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Water Balance Study in a Golegaon : Case Study

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Abstract: ***The water scarcity for Marathwada region, Maharashtra (India) occurs frequently after every year. Golegaon village which is situated in marathwada region received average annual rainfall of 614.21 mm according to past available data but still village face the drought condition for occasionally. Thus, water balance study was taken as the research for given Golegaon region using various technical tools. When studied the given study area, it has been founded the village can collected about 3014.43 TCM water in its catchment. The Total Water Demand (TWD) and Crop water requirement (CWR) for total cultivable area, human-livestock water requirement have to reschedule and redesign for given village. For this purpose we required to know the watershed of given region. Watershed and slope terrain of a region has been prepared using Arc GIS 10.1 software. After studying, specific yield of irrigated area and type of crop for village, it has been observed that whatsoever water precipitated within village boundary fulfils the demand. But due to lack of system, 550 TCM water get flush away and creating scarcity. Total remedy measures were suggested to built structures and cropping pattern to given region.***

Keywords:, Arc GIS; Crop pattern; Water Balance

I. INTRODUCTION

The scarcity of water has been faced by many regions of Maharashtra. The deficiency of water has persisted for four consecutive years and has affected crop production, crop pattern, and life of crop, groundwater, and water quality across the region. Jal-Yukta Shivarabhiyan (JYS) promotes an integration and coordination between various government agencies and program during planning and implementation levels and stresses on people's participation as one of the key objectives. The JYS is a successor of many earlier watershed programs which have already been implemented, and some of which are ongoing, such as the integrated watershed management programme (IWMP).

Zeeshan and Pachkor *(2015)* studied the JYS and has launched a new program named 'Jal-Yukta Shivar Abhiyan' to make Maharashtra a drought-free state by 2019. The JYS proposes a framework for village level water balance calculation which includes estimation of crop-water requirements, drinking water stress etc. After completion of irrigation projects in next two years, 50% area will be under irrigation. For the rest 50%, rainwater harvesting and decentralizing water sources are the only options to solve the issue of water scarcity. Kahalekar *(2016)* focused on one of the main planning components in JYS i.e. computation of village-level water balance which would be assessing whether the problem of water crisis is due to restricted availability of resource or due to over-usage of water for crops i.e. whether the crisis is natural or man-made. Awsarmal (2016) carried out similar study in Daregaon village of Phulambri Taluka, which has been the reconstruction of used bridge into the Nalla Bandra for increasing groundwater. Agrawal and Regulwar (2016) applied same analysis using HEC-RAS software for Dudhana River for slope analysis of river channel.

Duesterhaus (2008) conducted study to measure the water balance of a stock-watering pond in the Flint Hills region of east-central Kansas from June 2005 to October 2006. Evaporation accounted for 64% of total water loss annually, while seepage, cattle consumption, and transpiration accounted for 31%, 3%, and 2%, respectively. They observed greatest water loss in July, with total monthly losses over 358 mm and peak daily losses sometimes exceeding 18 mm d-1. Cattle consumption averaged 30 L day-1 animal-1 with peak usage of 46 L day-1 animal-1. On average, the Priestley-Taylor and Penman evaporation models estimated monthly evaporation to 3% and 5%, respectively. GezaHajnal, (2006) worked out water balance calculation that considers the effect of urbanization. This calculation method was applied to evaluate the water balance of the historic center of Budapest, for the Buda Castle Hill, where intense networks of cellars were found. The method, combined with hydrogeological tests and field measurements was tested at other Hungarian cities. The calculation considers both natural and man-induced water sources. Besides the commonly used natural factors such as precipitation, evaporation, runoff, infiltration, etc. it also uses input parameters such as broken pipelines or sewer systems. The water losses of these significantly influence, the natural water balance and provide additional and very often significant water input into the water system.

Objectives: The main objective of study was to determine the total water demand and estimation of quantity of water available in the Golegaon village. Also, to redesign the crop water requirement for given study.

II. STUDY AREA:

Golegaon village is located in Taluka Washitahsil District Osmanabad (M.S.), India with Latitude $18^{0}30^{'}$ N and Longitude is $75^{0}47^{'}$ E. According to Census 2011 information the location code or village code of Golegaon village is 561266. The total geographical area of the village is 490.78 hectares. Golegaon has a total population of 913 people in which Male Population is 456, Female Population is 457. Average annual rainfall is 614.21mm.

