A requirement of PoCRA Groundwater Recharge Plan

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Project on Climate Resilient Agriculture was envisaged with the objective to enhance climate resilience and profitability of smallholder farming systems in Marathwada and Vidarbha region. For this, the project needs to provide farm water security and reduce risks associated with inter- and intra-seasonal climate variability. The project strategized increasing the surface water storage capacity, groundwater recharge and in situ water conservation to improve water availability and increase farm productivity and income. The Department of Agriculture is to carry out the works for area treatment and drainage line treatment for impounding surface runoff and increasing in situ soil moisture. However, for doing works related to (i) groundwater recharge on suitable locations and (ii) identifying the new wells, their number and locations, it needs the expertise of GSDA. Towards (i) and (ii), GSDA has been given the task of preparation of groundwater recharge plans for clusters in the project area. GSDA uses GEC methodology (or a variation thereof) for estimating the groundwater resources in a region. GSDA has used this methodology for the preparation of cluster recharge plans in Jalswarajya 2. GEC methodology is made and revised by Groundwater Resource Estimation Committee from time to time constituted by the Ministry of Water Resources. Groundwater recharge plans prepared by GSDA should cover the following points.

GSDA Groundwater Recharge plan

1. The recharge plan will consist of the cluster-wise estimation of groundwater, runoff estimates and proposed interventions along with spatial maps.
2. The recharge plan will try to address the overall village water security by reducing the gap between supply and demand side, simultaneously solving the question of access to water through better allocation.
3. It will assess the feasibility of new dug wells and locations in the selected clusters.

GEC Methodology 1997

Groundwater estimation methodology, 1997 is based on water balance theory. Various input and output components of groundwater balance are computed to estimate the Ground Water Recharge.

Two basic approaches, viz (i) water table fluctuation method and (ii) rainfall infiltration factor method, form the basis for groundwater assessment. The rainfall recharge obtained by using the above methods provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate is then normalized for the normal monsoon season rainfall which in turn is obtained as the average of the monsoon season rainfall for the last 30 to 50 years.

Irrigation draft may be estimated separately for different types of well (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well, etc.). There are different methods for computing irrigation draft e.g well census method, cropping pattern method or power consumption method. To calculate irrigation draft, the well census method is commonly used. The season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well, etc.) is multiplied with the number of wells of that particular type to obtain season-wise groundwater extraction by that particular type of structure. The estimation of groundwater extraction is likely to be associated with considerable uncertainties in all the three methods as it is based on indirect assessment using factors such as electricity consumption, well census, and area irrigated from groundwater.

Once the groundwater draft is estimated, the assessment unit is categorized based on the stage of groundwater development which is the percentage of groundwater draft with respect to groundwater recharge. GEC 1997 Methodology links the categorization to dual criteria: one is the Stage of Ground Water Development and the other is Groundwater level trends.

GEC 1997 Methodology recommends ignoring the base flow component as it is difficult to assess. It suggests that net inflow, the base flow and recharge from the stream may also be dropped in absence of way to calculate these but should be incorporated wherever possible . Various norms for Specific yield, Rainfall Infiltration factor, recharge factor for various structures like ponds, canal, return irrigation factor, etc. are recommended by GEC 1997. If the rainfall recharge is computed using water table fluctuation method, 5% of the Total Annual GroundWater Recharge is taken as unaccounted Natural discharges else it is 10% of the Total Annual GroundWater Recharge.

GEC recommends that groundwater recharge should be estimated on groundwater level fluctuation and specific yield approach since this method takes into account the response of groundwater levels to groundwater input and output components. However, delayed groundwater recharge, extraction during kharif should be carefully considered. This, however, requires adequately spaced representative water level measurement for a sufficiently long period.

GEC 2015 committee recommends ways to take into account neglected components. If stream gauge stations are located in the assessment unit, the base flow and recharge from streams can be computed using the Stream Hydrograph Separation method, Numerical Modelling, and Analytical solutions. If the assessment unit is a watershed, a single stream monitoring station at the mouth of the watershed will provide the required data for the calculation of base flow. Any other information on local-level base flows such as those collected by research centers, educational institutes or NGOs may also be used to improve the estimates on base flows. It is recommended to initiate regional scale modeling with well-defined flow boundaries. Once the modelling is complete, the lateral throughflows (LF) across boundaries for any assessment unit can be obtained from the model.

