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PERFORMANCE EVALUATION OF UTHIRAMERUR TANK IRRIGATION SYSTEM USING SPATIAL TECHNOLOGIES AND PARTICIPATORY APPROACH

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ABSTRACT

Evaluating the performance of irrigation systems plays a vital role in attaining agricultural sustainability. Performance measures incorporated in an irrigation system monitoring program can provide a framework for assessing system improvement alternatives. Conventional methods of monitoring and evaluating irrigation systems are tedious and involves huge economic and manual resources. Baseline inventory of irrigated lands in spatial and time domains using spatial information technologies provide an array of performance evaluation. Performance evaluation is a major component of proper management, which in turn is the basis for optimal use of land and water resources. In the present study, questionnaire survey was carried out alongside remote sensing and GIS based analysis to identify problems in adequate, reliable and equitable supply of water delivery system and to analyze the water delivery performance of Uthiramerur tank. The study showed an alarming changes in the tank performance, land use and farm productivity and lack of agreement among the stakeholders of water user associations. If the situation prevails in similar manner, would pose a great threat to agricultural sustainability and nation's food security.

Introduction

Tank based irrigation is one of the oldest and continuing practice in India. Tanks provide direct as well as in-direct irrigation benefits through recharge of groundwater and hence safeguard the economic and ecological sustainability. An integrated approach of restoration programs for irrigation tanks is very important in achieving long term sustainability. There is a need of developing a framework for assessing economic and social issues in the irrigation tank degradation and to assess the impact of restoration program for irrigation tanks (Deivalatha.A et.al,2009).

Sakthivadivel. R (2012) described the specialty of tank water conservation systems, major deficiencies noticed in the tank complexes, strategies for restoration of tank eco-system, number of basic principles and actions to revitalize the tank evolution of tank rehabilitation, tank improvement for poverty alleviation, improvement of tanks for turnover resources, allocation for tank improvement, sources of funding for tank rehabilitation and maintenance, course corrections for tank rehabilitation, shift in rehabilitation planning and implementation processes, arresting groundwater decline and improve groundwater level, upscaling,gender involvement and role of NGO's in the tank irrigation system.

It is important to quantify the perception of the farmers on each of the components of irrigation service and evolve a service delivery index that condenses this information in a format that can be used to easily map the service delivery of a canal system(Nirmalya Choudhury, 2007). Vidhya et.al, (2005) analyzed that the factors for poor performance of selected distributaries using satellite data

and ground data collected by specially designed sample survey and to improve performance by prescribing corrective measures.

Normalized Differences Vegetation Index (NDVI) derived from satellite imagery are useful in estimating the recent vegetation changes, and to examine the relationship between vegetation condition and precipitation (Wang Su-Fen and Lin Wan-Ting, 2009). NDVI has the potential and the capacity to provide spatial information at global scale; of features and phenomena on earth on an almost real-time basis.They have the potential not only in identifying crop classes but also of estimating crop yield (**Sanaz Shafian et.al, 2005) and** Lau et.al, 1998). Remote Sensing, Geographical Information System (GIS) and Global Positioning System (GPS) are also useful in assessing the changes in the land-use pattern and the changes in the agriculture command area (R. Rani and K. Elangovan, 2012)

T. Murali Krishna et.al,(2009) concluded that agricultural drought has been a recurrent phenomenon in many parts of India. Remote sensing plays a vital role in real time monitoring of the agricultural drought conditions over large area, there by effectively supplementing the ground mechanism.

Present study aims at analyzing the water delivery performance of the tank irrigation system through questionnaire survey with farmers and NDVI analysis. This helps to create awareness to the government and also among farmers regarding the current situation of the irrigation system which thereby ensures proper management of the irrigation system in future, makes the water users association perform well in terms of equity, adequacy and reliability.

Study Area and Data Description

Uthiramerur tank, the second largest tank in Kancheepuram district, Tamilnadu, India is selected as the study area. Uthiramerur tank lies in Cheyyar sub basin of Palar river basin. Uthiramerur tank covers a command area of 5440 acre and irrigate 18 villages. It lies in 12°39′50"E latitude and 79°49′10"N longitude.Location map of the study area is shown in Fig. 1.

