins with a digital illustration of the bottom surface topography, or a digital elevation model. Availability of natural resources like land and water is studied using data from bhuvan, Survey of India toposheets and remote sensed data. Watershed structures proposed on the basis of contour map, drainage map, land use land pattern map and water requirement and runoff calculations. Design and cost estimation of structures recommended for Ingrul village

Index Terms: Keywords: Watershed management, GIS Digital Elevation Model, Watershed structures.

I. INTRODUCTION

A. Introduction to study

Watershed approach was put to practice for the first time in the country in 1949 by the Damodar Valley Corporation. Major multipurpose Irrigation projects launched in India aimed at improvement of mega watersheds. The Importance of micro watershed development was recognized and practiced in the country since 1973 due to their

commendation of the Task Force on Integrated Development of Drought Prone Areas. From 1979-80, watershed development was transferred to the state Governments as per the recommendations of the National Development Council. To inquire into these constraints and to suggest suitable remedies, a committee was appointed in 1993 under the leadership of Prof. C.H. Hanumantha Rao. On the basis of the recommendations of this committee, the Technical Committee on Drought prone area programme and Desert development programme (1996), the Ministry of Rural Development, Government of India brought in a new set of guidelines for the Watershed Development Programs in the Country. This chapter deals with the guidelines of the Watershed programs in India.

The concept of watershed management recognizes inter relationship among land use, soil, water and the linkage between uplands and downstream areas. The watershed is a wide spectrum of characteristic like (a) watershed topography which consists of mountains, hills, plains, gullies, valleys and so on; each is characterized by variable slope and area one location in watershed to another location. (b) Land mass of the watershed i.e. land use, soil types and underlying geology. (c) meteorological factors like rain, evaporation, radiation, wind, temperature etc. (d) socio-economic factors like per capita income, education status, health status etc. and (e) vegetation (agriculture, forestry and agro-forestry) Watershed management is not only an anti-erosional and anti-runoff approach but also a comprehensive integrated approach the land water resource management considering the ecological economic and social factors of the locality.

The field survey technique is important in geographical study but it consumes time and money but with the help of GIS and GPS it is better mean of data acquisition. The remote sensed data in addition to collateral data constitute requisite integrated information of watershed development on suitable basis. In recent years, GIS technology made great achievement and contributed significantly in the management of natural resources. This chapter, as a prelude to the field study, focuses its attention on the concept of watershed, micro watershed, and components of watershed development, problems and prospects of watershed development and methodological aspects of the study.

B. Introduction of GIS

GIS stands for geographic data system. an information system could be a computer program that manages information.

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A GIS may be a kind of data system that deals specifically with geographic or spatial data. Like different data systems, a GIS needs uncountable information that it will access, manipulate, and use to provide a product. Geographic data describes the spatial (location) factors of an object or space. This could be merely latitude and longitude coordinates however in most cases a lot of advanced factors are enclosed. GIS is the latest and modern research technique which is important to understand the geographic data. A GIS is combination of geographic as well as various collection of data which is useful to the generating a map, reports, manage and interpret location based on information in a planned. There is various GIS software used in market having different names are, ARCGIS, ARC INFO, MAP INFO and GRAM++. Now-a-days Government departments are also making a use of GIS software for different purposes. GIS is a computers system, so all outputs are depending upon the input data which is fed to any of the software. GIS is used for giving solutions to the water resources problems, assessing and mapping the ground water quality, understanding the natural environment and managing water resources on a required scale, selection of artificial recharge sites.

C. Components of GIS

GIS needs many basic components, they are as follows-

1. **Data:** the foremost vital element of a GIS is that the data. Geographic information and connected tabular data is collected in house or purchased from a commercial data supplier. The digital map forms the fundamental information input for GIS. Tabular data associated with the map objects may be connected to the digital information. AGIS can integrate spatial information with different information resources.

