International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

National Conference- "Business 4.0: Redefining the Future of Business"

Assessment of Water Conservation Measures on Groundwater Dynamics in Karwadi-Nandapur Watershed of Maharashtra State (India)

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ABSTRACT

As a unit of land and water management, the watershed offers immense scope to improve crop productivity-whether of rain fed crops or under small scale irrigation and biomass for livestock. The integrated watershed management program was conduted in Karwadi-Nandapur funded by ICAR and implemented by Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The Karwadi-Nandapur watershed is micro watershed of Kayadhu river which joins to the Godavari river basin. The catchment area of the watershed is 772.56 ha. The general slope of cultivated land in watershed ranges from l to 3 percent.Owing to the infiltration characteristics of the black soil, land use and drainage network, infiltration to the ground water in the watershed was limited.The study was conducted during 2012-13 to 2014-15 in Karwadi-Nandapur watershed in Hingoli district of Maharashtra state. It was revealed that the maximum monthly average rise in water level in the wells was found in September (4.66m) followed by February (4.58m). The well W4 showed the maximum rise (5.12m) in water level while, W7 showed the minimum rise (0.39 m) in water level. On an average the rise of 3.15 m in the water table was observed in the watershed during the post-implementation phase. The maximum well yield(11.69 m^3/hr) and maximum specific capacity(4.99 m^3/hr/m depth of drawdown) was found for W5 while it was observed that W1 well has the minimum well yield (1.92 m^3/hr) and W2 well has the minimum specific capacity (1.22 m^3/hr/m depth of drawdown). The average yield of all the wells is found to be 5.44 m^3/hr. The average specific capacity of all the wells is found to be 2.87 m^3/hr/m depth of drawdown. It was revealed from the observations that the well yields of the observation wells were gradually declined from November to May. The yields and specific yields of all the observation wells were maximum in November and minimum in May. This is due to the fact that the soil moisture is sufficient in the post monsoon season, the percolation is also satisfactory due to soil and water conservation measures in the watershed area and during summer season the values decreased due to the depletion of groundwater table resulting from the pumping of water for irrigation of rabi and summer crops.The substantial increase in water availability of the wells during the summer season was attributed to the effect of soil and water conservation interventions.

Key words: Watershed management, pre-implementation, post-implementation, specific yield, specific capacity, drawdown

Introduction:

A watershed is a geo-hydrological unit which drains water to a common point through a system of drains/streams. Simply stated it refers to the area from where the water to a particular drainage system like river or stream comes from.. Watersheds has different names at different levels, at macro-level (district or regional levels), at village level (hundreds or thousands of hectares), at farm level or even within the farm. The micro-watershed concept i.e. watershed less than 1500 ha, according to NABARD (National Bank for Agriculture and Rural Development) watershed development fund guidelines,2006) aims to establish an enabling environment for the integrated use, regulation and treatment of water and land resources of a watershed based ecosystem to accomplish the objectives of resource conservation and biomass production. One of the definitions of watershed management is ‘the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary.’ In India, most watershed projects are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor (Sharma and Scott, 2005). Different types of treatment activities carried out in a watershed include soil and moisture conservation measures in agricultural lands (contour/ field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retaining walls), water resource development/management (percolation pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture plantation and afforestation (Palanisami and Suresh Kumar, 2003). The aim has been to ensure the availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000). Today watershed development has become the main intervention for natural resource management like water, land, forest/vegetation, livestock and human resources in the watershed. Watershed Development programs began in the early 1970s as a way to address food security and rural poverty in India's rainfed regions.Rainfed areas are characterized by erratic, deficient, and delayed rainfall patterns.As a result, large-scale irrigation is often difficult or impossible and it is difficult to implement a standard remedy to improving crop production and livelihoods (Planning Commission, 2012). Rainfed regions have also historically experienced severe degradation due to heavy deforestation and unsustainable agricultural and livestock practices. Populations living in these regions are also some of India's poorest, with insufficient access to education and agricultural markets.The emphasis on watershed development recognizes that rainfed area needs to be developed and managed in a sustainable manner. Rainfed agriculture in India is characterized by low productivity, degraded natural resources and widespread poverty which made the development planners to implement productive, environmentally sustainable, socially equitable land and water management(Joshi et.al.,2008). The aim of watershed development programme has been to ensure the availability of drinking water, fuel wood, fodder and raise income and employment for farmers and landless labourers through improvement in agricultureal production and productivity (Wani et.al. 2008). The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques. Artificial recharge techniques are used to enhance the sustainable yield of ground water in areas where over-development has depleted the aquifer, conservation and storage of excess surface water for future requirements. The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development. (CGWB, 2000). Considering the above importance a micro watershed was chosen as a case study with the objective of assessing the impact on groundwater resources, especially on the water levels in the open wells, the yield and specific capacity of wells in the watershed. The scarce water resources are diminishing, the land resources are degrading due to soil erosion, therefore, the challenge is to manage land and water resources in a sustainable manner to achieve higher productivity levels, conserve resources for future generations and derive livelihoods in the most equitable manner possible.

