CASE STUDY

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APPLICATION OF REMOTE SENSING TECHNIQUES FOR WATER LOGGING STUDY IN TAWA COMMAND AREA

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PREFACE

India has very large and ambitious plans for the development of irrigation and, which are indeed very essential for diversifying agriculture as also for increasing and stabilizing crop production. It is expected that when the various irrigation projects are completed, irrigation will be practiced over at least double the present area. This is what it should be if the country has to make economic progress quickly. But if the intelligent use of water is not pre-planned, the dreadful history may repeat itself with all its attendant havocs of seepage, rise in water table, widespread waterlogging and salinity. Irrigated agriculture instead of ensuring prosperity and economic stability may threaten the very security of the land. Waterlogging throws a challenge to irrigated agriculture. The success depends how we take up that challenge and save our national heritage, the soil, from deterioration.

After commissioning of the Tawa Irrigation Project in 1975, there was a general rise in ground watertable. Zonal Agriculture Research Station (ZARS) powarkheda has maintained records of few wells since 1973. It is reported that there is a general rise of ground water depth 2.5 m.

Waterlogging due to seepage was realised by the farming community in 1978 over an area of 50 ha covering 19 villages, by the 1982 the problem was magnified covering 23 villages having an area of 200 ha.

This study is an attempt to assess the areas affected by waterlogging and areas potential sensitive to waterlogging in the Tawa command area. The study has been carried out by Dr. V.K.Choubey, Scientist E and Tanveer Ahmad, Senior Research Assistant of the Institute.

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ABSTRACT

Irrigation projects involving interbasin transfer of water without adequate drainage has disrupted the equilibrium between the ground water recharge and discharge resulting in accretions to the ground water table. The Tawa command area faces problems of waterlogging resulting from overirrigation & seepage losses through distributary system. The study was undertaken to assess waterlogged area in Tawa command using IRS satellite data.

A rapid and accurate assessment of the extent of waterlogged areas can be made from using remotely sensed data. Visual interpretation of IRS-LISS-I FCC of 20 Nov. 1989 and 23 March, 1989 (path 27 row 52) were carried out to prepare land use, drainage map and delineation of waterlogged area in the Tawa command area. IRS-LISS-I digital data (CCT's) of 19 May 1988, 20 Oct. 1988 and 20 Nov.1989 were analysed to assess the areas affected by waterlogging and the areas potential sensitive for waterlogging. An attempt has been made to validate the IRS derived waterlogged area with the available water table depth data.

The IRS-1A-LISS data have been proved to be very useful for the assessment of waterlogging. Density slicing is a useful technique to make an assessment of waterlogged areas.

The results obtained from this study indicate that in Oct.1988 an area of 80 sq.km was affected by waterlogging and about 140 sq.km area was sensitive for waterlogging, where water table lies in between 1 to 3 m. It is suggested that periodic assessment of waterlogging using remotely sensed data should be carried out at a regular interval.

1.0 INTRODUCTION

Consequent upon the spurt of country's population, there was an urgent need for increasing the agricultural production from the available land resources. This has necessitated the development of adequate irrigation facilities in the country.

Water being the vital requirement for the successful raising of the crops, its availability in optimum quantity in the root zone, particularly at the critical stages of the crop growth is essential. Such moisture requirement of crops can either be met from precipitation through most of the moisture is met through rainfall, it being erratic both in time and space and confined in most part of the country to four rainy months i.e from June to September, requires some support. To raise the crops in the nonrainy months and to meet the moisture requirement when rains have failed, the necessity of irrigation has been felt.

In India, rainfall is generally confined to 3-4 months in a year. Its distribution over the country is highly skew viz. 100 mm in West Rajasthan to over 11000 mm at Cherapunji in Meghalaya. On the top of all these unfavorable features, annual variation of rainfall is also highly uneven. The areas receiving less rainfall is also highly uneven. Various attempts have been made since the First Irrigation Commission (1901 - 03) to assess the water resources of India. The average annual natural run-off available in India is estimated to be 1880 cubic km. for the main land. Out of this, the utilisable water from surface structures is about 690 cubic km. Similarly, the Central Ground Water Board has estimated the possible utilisation from ground water as 418 cubic km. Thus, the assessed surface water resources of India are about 3 per cent of the world's surface water resources, whereas the country's population is about 16 per cent of world population. As such, the water resources in India are limited and for the ever growing population and increased number of industrial centre, unless a systematic attempt is made for the proper planning and management of water resources, the country will have serious problems in water availability to various sectors by the early 21 st century.

India has very large and ambitious plans for the development of irrigation and, which are indeed very essential for diversifying agriculture as also for increasing and stabilizing crop production. According to the Planning Commission (1974), the actual utilization of the irrigation potential was 22.6 million hectares in 1973-74 against the ultimate irrigation potential of 107 million hectares from both surface and ground water.

The Irrigation Commission in 1972 estimated the utilisable surface and ground-water resources as 8,70,000 million cubic meters; whereas, the actual utilisation was about 1,72,500 million cubic meters by March, 1974. The utilisable surface water of the country is estimated as 66.6 million hectare meters and groundwater as 20 .4 million hectare meters per year. It is expected that when the various irrigation projects are completed, irrigation will be practiced over at least double the present area. This is what it should be if the country has to make economic progress quickly. But if the intelligent use of water is not pre-planned, the dreadful history may repeat itself with all its attendant havocs of seepage, rise in water table, widespread waterlogging and salinity. Irrigated agriculture instead of ensuring prosperity and economic stability may threaten the very security of the land. Waterlogging throws a challenge to irrigated agriculture. The success depends how we take up that challenge and save our national heritage, the soil, from deterioration.

Under irrigated conditions, farmers do uncontrol irrigation thereby the excess water is added to the ground water table. With subsequent irrigation done unjudiciously, the excess water induces the raising of ground water table. Some times water logging in the low lying areas is also created due to seepage from irrigated upland and seepage from canal system. Over irrigation by canal water with inadequate water management practices further aggravates the situation which culminates into water logging and increase salinity. Also the obstruction of natural drainage by way of construction of roads, railways, aerodrums, various structures, etc., causes the ponding of monsoon run off on the upstream of the structures. This has happened at many places which in turn has disturbed the surface hydrology of the areas. The cultivation of intensive irrigation without adequate drainage facilities contributes substantially to ground water table. Although irrigation and drainage both should go hand in hand, the drainage aspect has not been given much attention that it deserves even in the major and medium irrigation projects. In absence of such drainage system, the problem of water logging is created. Another adverse impact of irrigation management is the creation of soil salinity and alkalinity which adversely affect the soil productivity.

Inadequate efficient drainage system in irrigation project, lack of surface and sub-surface drainage and poor maintenance, over irrigation and growing water intensive crops are some of the major causes of poor realisation of benefits from the canal irrigation systems. Many of the irrigation projects have not succeeded in producing the projected yields for the simple reasons that drainage for controlling the salinity and waterlogging was not considered as an integral part of the irrigation system. The National Commission for Irrigation (1972) and National Commission in Agriculture (1976), Ministry of Agriculture (1985) reported waterlogged area in India is 4.84,6.00 and 8.53 m ha respectively. However Ministry of Water Resources (1991) has estimated as 2.46 m.ha waterlogged area.It is now a recognised fact that investigation should be undertaken for all major projects at the planning stage itself to evaluate the likely impact of irrigation on the extent of possible rise of ground water table and more so in regard to the possibility of waterlogging and drainage congestion in the irrigation commands so that, if necessary, remedial measures are incorporated as an integral part at the stage of project formulation itself. Provision of drainage is thus infact an inbuilt safety device against the hazards of water delivery system. The extent, type and methodology of drainage provision, however depend upon the type of irrigation to be adopted, the cropping pattern, the type of soil, water management practices being followed and agroclimatic conditions.

2.0 REVIEW

Many of the irrigation projects have not succeeded in producing the projected yields for the simple reasons that drainage for controlling the salinity and waterlogging was not considered as an integral part of the irrigation system.

The National Commission for Irrigation (1972) and National Commission in Agriculture (1976), Ministry of Agriculture (1985) reported waterlogged area in India is 4.84,6.00 and 8.53 m ha respectively. However Ministry of Water Resources (1991) has estimated 2.46 m.ha waterlogged area. It is now a recognised fact that investigation should be undertaken for all major projects at the planning stage itself to evaluate the likely impact of irrigation on the extent of possible rise of ground water table and more so in regard to the possibility of waterlogging and drainage congestion in the irrigation commands so that, if necessary, remedial measures are incorporated as an integral part at the stage of project formulation itself.

Rao (1986 Agricultural Finance Corporation), identified the problem of drainage and suggested the effective drainage measures namely channel resectioning, clearing vegetation from drainage way and sub surface drains.