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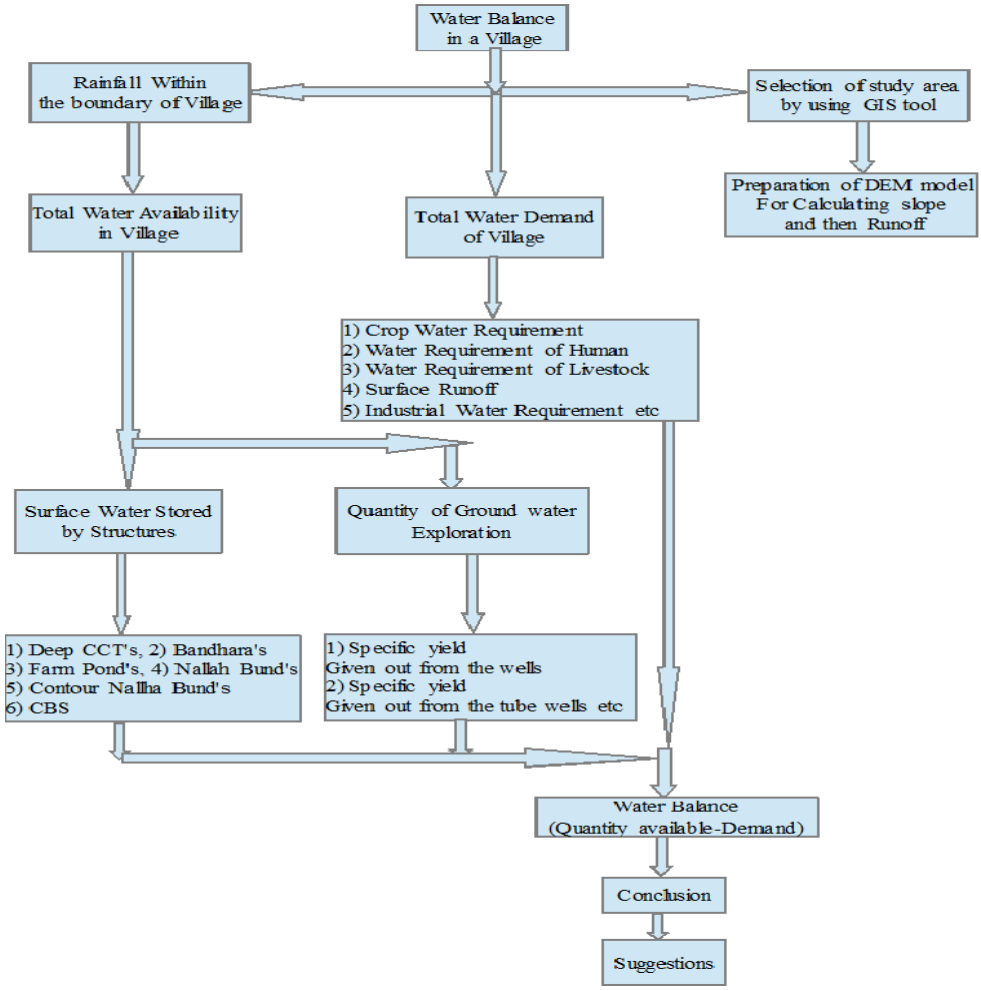

Fig.1 Process of research work

III. MATERIALS AND METHODOLOGY:

Data required:

Total geographical area of the village, Total area under irrigation, Types of crop taken, Water storing structures and their capacity, Total number of wells and their yearly specific yield , Total population of the village , Total livestock's in the village, Meteorological data (Rainfall, Temperature, Evaporation, Wind, and Humidity etc. and SOI Topo-sheets.

Software used: Arc GIS10.1, SURFER Software 9, ERDAS Imagine 9.2, AutoCAD.

Methodology: Detailed research plan carried out during the study was as per the follows. This shows the step by step procedure carried out during the research work shown in figure 1.

