International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 12, December - 2013

GIS Based Approach for Calculation of Canal Conveyance Losses

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Abstract

It is important for the irrigation engineers to initially understand and estimate the canal conveyance losses in irrigating the crops. These losses accounts more in the case of unlined canals when compared to lined canals. Calculation of these losses with respect to soil characteristics and topography is an added advantage in utilizing the optimum amount of water distribution to fields. GIS based system aids in analyzing the spatial information of a canal to enable better planning by engineers and farmers followed by effective management and supply of water resources. Integrating and analyzing the multiple themes using GIS helps to assess the water requirements and optimum amount of water distribution through canals. Utilizing GIS network model, the total length of the canal system was identified as 155.846 km. Using GIS software, the soil data base was created for the command area. The clay soils are predominant and found 49% in the study area whereas sandy and loamy soils occupied 29% and 22% respectively.

Introduction

This paper is a part of research work and highlights the advantages of GIS in mapping the canal network in using GIS network model, delineating the command area in to block/sub-Blocks and calculating the canal conveyance losses canal-wise and up to sub-block level with a special emphasis on canal water management. Losses in irrigation system lead to overall in-efficiency in terms of water productivity. Conveyance losses and field application losses plays a major role in distributing the optimum amount of Irrigation Water to the fields. Sarangi et al. (2011) carried out a study on Patna canal system and its distribution. The study was a GIS based schedule and calculation of irrigation requirements of Sone Command area. This involved digitization and database generation of canals, rainfall, ground water and soil information. The non spatial data was linked to spatial features with unique feature IDs. Enrique and John (2012) conducted a case study to estimate the conveyance efficiency within irrigation systems. A linear model was developed for estimating conveyance efficiency and two component factors on the basis of statistical analysis of daily water releases from the source of supply and delivery to the farmers in an irrigation district of Mexico.

Conveyance losses are defined as the losses due to seepage of water during the course of the canal. The conveyance losses are generally higher in course-textured soil, channels having a relatively higher elevation than the surrounding land, channels that are relatively long and also channels with poor maintenance. Conveyance loss can be calculated in terms of the return flow from one user and the value before the withdrawal of the next user. Conveyance loss is also determined by the loss attributed to canal seepage coupled with the estimate of evaporation. There are several methods used commonly to measure canal seepage. These include inflow-outflow studies, ponding tests, and seepage-meter studies. In this study, GIS technology and its powerful tools were used to calculate the conveyance losses by taking several parameters at one attempt.

STUDY AREA

Wazirabad command area falls under Zone I; block No.5 of left main canal of the Nagarjuna Sagar Project (NSP). The area is located between 16°39'2.84" and 16°56'40.81" N latitude and 79°25'16.01" and 79°40'52.90" E longitude. The study area is bounded by Musi River in the East, Krishna River in the South, Lalbahadur canal in the North and Tungapadu vagu in the West. In the command area reserved forest occupies 18 to 20 percent. The location map and the base map of the study area is shown in Fig 1.

