ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Performance Evaluation of Rehabilitated Irrigation Tanks using Hydrological Modelling

E Arivoli[1], N K Ambujam[2]

P.G. Student, M.E Integrated Water Resources Management, Centre for Water Resources, Anna University, Chennai, Tamil Nadu, India[1]

Professor & Director, Centre for Water Resources, Anna University, Chennai, Tamil Nadu, India[2]

ABSTRACT*:*Tank irrigation is considered as one of the ancient irrigation system. Since the age of south Indian tanks are century years old and had started to decline progressively. Due to inadequate rainfall, improper maintenance of tank components the tank irrigation system follows a declining trend, almost all the command area under any tank irrigation system depends on the wells located in the fields. By knowing this, the government of Tamil Nadu is trying to rejuvenate the existing irrigation tanks. One such rehabilitation programme is TN – IAMWARM. This paper focused on evaluating the performance of rehabilitated tanks for the past fifteen year (2000-2015) through hydrological simulation using MS-Excel as a tool and to study the impact of rehabilitation on tank performance. Gomukhi sub basin of vellar basin, Tamil Nadu, India is selected for the study, in which one non-system tank and a system tank is chosen. Monthly runoff to the tank and rainfed on the tank is taken as inflow, crop water requirement, evaporation and seepage is taken as monthly outflow. The monthly change in storage is used to simulate the ayacut area of the selected tanks which is taken as the performance of the tanks.

KEYWORDS:Performance evaluation, TN-IAMWARM, Water balance, Simulation, Hydrological modelling

I. INTRODUCTION

It is well known fact that tanks are small reservoirs that are generally constructed in villages for multiple purposes such as domestic, irrigation, livelihood, groundwater recharge; these tanks are considered as one of the biggest assets of villages and are common to all villagers. Tank Irrigation system is a cost effective irrigation system since most of the farmers in the state are marginal farmers. Tanks are classified as system tank and non-system tank based on the inflow, PWD tanks and panchayat tanks based on the ayacut area. A tank has its catchment area, feeder channel, embankment, sluices, weirs, field channels and ayacut area. Most of the tanks existing in the state of Tamil Nadu are century years old. Due to inadequate rainfall, encroachment on tank bed, poor maintenance of tank components the tank irrigation system keeps on decreasing. The share of tank irrigation in Tamil Nadu declines to 19% and the share of well irrigation increased to 50% [5]. There is an urge to rehabilitate these tanks and bring their condition to an improved state.

By knowing the significance of tanks the state Government is trying to rejuvenate these tanks under various schemes, many international agencies are also funding for tank rejuvenation in south Asia especially in south India. One such project is TN-IAMWARM, Tamil Nadu Irrigated Agriculture Modernization and Water-Bodies Restoration and Management (IAMWARM) is a Multidisciplinary Project funded by the World Bank. It has been implemented by the Government of Tamil Nadu with Water Resources Department as the nodal agency. The project has covered 63 selected sub basins out of 127 sub basins and covers an ayacut area of 6.17 lakh hectares.

Repair of sluice, strengthening of tank bund, desilting of supply channels, lining of field channels, eviction of encroachment on the tank bund are the works carried under the rehabilitation programme.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

II. METHODOLOGY ADOPTED

Gomukhi sub basin of vellar basin, Tamil Nadu, India is taken up for the study. A Non-system tank ‘Niraimathi’ and a System tank ‘Thenkeeranur big tank’ in Kallakurichi block of Villupuram district, Tamil Nadu, India is chosen for the evaluation. The corresponding co-ordinates are 11°42'53.21"N and 79° 0'8.65"E (non-system tank), 11°43'40.00"N and 78°58'10.00"E (system tank). There are about 39 system tanks and 41 non system tanks are available in the gomukhi sub basin and all the tanks have been rehabilitated under TN-IAMWARM programme. 60 water user’s associations are formed under the same programme.

The Non-system tank ‘Niraimathi’ was rehabilitated in the year 2011 whereas the system tank ‘Thenkeeranur big tank’ was rehabilitated in 2013. The ayacut area under the non-system tank is 59 ha and 68 ha for system tank, in which paddy and sugarcane are the major crops grown in that area. 4 ha of maize have grown under the system tank command. The simulation is carried for paddy and sugarcane separately for the past 15 years (2000-2015)

The methodology incorporates four segments viz. calculating monthly runoff and rainfed on the tank as inflow to the tank, calculating monthly Crop Water Requirement for paddy (Kharif & Rabi) and sugarcane separately, carry out monthly water balance, simulating ayacut area for the selected crops which is taken as the performance of the tanks.

II.1 Delineation of catchment area

The catchment area is delineated using ArcGIS 10. The base map is created from Google earth. The SRTM image of 30m x 30 m resolution is downloaded for the corresponding base map. The base map is geo referenced with its coordinates in ArcGIS 10. The catchment area for the selected tanks is delineated followed by flow direction and flow accumulation. The catchment area details are given below in the table (1).