2. **People - users:** GIS technology is of restricted price plans for applying it to real word issues. GIS users vary from technical specialists who design and maintain the system to people who use it for acting their everyday work. Those that use GIS are generally classified into two categories. The CAD or GIS operator who works is to vectors the map objects, the employment of this vectored information to perform question, analysis or the other is that the responsibility of a GIS engineer or user.

3. **Methods:** A winning GIS operates consistent with a well- designed set up and business rules, that are the models and operational practices distinctive to every organization. There are numerous techniques used for map creation and more usage for any project. The map creation will either be automated raster to vector creator or it will be manually vectored victimization the scanned pictures. The source of those digital maps is either map prepared by any survey agency or satellite imagination.

4. **Hardware:** It's the computer on that a GIS operates. The pc includes a hard disc drive to store information and therefore the further storage will be provided via network or by digital tape cassettes, optical CD-ROMs and different devices. A digitizer or a scanner is employed to convert maps and documents into digital type so the computer programs will use them.

5. **Software:** The software system for a GIS is spitted in five teams like data input and verification, data storage

and database management, data output and presentation, information, transformation.

II. LITERATURE REVIEW

In present study of watershed management, various research papers are studied. Many Authors studied watershed management by using different methods and recent technique like remote sensing, GIS and others.

Bhavana Umrikar [1] (2015) studied The Shringar Tali watershed, a representative of NNW-SSE running stream originating on lateritic plateau, has been selected to suggest a model for watershed development. Upendra R. Saharkar [2] (2016) in this paper, Author done watershed is using remote sensing and GIS software for Talegaon dabhade, pune district. In this study population and industrial area is increasing day by day so that ground water level is depleting by 0.2m per year and soil erosion also increased. Omkar Prakash Suryawanshi et al. [3] (2015) studied water resource management in their paper Water Resources Management for Sustainable Development of Sadale-Madale Village, Kolhapur. In this study they have shown that, for the effective water resource management Efforts are made to manage the resources by some economic as well as technical watershed management. Sharada S. Tanavade et al. [4] (2015). A Case Study of Watershed Development in Sangola Maharashtra advised that as Perennial supply of water is not obtainable. Author terminated if watershed development techniques are enforced, will lead to increase within the living standard and financial condition of individuals of Sangola town. Parag R. Thakare [5] et al. (2013) Aim of this project is to emphasize the importance of the water conservation to overcome from shortage of water. The activities undertaken during this project include soil and conservation measures like construction of Bandhara. Mrs.Vidula Arun Swami et al. [6] (2011) in this study Watershed Management, A Means of Sustainable Development a case study they shows that In this era of ever increasing water demands and rapidly depleting water resources coupled with Overpopulation, it has become necessary to develop the means to recharge the ground water resources which are necessary for future requirements. Pandurang D. Jankar et al.[7] (2013) A Case Study of Watershed Management for Madgyal Village, they shows that Geographic information system (GIS) an essential tool for watershed planning and management tasks. Priya Sangameswaran [8] (2006) This paper discusses the extent to which these changes have been equitable, with a particular focus on equity across different landholding categories. J. Nittin Johnson et al. [9] (2013) Study discuss Explosion in population, has light-emitting diode to extend in demand of varied natural resources, as well as that of the foremost precious resource-water, particularly for irrigation and agricultural functions. Vishal P. Kumbhar et al. [10] (2013) they have studied the effectiveness of watershed management through the case study, actual implementation of watershed management options such as farm pond,

gully plugs, contour trenching it is found that there is water available for irrigation to after watershed management options.

V. N. Sharada et al. [11] (2005) Author concluded that frequency of disasters, such as landslides, floods, droughts, cyclones, hailstorms, siltation of reservoirs and deterioration of water bodies is increasing. Integrated watershed management in these regions requires adoption of innovative soil conservation and crop management techniques to prevent land degradation, maintain soil fertility and ensure environmental security for achieving sustainable productivity.