Details of Case study:

Karawadi –Nandapur watershed is a micro watershed of Kayadhu River and is a micro watershed of PPG8/01/13 sub watershed. The nomenclature PPG8/01/13 is given by the Groundwater Survey and Development Agency (GSDA), Pune(M.S.). It is located at 19°35'50"N latitude and 77° 14'33" E longitude. Karwadi-Nandapur watershed is located in Kalamnuri tehsil of Hingoli district of Maharashtra (M.S.). The Karawadi –Nandapur watershed is located about 24 km away from the Aundha Nagnath City and about 20 km from Kalamnuri city and very near to Nandapur railway station in Kalamnuri Tahsil of Hingoli district. Karawadi –Nandapur watershed is situated at 481 m above MSL. On the East side of Karawadi –Nandapur watershed, Harwadi village is situated, on West side Jamgavan and Amdari villages are situated and on South side Aswale village is situated. The Karawadi – Nandapur watershed is bounded by ridge line with a single outlet of main nala which joins to Kayadhu River.

The catchment area of the watershed is 772.56 ha. The watershed comprises 480 ha of cultivable area, it consists of 48 ha of current fallow land, 233 ha area is non cultivable area out of which 155 ha is mostly the wasteland, 6.12 ha land is under habitation and 4.44 ha is under tanks and river. The watershed is characterized by hilly area having steep slopes ranging from 15 to 35% slope in the upper reach. The general slope of cultivated land in watershed ranges from l to 3 percent. However, at some location maximum slope of 15 percent is observed. Most of the area is covered by medium to deep soils and the soils are having the clay loam to clayey texture. The soils in the watershed are well drained. Nearly 70 ha area of the upper reaches of the watershed is vulnerable to very severe soil degradation due to occurrence of heavy storms in the watershed. Ground water from open wells as well as from bore wells is the chief source of irrigation and drinking water.Middle and lower portion of the watershed comprising 480 ha. Owing to the infiltration characteristics of the black soil, land use and drainage network, infiltration to the ground water was limited.Ground water in the open and bore wells was available only up to the month of December/January. This caused the imbalance between the demand and supply of drinking and irrigation water. The farmers of Karawadi-Nandapur watershed were able to grow the only crop in Kharif season. The area under cultivation in rabi season was very less and there was no any crop cultivated in summer season before implementation of watershed development programme.

The climate of the study area can be classified as sub–tropical. The watershed falls in the semi arid tropics with seasonal rainfall and high evaporative demands. The average annual rainfall is 892 mm. The rainfall is uneven, erratic and varies from year to year .The mean maximum temperature of 43^0C is normally recorded during April to June, while the minimum temperature of 15^0C is normally recorded during December -January.During summer, the climate is mostly hot and dry with high evaporative demands.In these fragile regions, it is common that rainfall occurs with high intensity leading to high runoff and soil erosion damaging bio-physical resources and agricultural crops. Impact assessment of watershed management programmes attempts to bring out the best possible balance between natural resources use and living being, as both are interdependent.