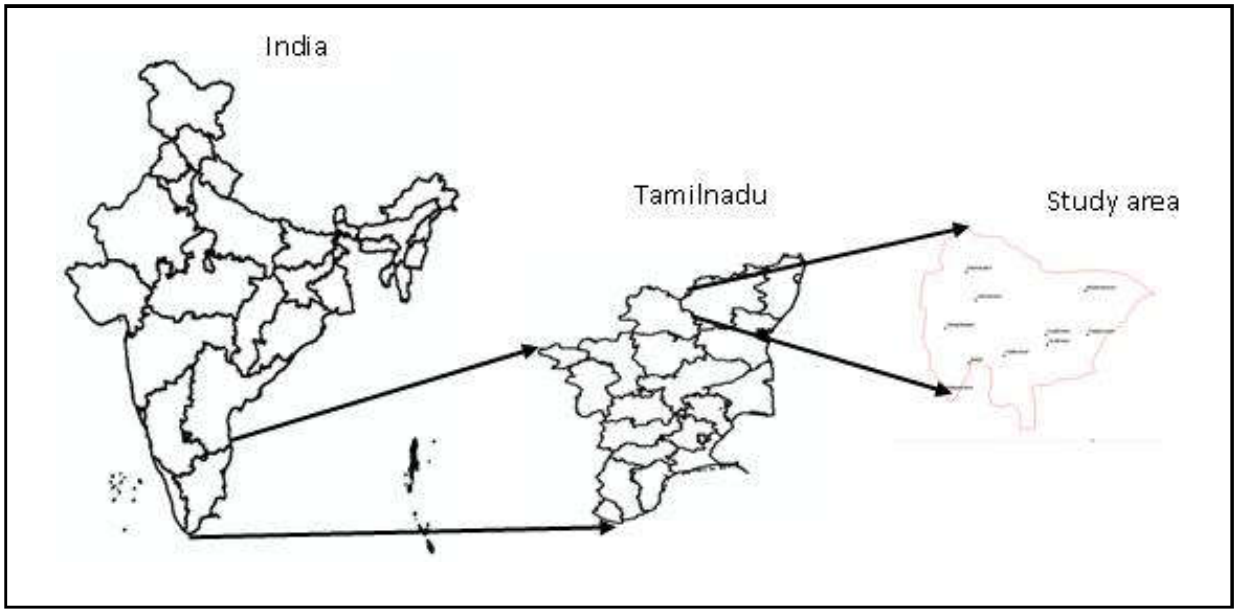

Fig.1. Location map of the study area

In the present study, MODIS 250m resolution vegetation indices product MOD13Q1 is used.The product contains 16-daycomposite of Normalized Difference Vegetation Index (NDVI),Enhanced Vegetation Index (EVI), blue, red, near infrared(NIR), mid-infrared (MIR) and pixel reliability (Huete et al.,2002, 1999; Solano et al., 2010). "Datarequired for the present study was obtained through the onlineData Pool at the NASA Land Processes Distributed ActiveArchive Center (LP DAAC), USGS/ Earth ResourcesObservation and Science (EROS) Center, Sioux Falls, SouthDakota (https://lpdaac.usgs.gov/get_data)" with the help ofUnited States Geological Survey (USGS) Earth Explorer (EE)tool (http://earthexplorer.usgs.gov/).

The annual rainfall data for 40 years from 1973 to 2012 was considered for dependability analysis. The annual rainfall data measured from the Uthiramerur rain gauge station was considered for the rainfall frequency analysis. The geographical location of the rain gauge station is 12°36′41" N latitude and 79°44′03" E longitude.

Methodology

The following Fig. 2 portrays the methodology applied in the project, Water Delivery Performance Analysis of Uthiramerur Tank Irrigation System. The analysis is carried out in three ways i.e., through questionnaire survey, rainfall frequency analysis and NDVI analysis using Remote Sensing and GIS.