Observations

GSDA plans to use the above methodology for the preparation of cluster recharge plans. Few observations related to existing methodology, its impacts with examples from PoCRA villages are given below.

1. Number of wells

GSDA is helping the department in fixing the number of wells and identify suitable locations for the wells. Few observations from the GSDA report titled “Groundwater Management Plan for aquifer no.1 WRB-2 2/2”, taluka Nandgaon, district Amravati are presented here. According to Maharashtra Groundwater (Development and Management) Act, 2009, New wells are not allowed in the notified area (exploited and overexploited units). GSDA has computed a norm of 1-1.5 ham annual draft per well. This is based on the assumption that this well will service an area of 1 ha. An indicative cropping pattern across multiple seasons used for this norm is given in Table 1(see annexure). Existing groundwater recharge is computed using GEC methodology. Next, for a given region, 70 % of the total annual recharged groundwater is divided by this unit draft norm, this provides the possible number of new wells in the given area.

To sustain the cropping pattern in one hectare based upon Table 1, crops requires 0.9 ham of water or water column of height 900 mm through well extraction. However, to extract this much amount of water one requires recharge from an area of 9 hectare and no other extraction should happen from this 9 hectare. Table 2 gives an example of this scenario where such computation has been done. At 2% specific yield and 5m water table fluctuation in a watershed, the groundwater recharge comes out to be 100mm i.e or 0.1ham per ha. Over 100 ha this recharge comes out to be 10ham. Assuming 70% permissible extractable recharge, the permissible number of wells comes out to be 8 in 100 ha. This also means out of 100 ha, cultivation is possible in only 10ha as one hectare requires 0.9 ham of water. This will lead to inequitable allocation of water to a few farmers who already have wells. 10% of the farms will utilize 100% of the recharge to sustain cropping pattern on 10% of land.

2-3 % is the maximum amount of specific yield observed across the basaltic shallow phreatic aquifer system due to the limited water-bearing capacity of the basalt rock which covers around 80% of Maharashtra. 3-8m is the water table fluctuation zone observed across Maharashtra during pre and post-monsoon season. This above situation is likely to happen all over Maharashtra.

2. Observations from PoCRA field visits

There are a few observations from well data collected from different villages given in Table 3. This data is representative of most sites across all the PoCRA districts that we have visited, and certainly for small and marginal farmers.

Firstly, most of the wells get dry by the month of Jan. or Feb. The total number of watering given from a well varies from 2-4. This number is much less than the assumed number of watering per well (17) required for computation of per unit well draft by GSDA given in Table 1. Next, the amount of water extracted from each well across different year varies from 2-4 TCM. It is not feasible to extract 9-10TCM (0.9-1ham) of water through these wells. Assuming an extraction of 2-4 TCM per well, and the recharge of roughly 100mm as GSDA has assumed, roughly 30-40 wells should be allowed in 1sq.km. this will allow more farmers to go for 1-2 crops rather than few farmers going for 3 crops or annual crops.

3. Importance of protective irrigation, Access to water and Community wells

Due to climate change, uncertainty in rainfall, intensity, the number of dry-spells and flooding events are increasing. In the case of Marathwada and Vidarbha region, the stress is magnified in drought-prone regions and areas with poor soils. Around 80% of the land in Maharashtra is under dryland or rainfed agriculture with limited water resources and highly fluctuating crop yields which are largely dependent on rainfall. In the case of dryland agriculture, soil moisture is the main source of water and hence the occurrence of dry spells has a large impact on crop productivity and hence on the farm incomes. Some farmers can cope with the dry spells and suffer mildly while others suffer badly. This depends on the natural/geographical factors like soil types, location of the farm (slope, nearness to stream etc.) and on socio-economic and infra-structural factors like having a well, drip/sprinkler sets, ability to transfer water from long and short distances, ability to buy water during water stress periods, etc.

Rabi cropping depends on the availability of residual soil moisture from the monsoon season and also on the availability of groundwater. Generally, in the dryland regions, groundwater is not available in abundance everywhere in the village. This makes it extremely difficult for them to provide supplemental protective irrigations during kharif and rabi season.

The solution to this problem is providing access to water to farmers through community wells at appropriate sites. It can help multiple farmers accessing this water even if his farm is near the stream or away from the stream. A number of farmers and cropping pattern and area under community wells should be fixed. Since the supply of water is limited, farmers selected for water sharing will regulate the water among themselves. It will solve the problem of those who want to give protective irrigations to their kharif crops and then rabi crops.