Patel (1989) suggested that water balance should be worked out between the amount of water supplies available at the head work and water required to be diverted for irrigation to the command area and losses in transmission.

The various causes for waterlogging as summarised by Chitale (1991) are i) seepage from unlined canals ii) damaged portions of lined channel beads, iii) blockage of natural drainage due to the net work of canal and roads, iv) poor working of existing surface drainage systems, v) very little utilization of ground water for irrigation, vi) internal flow of subsurface water, and vii) injudicious water management. He expressed that during the phase of irrigation, drainage is generally not provided in most of the developing countries.

Bouwer et al (1990), reported that waterlogging and salinisation of irrigated land are natural hazards of irrigation development especially in the semi-arid climate where irrigation is a must. Much of the waterlogging and salinization of irrigated land is due to the inadequacy of drainage measures and poor maintainence.

Todd (1956) the changes in ground water levels can be due to natural or artificial means. The changes in external loads induces variation in ground water level. Various external factors affecting are secular and seasonal stream flow, evaporation, atmospheric pressure and tidal effects.

Walton (1970) found changes in water level in open wells due to precipitation, evaporation and withdrawal during growing season. He indicated possibilities of developing relationship between these factors.

Agarwal and Malik (1982) studied the water table behaviour of Haryana State by dividing it into two zones, one the in central and south western region with brackish ground water. They found that the average annual rise of watertable ranged from 8 to 68 cm after the introduction of the canal in the central and south-western region while it declines from 10 to 15 cm per year in the good water quality region. The rise in watertable of central south-western region was mainly due to limited exploitation of groundwater, excess rainfall and canal water levels.

Sondhi et al (1987) assessed the ground water resources of a canal command area at Mahi Right Bank Canal (MRBC) for the period 1976-77 to 1979-80. They quantified the different components of ground water recharge using ground water recharge equation and water balance equation. Their study reveled that the average annual recharge to ground water basin during the study period was of the order of 1260 million cubic metres. Part of this a quantity of 500 million cubic metres contribute towards the increase of the ground water storage.

Naqvi (1987) observed high rate of rise in water table after the introduction of canal in the Tawa command area. The introduction of canal had distorted the regular periodic character of the water table. As a result instead of single peak more than one peak was observed.

Choubey (1993) had conducted a study to assess waterlogged in Indira Gandhi Nahar Pariyojna stage I using remotely sensed data and concluded that rapid and accurate assessment of the waterlogged area can be made by the use of remotely sensed data.

2.1 WATERLOGGED AREAS IN TAWA COMMAND AREA

After commissioning of the Tawa Irrigation Project in 1975, there was a general rise in ground watertable. Zonal Agriculture Research Station (ZARS) powarkheda has maintained records of few wells since 1973. It is reported that there is a general rise of ground water depth to 2.5 m.

Waterlogging due to seepage was realised by the farming community in 1978 over an area of 50 ha covering 19 villages, by the 1982 the problem was magnified covering 23 villages having an area of 200 ha. Villagers started feeling dampness and a case of house collapse in 1983 called upon the attention of public representatives (ZARS Annual Progress Report 1989-90). A Task Force Sub Committee was constituted by the Government of Madhya Pradesh in 1983 to suggest the remedial measures.

The recommendations of the Task Force sub committee for Nimsadia villages is the lining of the Hoshangabad distributory from chainage 347 to 425 with brick on edge over polythene film. Also 20 numbers of private wells near habitation be put to pumping for which incentive be given to owners for operating pumps. In case of Pathodi, Chandpura and Kulamudi villages the suggestion was for the construction of 3 pump wells and 8 inverted wells in higher reaches of affected area.

Subsequent to the recommendations of Task Force committee, five pumping wells and nine inverted wells were drilled at pathodi and Chandpura villages during summer 1984. The location of these measures are measured by ZARS Water Management Project, powarkheda by recording fortnightly water table observations at the existing wells and it was found that there was no significant improvement.

The investigations for the research project during 1986 and 1987, revealed that borrow pits dug for making embankment of channel works is one of the sources of constant groundwater recharge . Traversing the entire area it was noticed that the natural drains are infested with Ipomea aquatica and occasional aquatic weeds. These obstructions not only caused silting but drastically reduced the carrying capacity of the drains.

The inverted wells were converted into pumping wells. The pumped water is being utilised for irrigation through existing water courses. Fortnightly water table data is recorded for six of these wells. In addition sub-surface drains were also constructed to remove excess water from fields situated adjacent to distributory. As a result of the measures the fields were cultivable as can be seen from Plate.

Bhatia et al (1990) reported that approximately 34,000 ha in Tawa command is classified as waterlogged where water table lies between 0to 3 m below ground level and approximately 330 ha of land have gone out of production.

No attempt has been made so far by M.P.Irrigation department and other organisations to assess and monitor waterlogging problem in the command by remotely sensed data.

3.0 STATEMENT OF PROBLEM

There has been no systematic survey so far in Tawa command area to assess the total area affected by waterlogging. Results of the studies undertaken in the country, demonstrate the usefulness of remote sensing techniques for the assessment and monitoring waterlogged areas. A rapid and accurate assessment of the waterlogged area can be made by the use of remotely sensed data.

In this study an attempt has been made to evolve a methodology for the assessment of waterlogging in the Tawa command area. Visual interpretation of IRS-1A-LISS-I, false color composites have been used for the preparation of land use, drainage and waterlogged areas mapping. Digital image analysis has been done by ILWIS image processing system for IRS-1A-LISS-I data of May, Oct.1988 and Nov.1989 for the assessment of waterlogged area and the sensitive areas for waterlogging.

4.0 STUDY AREA

4.1 Location

Tawa project is the first irrigation project in Narmada basin. The dam was constructed across the river Tawa, a tributary of the Narmada river, at a distance of 33 km from Itarsi railway station. The reservoir has a gross storage of 0.231 M ha m with a live storage of 0.205 M ha m. It envisages to provide irrigation to its command area of 0.247 M ha of Hoshangabad district through the left and the right bank of main canal system having a gross command of 0.333 M ha. The catchment area of the dam is 5982.9 Km.

The entire Tawa command area located in the central portion of the Narmada valley of Hoshangabad district of Madhya Pradesh, lies between the latitude 21 53' to 22 59'N, the longitude 76 47 to 78 44' E and at altitudes ranging between 290 - 335m. Figure 1 shows Tawa command area, catchment area, left and right bank main canal and Fig.2 shows the study area (Tawa command) delineated from imagery. The entire command area is sloping toward the north with varying slopes as presented in Table 1.

Table 1. Slope ranges of the command area

Slope (percent)	Percent area
0.0 to 0.5	60
0.5 to 3.0	32
above 3.0	8

The salient features of Tawa project are given in Table 2.

The project completed its first and second phases in 1975 and 1984 respectively. The second phase consisted of stage I and stage II planning and execution of on-farm development works.