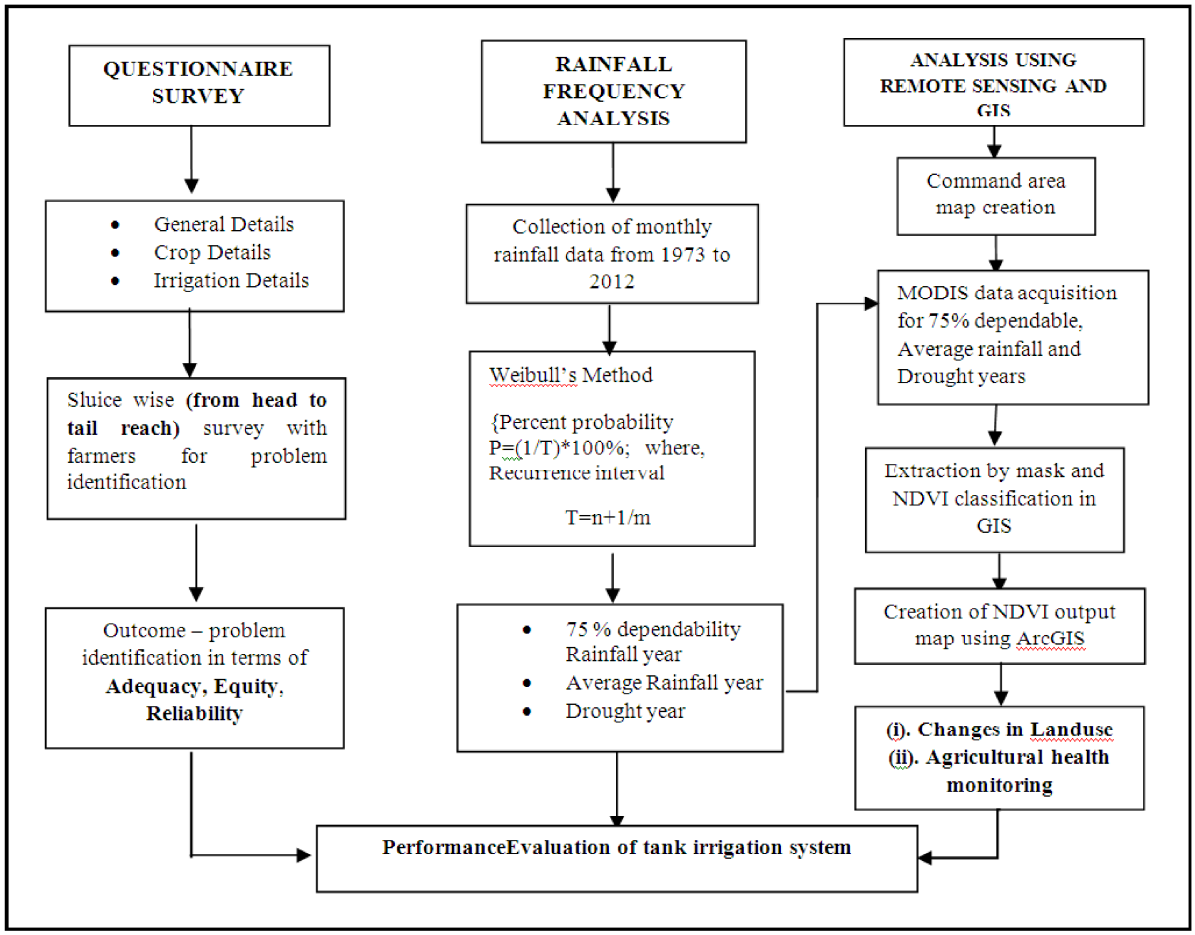

Fig. 2. Methodology flow-chart

The questionnaire consists of twenty five questions divided into three sections (i). General Information, (ii). Crop Details, (iii). Irrigation details. First section was meant to collect the farmer details like their name, age, gender, education, occupation, land holding size, farming experience in years. Second section was meant to collect the farming details like crop type, crop calendar, crop pattern, fertilization, and yield. Third section was meant to collect irrigation related details in terms of equity, adequacy and quality.