In other words, what is critical is that the net discharge in the area is not more than the net recharge. This may be ensured through allotting 2-4 TCM per well and documenting cropped area, irrigated area and water transfers for new wells.

During the field visits to PoCRA villages, different mechanisms of water sharing, transfers and lifting were observed across the region. Farmers purchase land near the stream or already owns land in the discharge zone, with the help of pipes they transfer it to the other parcel of land generally in the recharge zone. One farmer provides water to another farmer in exchange for ⅓ or ¼ of the produce. Generally, a well is owned by one family member in one part of the land, exchange of water also happens within the family after the division of land.

This also tells us that it is possible to institutionalize and strengthen such collective mechanisms with the help of government interventions.

4. Kadwanchi village - Groundwater recharge and extraction

Let us now discuss about the Kadwanchi Village, and existing mechanisms for extracting groundwater recharge and storing it in farm ponds. the LU/LC of the village is given in Table 4. The village has 1508 ha area, out of this 1106 ha is cultivable and the rest is non-agriculture land. The total fallow and scrubland in the village is 191 ha. The watershed boundary of Kadvanchi is more than its village boundary. In the north of the village, there is more non-agriculture land which is in the watershed but out of village boundary. This area (~200 ha) is significant and there is a percolation tank and some bunds there. This is not accounted for in the current balance. The non-agriculture land plays a huge role in increasing the groundwater recharge in a watershed or village. The village has a mix of crops throughout the year (2017) across different seasons as given in Table 5. Major grown crops are Soybean, Cotton, Jowar, and grapes. The farmers who grow annual crops have both wells and farm ponds. Many new orchards have been started in the last 2-3 years. Both drainage and area treatment work has been done extensively in the village over the years and is given in Table 6. There are around 450 dug wells in the village visible from the google earth and 456 farm ponds available from the village report. There are no inlet-outlet based farm ponds, all the farm ponds are lined. There are 19 CNBS, 6 ENBS and 2 KT weirs in the village which act as surface water storage and groundwater recharge structures.

In a good year(2016), the rainfall is 959 mm which generates the runoff equal to 8069 TCM based upon our model (link) within the village boundary. In a bad year(2015), the rainfall is 523 mm which generates runoff equals to 3522 TCM (from model). We accounted for drip efficiency in the model by reducing PET by 60%. Tankers are brought by a few farmers in some years but is not the norm. The total groundwater recharge after considering the impact of compartment bunding/CCT comes out to be 993 TCM in a good year whereas in a bad year it comes out to be 747 TCM. The total farm pond (lined) storage in the village itself is 1313 TCM which is more than groundwater recharge in both good and bad year. Moreover, after filling the farm ponds there is sufficient groundwater available till Jan/Feb. Farmers are able to meet the needs of annual crops in both good and bad year through existing storage in the village. This demand comes out to be 1849 TCM in a good year and 2167 TCM in a bad year(Model).

From Table 7 for cash crops in a good year, it seems there is not much water left to meet its needs. In actual condition, this is not the case as all the crops have given good yields and water has been applied to them. It is also observed that there is hardly any runoff water which leaves the village, particularly during the bad year. There is a small dam in Pirkalyan village downstream, which rarely gets filled now. This clearly suggests that through the drainage line structures, wells near the streams have sufficient water available. These farm ponds are filled from wells near streams are indirectly getting filled through runoff available locally to wells. To give an idea of the situation most of the existing structures have been identified and marked on GIS map using google earth and given in Fig 2 and Fig 3 overlayed over google image, village, and drainage boundary. One can clearly see most of the wells are in the stream or its vicinity. Near each well, there is at least one farm pond.

The conclusion is drainage treatment enhances the GW recharge for immediate use by wells near streams. This situation is common across many villages. In our water budget, this extraction of water is debited from runoff rather than groundwater recharge. Groundwater recharge plans should be made accordingly by considering such stream proximity zones and extra water available through runoff in these zones.