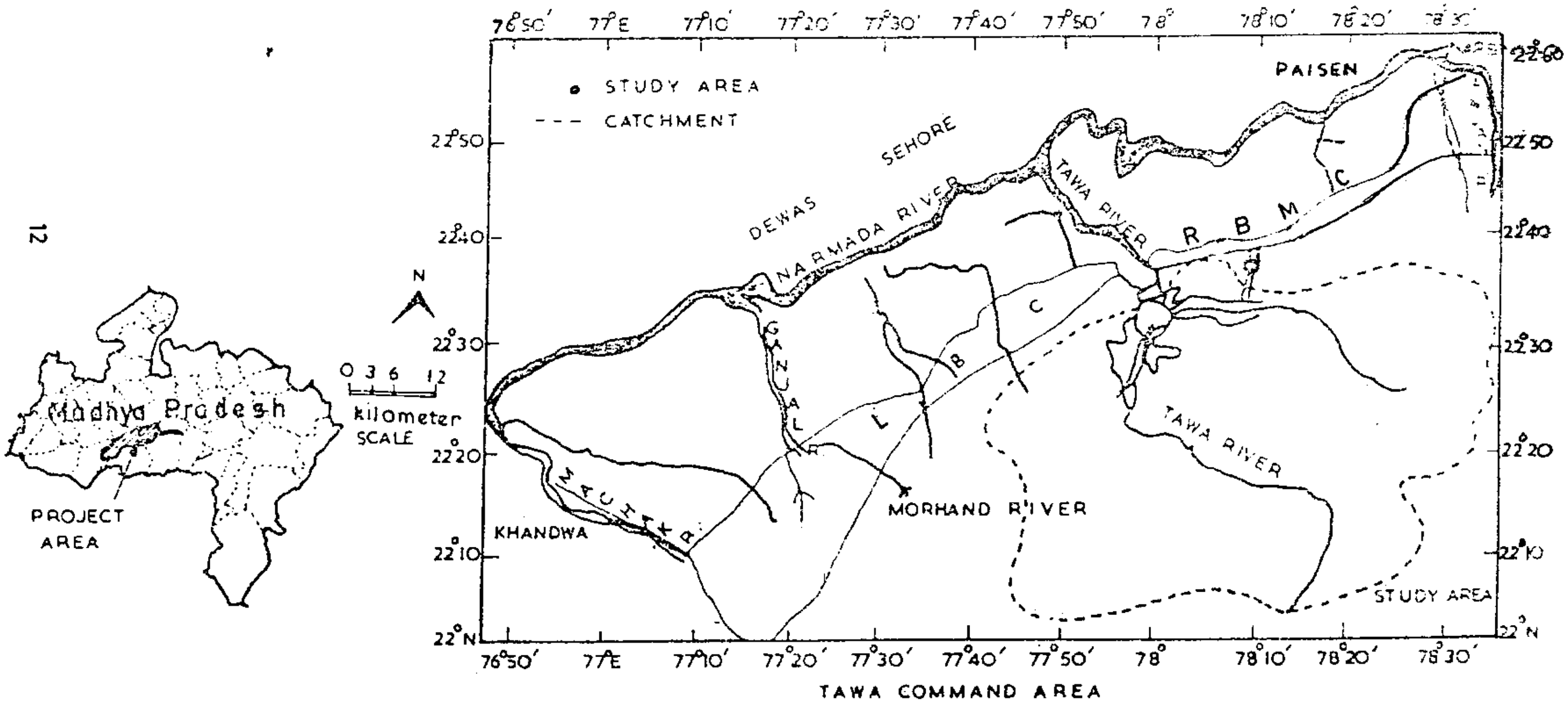

FIG. 1 MAP OF TAWA COMMAND AREA SHOWING CATCHMENT RESEARVOIR LOCATION, MAIN CANAL SYSTEM

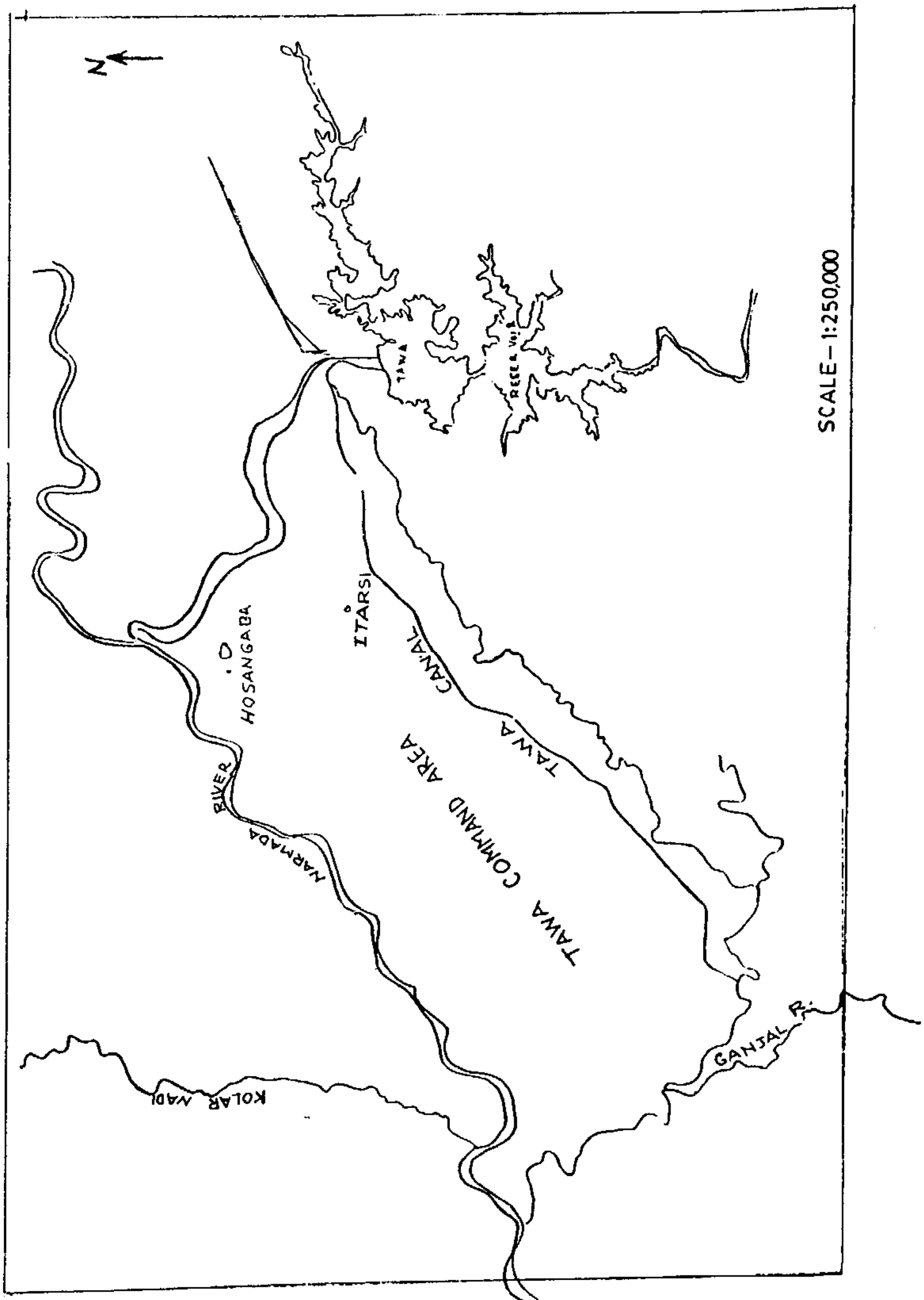
N
TAWA
HOSANGABA
ITARSI
TAWA CANAL
TAWA COMMAND AREA
NARMADA RIVER
KOLAR NADI
GANJAL R.
SCALE-1:250,000

FIG. 2

Table A-1 Salient features of Tawa Command Area

1	Location Hoshangabad district/division, Madhya Pradesh.		
2	Catchment area	5982.90 Sq Km	
3	Average annual rainfall	1546.13 mm	
4	Flood discharge	10.90×10^5 cusec	
5	Moderated design flood	7.25×10^5 cusec	
6	Reservoir storage capacity (at R.L. 355.397	0.231 mha.m	
7	Dead storage at R.L.334.243m	0.026 mham	
8	Live storage at R.L.355.397m	0.205 mham	
9	Maxium water level	356.692 m	
10	Top level of the dam	359.664 m	
11	Sill level of L.D.C.	334.243 m	
12	Sill level of R.D.C.	338.328 m	
13	Sill level of R.B.C.	338.328 m	
14	Water spread area	20055 ha	
15	Village affected		
	a) Forest	27	
	b) Revenue	17	
16	Culturable are submerged	1081 ha	
17	Maximum dam length	237.744 m spillway	
	Maximum height from foundation	57.912 m	
	Spillwayates	13 Nos. (15.24x12.19m)	
18	Earthen dam length		
	Left	690.372 m	
	Right	521.208 m	
	Saddle I	182.880 m	
	Saddle II	182.880 m	
	Maximum height	32.528 m.	
19	Canals	Left Bank	Right Bank
	i) length of main canal	131 km	-
	ii) Handia branch	56 km	-
	iii) connecting channels	-	7.5 km
	iv) Bagra branch	-	24 km
	v) Pipariya branch	-	60 km
	vi) length of distribution system	1484 km	450 km
20	Design discharge of main canal	$94.76 m^3/sec$	$26.77 m^3/sec$
21	Command areas		
	a) Gross		
	i) Available	4,49,972 ha	1,13,008 ha
	ii) Benefitted	2,88,956 ha	50,587 ha
	b) Culturable		
	i) Available	3,13,073 ha	87,147 ha
	ii) Command	1,86,162 ha	60,702 ha
22	Cropped area proposed for irrigation	2,56,904 ha	78,881 ha
23	Village to be benefitted	510	270
24	Cropping intensity		
	a) Kharif	67%	58%
	b) Rabi	64%	67%
	c) Summer	4%	-
25	Estimated cost of Tawa Irrigation project	Rs. 91.42 crores	
26	Estimated additional annual agricultural production	19.89 lakh tonnes (value Rs. 56.91 crores)	
27	Soil types		
	Zone A. Sandy loam & sandy clay	65,443 ha	
	Zone B. Clay and sandy clay	1,69,728 ha	
	Zone C. Clay loam	1,27,119 ha	
28	Slope grades	Percentage area	
	3% and above	8	
	.5% to 3%	32	
	Less than .5%	60	
29	Revised cropping pattern (%)		

Zone	Kharif Present	Kharif Proposed	Rabi Present	Rabi Proposed
A	28	45	72	79
B	23	39	77	84
C	39	55	61	65

Subsequent to initiation of field irrigation in 1975, the water logging problems were experienced in its command area in 1978, which grew in its size with time. The study area falls under wheat belt.