Well distributed rainfall is an important factor determining yield. The yearly rainfall pattern over several years does not have any perceptible pattern of the rainfall trend over the years and clearly, the fluctuations are randomly distributed around the normal rainfall.Hence rainfall frequency analysis was carried out using Weibull's method to find the performance of irrigation system.

In order to carry out the NDVI analysis, the details of the crop season of paddy, the major crop of the command area of Uthiramerur tank were collected during the field visit. Crop season of paddy in Uthiramerur and heading stage: Samba (Nov to Mar) - Feb 1st week, Sornavari (Apr to Jul) - Jun 1st week, Navarai (Jul to Nov) - Sep 4th week. The following are the growth stages of paddy (a). Vegetative, (b). Reproductive and (c). Germination (0days)-heading (55days)-maturity (120days)

Results and Discussions

Questionnaire Survey

From the survey, it is revealed that there is adequate and reliable water supply to the head reach of the tank. The major crop is paddy and the yield is normal. The survey with the middle reach farmers, revealed that there is inadequate but reliable water supply and the yield is less when compared with the yield in head reach area. At the tail end, there is no reliable and adequate supply of water and also there is no equitable supply of water and hence yield is low in this area.

Rainfall Frequency Analysis

The design of water management systems is based more on extreme values than on average values. If the mean value is used in the design of an irrigation system then on average, in one out of every two years there will not be enough water to meet the demands of the crop and yield will be reduced. If the mean is used in drainage design, then one out of every two years the crops will be flooded. It is better to use design values with lower associated risk.. Hence rainfall frequency analysis was carried out to find the performance of irrigation system.The formula used to calculate the dependability of rainfall is

Percent probability $P=(1/T)*100\%$;

where, Recurrence interval $T=(n+1)/m$; Where m= rank and n= no. of data.

From Table.2, it is observed75% dependable rain fall is occurred in the year 2002, average identified in the years 2009 and drought year is occurred in 2012. The water delivery performance analysis of Uthiramerur tank irrigation system using Remote Sensing data and GIS was carried out considering the above identified years.

Table. 2: Rainfall frequency analysis

WEIBULL'S METHOD				
YEAR	ANNUAL RAINFALL	RANK (m)	RECURRENCE INTERVAL T=n+1/m	PERCENT PROBABILITY P=(1/T)*100%
1985	1836.1	1	41	2.43902439
1974	1789	2	22	4.545454545
2010	1712.1	3	13.66666667	7.317073171
1998	1558	4	11	9.090909091
2007	1492	5	8.2	12.19512195
2001	1484	6	7.333333333	13.63636364
2005	1470	7	5.857142857	17.07317073
1996	1451	8	5.5	18.18181818
1983	1408.4	9	4.555555556	21.95121951
1984	1407.9	10	4.4	22.72727273
2008	1387	11	3.727272727	26.82926829
1991	1303.6	12	3.666666667	27.27272727
2000	1218	13	3.153846154	31.70731707
1981	1207.3	14	3.142857143	31.81818182
2003	1164	15	2.733333333	36.58536585
1993	1130	16	2.75	36.36363636
2004	1115	17	2.411764706	41.46341463
1995	1113	18	2.444444444	40.90909091
1997	1105	19	2.157894737	46.34146341
1999	1081	20	2.2	45.45454545
1971	1076	21	1.952380952	51.2195122
2009	1017	22	2	50
1973	1007	23	1.782608696	56.09756098
1978	897	24	1.833333333	54.54545455
1986	896	25	1.64	60.97560976
1975	869	26	1.692307692	59.09090909
1982	812.8	27	1.518518519	65.85365854
2006	781.4	28	1.571428571	63.63636364
1987	778.8	29	1.413793103	70.73170732
1977	767	30	1.466666667	68.18181818
2002	763	31	1.322580645	75.6097561
1990	761	32	1.375	72.72727273
1979	666	33	1.242424242	80.48780488
1992	653	34	1.294117647	77.27272727
1976	590	35	1.171428571	85.36585366
1980	558	36	1.222222222	81.81818182
1972	547	37	1.108108108	90.24390244
1994	481.5	38	1.157894737	86.36363636
1989	442	39	1.051282051	95.12195122
2012	404	40	1.1	90.90909091
	n=40			

NDVI Analysis

A comparative analysis was carried out for the years normal rainfall year (2009), 75% rainfall dependable year (2002) and drought year (2012). The heading stage of paddy of three seasons namely Samba, Sornavari and Navarai were considered for the NDVI analysis (Fig. 3, 4 & 5).