5. Other issues

There are certain quantities computed or used by GSDA while preparation of groundwater recharge plan for aquifer no.1 WRB-2 2/2,taluka Nandgaon, district Amravati, these need some clarity (Table 9). Source used by GSDA for a number of watering required per crop is not clear. E.g for soybean it is 2 and for cotton, it is 4 for the full season given. Amount of water required by crop per watering used in the report is different for different crops. The source is not clear for this. E.g for soybean it is 0.05 Ham and for cotton it is 0.063 Ham per hectare. Total crop water requirement (crop PET) for many crops seems to be very less. The number of watering has been divided into watering available from drip, sprinkler, rain and surface water. Division of amount of water coming from rainfall and groundwater is not clear. Source for calculating the total number of wells and dug wells is not clear. The average depth of wells and water table fluctuations is provided in the range, if GSDA is planning to survey multiple wells then based upon the behaviour of wells these figures should be used in suitable zones rather than using overall average figure for complete cluster. It is mentioned in the GSDA MoU that specific yield, transmissivity, specific capacity, computation of aquifer performance tests will be done while computing groundwater recharge. In using pumping tests to obtain specific yield value, it may be noted that unless the tests are of sufficiently long duration (minimum pumping duration of 16 hrs), proper assessment of specific yield value is difficult.

In the report, using average pump discharge of 15 cum/hr, average pumping hours a day and average pump operating days in each month, an annual average draft of a well in Ham is computed which comes out to be 1.0275 Ham or 1027mm per ha from one well. This number will vary based upon the location of the wells and won't be constant in complete cluster. It is also not clear how the average discharge figure is computed.

The two steps in estimating recharge in the GEC methodology are (i) to estimate water level fluctuation in a set of wells, and (ii) to estimate the specific yield.

GEC 1997 recommends using dry season groundwater balance method for estimating specific yield. The specific yield is estimated from groundwater balance in the dry season, and based on this specific yield value, the recharge is estimated from groundwater balance in the monsoon season. The approach is suitable in hard rock areas where data regarding base flow in the dry season is available or base flow in the dry season is practically zero. For doing this winter and summer water levels are required. GSDA team will be visiting selected PoCRA village for 3-4 days. In such a short duration for the preparation of a groundwater recharge plan, it is difficult to obtain water levels for different wells and do pumping tests. The specific yield determined by the pumping test is for the aquifer material which occurs within the cone of depression created during the pumping test. It may introduce an error in computation unless and until there is a sufficient number of pumping tests conducted in the assessment sub-unit.

6. Soil water balance model and its Integration with recharge plan

IIT Bombay has prepared a regional daily water balance procedure based on standard SWAT models and validated in several villages. The main outputs of the daily water balance model are surface runoff, soil moisture stock, actual crop evapotranspiration (AET) and natural groundwater recharge on a daily time step. The model uses daily rainfall and also allows application of irrigation by the farmer. For further details please refer to this link. It is essential that GSDA understands the working of soil water balance model.

It would be useful to compare our model with existing GSDA estimation procedures. For example, GSDA computes normalized annual groundwater recharge using past total rainfall data. Our water balance model runs at the daily level and at current year rainfall. Integration of normalized recharge with the daily real-time computed groundwater recharge should be attempted.

8. Impact of groundwater recharge structures

Based upon the groundwater recharge plans PoCRA will implement groundwater recharge structures at various locations in the project. To understand the impact of such structures on groundwater recharge and change in cropping pattern if any, reports and some case studies related to groundwater recharge structures done by GSDA or any other institute are required, as project investment in the entire area will reach Rs 100-150 crore for creating recharge structures.

VNMKV Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani has designed and evaluated an artificial dug well recharge system model. This system was constructed near the open well for groundwater enhancement. The daily runoff events during the year 2011 to 2013 were computed from SCS curve number method. This runoff volume was utilized for artificial well recharging for enhancing the groundwater levels in the well.

Comparison of water levels of 2011 to 2013 indicated that there was an increase in water level in the tune of 0.3 m to 3.4 m due to artificial well recharging resulted in an increase in groundwater potential. The amount of runoff generated is not getting translated into the increase in storage of well. E.g in the year 2011 from the area of 1.8 ha 3.6 TCM runoff was generated but recharge is less than 1 TCM (assuming all the runoff water is getting diverted to well after filtering). Current water table fluctuation numbers also include the amount of recharge from the area around the well through percolation. There is no lifting of water from well for irrigating crops. So impact in terms of cropping pattern and area change is not known.

GSDA proposes Trench with shafts, Recharge Shafts, Recharge Trenches, Gabion Bandhara, Cement Nala weirs, Under Ground Bandhara, Water Absorption trenches, Well Flooding with suitable locations in their groundwater recharge plan. However, given the amount of investments to be made for building these structures it would be useful to understand the impact made by these structures in the other places where GSDA has implemented similar recharge plans. Few case studies or impact studies done by GSDA regarding these structures is required.