III. STUDY AREA AND DATA COLLECTION

A. Village Introduction -

Ingrul is a village situated in Shirala Block of Sangli district in Maharashtra. Situated in rural region of Sangli district of Maharashtra, it is one among the 97 villages of Shirala Block of Sangli district. According to the administration records, the village number of Ingrul is 568299. The village has 533 homes. It belongs to Desh or Paschim Maharashtra region. It belongs to Pune Division. It is located 53 km towards west from District headquarters Sangli, 16 km from Shirala. Ingrul Pin code is 415408 and postal head office is Shirala Ingrul village is also a Grampanchayat. The total geographical area of the village is 712 hectares. Ingrul has a total population of 2239 people. There are about 533 houses in Ingrul village. Latitude: 16.9550N, Longitude: 74.1585E and Elevation: 587 m.

B. Basic details of Ingrul village -

Following table contains the basic details of ingrul village.

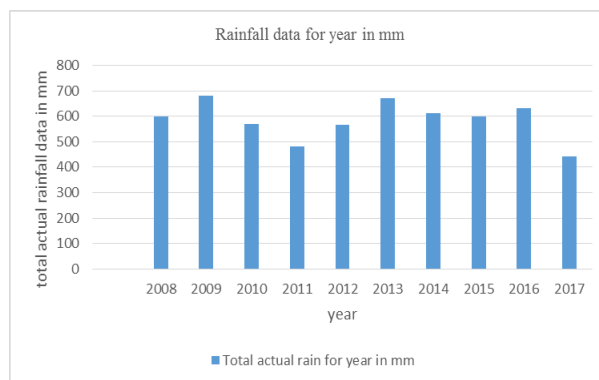
Basic details of Ingrul	
Details	Quantity
Geographical area	712 hectares
Irrigated area	269 Hectares
Population	2239
Female population	1110 (49.21%)
Male population	1129 (51.8%)
Average rainfall	587.38 mm
Depends on farming	84%
Irrigation facility	Bore-well & dug wells

C. Ingrul village Rainfall data -

From year 2008 – 2017 rainfall data is given as below;

Rainfall data for Ingrul

Year	Rainfall for year (mm)
2008	599
2009	681
2010	571
2011	480
2012	568
2013	671
2014	612
2015	598
2016	632
2017	442



Graph No. 1: Yearly total actual rainfall in mm for Ingrul

D. Profile of Ingrul village -

Profile of Ingrul (Data as per 2017 record)

Name of the city	Ingrul
Literacy-rate	68%
Primary health center	At Ingrul
Educational facilities	Up to 10 th
Library	1
School	2
Anganwadi	1
Talathi office	No
Post office	1

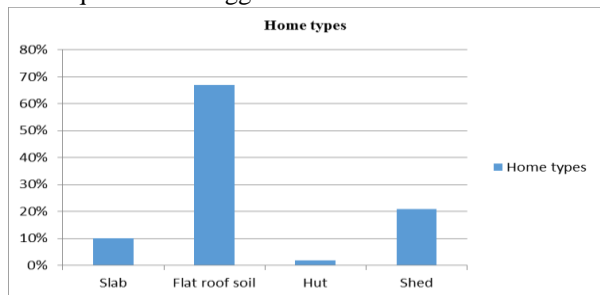
Animal record (Approx.)

Milk animals	988
Farm use animals	16

No. of poultry birds 1151
Total cattle's 2155

Housing types

As per socio-economic survey, there are varies types of homes. Slab (10%), flat roof soil type (67%), shed (21%), hut (2%) are available. For the type home, watershed management technique like top rainwater harvesting technique is to be suggested.



Graph No.1: Types of homes in Ingrul

• *Existing ground water structures*

These are very important structures in utilizing rainwater for drinking as well as irrigational purposes. Following table shows the present status of ground water structures in Ingrul watershed.

Table No.1: Present status of ground water structures in watershed. (Tentative Data)

Particulars	Ponds	Wells	CNB	CB
No. of structures	2	9	1	2
Use limit	private	Private	Public	Private
Use for drinking purpose	-	Yes	-	-
Use for irrigation purpose	-	Yes	Yes	Yes
Availability of water for drinking purpose (approximate)	-	Till Nov-Dec	-	-
Availability of water for irrigation purpose (approximate)	-	June to January	June to February	June to September

IV. METODOLOGY

Following are the methods used to complete the watershed management in Ingrul village:

1. Literature review regarding the subject.
2. Pre-visit to the Ingrul village.
3. Visit to the agricultural department Tal. Shirala for the primary data collection.
4. Visit to grampanchayat of Ingrul village.