4.2 CLIMATE

The study area falls under the semiarid zone. The meteorological data for the study area obtained from the Zonal Agricultural Research Station (ZARS), Powarkheda of Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur.

The area receives an average rainfall of 1182.10 mm through 55 rainy days mostly during June, July and August. About 92 % of rainfall occurs during monsoon from the 3rd week of June to the 2nd week of September. Rainfall though is seasonal but is very erratic. Floods occur generally during the 3rd week of July to the 2nd week of August and long dry spells are experienced either during the sowing season (2nd and 3rd week of July and/or the later parts of August and early September. High wind speeds of the order of 8-9 km/h are experienced during monsoon. During non-monsoon period wind speed varies between 4-6.65 km/h. The maximum temperature range from 20.0 C (January) to 42.3 C (May). A minimum of 7.2 C has been experienced during January 1986.

4.3 TOPOGRAPHY AND SOILS

The study area in general has a slope of 0-5 percent covering about 70 per cent while 30 percent area falls under slope range of 0.5 to 3.0 per cent.

The details of physical and chemical properties of soil obtained from ZARS Powarkheda, and soil survey report (1985) are presented in Table 3 and well logs of two locations namely Chandpura and Pathodi are shown in Fig 3. Though the soil is termed as vertisol, the nutrient content is not so good (Kale 1993). The possible reason could be heavy leaching due to waterlogging. Table 4 provides the hydraulic conductivity of the soils at different depths.

The soils of the area are heavy clay structured, ordered as vertisol with a sub order of ustered. The land is categorized under class II as per the land capability classification (Kale 1993).

Table 3. Physical and chemical properties of soils.

Sl.No	Particulars	Powarkheda	Chandpura
1.	Soil Texture	powarkheda	Clay
	Soil separates		
	Sand %	30.35	30.50
	Silt %	24.35	24.90
	Clay %	45.30	44.60
2.	Field capacity %		
	at 0-15 cm	32.15	31.80
	at 90-120 cm	23.90	24.10
3.	Permanent wilting point%		
	at 30-40 cm	12.68	12.15
	at 90-120 cm	15.57	24.10
4.	Bulk density, g/cc		
	0-15 cm soil profile	1.38	1.35
	15-30 cm soil profile	1.42	1.43
	30-45 cm soil profile	1.50	1.54
	45-60 cm soil profile	1.84	1.90
5.	PH	7.6	0.9
6.	Electrical conductivity		
	mili mhos/cm	037	0.40
7.	Organic carbon,%	0.58	0.62
8.	Available N, Kg/ha	218	228
9.	Available P, kg/ha	18	22
10.	Available K, kg/ha	428	413
11.	Caco3	3.39	3.60

Source : Annual Report, ZARS, Powarkheda (1989-90)

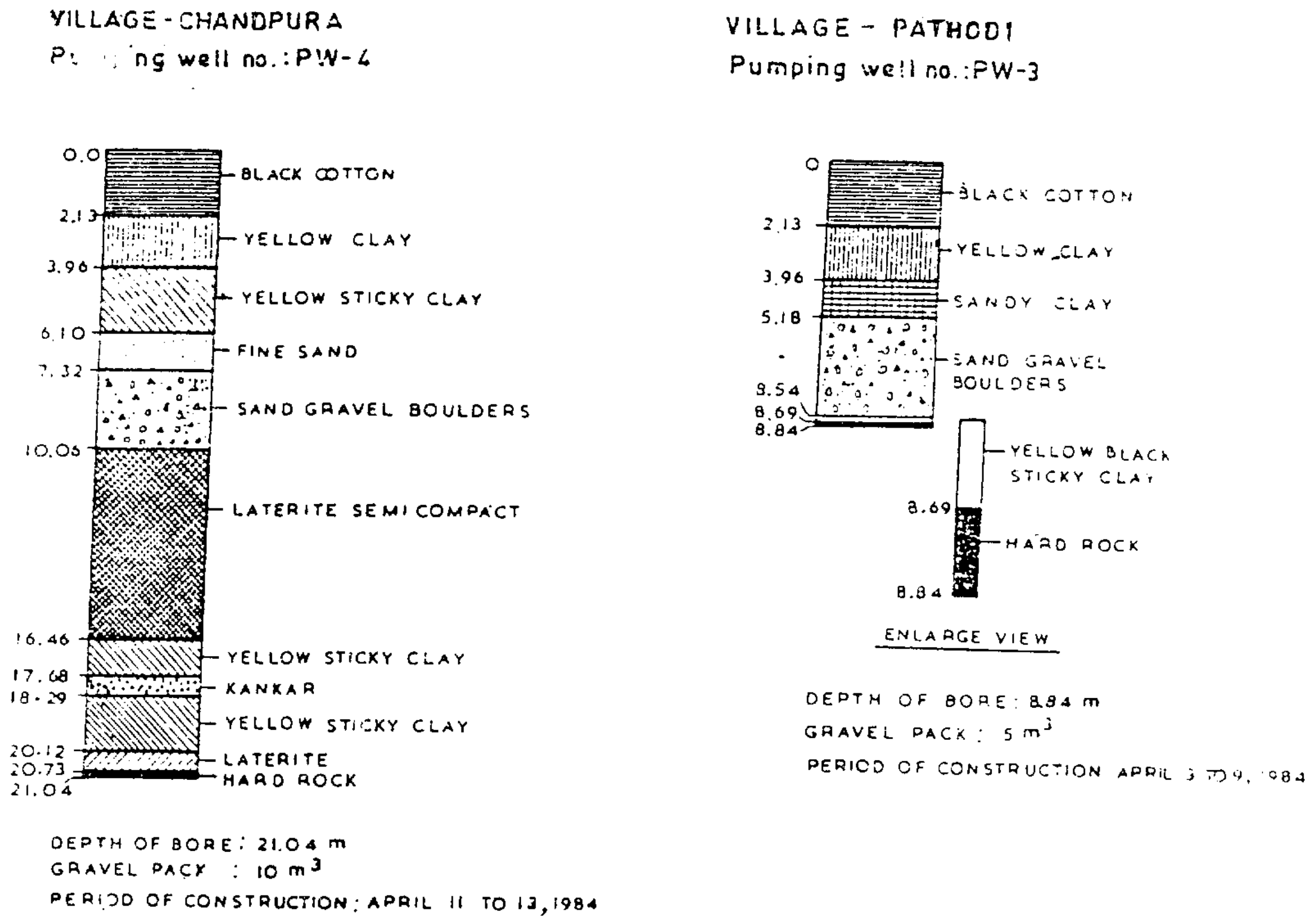

FIG. 3 DETAILS OF WELL LOGSAT VILLAGES CHANDPURA AND PATHODI
(*ADOPTED FROM KALE 1993*)

Table 4 Hydraulic conductivity of the soils at different depths

Location	Depth rang m	Hydraulic mm/h	Conductivity class
Powarkheda	0.00-0.75	1.81	slow
	0.75-1.50	0.26	very slow
	1.50-2.55	0.37	very slow
Chandpura	0.00-0.75	2.07	slow
	0.75-1.50	0.68	very slow
	1.50-2.25	0.58	very slow

4.4 CROPPING PATTERN

The average existing cropping pattern from the data collected for the years 1986-87 to 1991-92 is presented in Table 5. It is clear from the table that soybean in kharif and wheat in rabi are the main crops. Despite of the irrigation facility 50 per cent of the cultivated area in rabi is rainfed. The cultivated area under oil seed is more than cereals.

Table 5. Cropping pattern of the command area

Kharif rainfed	Kharif irrigated	Rabi rainfed	Rabi irrigated
Paddy	Groundnut	wheat	Wheat (L)
Jowar	Brinjal	Gram	Wheat (HYV)
Jowar	Chillies	Masoor	gram
Soybean	Chwpea	Teoda	Massor
Black Soybean	--	Alsi	Teoda
Moong	--	Mustard	Alsi
Urd	--	-- --	--
Arhar	--	-- --	--
			Bhindi
			Potato

5.0 METHODOLOGY

5.1 DATA USED

Following Indian Remote Sensing Satellite data were used in this study.

S.N.	Path Row	CCT/FCC	Date	Scale
1.	27-52	CCT	20 Oct 88	--
2.	27-52	CCT	20 Nov 89	
3.	27-52	CCT	19 May 88	
4.	27-52	FCC	23 March 89	1:250,000
5.	27-52	FCC	20 Nov. 89	1:250,000

Toposheet 55 at F & J scale 1:250,000 were used.