The questionnaire was used to collect the primary data from respondents. While preparing the questionnaire the questions was set according to the objectives of the research work. These questionnaires were distributed to the selected farmers/beneficiaries and taken back once filled. Questionnaire was structured and informative. The questionnaire was prepared by understanding awareness about different aspects of watershed development works. Numbers, tick and description is expected from respondent in the form of answer.

Results and Discussion:

Table 1: The comparative rise in water levels in the wells during 2012-2013, 2013-2014 and 2014-2015

Well No.	**Rise in Water Levels (m)**		
	2012	**2013**	**2014**
W1	1.41	1.40	0.83
W2	4.94	5.12	3.64
W3	4.68	4.92	3.93
W4	5.37	6.00	3.98
W5	3.64	3.95	2.71
W6	5.01	5.11	3.82
W7	0.42	0.43	0.32
W8	1.46	1.48	1.09
Total	26.93	28.41	20.32
Average rise	3.37	3.55	2.54

From the Table 1, it was observed the rise in water levels in the wells in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2012-2013 was 1.41, 4.94, 4.68, 5.37, 3.64, 5.01, 0.42 and 1.46 m respectively while, the rise in water levels in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2013-2014 was 1.40, 5.12, 4.92, 6.00, 3.95, 5.11, 0.43 and 1.48 m respectively. It can be concluded that rise in the water levels in the observation wells was highest in 2013-2014 as compared to that of in 2012-2013. This is attributed to the amount of rainfall received during 2012-2013 and 2013-2014 which was 684 mm and 1152 mm respectively.

From the Table 1, it was found that the rise in water levels in the wells in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2013-2014 was 1.40, 5.12, 4.92, 6.00, 3.95, 5.11, 0.43 and 1.48 m respectively while the rise in water levels in the wells in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2014-2015 was 1.21, 4.57, 4.51, 5.12, 3.43, 4.65, 0.39 and 1.35m respectively. The rise in water level in each well was found higher in 2013-2014 as compared to that of in 2014-2015. This is due to the fact that the amount of rainfall (1152 mm) received in 2013-2014 was more than the amount of rainfall (469 mm) received in 2014-2015.

From the Table 1, it was seen that the rise in water levels in the wells in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2012-2013 was 1.41, 4.94, 4.68, 5.37, 3.64, 5.01, 0.42 and 1.46 m respectively while, the rise in water levels in W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 during 2014-2015 was 1.21, 4.57, 4.51, 5.12, 3.43, 4.65, 0.39 and 1.35m respectively. It can be concluded that rise in the water levels in the wells was highest in 2012-2013 as compared to that of in 2014-2015. This is attributed to the amount of rainfall received during 2012-2013 and 2014-2015 which was 684 mm and 469 mm respectively.From the Table 4.23 and fig. 4.34, it was revealed that the average annual rise in water level in the wells during 2013-2013, 2013-2014 and 2014-2015 was 3.37, 3.55 and 2.54m respectively. It was observed that the rise in water levels in all the wells was the impact of amount of rainfall received in the respective years and the soil and water conservation measures implemented in Karwadi-Nandapur watershed.

115.2 cm for all the wells located in the watershed. Thus, a total amount of 307.8 mm of the total precipitation was recharged to the groundwater.

It is observed from the Table 4.23 that the rainfall received till 31st October during the year 2014-15 was 469 mm. The average rise in the water level in the wells was found between 182 cm in W1 to 458 cm in W_4. The average rise in water level in all the wells is found to be 350 cm. assuming the specific yield of the aquifer material as 4.5%, it is found that the precipitation in the range of 8.19 – 20.61 cm depth was recharged to the ground water table. The amount of precipitation percolated to groundwater was observed in the range of 17.46 to 43.94 % for the wells W_1 and W_4 respectively with an average of 33.58 % of the total precipitation of 46.9 cm for all the wells located in the watershed. Thus, a total amount of 157.4 mm of the total precipitation was recharged to the groundwater.