Annexure

Table 1 Crop water requirement per ha given by GSDA

Crop	Area Ha	Number of watering	Water required per watering ham	Total water requirement ham 12 months	Total water requirement ham 8 months
Soybean	1	2	0.0635	0.1270	0.1270
Wheat	1	7	0.0762	0.5334	0.5334
Vegetables	0.8	8	0.0762	0.4877	
			Total	1.1481	0.06604
			Average	0.9042	

Table 2 Norm of 8 wells per square km.

Sr.No	Item	value
1	Area Sq. km	1
2	Area Ha	100
3	Water fluctuation m	5
4	Specific yield %	2
5	Annual groundwater availability ham (2*3*4)	10
6	70 % of annual available groundwater	7
7	per well annual draft	0.9
8	Based upon 70 % usable groundwater permissible number of wells	8

Table 3 observations from the field visits

District	Village	Gat No.	Crop pattern	Total Area (acre)	Depth of well (feet)	Total Number of waterings	Total extraction (TCM)	Year	Till when does it last?
Beed	Yelda	193	Tur, cotton, wheat	6	55	2	1.98	2017	Feb

Beed	Yelda	193	Tur, cotton, wheat	6	55	2	1.93	2018	Dec
Beed	Yelda	347	Tur, cotton, soyabean, harbhara, jowar	2.6	50	3	2.38	2017	Jan
Beed	Yelda	347	Tur, cotton, soyabean, harbhara, jowar	2.6	50	3	2.38	2018	Nov
Amravati	Mamdapur	295	Soyabean, Tur, Cotton	2.6	40	3	2.81	2017	Feb
Amravati	Mamdapur	295	Soyabean, Tur, Cotton	2.6	40	3	3.04	2018	Feb
Amravati	Mamdapur	98	Soyabean, Tur, Cotton	3.5	48	3	2.36	2017	May
Amravati	Mamdapur	98	Tur, cotton	3.5	48	3	2.36	2018	Feb
Jalgaon	Yewati	170	Tur cotton, udid	5.5	50	2	1.37	2017	Jan
Jalgaon	Yewati	170	Tur cotton, udid	5.5	50	2	1.80	2018	Dec
Jalgaon	Yewati	467	Tur, cotton	7	40	2	3.11	2017	Jan
Wardha	Wabgaon	483	Tur, cotton	7	45	2	2.48	2017	Jan
Wardha	Wabgaon	483	Tur, cotton, chana	7	45	2	1.48	2018	Nov
Wardha	Wabgaon	365	Tur, cotton	3	40	2	1.48	2017	May
Wardha	Wabgaon	365	Tur, cotton	3	40	4	1.93	2018	Feb
Jalna	Chapadgaon	210	Soybean, cotton, udid, tur, Wheat	20	52	4	2.23	2017	Feb
Jalna	Chapadgaon	210	Soybean, cotton, udid, tur, Wheat	20	52	4	2.23	2018	Feb
Jalna	Chapadgaon	293	Tur, chana, udid, cotton	10	75	4	3.88	2017	Jan

Table 4 Landuse/Landcover in Kadwanchi village

Land use	Area Ha
Total geographical land	1508
Forested	211
scrub/fallow	47

fallow land (kayam +chalu)	144
cultivable land	1106

Table 5 Cropping pattern in Kadwanchi village

Sr	**Kharif crops**		**Annual crops**		**Rabi**	
1	Jowar	0	Grapes	320	Jowar	288
2	Bajra	19	Pomegranate	20	Bajri	0
3	Tur	63	Seetafal	2	Wheat	40
4	Mung	22	Mosambi	2	Harbhara	55
5	Udid	0	Mango	1.5	kanda/ vangi	10
6	Soybean	256			Maize fodder	15
7	Cotton	318			Marigold	0
8	Chilli	0				
9	Onion	0				
10	bhajipala	12				
11	Maize fodder	55				
12	Jowar fodder	71				
13	Marigold	0				

Table 6 Existing Structures in Kadwanchi village

Type	No/Ha	Water harvested TCM	Total storage in mm in village	Category
Compartment bunding	978	440.1	29.18435	W2
Farm ponds	456	1003.2	66.5252	W1
CNB	19	292.6	19.40318	W1
KT Weir	2	18	1.193634	W1