Table (1) Catchment area details of the selected tanks

Tank	Free catchment area in sq.km	Combined catchment area in sq.km	Net catchment area in sq.km
Non-system (Niraimathi)	8.8	13.7	9.78
System (Thenkeeranur big tank)	5.4	13.7	7.06

- Net catchment area = $\left(20\%\ of\ intercepted\ area + |Free\ catchment\ area\right)$
- Intercepted area = $\left(Combined\ catchment\ area - free\ catchment\ area\right)$

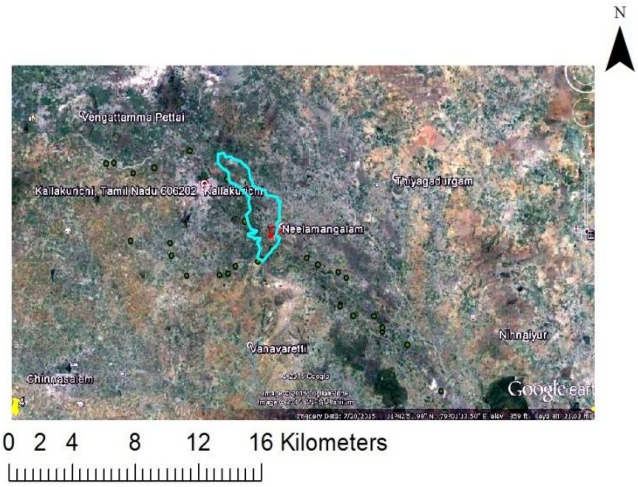
The catchment area maps are given below in the figure 1 a, b, c

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

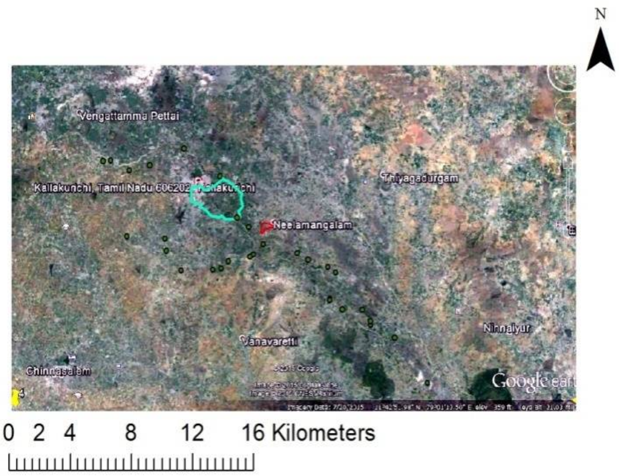
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