NDVI Classification for various classes derived from literatures is Fallow land: 0.09 to 0.1, Paddy under stress condition: 0.1 to 0.2, Settlements: 0.2 to 0.3, Paddy under normal condition: 0.3 to 0.6, Orchards: 0.6 to 0.8The output shows the presence of paddy under normal condition, paddy under stress condition, fallow land, settlement and orchard. The percentage change in the land under each classification indicates the water delivery performance of Uthiramerur tank irrigation system.More the percentage of paddy under normal condition, better the water delivery performance of the tank irrigation system. If the percentage of paddy under stress condition is high, it indicates declining the water delivery performance of the tank irrigation system.

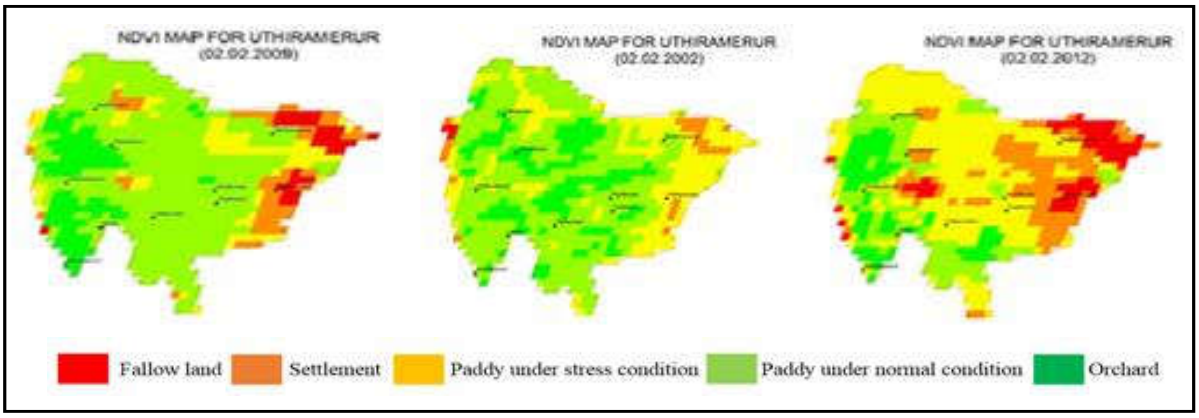

Fig. 3. NDVI map during Samba season- 2009, 2002 and 2012

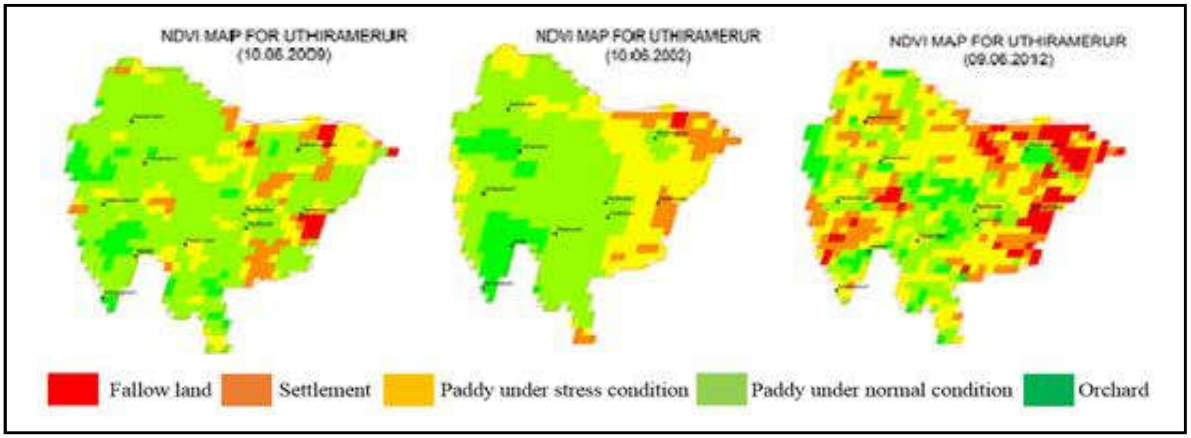

Fig. 4. NDVI map during Sornavari season- 2009, 2002 and 2012

The area analysis was carried out by comparing the total area covered by each classification of land use i.e., fallow land, settlement, paddy under stress, paddy under normal condition and orchard for the three years 2002, 2009 and 2012. The area was calculated by multiplying the total number of pixel values and area of one pixel i.e., 62500 m^2.From the Fig. 5, it is inferred that the agricultural land is getting reduced and the fallow land being increased and hence this in turn indicates that the water delivery performance of Uthiramerur tank irrigation system is getting declined.

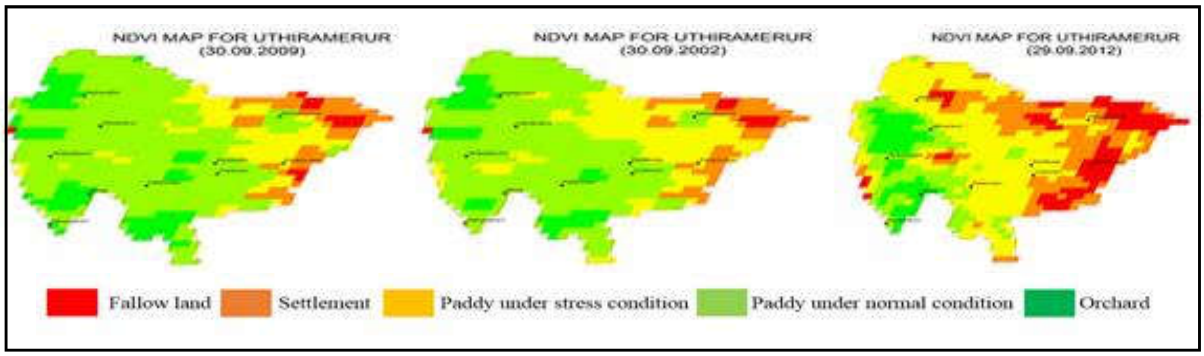

Fig. 5. NDVI map during Navarai season- 2009, 2002 and 2012

Conclusion

It is evident from the survey that there is no equitable, reliable and adequate water distribution in the study area and particularly tail end is affected mostly because of this problem. The NDVI (Normalized Difference Vegetative Index) analysis showed that the fallow land in the tanks command area during 2002 was lessand it is increased by 49% in 2009.There is a drastic change in the command area during 2012 and thefallow land is 85% more than in 2009.