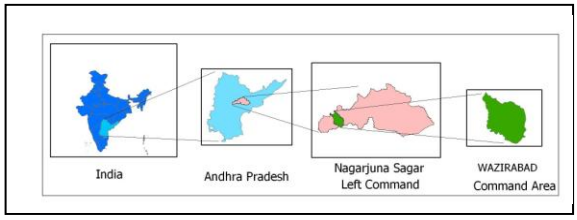

Fig. 1 - Location Map of the Wazirabad Canal Command Area

GEOSPATIAL DATA BASE CREATION

The existing Survey of India topo maps, soil and block maps are scanned in 400 dpi and imported in Erdas Imagery in .img format. Georeferencing is done using Erdas software. Base features viz., canal, road, settlement, rail, forest, drainage and water body were digitized and converted to GIS shape files from SOI topo maps and updated using the satellite imageries. Soil map was digitized and converted to GIS format to facilitate overlay analysis for calculation of conveyance losses. Canal network data structure is important to assess the spatial distribution of the water demand and supply for the irrigation planning and management. The irrigation in Wazirabad command area is distributed by unlined canals. The data was prepared in a network module which constitutes nodes and lines. The node data refers to sluice OT and line refers to canal. The flow direction and continuity errors were taken care while digitization and later checked for continuity in the Arc GIS network module. The canal IDs are created with a unique multi digit number that constitutes an alphanumeric combination. All canal reaches have only one upstream reach but have more than one downstream reaches. Moreover, only the upstream reach ID is kept for each section in the developed data system. The hierarchy of relationship can be retrieved through the use of upper id. The block and sub-block boundaries under each canal are delineated reference to canal network, DEM, Aspect and drainage network. The blocks and sub-blocks are mapped as per the type of canal and its flow direction. If the canal is a ridge canal blocks are identified on both sides of it and if it is a contour canal blocks are on one side only. Spread of a block or sub-block is between the canal and the drainage line. The study methodology is shown in Fig 1. The canal map and the overlay map of canal and soil map of the study area is shown in Fig 2 and Fig 3.