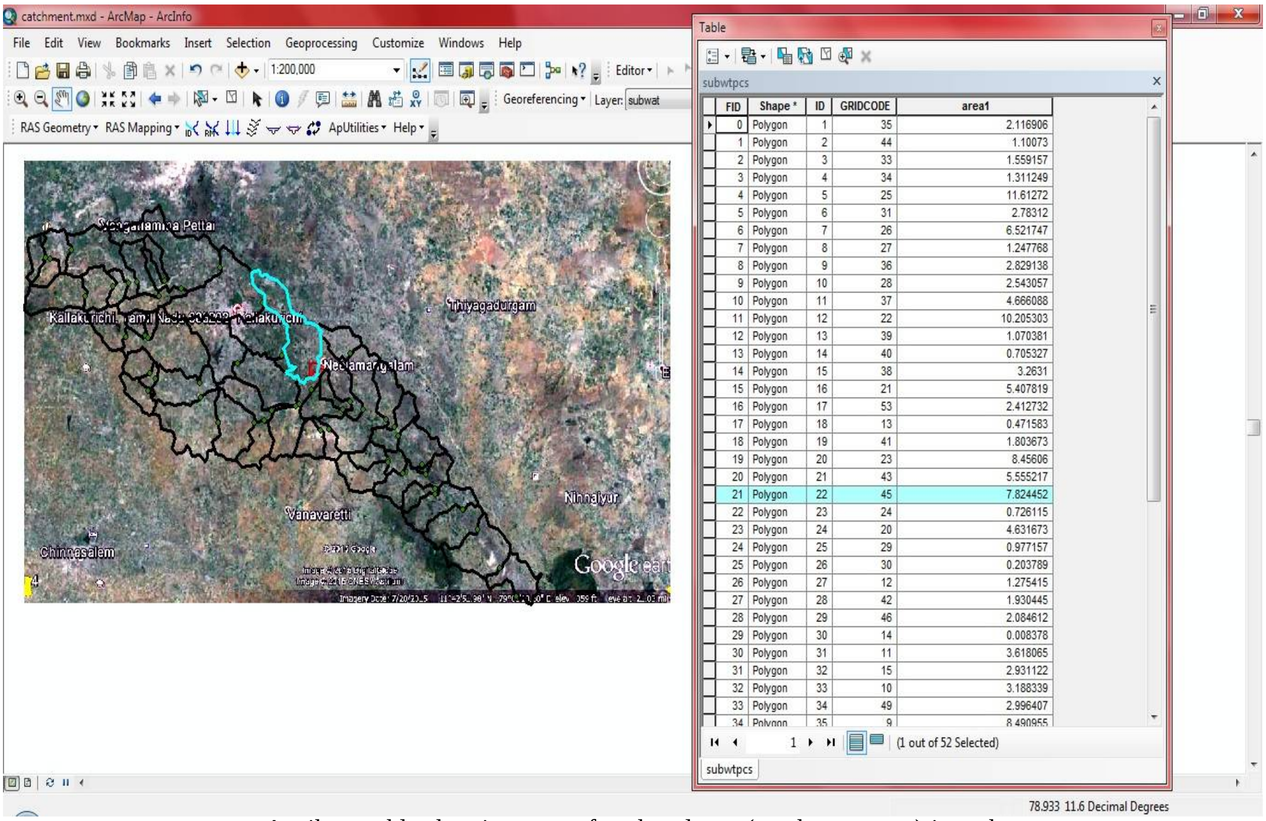
Vol. 5, Issue 5, May 2016



Figure(1)a. Free catchment of Non-system tank (Niraimathi)



b. Free catchment of System tank (Thenkeeranur big tank)



FID	Shape *	ID	GRIDCODE	area1
0	Polygon	1	35	2.116906
1	Polygon	2	44	1.10073
2	Polygon	3	33	1.559157
3	Polygon	4	34	1.311249
4	Polygon	5	25	11.61272
5	Polygon	6	31	2.78312
6	Polygon	7	26	6.521747
7	Polygon	8	27	1.247768
8	Polygon	9	36	2.829138
9	Polygon	10	28	2.543057
10	Polygon	11	37	4.666088
11	Polygon	12	22	10.205303
12	Polygon	13	39	1.070381
13	Polygon	14	40	0.705327
14	Polygon	15	38	3.2631
15	Polygon	16	21	5.407819
16	Polygon	17	53	2.412732
17	Polygon	18	13	0.471583
18	Polygon	19	41	1.803673
19	Polygon	20	23	8.45606
20	Polygon	21	43	5.555217
21	Polygon	22	45	7.824452
22	Polygon	23	24	0.726115
23	Polygon	24	20	4.631673
24	Polygon	25	29	0.977157
25	Polygon	26	30	0.203789
26	Polygon	27	12	1.275415
27	Polygon	28	42	1.930445
28	Polygon	29	46	2.084612
29	Polygon	30	14	0.008378
30	Polygon	31	11	3.618065
31	Polygon	32	15	2.931122
32	Polygon	33	10	3.188339
33	Polygon	34	49	2.996407
34	Polygon	35	9	8.490955

c. Attribute table showing area of each polygon(catchment area) in sq.km

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

II.2 CALCULATION OF MONTHLY RAINFALL-RUNOFF FOR NON-SYSTEM TANK FOR THE YEAR 2000-01

The monthly rainfall-runoff to the tank is calculated using strange's table. The monthly rainfall-runoff into the tank is taken as monthly inflow into the tank. The rainfall data for the past 15 years (2000-2015) recorded in gomukhi dam rain gauge station is taken as basic input. The type of catchment chosen is combination of average and bad, with this catchment type combination, rainfall data the monthly rainfall-runoff is calculated using strange's table for 15 years. The rainfall-runoff for 1st year 2000-2001 is given below in the table (2).

Table (2)Rainfall-runoff for Non-system tank for the hydrological year 2000-01

Year (2000-01)	June	July	August	September	October	November	December	January	February	March	April	May
Rainfall in mm	24	19.9	106.4	260.9	256.5	149.1	99.8	4.3	0	0	127.9	53.7
Yield from the catchment in M.cum	0	0	0.05	0.0735	0.0697	0.0129	0.0042	0	0	0	0.0081	0.0006

II.3 CALCULATION OF MONTHLY CROP WATER REQUIREMENT FOR NON-SYSTEM TANK FOR PADDY FOR THE YEAR 2000-01

Two crops were identified in the selected tank command area namely paddy and sugarcane. The monthly crop water requirement is calculated using modified penman method. In case of paddy two season were identified namely Kharif and Rabi whereas sugarcane is a perennial crop. The calculation of crop water requirement incorporates addition for nursery in case of paddy, addition for land preparation in the first month, addition for percolation and minimum depth, conveyance losses and field capacity (actual field values). The non-system tank was rehabilitated in the year 2011, before the conveyance efficiency of field channel was 30%. After its rehabilitation the conveyance efficiency was 45%. In case of system tank, rehabilitation was done in the year 2013 and the conveyance efficiency of field channel was 30% before and after its rehabilitation. The type of soil found in the field is black soil which has high clay content thus the field capacity is 40%. Till 2011 the conveyance losses was added to be 70% and after 2011 (rehabilitation done) the losses was reduced to 55% in non-system tank. The calculation of crop water requirement for paddy and sugarcane for the year 2000-01 is given in the table (3)&(4) respectively.