The settlement within the command area was less in the years of 2002 and 2009. Because of urbanization and construction of roads like state and national highways through villages causes the agricultural land to change as construction plots for real estate business. Thus agricultural land is converted to man occupied areas and settlement is increased. The average settlement of the command area during 2009 shows 4% raise and during 2012 shows 57% raise when compared to 2002.The orchard crops are cultivated within the boundaries of command area. Because of the water unavailability within the command area even the orchard cultivation showed decadal change. The orchards are found to be more in the year of 2002 and it is decreased by 10% and 12% respectively in the years of 2009 and 2012.

The NDVI values clearly showed that growth rate of crops in the command area is declining and it is sure that the values approaching higher rates in the future. The main reason for this crop stress is water unavailability. The analyses proved the above mentioned statements. The paddy under normal condition is 70% less in 2012 than in the normal year. The paddy under stress condition is founded to be increasing and analysis shows that 66% raise in the value during 2012.

The above results were obtained mainly because of problems in water sharing, which should be taken care by water user association of that command area. Thus the study reveals that water user association of the command area is not performing well. Due to these problems farmers are force to take other alternative jobs like masonry works and in construction activities. They also involved them in jobs like cattle rearing, fishing and other allied agricultural activities. If this situation continue,it will place a great stress on agricultural sustainability and food security.

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