Table 4.24: Groundwater Recharge in Observation wells located in Karwadi-Nandapur Watershed during Post-implementation phase

Well No.	2012-13				2013-14				2014-15			
	Rainfall (cm)	Rise in water level (cm)	GW recharge Pi (cm)	Recharge (%)	Rainfall (cm)	Rise in water level (cm)	GW recharge Pi (cm)	Recharge (%)	Rainfall (cm)	Rise in water level (cm)	GW recharge Pi (cm)	Recharge (%)
W_1	68.4	254.00	11.43	16.71	115.20	254.00	11.43	9.92	46.90	182.00	8.19	17.46
W_2	68.4	581.00	26.15	38.22	115.20	580.00	26.10	22.66	46.90	458.00	20.61	43.94
W_3	68.4	399.00	17.96	26.25	115.20	399.00	17.96	15.59	46.90	312.00	14.04	29.94
W_4	68.4	619.00	27.86	40.72	115.20	613.00	27.59	23.95	46.90	458.00	20.61	43.94
W_5	68.4	441.00	19.85	29.01	115.20	438.00	19.71	17.11	46.90	339.00	15.26	32.53
W_6	68.4	581.00	26.15	38.22	115.20	573.00	25.79	22.38	46.90	456.00	20.52	43.75
W_7	68.4	465.00	20.93	30.59	115.20	467.00	21.02	18.24	46.90	359.00	16.16	34.45
W_8	68.4	260.00	11.70	17.11	115.20	288.00	12.96	11.25	46.90	236.00	10.62	22.64
Average	68.4	450.00	20.25	**29.61**	115.20	451.50	20.32	**17.64**	46.90	350.00	15.75	**33.58**

From the table 4.24, it is revealed that the rainfall received till 31st October during the year 2012-13 was 684 mm. The average rise in the water level in the wells was found between 254 cm in W1 to 619 cm in W_4. The average rise in water level in all the wells is found to be 450 cm. assuming the specific yield of the aquifer material as 4.5%, it is found that the precipitation in the range of 11.43 - 27.86 cm depth was recharged to the ground water table. The amount of precipitation percolated to groundwater was observed in the range of 16.71 to 40.72 % for the wells W_1 and W_4 respectively with an average of 29.61% of the total precipitation of 68.4 cm for all the wells located in the watershed. Thus, a total amount of 202.5 mm of the total precipitation was recharged to the groundwater.

It is seen from the Table 4.24 that the rainfall received till 31st October during the year 2013-14 was 1152 mm. The average rise in the water level in the wells was found between 254cm in W_1 to 613 cm in W_4. The average rise in water level in all the wells is found to be 451.5 cm. assuming the specific yield of the aquifer material as 4.5%, it is found that the precipitation in the range of 11.43 - 27.86 cm depth was recharged to the ground water table. The amount of precipitation percolated to groundwater was observed in the range of 9.92 to 23.95 % for the wells W1 and W4 respectively with an average of 17.64 % of the total precipitation of115.2 cm for all the wells located in the watershed. Thus, a total amount of 307.8 mm of the total precipitation was recharged to the groundwater.

It is observed from the Table 4.23 that the rainfall received till 31st October during the year 2014-15 was 469 mm. The average rise in the water level in the wells was found between 182 cm in W1 to 458 cm in W_4. The average rise in water level in all the wells is found to be 350 cm. assuming the specific yield of the aquifer material as 4.5%, it is found that the precipitation in the range of 8.19 – 20.61 cm depth was recharged to the ground water table. The amount of precipitation percolated to groundwater was observed in the range of 17.46 to 43.94 % for the wells W_1 and W_4 respectively with an average of 33.58 % of the total precipitation of 46.9 cm for all the wells located in the watershed. Thus, a total amount of 157.4 mm of the total precipitation was recharged to the groundwater.