Table (3) Calculation of crop water requirement for paddy for kharif season for 2000-01

S.NO	Description	July	August	September	October	Total
1	ET in mm	213.9	192	148.8	151.9	706.6
2	Kc	1.1	1.1	1.1	0.95	
3	Monthly water requirement in mm	235.29	211.2	163.68	144.305	754.475
4	Nursery	40	0	0	0	40
5	Land preparation in mm	160	0	0	0	160
6	Percolation 10mm/day	300	300	300	300	1200
7	Min depth in mm	50	0	50	0	100
8	Gross total in mm	785.29	511.2	513.68	444.305	2254.475

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

9	Monthly rainfall in mm	19.9	106.4	260.9	256.5	643.7
10	Effective @ 50%	9.95	53.2	130.45	128.25	321.85
11	Net Irrigation requirement in mm	775.34	458	383.23	316.055	1932.625
12	Conveyance efficiency @ 30%	1318.08	778.60	651.49	537.29	3285.46
13	Field efficiency @ 40%	2108.92	1245.76	1042.39	859.67	5256.74
14	Total in mm	2108.92	1245.76	1042.39	859.67	5256.74
15	Total CWR/ha in m^3	21089.25	12457.60	10423.86	8596.70	52567.4
16	Total CWR/ha in M.cum	0.02109	0.01246	0.01042	0.00860	0.0526

Table (4) Crop Water Requirement for sugarcane for the year 2000-01

S. NO	Description	July	August	September	October	November	December	January	February	March	April	Total
1	ET in mm	213.9	192	148.8	151.9	136.4	150	173.6	204.6	195	260.4	1826.6
2	Kc	0.4	0.4	0.4	1.25	1.25	1.25	1.25	1.25	0.75	0.75	
3	Monthly water requirement in mm	85.6	76.8	59.52	190	170.5	187.5	217	255.8	146	195	1584
4	Nursery	0	0	0	0	0	0	0	0	0	0	0
5	Land preparation in mm	50	0	0	0	0	0	0	0	0	0	50
6	Percolation 10mm/day	300	300	300	300	300	300	300	300	300	300	3000
7	Min depth in mm	50	0	50	0	50	0	50	0	50	0	250
8	Gross total in mm	485.56	376.8	409.52	489.875	520.5	487.5	567	555.75	496.25	495.3	4884.055
9	Monthly rainfall in mm	19.9	106.4	260.9	256.5	99.8	4.3	0	0	127.9	53.7	929.4
10	Effective @ 50%	9.95	53.2	130.45	128.25	49.9	2.15	0	0	63.95	26.85	464.7
11	Net Irrigation requirement in mm	475.61	323.6	279.07	361.625	470.6	485.35	567	555.75	432.3	468.45	4419.355
12	Conveyance efficiency @ 30%	808.54	550.12	474.42	614.76	800.02	825.10	963.90	944.78	734.91	796.37	7512.9035
13	Field efficiency @ 40%	1293.66	880.19	759.07	983.62	1280.03	1320.15	1542.24	1511.64	1175.86	1274.18	12020.6456
14	Total in mm	1293.66	880.19	759.07	983.62	1280.032	1320.152	1542.24	1511.64	1175.856	1274.184	12020.6456
15	Total CWR/ha in m^3	12936.59	8801.92	7590.70	9836.20	12800.32	13201.52	15422.4	15116.4	11758.56	12741.84	120206.456

16	Total CWR/ha in M.cum	0.01294	0.00880	0.00759	0.00984	0.0128003	0.013202	0.015422	0.0151164	0.011759	0.012742	0.12020646

II.4 WATER BALANCE FOR THE SELECTED TANKS

The inflow to the tank is monthly runoff from the rainfall, rainfed on the tank whereas system tank is getting additional inflow of 0.00002M.cum from nearby anicut (thenkeeranur). Monthly crop water requirement, evaporation, seepage are the monthly outflows from the tank. By doing water balance, the probable ayacut area that the tank can able to irrigate is found which is taken as the performance of the tanks. The water balance study for the selected tanks for the year 2000-01 is given in the figures 2. a&b respectively.

YEAR	MONTH	INITIAL STORAGE	RAINFALL	RUN OFF	AMC	RAIN FED	GROSS INFLOW	LOSSES	NET INFLOW	PADDY CWR/ha	PADDY AREA	TOTAL CWR	END STORAGE
2000-2001	JUNE	0	24	0	0.0000	0.016	0.0156	0.0008	0.0148	0	0.000	0.000	0.0148
	JULY	0.0148	19.9	0	0.0000	0.013	0.0277	0.0014	0.0263	0.0211	1.25	0.026	0.0000
	AUGUST	0.0000	106.4	0.0500	0.0125	0.069	0.1065	0.0053	0.1011	0.0125	8.09	0.101	0.0000
	SEPTEMBER	0.0000	260.9	0.0735	0.0147	0.169	0.2279	0.0114	0.2165	0.0104	20.82	0.217	0.0000
	OCTOBER	0.0000	256.5	0.0697	0.0139	0.166	0.2220	0.0111	0.2109	0.0086	24.52	0.211	0.0000
	NOVEMBER	0.0000	149.1	0.0130	0.0019	0.097	0.1076	0.0054	0.1023	0	0.00	0.000	0.1023
	DECEMBER	0.1023	99.8	0.0042	0.0004	0.065	0.1707	0.0085	0.1622	0.0177	9.16	0.162	0.0000
	JANUARY	0.0000	4.3	0	0.0000	0.003	0.0028	0.0001	0.0026	0.0126	0.00	0.000	0.0026
	FEBRUARY	0.0026	0.1	0	0.0000	0.000	0.0027	0.0001	0.0025	0.0147	0.00	0	0.0025
	MARCH	0.0025	0	0	0.0000	0.000	0.0000	0	0.0000	0.0134	0.00	0	0.0000
	APRIL	0	127.9	0.0081	0.0020	0.083	0.0890	0.0044	0.0845	0	0.00	0	0.0845
	MAY	0.0845	53.7	0.0006	0.0001	0.035	0.0352	0.0018	0.0335	0	0.00	0	0.0335