5.2 ANALYSIS

IRS-1A-LISS-I false color composite (path 27 row 52) of March 23,1989 and Nov, 20, 1989 were visually interpreted to prepare land use, drainage pattern and map showing waterlogged area in the command.

IRS-LISS-I computer compatible tapes of May, 19,1988, Oct. 20, 1988 and Nov.20, 1989 were analysed by ILWIS image processing system to assess waterlogged area in the command during pre and post monsoon period.

A land use / cover map depicting irrigated cropped land, shrub land, forest and standing water area has been prepared. Waterlogged areas were identified on the basis of following indicators:

i. Presence of high soil moisture

ii. standing shallow surface water

iii. Presence of perennial vegetation.

The presence of high soil moisture and shallow standing water is indicated by bluish tone on FCC. The perennial vegetation could be identified from its characteristic pink or red on FCC.

To ensure that the areas with multicropping pattern do not get misclassified, crop calenders of all the crops grown in the area were checked on the data of imagery i.e. March, 23,1989.

Subscene of Tawa command area extracted from IRS computer compatible tapes for May, October and November 1989. ILWIS image processing system has been used for image analysis. Band ratioing, density slicing has been carried out for all the three scenes.

Initially all the four bands were used in analysis, however infra-red Band 4 was selected for density slicing. Waterlogged areas in the command were identified and mapped during May and October 1988 and November 1989.

A field trip was made in the month of Feb 1995 to carryout field checks and collection of hydrometeorological and ground water table depth data.

6.0 RESULTS AND DISCUSSIONS

After commissioning of the Tawa Irrigation Project in 1975, there was a general rise in ground water table. ZARS powarkheda has maintained records of few wells since 1973. It is reported that there is a general rise of ground water depth to 2.5 m.Depth to water table for selected villages in Tawa command before and after commissioning of Tawa project are given in table 6.

Waterlogging due to seepage was realised by the farming community in 1978 over an area of 50 ha covering 19 villages, by the 1982 the problem was magnified covering 23 villages having an area of 200 ha. Villagers started feeling dampness and a case of house collapse in 1983 called upon the attention of public representatives (ZARS Annual Progress Report 1989-90). A Task Force Sub Committee was constituted by the Government of Madhya Pradesh in 1983 to suggest the remedial measures.

Table 6 Depth of watertable in Tawa command (meters)

Village	Depth of watertable before irrigation (1974)	Depth of watertable after irrigation (1984)
Phepartal	12.2-18.3	5.5-10.0
Rohana	10.7-16.0	3.7
Baikhedi	12.2	2.4
Sawalkheda	10.7-12.2	1.2- 2.4
Bairkhedi	9.1-12.2	6.5
Dolara	10.7-12.2	5.2- 6.1
Chandward	12.2	3.1- 4.8
Baggawa	13.7-15.2	6.1-14.6
Dongarwade	12.2-18.3	16.0
Powerkheda	11.5-12.0	1.6- 4.4
Pathodi	7.5-11.5	0.0- 2.7
Nataya	7.6-9.1	0.0- 2.0
Beora	11.0-12.0	0.0- 1.5
Nimsadia	7.6-9.0	0.0- 1.5

Source: Adopted from Bowonder et al, 1987

IRS-LISS-I false color composites (FCC) of 23 March and 20 November 1989 were visually interpreted and computer compatible tapes (CCT) of 19 May, 1988, 20 Oct. 1988 and 20 Nov, 1989 were analysed to assess waterlogged area in the command during pre and post monsoon period.

6.1 LAND USE MAP

A land use / cover map has been prepared from IRS FCC at a scale of 1:250 000. The command area has been categorised into four major land use classes (Fig 4).

LAND USE/COVER MAP OF TAWA COMMAND AREA

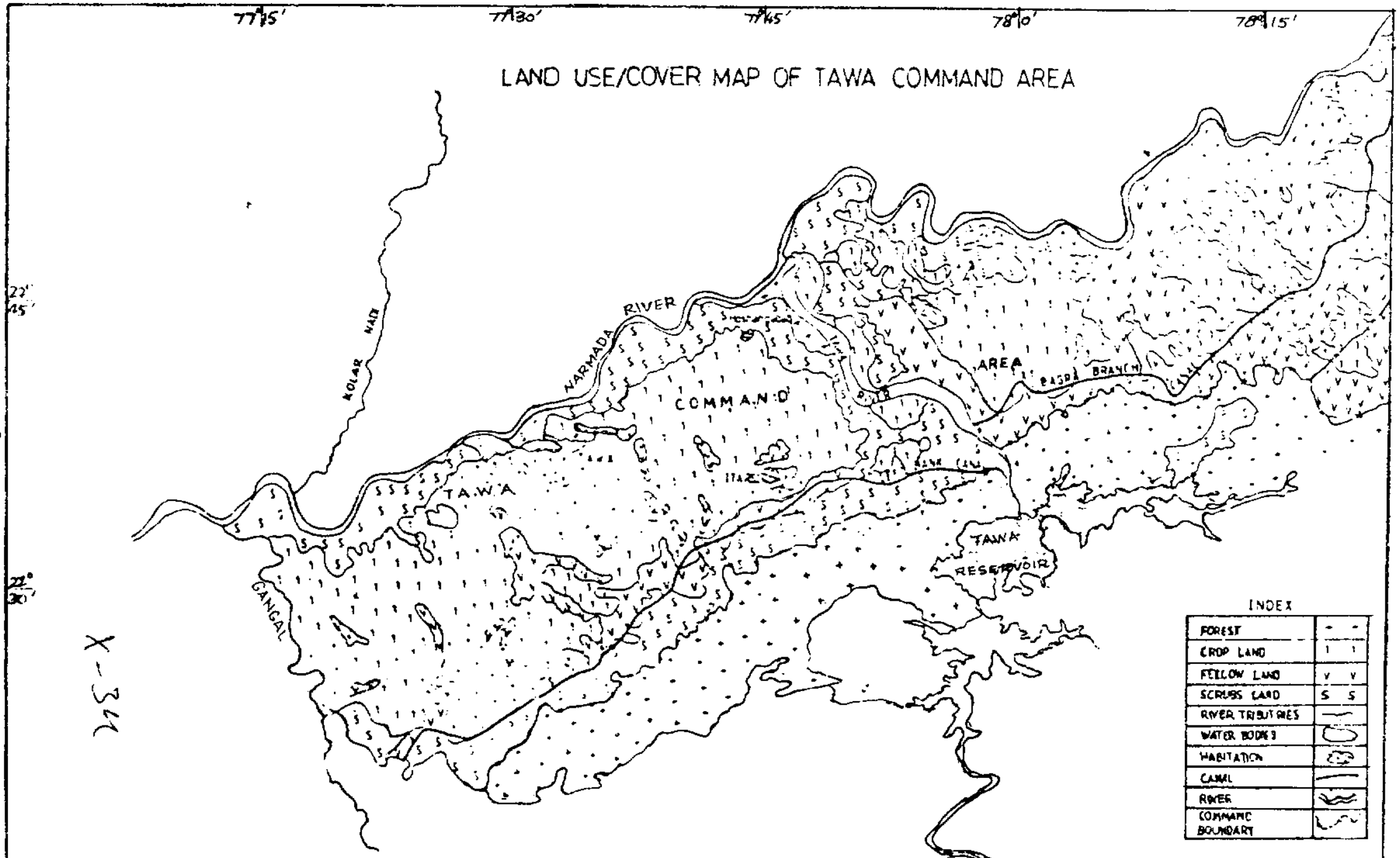

FIG. 4

1. Agriculture land

   The agricultutre land (cropped) appears reddish to brownish in colour with smooth texture in plain areas. The cropped and fallow land occupy about 2111 sq.km in command area.

2. Forest land

   Forest areas (514.10 sq.km) showed bright red color and coarse texture and observed in a hilly terrain.

3. Water bodies

   Water bodies such as reservoir, pond, waterlogged area can be identified in FCC by deep blue color with smooth texture.

4. Shrub Land

   Shrubs land observed along Narmada river and canal and periphery of the forest. The shrub land (323.5 sq.km) has been identified by brown tone with fine texture.

Drainage map of the command area has also been prepared from FCC (Fig.5). The Narmada river is perennial river outside the command area rest are the seasonal rivers.

Subscene of Tawa command area extracted from CCT for 19 May, 20 Oct. 1988 and 20 Nov.1989. ILWIS image processing system has been used for image analysis. Density slicing for all the three dates were carried out using near infra-rad band 4. IRS data of October 1988 chosen to select minimum and maximum pixel values range for the density slicing.