5. Socio economic Survey conducted in Ingrul village for discussion to the villagers and gramsevak.
6. Requirement of water for domestic, agriculture and livestock was calculated based on the data collected.
7. Present structure for watershed management studied.
8. Source of water, availability of water and runoff was calculated.
9. Demand of water calculated.
10. Maps are downloaded with the help of survey of India, nakshe, GSDA site etc.
11. With the help of GIS software DEM sheet, contour map, drainage map, Land Use Land Cover map etc. prepared.
12. Proposed new structures for watershed management in Ingrul village.
13. Calculated cost required for new proposed structure for the Ingrul village.
14. Recommendation given based on result and data analysis.

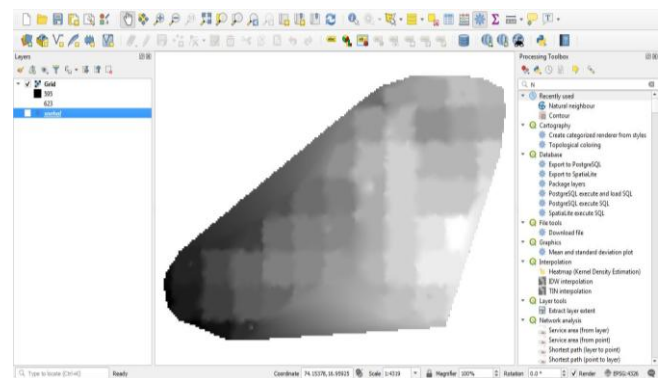
A. GIS work study

• Preparation of Thematic Maps:

The base map and remote-sensing data is used to prepare different thematic map layers e.g. drainage map, contour map, slope maps, map showing proposed water harvesting structures etc. The watershed boundary contours, drainage is digitized on the base map and contour and drainage maps are generated. The Satellite data (digital) was geo-referenced and rectified with the help of base map layer.

• DEM Sheet:

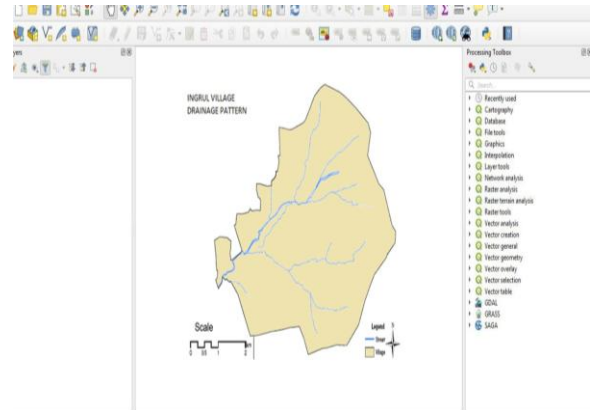
A digital elevation model is a specialized database that represents the relief of a surface between points of known elevation. It is digital representation of the land surface elevation. DEM frequently used to refer to any digital representation of a topographic surface.