Figure(2) a. Water balance for Non-system tank for the year 2000-01 (Paddy)

YEAR	MONTH	INITIAL STORAGE	RAINFALL	RUN OFF	AMC	RAIN FED	GROSS INFLOW	LOSSES	NET INFLOW	PADDY CWR/ha	PADDY AREA	TOTAL CWR	END STORAGE
2000-2001	JUNE	0	24	0	0.0000	0.016	0.0156	0.0008	0.0148	0	0.000	0.000	0.0148
	JULY	0.0148	19.9	0	0.0000	0.013	0.0277	0.0014	0.0263	0.0129	2.03	0.026	0.0000
	AUGUST	0.0000	106.4	0.0500	0.0125	0.069	0.1065	0.0053	0.1011	0.0088	11.49	0.101	0.0000
	SEPTEMBER	0.0000	260.9	0.0735	0.0147	0.169	0.2279	0.0114	0.2165	0.0076	28.52	0.217	0.0000
	OCTOBER	0.0000	256.5	0.0697	0.0139	0.166	0.2220	0.0111	0.2109	0.0098	21.44	0.211	0.0000
	NOVEMBER	0.0000	149.1	0.0130	0.0019	0.097	0.1076	0.0054	0.1023	0.0128	7.99	0.102	0.0000
	DECEMBER	0.1023	99.8	0.0042	0.0004	0.065	0.1707	0.0085	0.1622	0.0132	12.28	0.162	0.0000
	JANUARY	0.0000	4.3	0	0.0000	0.003	0.0028	0.0001	0.0026	0.0154	0.00	0.000	0.0026
	FEBRUARY	0.0026	0.1	0	0.0000	0.000	0.0027	0.0001	0.0025	0.0151	0.00	0	0.0025
	MARCH	0.0025	0	0	0.0000	0.000	0.0000	0	0.0000	0.0118	0.00	0	0.0000
	APRIL	0	127.9	0.0081	0.0020	0.083	0.0890	0.0044	0.0845	0.0127	6.63	0	0.0845
	MAY	0.0845	53.7	0.0006	0.0001	0.035	0.0352	0.0018	0.0335	0	0.00	0	0.0335

Figure(2) b. Water balance for Non-system tank for the year 2000-01 (Sugarcane)

The rainfed contribution is taken as the product of rainfall in m and waterspread area in $M.m^2$ of the tank.The volume units are represented in $M.m^3$.

III. RESULTS AND DISCUSSIONS

The simulated results for the non-system tank and system tank for the selected crops in each season are obtained and they are given in the tables (5), (6), (7), (8).

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

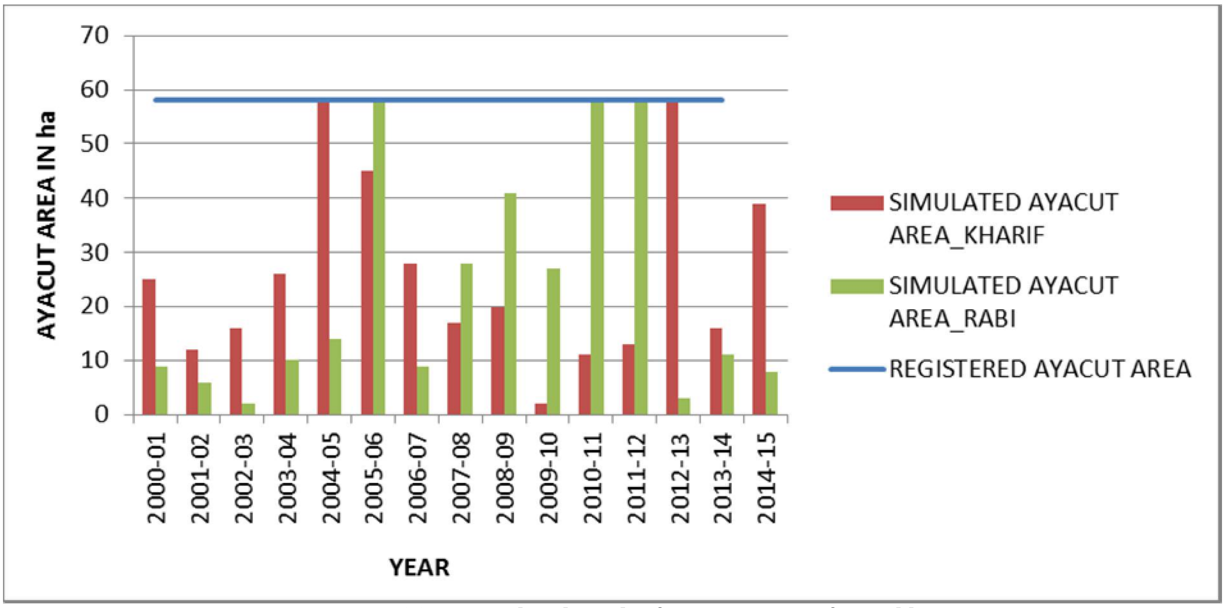
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Table (5) Simulated results for Non-system tank for paddy