It has been observed that the pixel values for the deep clear water of the reservoir were in the range of 9-15 in infra-rad band 4, whereas on the periphery of the reservoir, pixel values were in the range of 20-25. The same pixel range 20-25 was observed in ponds and rivers. Therefore for density slicing the

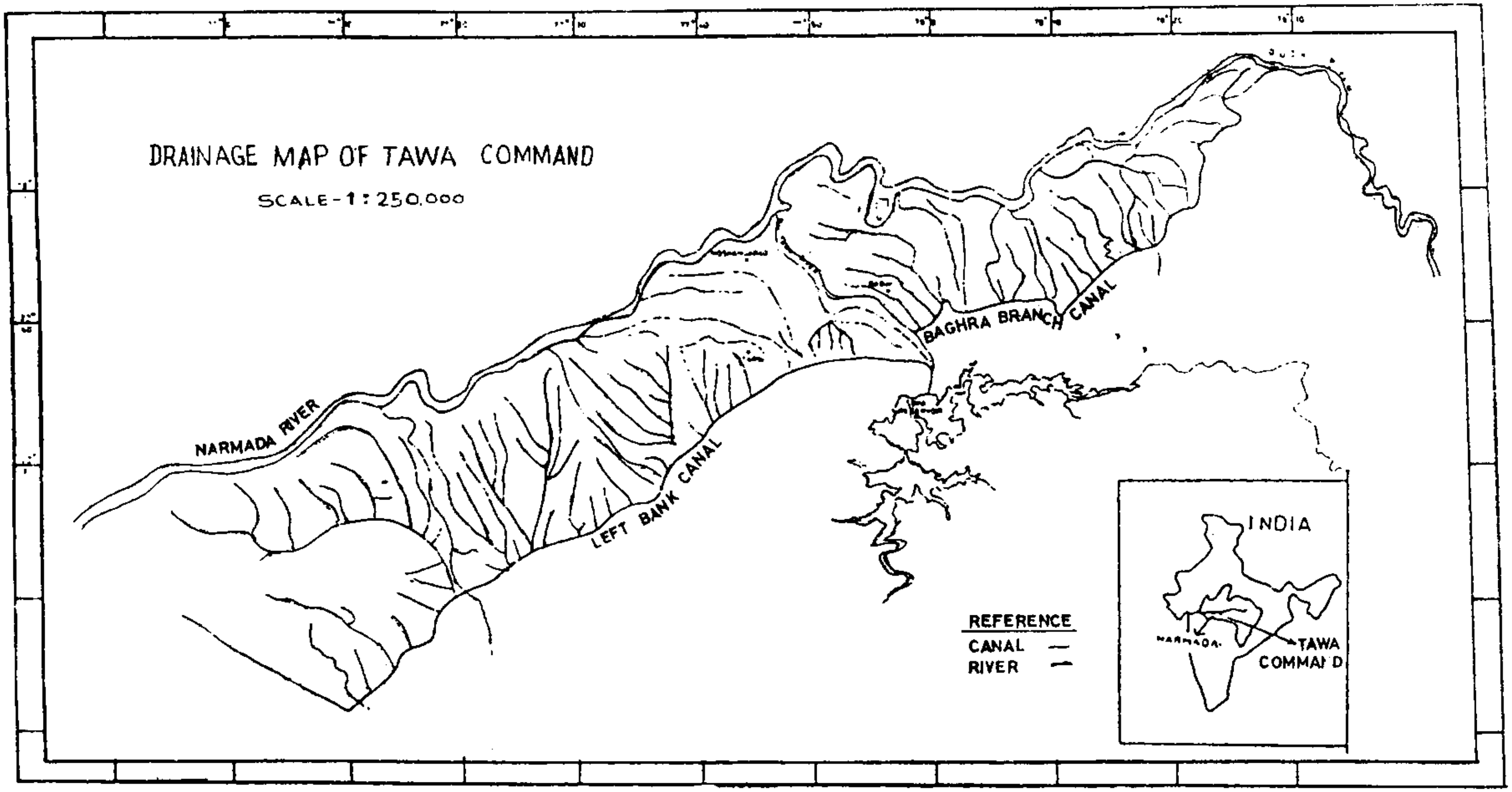
DRAINAGE MAP OF TAWA COMMAND
SCALE-1:250,000
NARMADA RIVER
LEFT BANK CANAL
BAGHRA BRANCH CANAL
REFERENCE
CANAL
RIVER
INDIA
NARMADA
TAWA
COMMAND

FIG. 5

pixel range of 15-25 was applied to band 4 for October and May 1988 and November 1989 scene for command area. The output image exhibited standing water (waterlogging class I) in the command area.

In order to idenify the potential sensitive areas for waterlogging (water table depth at > 1 m), the maximum pixel value was incremented by one (pixel range 15-26) and again the density slicing was performed for all the scenes. All the three scenes exhibited more waterlogged area than the previous one. Again the maximum pixel value was incremented by one and slicing was performed. In this way three map were obtained showing different waterlogged areas for three different pixel ranges. The potential sensitive areas for waterlogging obtained by pixel ranges 15-26 and 15-28, were verified in the field. Such areas are the extension of standing water areas in low lying terrain follow the general slope of the terrain, which is in the North direction. In such areas the water table lies in between 1 to 3 m.

Pixel range	15 - 25
Pixel range	15 - 26
pixel range	15 - 28

During visual interpretation and image analysis 24 locations were identifed for the field verification. The locations are shown in Fig.6. A field survey was carried out in the month of Feb.1995. It was found that 96 per cent of the waterlogged fields have slope less than 0.5 per cent and the slope is from south-east to north-west direction. The ground elevations of adjoining high altitude fields vary between RL 310.0 to 316.0 m, whereas

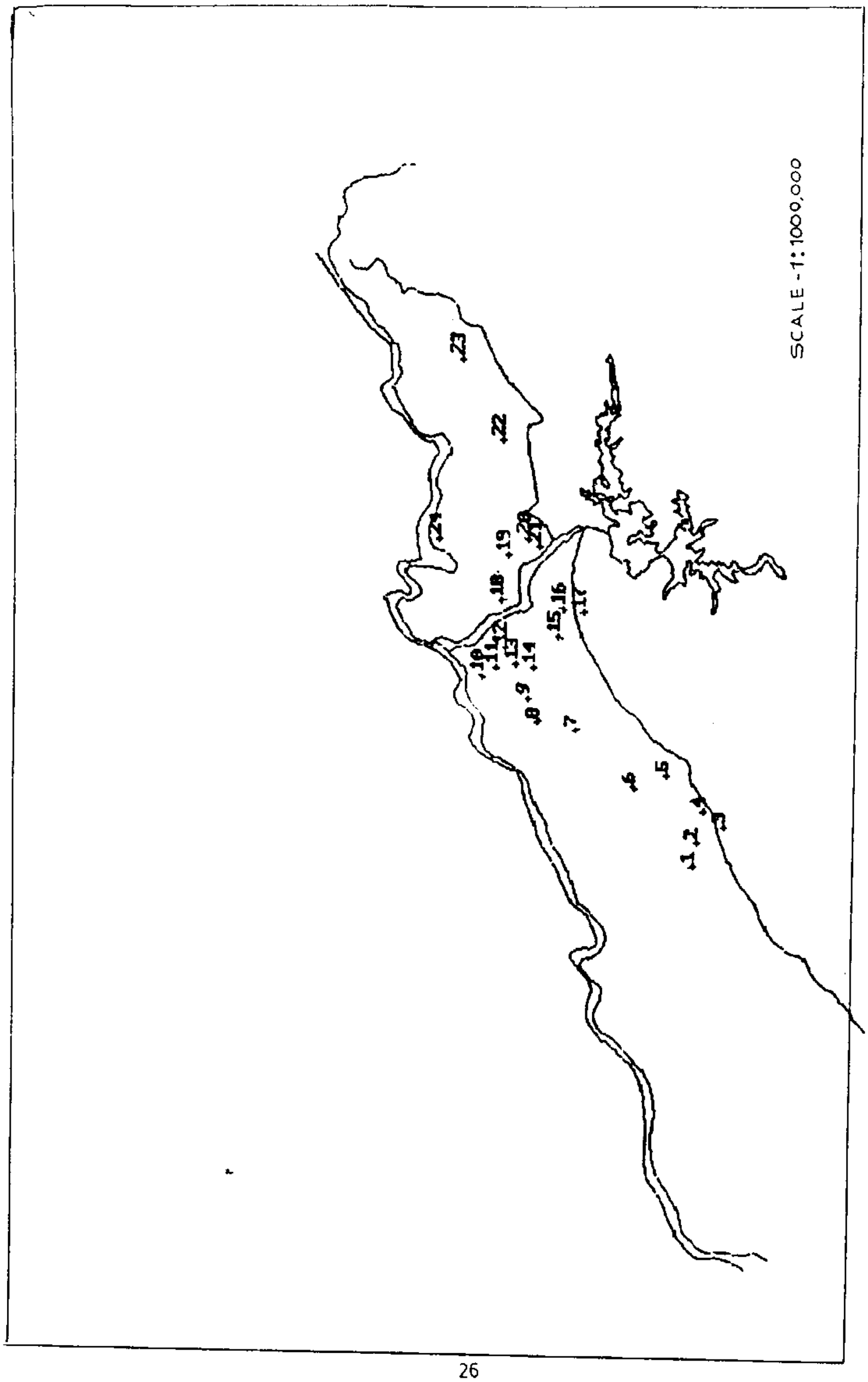
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FIG. 6

the problem area elevations vary between 297.2 to 299.6 m. Hoshangabad distributory passes at an elevation of 313.93 m at a chainage 440. Hence, elevation difference of about 14-16 m exists (Kale 1993).