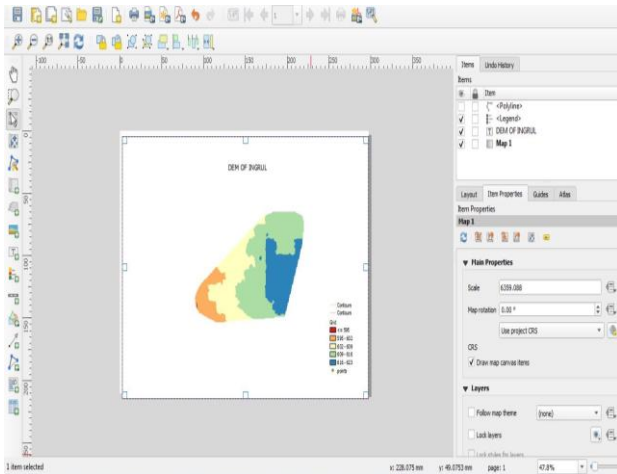
Map1: DEM sheet1 of Ingrul village

	LAT	LONG	ALT
1	18.93188	74.15321	395
2	18.93247	74.15321	395
3	18.9324	74.15327	395
4	18.93389	74.15329	398
5	18.93377	74.15329	398
6	18.93389	74.15329	398
7	18.93377	74.15329	398
8	18.93389	74.15329	398
9	18.93396	74.15324	395
10	18.93402	74.15327	399
11	18.93402	74.15327	399
12	18.93418	74.15338	399
13	18.93428	74.15340	399
14	18.93425	74.15344	399
15	18.93439	74.15345	399
16	18.93449	74.15325	399
17	18.93452	74.15329	399
18	18.9346	74.15329	399
19	18.93464	74.15329	399
20	18.93465	74.15327	399
21	18.93467	74.15327	399
22	18.93469	74.15327	399
23	18.9346	74.15329	399

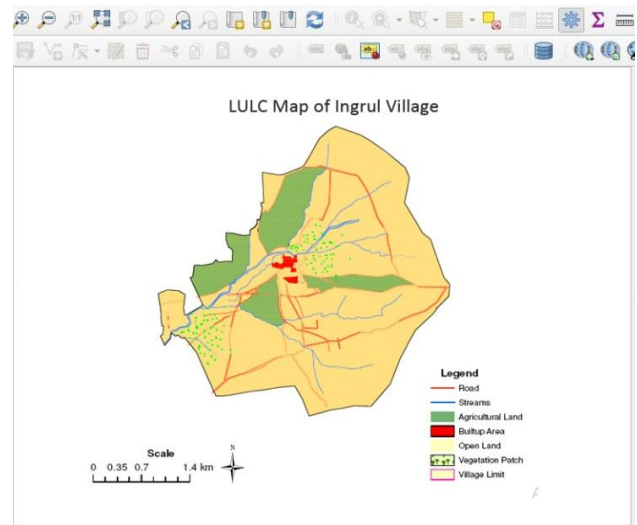
Attribute table



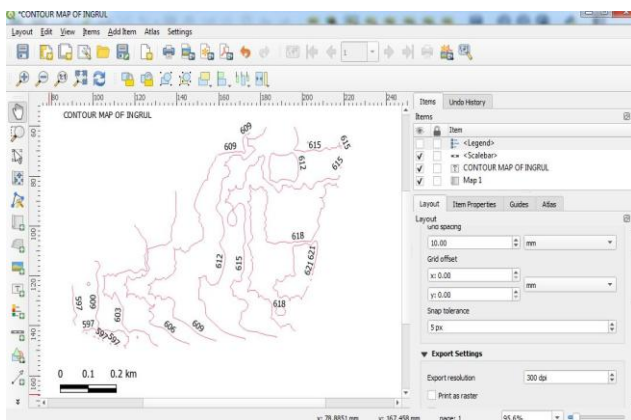
Map4: Drainage map of Ingrul village



Map2: DEM sheet of Ingrul village



Map5: Land use land cover map of Ingrul village



Map3: contour map of Ingrul village

• Drainage map

Drainage map is prepared by digitizing the individual streams from the Survey of India topographic sheets E43P3-47 0/3/NE First scale 1:25,000. Ingrul watershed is a 4th order basin having dendritic to sub-dendritic drainage pattern. As the order of streams goes on increasing, number of streams goes on decreasing.

V. RESULT AND DISCUSSION

A) Runoff calculations:

Average yearly rainfall in Ingrul = 58cm.

1. Runoff by Inglis formula = $[P (P-17.78)] / 254 = 9.18\text{cm}$.

2. Total available water =

Area of watershed (Sq. m) x Rainfall=4129600cum.

a) Ground water recharge =

Area of watershed (Sq.m) x Avg.fluctuation x Specific yield= 2136000 cum.

b) Evapotranspiration =

(30%) of Precipitation =1238880cum.