IV. RESULTS AND DISCUSSION

Figure 2 shows the chart showing variation of year's v/s total annual rainfall for last eight consecutive years. As per the record it is concluded that rainfall was uneven in the area and after every 2-3 years less rainfall is occurring in the area. So to avoid the draught condition it is required to make some planning and study. From records it is concluded that in the year 2006 and 2010 there was a sufficient annual rainfall and it was 918.2 mm and 839.9 mm respectively. And in the year 2012 and 2013 there was a minimum annual rainfall and it was 239 mm and 513.1 mm respectively.From these records the average annual rainfall in the Golegaon is 614.21 mm.

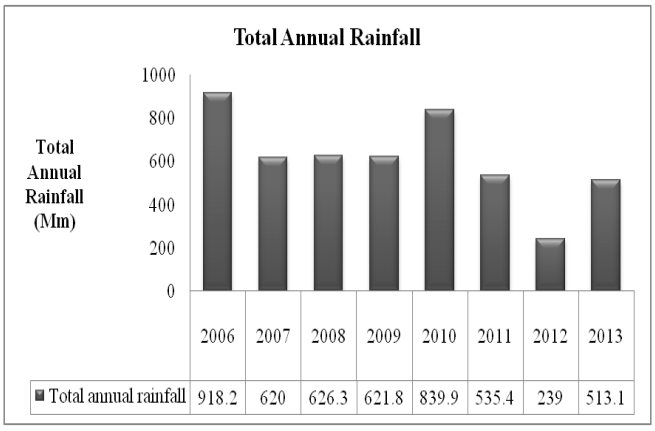

Fig.2 Variation of total annual rainfall year-wise

Volume of water collected within the village boundary after rainfall: As per the records of precipitation of last eight years the average annual rainfall in this region (i.e. at the Latitude: 75

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DEG. E, Longitude: 19 DEG. E) is 614.2125 mm. Total geographical area of the village is 490.78 ha.

Total volume of water precipitated in the village = Average annual rainfall* Area of village

= 614.2125*490.78*10 m^3

= 3014432.1075 m^3

So total annual volume collected within the boundary of the village was 3014432.1075 m^3

Annual domestic water requirement: According to Census 2011 information the location code or village code of Golegaon village is 561266. Golegaon has a total population of 913 people in which Male Population is 456, Female Population is 457. There are about 210 houses in Golegaon village. As per ISI standards for communities with population up to 20000 and without flushing system the water supply through house service connection is between 70 to 100 lphd. By these standards total annual domestic water requirement is as per the follows.

Total annual domestic water requirement = Total population*365*70

= 913*365*70

= 23327150 liters

= (23327150/1000) m^3

= 23327.15 m^3

Crop water requirement: Following table 1 shows that annual area under different crops and its total water requirement. Also, it contains irrigated and non-irrigated area and standard water requirement of these respective crops. The crop data was collected from the Talathi office and 7/12 records department of the village and standards were taken from the FAO (Food and agricultural organization) website.

Table 1: Annual Average Area under Different Crops and Its Total Water Requirement

Sr. No.	Name of crop	Average area ($m^{2)}$		Seasonal water requirement (m) (C)	Total Crop water requirement ($m^{3)}$
		Irrigated (A)	Non-irrigated (B)		D = (A+B)*C
1	Gram	42900	351500	0.65	256360
2	Soybean	-	723300	0.45	325485
3	Sugarcane	74000	127700	1.5	302550
4	Maize	91100	697100	0.5	394100
5	Wheat	18000	76800	0.45	42660
6	Sorghum	75800	1013200	0.45	490050
7	Black- gram	-	153400	0.28	42952
8	Hybrid	-	56300	0.45	25335
9	Cotton	40700	285400	0.7	228270
10	Green-gram	-	54900	0.85	46665
11	Pigeon-pea	67400	343900	0.65	267345
12	Pearl millet	-	313700	0.65	203905
13	Onion	17000	23600	0.35	14210
14	Pomegranate	20000	-	4500 $m^{3/}$ha	9000
15	Banana	10000	-	1.2	12000
16	Rice	4800	-	0.45	2160
17	Safflower	-	2000	0.6	1200
18	Grapes	1000	-	0.5	500
Total crop water requirement of Golegaon village					**2664747 m^3**