Traversing the command area it was noticed that the natural drains are infested with Ipomea aquatica and occasional aquatic weeds. These obstructions not only caused silting but drastically reduced the carrying capacity of the drains.

Water table depth data were collected from M.P.Ground Water Department, Hoshangabad for premonsoon and postmonsoon months i.e. May & oct.1988. Pre-post monsoon ground water fluctuations of selected wells are shown in Fig.7 and the waterlevel data for 24 well locations for the pre-post monsoon period 1988 are given in table 7.

Table 7. Water level data of representive wells for 1988 pre & post monsoon

Well Nos.	Name of station	Pre(meter)	Post(meter)
1	Babanahhau	3.00	1.10
2	Khara	0.90	0.00
3	Amupura	5.30	3.80
4	Jamani	8.10	2.85
5.	Nandarwada	3.40	2.60
6	Dharmkundi	7.05	3.35
7	Dolakia	7.50	5.00
8	Sayalkheda	1.40	3.00
9	Rohna	5.70	5.05
10	Hoshangabad	21.90	19.85
11	Jasalpur	4.50	3.80
12	Nimsadia	4.20	3.22
13	Pawarkheda	4.90	3.35
14	Byawara	7.30	3.60
15	Itarsi	4.75	3.00
16	Sangakheda	13.05	12.00
17	Chhidgaon	4.4	3.80
18	Anchalkheda	5.35	4.05
19	Babia	9.70	8.60
20	Ankahmou	10.50	8.30
21	Guyarwada	9.70	5.50
22	Barangi	7.60	3.35
23	Shobhapur	7.90	4.50
24	Nasirabad	12.15	11.60

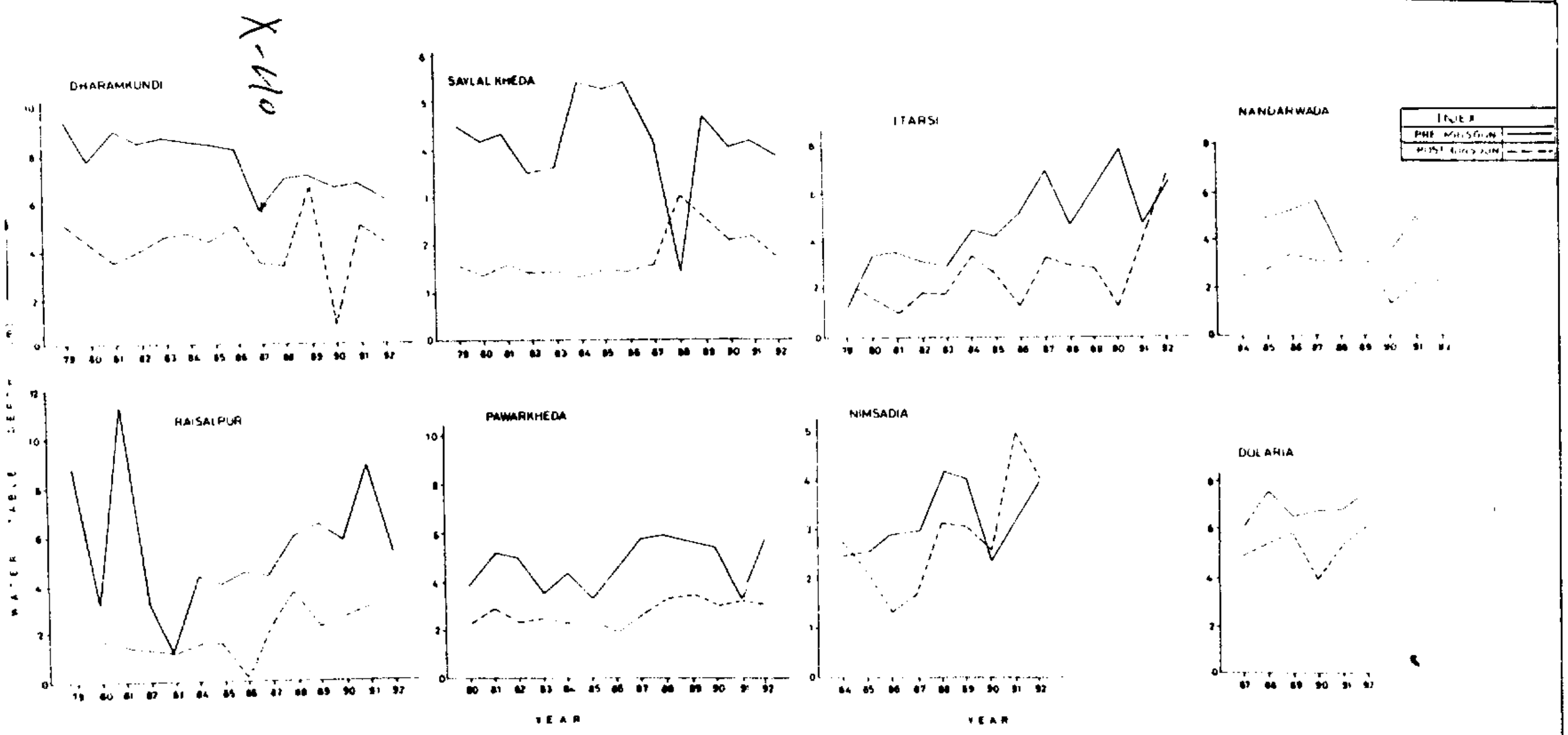

FIG 77. PRE - POST MONSOON GROUND WATER FLUCTUATIONS OF REPRESENTIVE WELLS.

The water table depth data were transfered on the waterlogged areas map prepared from IRS data . Area having water table depth at 1 to 3 m from surface are considered as potential sensitve areas for waterlogging.

Based on the field observations, maps showing waterlogged areas were finalised. It has been found that pixel ranges 15-25, (standing water) 15-26 and 15-28 manifestation of surface (soil moisture and perennial vegetation) are suitable for the assessment of standing water areas and potential sensitive areas for waterlogging.

The result of the data analysis for the assessment of waterlogging for 20 October 1988 and 20 November 1989 are shown in Figs 8 abc and Figs 9 abc respectively. The assessment of waterlogged areas for 20 October 1988 are tabulated in tables 8 a & b.

Table 8a. Waterlogged area (standing water) in Tawa command (sq.km).

S.No.	Date of satellite overpass	Area
1.	19.05.1988	49
2.	20.10.1988	80
3.	20.11.1989	93

Table 8b. Potentially sensitive areas to waterlogging

Date	Water table depth (in meters)	Waterlogged area
20.10.1988	0-1 m	80
20.10.1988	1-3 m	140