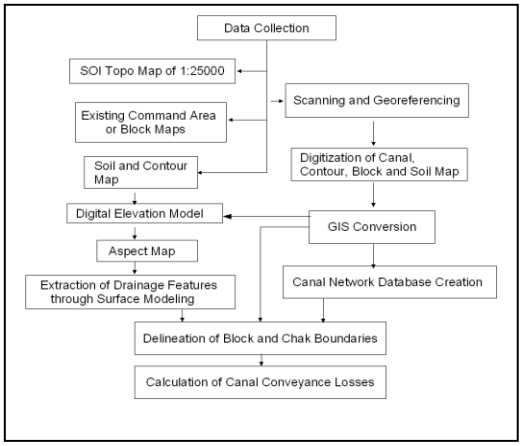

Fig 1 Methodology for the study

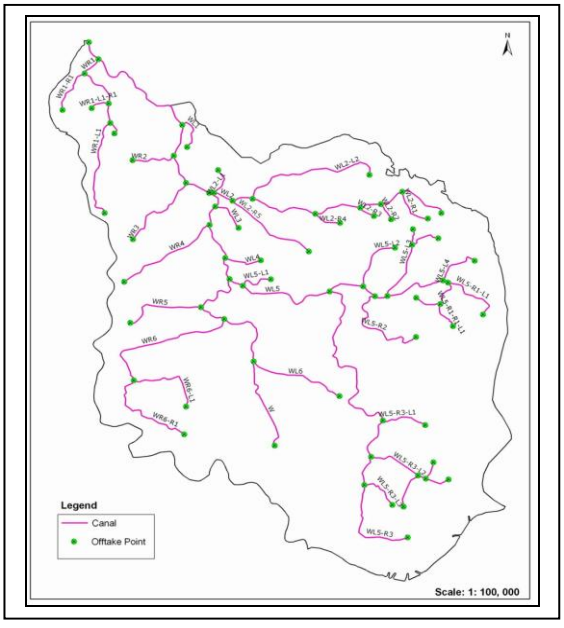

Fig 2 Canal Map of the Study Area

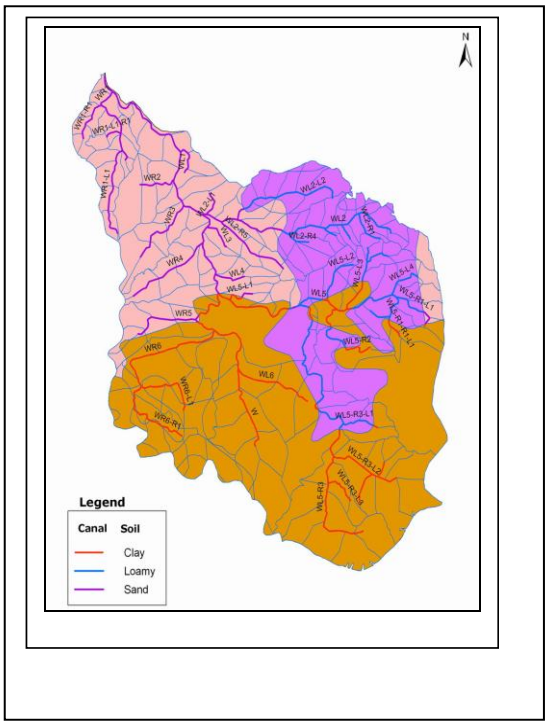

Fig 3 Canal map overlay on Soil Map in GIS Platform

CALCULATION OF CANAL CONVEYANCE LOSSES IN GIS

A combination of factors from FAO and US Bureau of Reclamation Data is considered for calculation of conveyance losses. Since the canals are old and the underlying soil is silted from years with very fine sand (almost impermeable), the present conveyance losses due to percolation in the canal section are very less and the difference between the soils is only countable in seepage losses. This slight difference of losses between different soils is seen as the criteria for calculating the conveyance losses. In this study the parameters viz., canal network and the lengths between the canal off takes, detailed block areas under major to minor canals and soil characteristics of the command area are taken as thematic inputs. According to FAO, in large command areas and canal systems large quantity of water is lost than in small command areas and small canal network due to a longer canal system. Due to this the Wazirabad canal system has been categorized into long, medium and short canals. This study has shown the spatially distributed losses under each canal for each soil type. Conveyance losses have been calculated by GIS Overlay analysis by intersecting canal theme with soil theme based on the efficiencies of unlined canals on different soil categories. The conveyance loss per meter channel length differs per channel type and is 0.2 m³ per day (Van Lieshout and Brouwer, 2009) for clay channels and will increase proportionately based on the efficiencies of unlined canals on various soils. FAO is defined some indicative values of canal conveyance efficiency for unlined canals based on the soil type and canal lengths. These values are taken for calculation of conveyance losses interactively using GIS software. Using the soil and canal length parameters the losses criteria had been arrived with reference to the Table 1.

Table 1 Criteria for calculation of conveyance losses

Canal Category	Conveyance loss for unlined canals (Cubic Meter/Day)		
	Sand	Loam	Clay
Long-L(>2000 m)	0.28(60 %)	0.25(70%)	0.23(80%)
Medium-M(200-2000 m)	0.25(70 %)	0.23(75%)	0.21(85%)
Short-S(<200 m)	0.24(80 %)	0.22(85%)	0.2(90%)

RESULTS AND DISCUSSIONS

By means of the canal network, soil, crop, WUA and block themes, the conveyance losses were calculated in the GIS platform using Arc GIS software. The conveyance losses estimated in the GIS software for the entire canal section are 7936 million litres. The conveyance losses for the entire canal network in the command area was estimated and used same for both the years to calculate irrigation demand due to the non change of canal sections and also soil beneath the canal. The conveyance losses invariably vary from canal to canal due to the above factors. Significant difference is observed between the sandy and clayey command areas. This is due to the varied soil types (sandy is porous) in the command area. The variations are ranging from 1 to 25 MLD (million litres per day) per km. The losses of the canals WL5 and WR1 are 25

and 10 MLD per KM. The conveyance losses calculated from GIS for each canal/block are given in Table 2.

Table 2- Canal/Block wise Conveyance Losses

SNO	Block Area in ha	Canal/Block	Canal-Length in Meters	Conveyance loss(lit/sec)
1	213.098	WL1	1496.440	4.330
2	3434.967	WL2	26457.494	40.124
3	209.461	WL3	1492.796	4.320
4	294.372	WL4	1581.590	4.576
5	7721.426	WL5	57092.800	90.707
6	1073.667	WL6	4049.046	10.779
7	1185.734	WR1	11427.452	2.582
8	383.599	WR2	1897.032	5.489
9	711.869	WR3	3650.757	11.831
10	712.862	WR4	4473.000	14.496
11	803.668	WR5	3486.690	11.299
12	2141.272	WR6	13784.440	16.211
13	7839.440	W	24956.594	89.39