Year	Registered ayacut area in ha	Simulated area in ha	
		Kharif	Rabi
2000-01	58	25	9
2001-02	58	12	6
2002-03	58	16	2
2003-04	58	26	10
2004-05	58	58	14
2005-06	58	45	58
2006-07	58	28	9
2007-08	58	17	28
2008-09	58	20	41
2009-10	58	2	27
2010-11	58	11	58
2011-12	**58**	**13**	**58**
2012-13	**58**	**58**	**3**
2013-14	**58**	**16**	**11**
2014-15	**58**	**39**	**8**



Figure(3) a. Simulated results for Non-system for paddy

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Table (6) simulated results for Non-system tank for sugarcane

Year	Registered area in ha	Simulated area in ha
2000-01	58	29
2001-02	58	12
2002-03	58	14
2003-04	58	52
2004-05	58	58
2005-06	58	58
2006-07	58	25
2007-08	58	31
2008-09	58	58
2009-10	58	35
2010-11	58	58
2011-12	**58**	**58**
2012-13	**58**	**53**
2013-14	**58**	**23**
2014-15	**58**	**47**

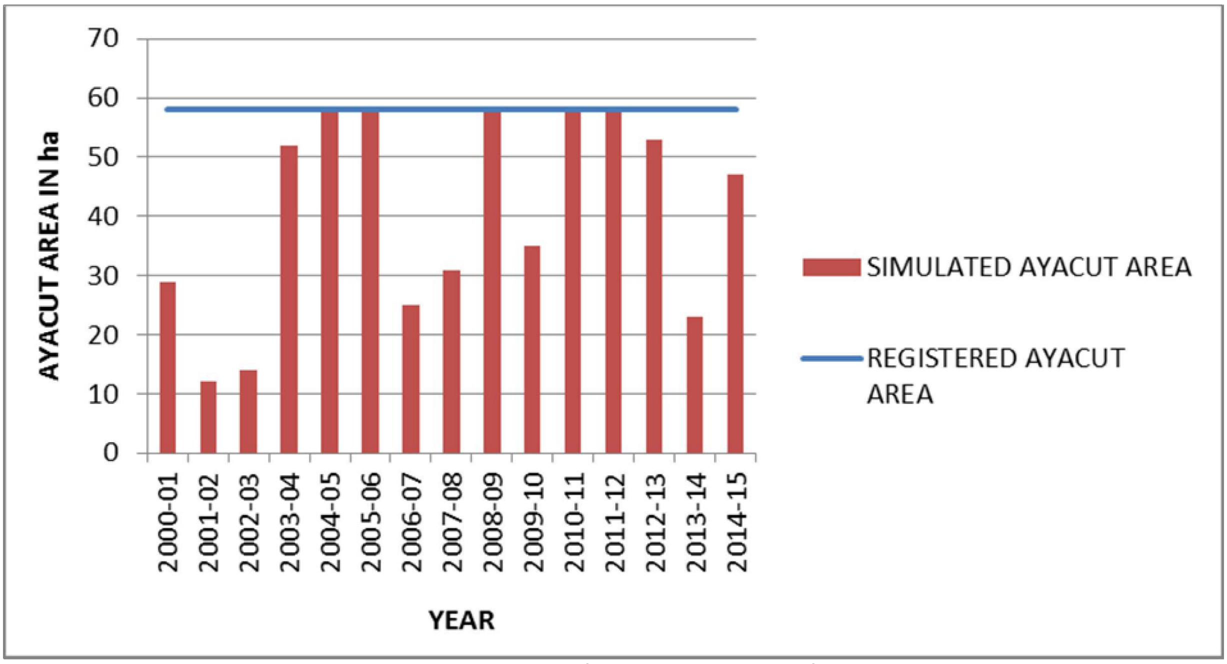