3. Runoff by using basic formula Runoff =

Precipitation - Basin recharge = 1993600cum.

Water available for artificial recharge for watershed development =

Runoff – Evapotranspiration=
1993600-1238880=754720cum.

B) Water requirement calculation:

1. Water requirement for domestic use water requirement per capita= 40liter/day = 2239 x 40 = 89560 litres.

Annual water requirement for domestic =
89560 x 365 =326894cum.

2. Water requirement for livestock

For milk animals = 988x60liter/day = 59280
 For farm use animals = 16x65liter/day = 1040
 For bird = 1151x3liter/day = 3453
 Total requirement = 59280+1040+3453 = 7946
 Total water requirement for animal= 7946x365liter/year =29002.9cum.

3. Water require for irrigation

Table no. 2-water required for irrigation

Crop Name	Area (Ha)	Requirement Per Ha. TCM	Total Need Water TCM
Rice	55	0.89	48.95
Soybean	10	0.45	4.5
Groundnut	35	0.65	22.75
Maize	30	0.50	15.00
Sorghum	20	0.45	9.00
Sugarcane	63	1.50	94.5
Wheat	21	0.45	9.45
Others	35	0.65	22.75
Total	269.00		226.90

4. Total Water requirement:

Sr.No.	Particulars	Total Yearly Requirement (Cum)
1	Domestic	326894
2	Livestock	29002.9
3	Irrigation	226000
	Total	581896.1

Total water requirement for Ingrul village is 581896.1 cum.

A) Water to be stored in watershed:

Total availability of water for recharge is 754720cum.

Sr. No.	Type of structure	No. of structures	Water to be stored (cum)	Total water available(cum)
1	Rain water harvesting	523	24168.437	604032.3cum
2	Farm pond	5	9180	
3	Vanrai Bandhara	4	101104	
4	Check dam	5	126380	
5	CCT	1	117200	
6	Crop requirement	1	226000	

After constructing watershed structures 604032.437cubic meter water is stored. Which is about 81% of total available water for recharge can be stored.

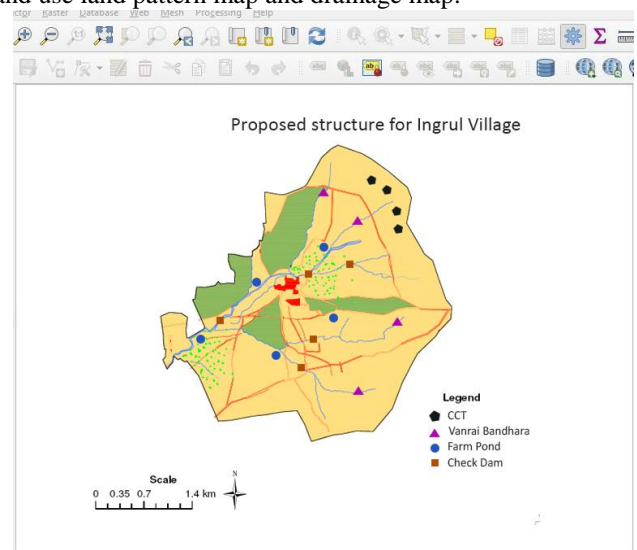
B) Proposed watershed management structure Estimation:

Sr . N o.	Type of structure	No. of structures	Cost of structure per unit	Total cost in Rupees
1	Farm pond	5	31600	1,58,000
2	CCT	40ha	14000	5,60,000
3	Vanrai Bandhara	4	15420	61,680
4	Rain water harvesting	523	19150	10015450
5	Check dam	5	93200	4,66,000
Total:				1,12,61,130

Total cost for constructing watershed management structures for Ingrul village is 11261130 rupees.

C)Locations for proposed watershed structure:

With the help of GIS data and GSDA guidelines following sites are suitable for watershed structures. It is very easier to locate locations for structures with the help of contour map, land use land pattern map and drainage map.