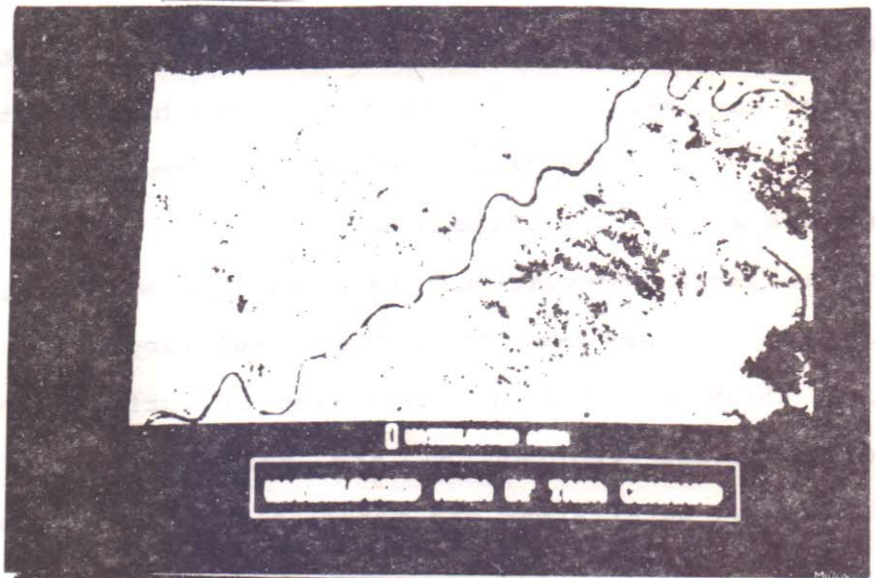

FIG 8 a

FIG 8b

FIG 8c

FIG 9a

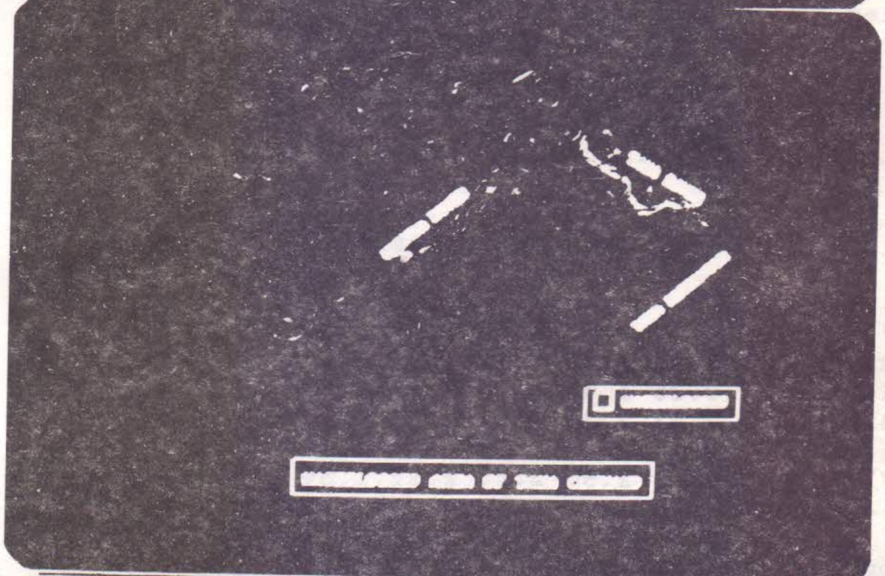

FIG 9b

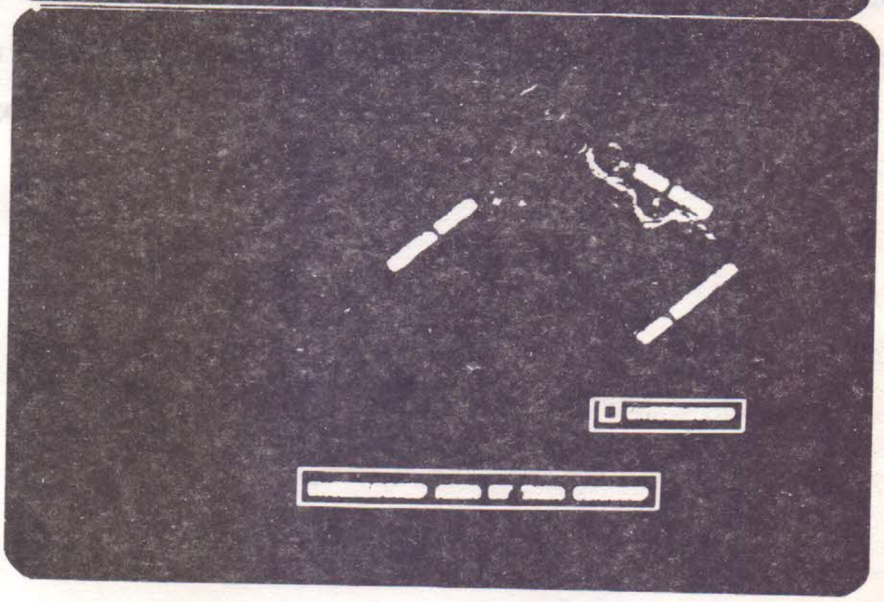

FIG 9c

The results obtained from this study indicate that during postmonsoon months i.e, Oct.1988 and Nov.1989, the affected waterlogged areas were aproximately 80 and 93 sq.km respectively. Whereas the potential sensitive area for waterlogging was 140 sq.km, where ground water table lies in between 1 to 3 m.

The water levels in selected wells in Tawa command area for December (mid irrigation) are presented in Table 9. It is clear from the table that in 1984, watertable in all the wells have increased due to the introduction of canal.

Table 9. Water table record of different wells for December over Years.

		Depth in meters.						
		Years						
Well No	Month	1975	1984	1985	1986	1987	1988	1989
3	Dec	7.50	2.35	2.50	2.90	3.30	3.08	2.69
9	Dec	8.00	2.35	2.50	2.90	3.30	3.08	2.69
10	Dec	6.80	0.47	0.26	1.41	3.60	1.22	1.01
11	Dec	8.15	2.35	2.93	2.25	2.72	2.35	1.80
32	Dec	6.70	0.30	0.37	0.60	1.30	0.53	0.30
36	Dec	7.85	---	---	2.50	2.88	2.21	1.54

(Adopted from Kale, 1993).

The larger waterlogged area in Nov.1989 (93 sq.km) was may be due to the gradual increase in ground water table depth (table 9).

CONCLUSIONS

After commissioning of the Tawa Irrigation Project in 1975, there was a general rise in ground watertable. Zonal Agriculture Research Station (ZARS) powarkheda has maintained records of few wells since 1973. It is reported that there is a general rise of ground water depth to 2.5 m.

A rapid and accurate assessment of the waterlogged area can be made by the use of remotely sensed data

IRS-1A-LISS-I infra-red band 4 data has been proved to be very useful for the assessment of waterlogged areas, and sensitive area for waterlogging in the command.

Density slicing is a useful technique to make an assessment of waterlogged areas. Selection of pixel range based on field informations such as topography (low lying areas) soil moisture and vegetation may help in the identification of sensitive area for waterlogging.

The result obtained from this study indicate that in Oct.1988 an area of 80 sq.km was affected by waterlogging and about 140 sq.km area was sensitive for waterlogging.

It is suggested that periodic assessment of waterlogging using remotely sensed data should be carried out at a regular interval.

REFERENCES

Agrawal, M. C and Malik, R.K. (1982). Study of water table behavior in Hayrana. Proc. 19th annual convention of ISAE, College of Technology and Agricultural Engg. Udaipur.

Annual progress report 1989-90. Zonal Agricultural Research Station, Powarkheda, M.P.

Annual report 1990-91 Ministry of Water Resources, Govt. of India.

Batta,R.K., Sehgal,J.L and Choudhary,T.N (1990). Waterlogging in irrigation commands. All india seminar on waterlogging & drainage Dec 7-8, Roorkee.

Bowonder, B and Ravi, C (1983). Waterlogging in Siramsagar irrigation project International J. of Water Resources Development 1 (2): 157-171.

Bowonder, B., Ramana, K.V and Ravi,C and Srinivas C (1987) Land use; Waterlogging and irrigation management, Land use policy, 4(3), 331-341.

Bouwer, H., Dedric, A.R. and Jaynes, D.B (1990) Irrigation Management for ground water quality Protection Irrigation and drainage system 4:375-383

Chitale, M.A (1991) Environmental Management in water resources project-Indian experiences of irrigation power project J. of Indian Water Resources Society 1(2),56-59

Choubey, V.K (1994). Assement of waterlogging area in INGP stage I by remote sensing techniques. Report No. CS (AR) 138 NIH Roorkee.

Kale, V.S (1993) Waterlogging in Tawa command area. Unpublished Ph.D thesis, Deptt. of Soil and Water coservation Engg., IIT Kharagpur.

Naqvi,S.N. (1987) Water table changes in canal command area- A case study of Tawa command area Unpublished M.Tech thesis College of Agricultural Engineering J.N.K.V.V Jabalpur.

National commission for Agriculture report (1972).

National Commission in Agriculture report (1976).

Patel, C.C (1989) Water management planning for Pingla block Unpublished in M.Tech thesis Deptt. of Agricultural Engineering IIT Kharagpur.

Rao, B. K (1986) Evaluation and intervention in Tawa irrigation project. Part IV report Agricultural finance corporation Ltd Bombay.

Report of Task Force sub-committee for suggesting remedial measures for waterlogged area in Tawa and Barna command 1983, Govt. of Madhya Pradesh.pp 20-80.

Sondhi S.K and Sharma,P13.5 (1987)Resource analysis and plan for efficient water management - A case study Mahi right bank canal command area IARI Bulletin 42.

Todd, D.K (1959) Ground water hydrology Johan Willey and sons Inc. New York, USA.

Watton, W.C (1990). Ground water resources evaluation Mc Graw Hill book Co. New York, USA.

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