Figure 3 b.simulated results for Non-system tank for sugarcane

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

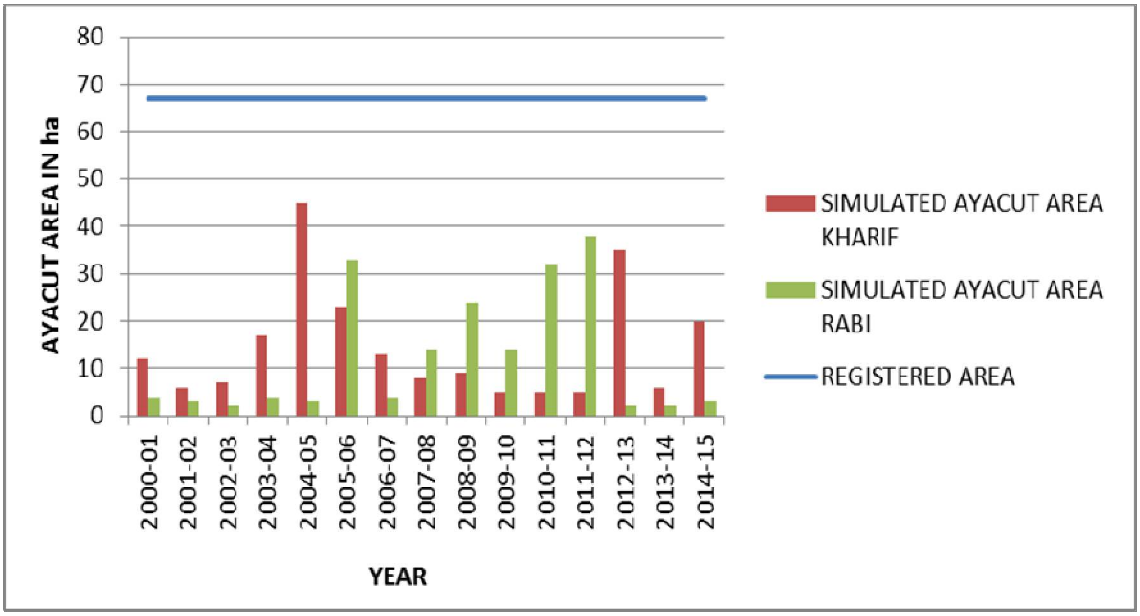
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Table (7) Simulated results for system tank for paddy

Year	Registered area in ha	Simulated area in ha	
		Kharif	Rabi
2000-01	67	12	4
2001-02	67	6	3
2002-03	67	7	2
2003-04	67	17	4
2004-05	67	45	3
2005-06	67	23	33
2006-07	67	13	4
2007-08	67	8	14
2008-09	67	9	24
2009-10	67	5	14
2010-11	67	5	32
2011-12	67	5	38
2012-13	67	35	2
2013-14	**67**	**6**	**2**
2014-15	**67**	**20**	**3**



Figure(4) a. Simulated results for system tank for paddy

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

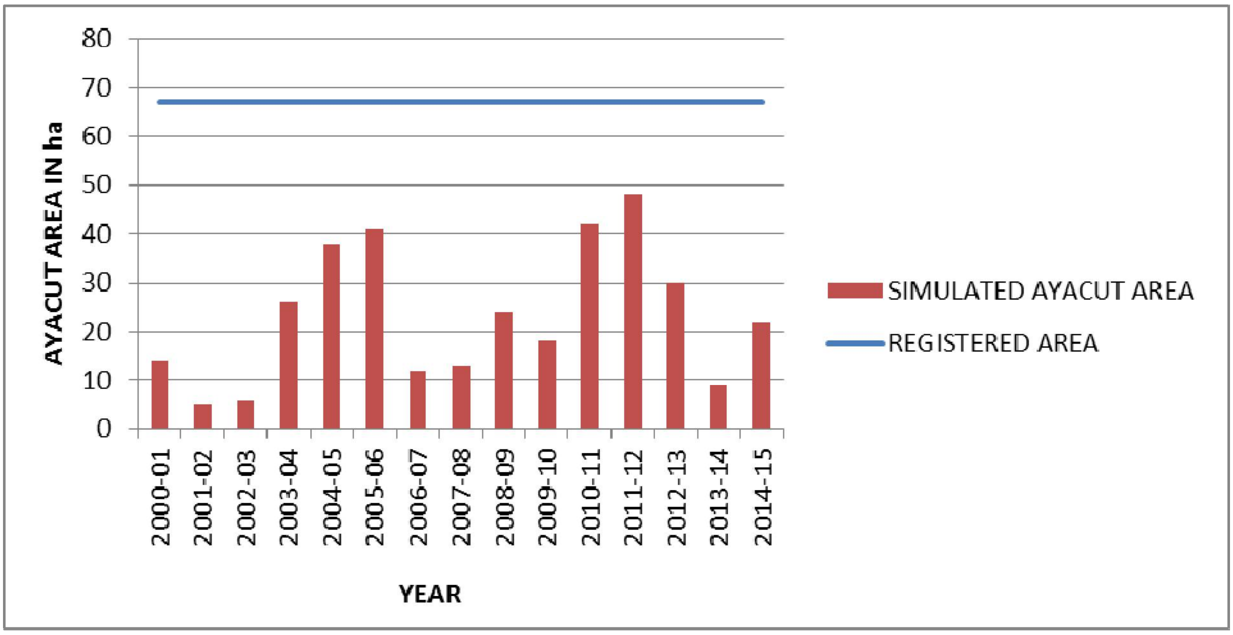
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Table (8) Simulated results for system tank for sugarcane