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Table 2: Details of livestock andHumans yearly water requirement

Category of Animal (2	Total Count 3	As per FAO/ISI (liters/day) 4	Requirement (liters/year) 5 =3*4*365	Requirement (m^3/year) 6
Humans	913	70	23327150	23327.15
Cows/bullock's	340	83	10300300	10300.30
Buffalo's	32	83	969440	969.44
Ship's	255	5.2	483990	483.99
Chicken's	163	0.5	29747.5	29.7475
02 Poultry (Total Bird's)	6500	0.5	1186250	11.86250
Total livestock's water requirement (m^3/year)				**35122.49**

Livestock water requirement: Table 2 gives the details of total number of livestock in the village and their yearly water requirement (as per the 19th censes). FAO (food and agricultural organization) and ISI (Indian standards) had been given the standard water requirement of animals and humans. Basis of this standard requirement total annual requirement of livestock and human was calculated.

Runoff requirement: To calculate the runoff requirement digital elevation model (DEM) of the Golegaon was prepared by using Arc GIS 10.1 software which is shown in below fig. 3. To calculate the total yearly runoff generated from the area, slope was divided into three categories as shown in table 3 This table shows the rainfall, runoff calculation, using strange's table.

Table 3: Strange's slopes values

Sr. No.	Watershed type	Runoff (TCM/ha)	Area (ha)	Runoff (TCM)
1	Slope less than 5%	0.7855	153.94	120.92
2	Slope in between 5 to 20%	1.1236	222.06	249.50
3	Slope more than 20%	1.5711	114.78	180.33
4	Total		490.78	550.75

Water impounded by the structures: From the center of the village one nallha is flowing from west to east direction which is approximately 2.8 km long and the average width of this nallha is about 3.2 m and average depth is 2.2 m. There were 4 Bandhara's are available on the Nallha flowing through the center of the village. The Nallha is flowing in the rainy season when rainfall occurs and about 2 months in the winter (Kharip) season. In the rest of the months Nallha is dry. This four Bandhara's were constructed under the Jalyukta Shivarabhiyan JYS of Maharashtra government. Details of this Bandhara's are presented in the following table 4. Data tabulated in the table 3 are obtained by measuring the actual length, width and depth of the structures and then total volume of water impounded by the structures was calculated. So the total quantity of water stored by the structure was approximately 11980.479 m^3.

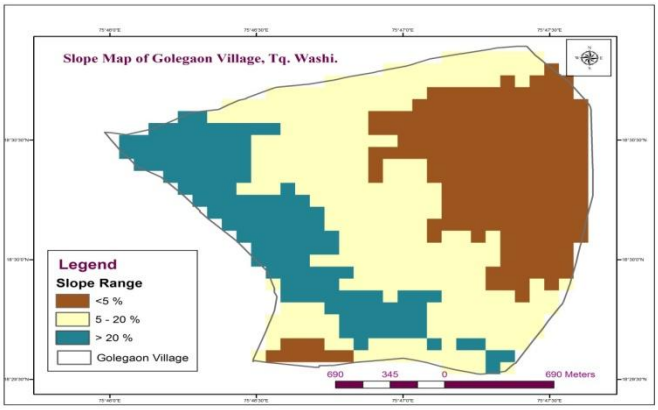

Fig.3 Slope map of golegaon

Table 4: Details of Bandhara's and its capacity

Bandhara No. (2)	Length (m) (3)	Width (m) (4)	Depth (m) (5)	Volume stored (m^3) (6)=(3)*(4)*(5)
1	113.68	15.90	2.65	4789.90
2	111.30	15.90	2.80	4955.07
3	103.35	14.31	2.80	4141.02
4	95.40	15.10	2.25	3228.98
Quantity of water stored by structures				17114.97

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30% evaporation loss in a year	5134.491
Actual quantity of water available for the irrigation in Bandhara's was	**11980.479 m^3**

Evaluation of specific yield: On the banks of the Nallha there were many numbers of wells and bore wells were constructed by the farmers. There were 60 numbers of wells and 55 bore wells were constructed within the village boundary by the farmers up to the 2015-16. They were irrigating about 49.04 ha area by using ground water obtained from the wells and tube wells and which were approximately 138249 m^3. The details of irrigated area and quantity of water used to irrigate this area are presented in following table 4 shows all crops are irrigated in the months November, December, January and February. To get the approximate volume of ground water used for irrigation we have to divide total water requirement by 3 or 2 depends on the types of crop and total growing period because actual irrigation given to the crops by the ground water is $1/3^{rd}$ of its requirement. Following table 5 gives the approximate values of specific yield taken out for the individual crop.