CCT	147	66.15	4.386605	W2
		1820.05	120.693	

Table 7 Kadwanchi Good year analysis

Kadvanchi good year 2016 : 959mm; Cultivable area: 1106 ha; geographical area: 1508 ha; With drip impact: 0.6 PET											
Water availability	Monsoon Runoff generated (TCM)	Available TCM		Irrigation demand	Deficit TCM	PET TCM	Irrigation allocation TCM	yield %	Area ha	Index	Index value
W1		1,313.8		P1 crops: annual	1,849	3,191.0	1,848.6	1.00	348.0	P1 risk index	0.8
W2		480.9		P2 crops: Kharif	131	999.0	130.6	1.00	268.0	P2 index	0.5
GW recharge from rain	8,069	513.5		P2 crops: Rabi	204	270.0	203.9	1.00	50.0		
W3		25.3		P3 crops: Kharif	1,005	3,362.0	-	0.70	548.0		
				P3 crops: Rabi	974	1,469.0	25.3	0.35	358.0		
Total		2,333.6		Total	4,161.8	9,291.0	2,208.4		1,570.0		

Table 8 Kadwanchi Bad year analysis

Kadvanchi bad year 2015 : 523mm ; Cultivable area: 1106 ha; geographical area: 1508 ha; Drip impact: 60% PET reduction											
Water availability	Monsoon Runoff generated (TCM)	Available TCM		Irrigation demand	Deficit TCM	PET TCM	Irrigation allocation TCM	yield %	Area ha	Index	Index value
W1		1,313.8		P1 crops : annual	2,167	3,169.0	2,061.7	0.97	348.0	P1 risk index	1.0
W2		480.9		P2 crops : Kharif	421	988.0	-	0.57	268.0	P2 index	-
GW recharge from rain	3,522	287.0		P2 crops : Rabi	227	270.0	-	0.16	50.0		
W3		25.3		P3 crops : Kharif	1,804	3,345.0	-	0.46	548.0		
				P3 crops : Rabi	1,140	1,469.0	25.3	0.24	358.0		
Total		2,087.0		Total	4,620.3	9,241.0	2,087.0		1,570.0		

P1 crops are annual crops; P2 crops are seasonal irrigated crops and P3 crops are rainfed. W1 water is water available in stream proximity due to drainage line treatment; W2 is groundwater recharged due to CCT/compartment bunding - this is available to off-stream farms that have an extraction device in the kharif period and later joins W1 water. W3 water is moisture added due to compartment bunding which is accessible to rainfed farms.