Due to additional groundwater recharge, a total of 224.5 ha were irrigated in post-kharif season and 25.5 ha in post-rabi season, mostly groundnut. Based on three years (2012-2014) of observations of water levels in open wells, the estimated average rise of groundwater was 417 cm. Thus the average contribution of the seasonal rainfall to groundwater in the watershed could be estimated at 26.94% of the seasonal rainfall (assuming the specific yield of the aquifer material as 4.5%). Similar studies were conducted in Adarsha watershed Kothapally in Andhra Pradesh by Pathak *et.al.*(2002). It is revealed that the soil and water conservation interventions implemented in the watershed have increased the irrigated area by 200 ha in post-kharif season and 100 ha in post-rabi season. The average groundwater level in open wells was increased by 417 cm during the study period. Thus contributing approximately 27% of the seasonal rainfall to the ground water recharge.

From Fig.4.35, it is clear that the maximum monthly average rise in water level in the wells was found in September followed by February. The minimum monthly average rise in water level in the wells was found in June followed by May. The maximum rise in water level was observed in September because nearly 85% of the rainfall is received till September as compared to rainfall received in monsoon. The monthly average rise in water level in the observation wells was found to be 4.58, 3.80, 2.93 and 2.18 m in the month of February, March, April and May respectively. This is due to the fact that all the observation wells were dry in these four months during the pre development phase. From the above it is clear that the rise in water level in the different month ranges from 1.82 m to 4.66 m. The average rise in water table in the study area was found to be 3.32 m.

Yield of wells

It is observed that the average well yields were 1.92, 2.35, 3.38, 8.30, 11.69, 7.94, 3.62 and 4.28 m^3/hr for W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 respectively. The average specific capacity were found to be 1.49, 1.22, 3.75, 3.75, 4.99, 4.60, 1.28 and 1.88 m^3/hr/m depth of drawdown for W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 respectively. The maximum well yield and maximum specific capacity was found for W_5 while it was observed that W_1 well has the minimum well yield and W_2 well has the minimum specific capacity. The monthly observations of the drawdown, recoupment time and volume of water coming in all the observation wells were observed from November onwards. From the observations it is revealed that the well yields of the observation wells were gradually declined from November to May. The yields of all the observation wells were maximum in November. The yields of all the observation wells were minimum in May. The average yield of all the wells is found to be 5.44 m^3/hr. During the pre-implementation phase all the observation wells didn't yield in the months from February to May and during the post-implementation phase the average yields of the wells were increased to 4.49, 3.90, 3.09 and 2.42 m^3/hr in the same duration.

Specific capacity of wells

From the observations, it was observed that the specific capacities of the observation wells were gradually declined from November to May. The specific capacities of all the observation wells were maximum in November. They are 2.20, 1.79, 5.53, 5.53, 7.36, 6.78, 1.89 and 2.77 m^3/hr/m depth of drawdown for W_1, W_2, W_3, W_4, W_5, W_6, W_7 and W_8 respectively. The specific capacities of all the observation wells were minimum in May. The average specific capacity of all the wells is found to be 2.87 m^3/hr/m depth of drawdown. During the post-implementation phase the average specific capacities of the wells were increased to maximum upto 2.54 m^3/hr/m depth of drawdown. This indicates that the substantial increase in water availability in the wells during the summer season is the effect of watershed development interventions. The well yield and specific capacity declined gradually from November to May due to the fact that the soil moisture is sufficient in the post monsoon season, the percolation is also satisfactory due to soil and water conservations in the watershed area and during summer season the values decreased due to the depletion of groundwater table resulting from the pumping of water for irrigation of rabi and summer crops. This indicates that the substantial increase in water availability of the wells during the summer season is the effect of watershed development interventions.

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