Year	Registered area in ha	Simulated area in ha
2000-01	67	14
2001-02	67	5
2002-03	67	6
2003-04	67	26
2004-05	67	38
2005-06	67	41
2006-07	67	12
2007-08	67	13
2008-09	67	24
2009-10	67	18
2010-11	67	42
2011-12	67	48
2012-13	67	30
2013-14	**67**	**9**
2014-15	**67**	**22**



Figure(4)b.Simulated results for system tank for sugarcane

DOI:10.15680/IJIRSET.2016.0505006

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Another scenario is made for 45% (present) Vs 100% Conveyance efficiency. It has been inferred that, even 100% conveyance efficiency cannot able to irrigate entire ayacut area thus rainfall pattern, inflow to the tank also influences the performance of the tank. The results are given in the table 9.

Table (9)45% conveyance efficiency Vs 100% conveyance efficiency

Year	45% Conveyance efficiency in Kharif for non-system tank for paddy	100% Conveyance efficiency in Kharif for non-system tank for paddy
2011-12	13	20
2012-13	58	58
2013-14	16	24
2014-15	39	58
YEAR	45% Conveyance efficiency in Rabi for non-system tank for paddy	100% Conveyance efficiency in Rabi for non-system tank for paddy
2011-12	58	58
2012-13	3	13
2013-14	11	18
2014-15	8	14

III.1 INFERENCES

1. The simulated results show that the present conveyance efficiency of field channels is insufficient to irrigate the entire area. Whenever the rainfall exceeds 50 cm the tank can able to irrigate the maximum area with this conveyance efficiency throughout the system,

2. Conjunctive use of well water helps to sustain farming in the remaining season,

3. From the simulation model, it is found that 70% and 55% of the water losses through conveyance in non-system and system tank respectively, thus the present conveyance efficiency (45%) and (30%) is insufficient to irrigate entire area in case of moderate and scanty rainfall,

4. However the present conveyance efficiency is sufficient to irrigate maximum ayacut area in case of rainfall exceeds 50 cm,

5. The inflow to the tank depends on the rainfall and the crop water requirement(outflow) depends on the ET value of the particular month, thus the climatic factors also influences the performance of the tank,

6. There is no significant change in the performance of the tank before and after its rehabilitation.

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

IV. CONCLUSION

From the hydrological modelling it can be concluded that there is no significant impact of rehabilitation on both the tanks.One significant finding from the study is there should be an efficient field channel to deliver the water form tank to the field till its end. Thus field channel is one of the most significant tank components to be rehabilitated.The climatic components such as rainfall pattern, temperature range are also the factors which alter the performance of the tank. Well irrigation plays a significant role in the remaining seasons of the selected tanks.

REFERENCES

[1] Anuradha, B., Ambujam, N.K., Karunakaran, K., Rajeswari, B., "Impact of Tank Rehabilitation-An Analytical Study of Peri Urban Tank of Tamil Nadu", Water and Energy International, vol66, pp.17-23, 2009.
[2] Anuradha, B and Ambujam, N.K., 'Impact of Water Resources Protection on Local Ground Water Market', Journal of Water Resource and Protection, vol.2, pp. 727-730, 2010.
[3] Anuradha, B and Ambujam, N.K., 'Impact of Tank Rehabilitation On Improved Efficiency of Storage Structures', International Journal of Engineering Research and Applications, vol.2, pp. 1941-1943, 2012.
[4] Mohan Krishna., 'Hydrological Simulation of a Rain fed Minor Irrigation Tank', International Journal of Engineering Research and Appications,vol.2, pp.1493-1506, 2013.
[5] Palanisamy, K., "Sustainable Management on Tank Irrigation System in India", Bulletin 24, Water Technology Centre, Tamil Nadu Agricultural University Press, Coimbatore, 2002.
[6] Palanisami Kuppannan., Jagadeesan Muniandi., Fujita Koichi., KonoYasuyuki.,"Impacts of the Tank Modernization Programme on Tank Performance in Tamil Nadu state, India", 2008.
[7] 'Vellar Basin Report', Institute of Water Studies, Vol I&II,Tharamani, Chennai Tamil Nadu, 2013.
[8] Subramanya, K., "Engineering Hydrology", Tata McGraw-Hill publication, fourth edition.
[9] Shanmugam, C, R., and Kanagavalli, J., "Technology of Tanks", Reflection publications trust, revised edition, 2013.
[10] Tutorial video on watershed delineation accessedon Jan8th, 2016.

BIOGRAPHY

Final year post graduate student of Integrated Water Resources Management, Centre for Water Resources, Anna University, Chennai. This project has been funded by IDRC-canada and Saci Waters, Hyderabad, India.

Professor and Director, Centre for Water Resources, Anna University, Chennai. She is specialized in evaluating performance of tank irrigation systems, waste water irrigation and optimization techniques. She has guided several Ph.D's and M.E thesis.