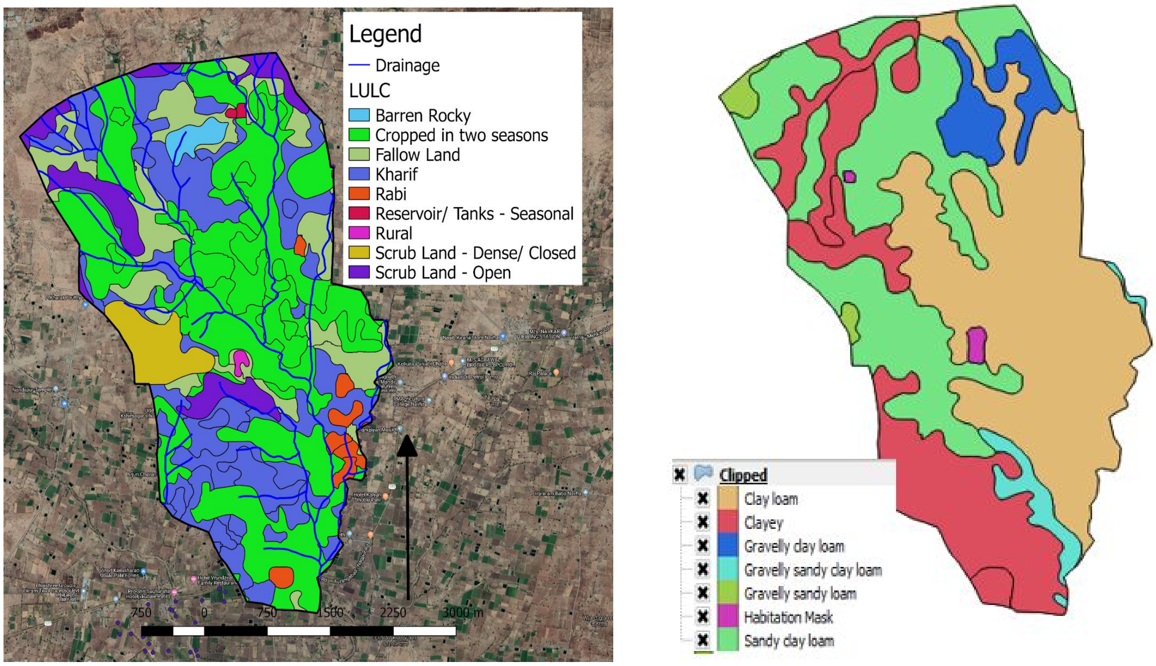

Fig 1 Lanuse and soil map of Kadwanchi village

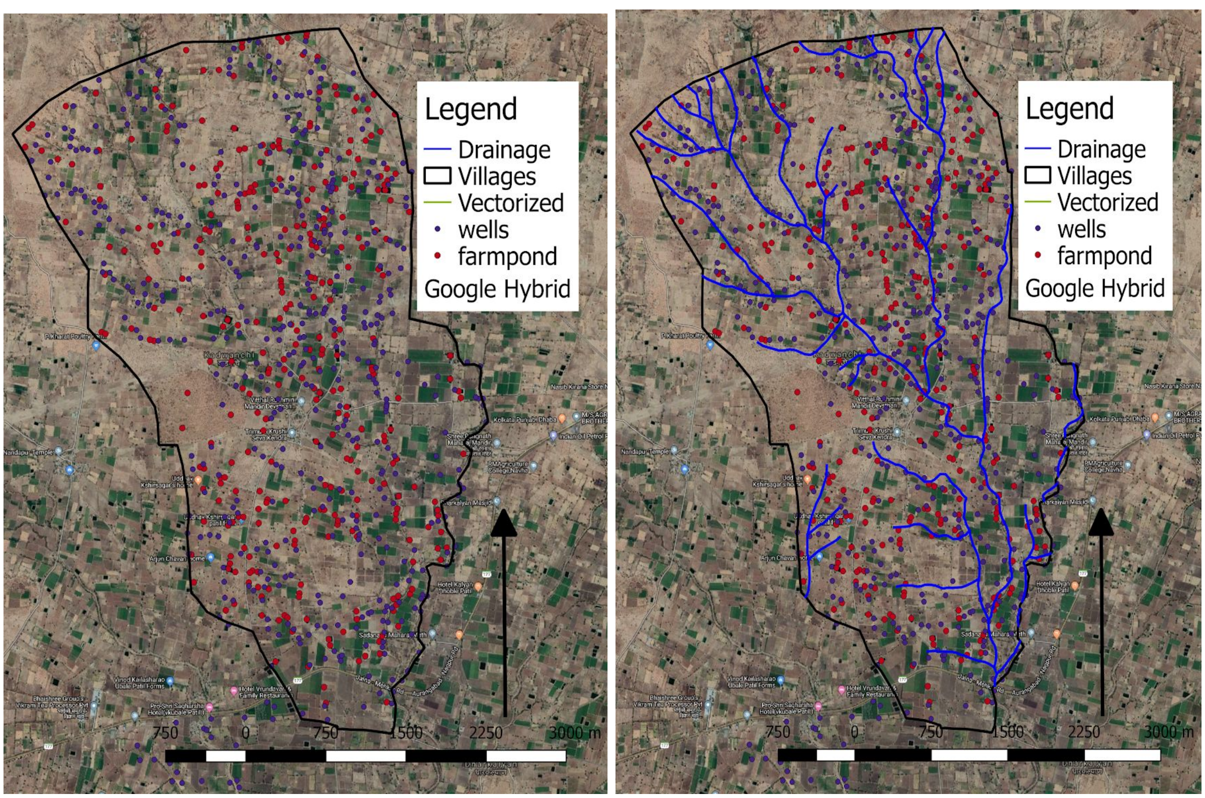

Fig 2 Farm Ponds, wells and drainage on Kadwanchi village

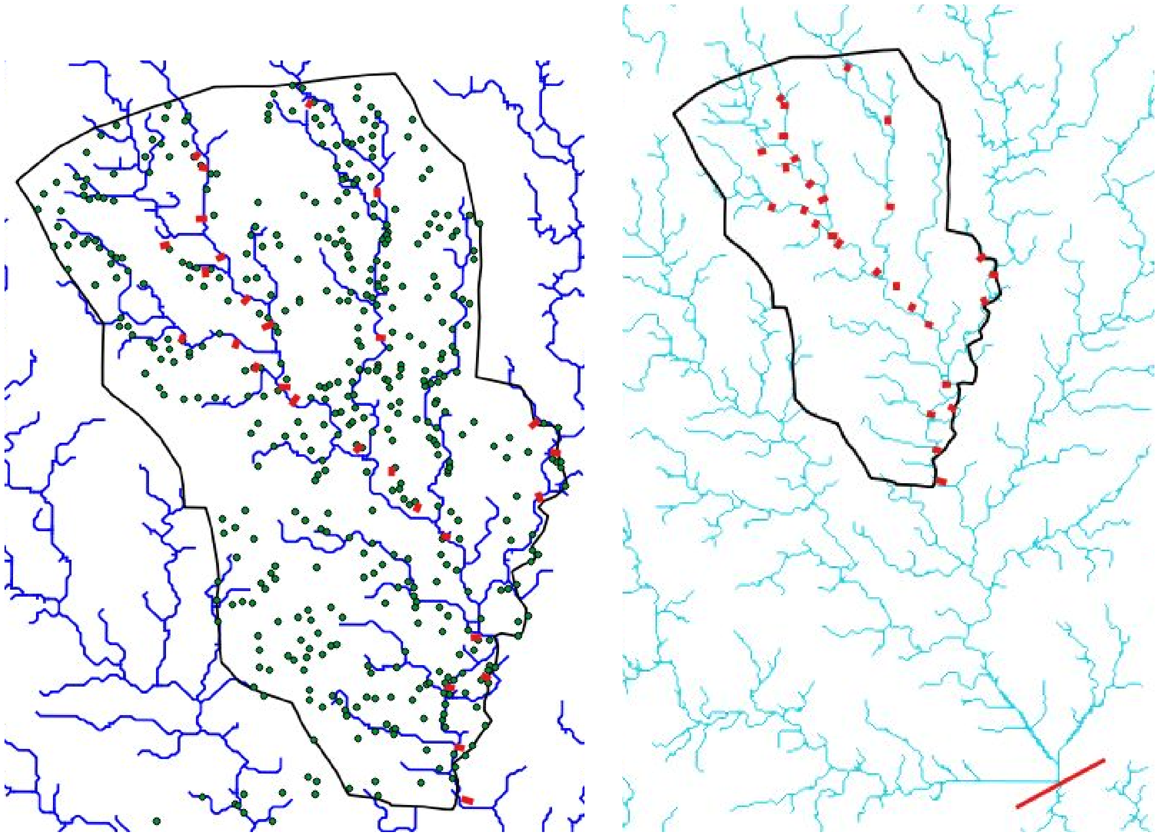

Fig 3 Wells(green) and existing CNB, ENB, KT weir (Red) Map

Table 9 Stage of groundwater development

	Stage of groundwater development		Comments
	Monsoon Recharge	Ham	
1	Rainfall recharge during monsoon (by WTF) in Ham =(area × wtf × sy) (759.71*4.3*0.03)	98	Specific Yield - how many pump tests
2	Recharge from WCS during monsoon in Ham (25% of total storage)	3.4	
3	Recharge from groundwater irrigation during monsoon in Ham (10 % of water applied) as per GEC norms	3.86	
4	Groundwater Draft during monsoon in Ham	38.6	Number of watering per crop, Amount of watering for different crops- How

5	Total groundwater recharge during monsoon in Ham =(1+2+(4-3))	136.14	
	Non-Monsoon Recharge		
5	Recharge from WCS during non-monsoon in Ham(25 % of total storage)	3.4	
6	Recharge from canal in Ham	0	
7	Recharge from Surface water irrigation during non-monsoon in Ham	0	Number of watering per crop, Amount of watering for different crops- How
8	Recharge from Groundwater irrigation during non-monsoon in Ham (10% of water applied) as per GEC norms	10.8	Number of watering per crop, Amount of watering for different crops- How
9	Recharge from Tanks and ponds in Ham (as per GEC norms)40%	0	
10	Total groundwater recharge during non-monsoon in Ham	14.2	
11	Gross groundwater recharge (5+10) in Ham	150.34	
12	Net groundwater availability in Ham (11-(5%0f 11)) by deducting base flow	142.82	
13	Gross groundwater draft for all uses (from earlier sections) in Ham	149.51	Number of wells, pumping hours and months of pump operation, average discharge per pump - How
14	Groundwater surplus (+)/deficit(-) = 12-13 in Ham	-6.69	
15	Stage of groundwater development (13/12)	104.68	