CONCLUSIONS

Using GIS Technology and its powerful tools helps to calculate the losses accurately by taking several parameters at one attempt. In the present study 212 sub-blocks were delineated under Wazirabad command area in GIS environment. The total command area was calculated in GIS platform was 26,725 ha. Utilizing GIS network model, the total length of the canal system was identified as 155.846 km. Using GIS software, the soil data base was created for the command area. The clay soils are predominant and found 49% in the study area whereas sandy and loamy soils occupied 29% and 22% respectively. Significant difference is observed between the sandy and clayey command areas. This is due to the varied soil types (sandy is porous) in the command area. The variations are ranging from 1 to 25 MLD (million litres per day) per km. The losses of the canals WL5 and WR1 are 25 and 10 MLD per km.

REFERENCES

[1] Brouwer C., Hoevenaars J.P.M. and Van Bosch B.E. (1992), FAO, "Scheme irrigation water needs and supply". Irrigation Water Management: Training Manual No. 6.

[2] Dadhwal V.K. and Ray SS. (2000). "Crop Assessment using Remote sensing-Part II: Crop condition and yield assessment". Indian Journal of Agricultural Economics, 55(2): 55-67.

[3] El-Magd I.A. and Tanton T.W. (2003). "GIS Modeling for Irrigation Water Scheduling". Proceedings of the GIS Research UK, GISRUK2003, City University, April, 2003.

[4] Enrique V. Palacios. and John C. Day.(2012). "A new approach for estimating irrigation conveyance losses and their economic evaluation". Journal of the American Water Resources Association, Volume 13, Issue 4, pages 709–720.

[5] Erhan Akkuzu., Halil Baki Ünal., Bekir S Karata. (2002). "Determination of Water Conveyance Loss in the Menemen Open Canal Irrigation Network". Turkish journal of agriculture, For., 31, (2007), 11-22, Turkey.

[6] Jayasekera and Walker. (1990). "Remotely sensed data and geographic information system for management and appraisal of large scale irrigation projects in the developing countries". Advances in planning, design and management of irrigation systems as related to sustainable land use, Leuven (Belgium), 14-17 Sep 1992.

[7] Jan Burdziej. (2003). "GIS and 3-Dimensional Digital Terrain modeling". Geo-information systems course, GIS center, Lund University, Sweden.

[8] Krishna Rao B. and Rajput T. B. S. (2009). "Decision support system for efficient water management in canal command Areas". Current Science, Vol. 97, No. 1.

[9] Navalgund R.R. and Ray SS. (2000). "Geomatics in natural resources management". Proceedings of Geomatics-2000, Pune, India, NRI-NR14.

[10] Nitin Dubey., Nema R. K., Awasthi M. K. and Tiwari.(2005). "Topographic analysis through Digital Elevation Model (DEM) for Patan Branch Canal command area using RS and GIS". Land and Water Management, Book 1, Conference paper, Command area development and management , pp. 136-141.

[11] Santhi., Muttiah. and Arnold. (2004). "A GIS−Based regional planning tool for irrigation demand assessment and savings using SWAT". Soil and water division of ASAE.

[12] Sarangi A., Rao N.H., Sheena M Brownee and Singh A.K.(2011). "Use of Geographic Information System (GIS)

tool in watershed hydrology and irrigation water management". Article, Geospatial world.

[13] Van Lieshout A.M. and Brouwer.(2009). "Irrigation water requirement". Department, Earth Resources Surveys, International Institute for Aerospace Survey and Earth Sciences (ITC), P.O. Box 6, 7500 AA Enschede, The Netherlands.

[14] Walker W.R. (1989). "FAO Guidelines for designing and evaluation of surface irrigation systems". FAO Irrigation and drainage paper 45.