VI. CONCLUSION

In Ingrul village, there is water scarcity during months of February to May for drinking as well as for irrigation. Population of Ingrul village is increasing rapidly. The annual average rainfall is also not sufficient. Following are the concluding remarks given below:



1) Ingrul village will become self-dependent from water supply point of view if the proposed structures as mentioned below are implemented:

Sr. No.	Structure	Numbers
1	Farm pond	5
2	Vanrai bandhara	4
3	Rain water harvesting	523
4	CCT	1
5	Check dam	5

- 2) It is found that 81% of this available water can be recharged in watershed area for Ingrul village.
- 3) Total cost of rainwater harvesting structures is 10015450 rupees and it can be easily managed by individual basis by villagers. It will effectively solve problem of drinking water and domestic use. This will help to effective watershed management in the Ingrul village.
- 4) Various watershed measures like farm pond, check dam, vanrai bandhara, should be implemented to cope up with the drought conditions. With the help of GIS software location of watershed structures are easily located.
- 5) Maintenance programme for water storage structure should be done regularly like removing silt in the wells and check dam it will result in increased water storage capacity of above structures and increase ground water table.
- 6) Growing of cash crops, use of drip irrigation, awareness camps regarding agriculture, irrigation as well as government schemes and subsidy schemes will benefit the farmers of Ingrul village.
- 7) Perennial source of water is not available to fulfill the requirement. If watershed development techniques are implemented, it will result in increase in the living standard and economic condition of people of Ingrul village.
- 8) GIS is effective tool for watershed management.

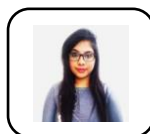
REFERENCES

1. Soil erosion and conservation by R. P. Tripathi and H. P. Singh.
2. "Watershed Management" by J.V.S. Murti published in 1997.
3. Government of Maharashtra, Dept. of Agriculture, Comprehensive District Agriculture Plan.
4. Government of India, Common Guidelines for Watershed Development projects, 2008, New Delhi, India.
5. P.K.Joshi, V. Pangare, B. Shiferaw S.P.Wani, J.Bouma and C.Scott, "Watershed Develop In India : Synthesis Of Past Experience And Need For Future Research" Vol.59, Ind. Jn.Of Agri. Econ. Vol.59 July-Sep.2004
6. A. Hazare, G. Pangare and V. Lokur, Adarsha Gaon Yojana: government participation in a peoples programme (ideal village project of the govt. of Maharashtra). Pune, India, 1996.
7. V.N. Sharda, "Integrated Watershed Management: Managing Valleys and Hills in the Himalayas" International Water Management Institute, South Asia Regional Office, New Delhi/Patancheru, India, 2005 Pp.61-81.
8. Vishal P. Kumbhar, Mrs.Sushma S. Kulkarni, Mrs.Vidula A. Swami (2013) "Effectiveness of Watershed Management- Means of Economical Development- A Case Study," Journal of Mechanical and Civil Engineering, Volume 6, Issue 6 (May. - Jun. 2013), PP 07-14
9. Pandurang D. Jankar (2013) "A Case Study of Watershed Management for Madgyal Village," International Journal of Advanced Engineering Research and Studies, //II/IV/July-Sept.2013/69-72 E-ISSN2249-8974.
10. Sundararajan T. Govindarajan S. (2013) "Impact of Watershed Management on the Groundwater and Irrigation Potential: A Case

Study," International Journal of Engineering and Innovative Technology vol. - 2, Issue -8 pp. 42-45.

11. G.S.D.A., Maharashtra State, Pune "Jalсандharan Margadarshika "1999. <https://gsda.maharashtra.gov.in>
12. Department of Land Resources, Ministry of rural development, Gov. of India, "Guidelines for Watershed development revised in 2001.
13. Impact of Watershed Management on the Groundwater and Irrigation Potential: A Case Study ,J.Nittin Johnson, S.Govindaradjane, T.Sundararajan, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 8, February 2013

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