Water balance calculation: As per the rainfall, availability of water storing structures, tube wells and open wells etc. also as per the water requirement of crop, human and livestock's calculations of water balance was made and which was presented in the table 6.

Table 5: Irrigated area and quantity of water used to irrigate this area

Name of crop	**Average area irrigated ($m^{2)}$**	**Seasonal water requirement(m)**	**Approximate CWR ($m^{3)}$**	**Approximate specific yield taken out ($m^{3)}$**
-2	**-3**	**-4**	**(5) = (3) *(4)**	**-6**
Gram	42900	0.65	27885	(27885/2)=13943
Soybean	-	0.45	0	0
Sugarcane	74000	1.5	111000	(111000/3)=37000
Maize	91100	0.5	45550	(45550/2)=22775
Wheat	18000	0.45	8100	8100
Sorghum	75800	0.45	34110	(34110/2)=17055
Black- gram	-	0.28	0	0
Hybrid	-	0.45	0	0
Cotton	40700	0.7	28490	(40700/3)=9497
Green-gram	-	0.85	0	0
Pigeon-pea	67400	0.65	43810	(431810/3)=14603
Pearl millet	-	0.65	0	0
Onion	17000	0.35	5950	5950
Pomegranate	20000	4500 $m^{3/}$ha	9000	(9000/3)=3000
Banana	10000	1.2	12000	(12000/3)=4000
Rice	4800	0.45	2160	2160
Safflower	-	0.6	0	0
Grapes	1000	0.5	500	(500/3)=167
Specific yield used (Irrigated area= 49.04 ha)				138249 m^3

Table 6: Water balance calculation

Description	**Quantity of water m^3/ year**	**Quantity of water TCM**
Quantity of water precipitated within village boundary.	3014432.1	3014.43
Quantity of water available (it is the part of precipitation so it can be deducted from precipitation value) i+ii	150229.47	150.22
i). Water impounded by structures	11980.479	11.98
ii). Approximate specific yield taken out	138249	138.24
Actual quantity of water available for the village (1-2)	2864202.63	2864.2
Water demand (a+(b. iii)+ c+ d)	3112370.49	3112.37
a). Domestic water requirement	23327.15	23.32

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b). i. Crop water requirement	2664747	2664.74
b). ii. Water availability for Crops by specific yield	138249	138.24
b). iii). Actual Crop water requirement	2526498	252.64
c). Livestock's water requirement	11795.34	11.79
d). Runoff	550750	550.75
Actual Deficit water for village (4-3)	**248167.86**	**248.16**

V. CONCLUSION:

In the study area quantity of water stored in the structures and specific yield taken out to irrigate 49.04 ha area has been observed 150.22 TCM. Amount of water required by considering CWR, Human and Livestock's water requirement in the village was 3112.37 TCM while total runoff requirement of the area was 550.75 TCM. After analysis deficiency of water observed was 248.16 TCM which was less than total runoff generated from the village. If we construct structure and considered 30% evaporation loss then total deficiency is 322.60 TCM which is also less than total runoff generated from the area. Slope 5% to 20% covers maximum area and it is 222.06 ha. Slope less than 5% covers area about 153.94 ha and slope more than 20% covers area about 114.78 ha. Boundary of the village covers 491.78 ha area. About 339.54 ha area was under cultivation. From the crop records it was observed that farmers from that area believe on traditional farming and they are taking crops like Cotton, Sugarcane, Soybean, Maize, gram, pigeon-pea, sorghum, pearl millet, onion and wheat etc year after year. Farmers needsto adopt modern techniques of water application such as drip irrigation and sprinkler irrigation so that maximum water use efficiency will be obtained.

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