CHAPTER 1
INTRODUCTION

INTRODUCTION

Introduction of irrigation in arid and semi-arid areas has been considered as the most effective way for improving the agricultural production. However, owing to changes in natural hydrological balance after the introduction of irrigation, the rise in water-table is observed in most of the projects. This condition leads to waterlogging and consequently salinization of soil leading to partial or complete crop failures. This history repeates again and again in India since its first known appearance in 1855 in the tract of western Jamuna canal without any visible signs of its end. There has been no accurate estimate of the areas affected by waterlogging in India. Framji (1974) has reported that nearly 3.5 million hectares of area has become waterlogged with the rise in water table in the root zone. A recent study carried out by the Administrative Staff College of India puts the figure of waterlogged area at about 10.00 million hactares and the menace is increasing day by day (Rao and Singh,1990). The study area Khambhat taluka of Gujarat is also facing the same problem under Mahi River Bank Canal command since 1959 and regular monitoring of the area for planning the remedial measures in the reclamation of affected area and conservation of unaffected lands becomes the atmost necessity of this area. Since the Satellite Remote Sensing is of immence value in monitoring the land degradation, an attempt has been made to monitor the waterlogged areas of Khambhat taluka by remote sensing technique and with a parellal attempt to study the amelioration of the waterlogging ill effects on crops in this present study.

1. WATERLOGGING:-

Strictly speaking waterlogging is mainly a subsurface phenomenon in which the influence of water-table on the root-zone retards the plant growth, seriously affecting the productivity of land. Thus the waterlogging is a naturally occuring or artificially induced phenomenon in which the water-table rises high so that the water-table or atleast the capillary fringe reaches the root zone. Waterlogging can also be defined as the replacement of the gas (air) phase of the soil by the liquid (water) phase and involves no change in the free energy of the water (Levitt,1980). These waterlogged areas are not only hampering the growth of plants but also hastening the deterioration of soil by becoming saline areas.

1.1 CAUSES OF WATERLOGGING :

The rise of water table leading to waterlogging may be due to the following reasons.

1. **Seepage of water through the bank of canals:-** Water seeping from the bed and sides of adjoining canals or reservoirs etc. situated at a higher level than the affected land results in higher water table.

2. **Over and Intensive irrigation :-** Contineous irrigation leads to heavy downward percolation. Since ground water motion is slow in lateral direction the watertable at a distance away fails to receive recharge soon, ultimately the ground water mounds are formed rising water table.

3. **Seepage of water from adjoining highlands:-** Water from adjoining highlands seeps into the subsoil of low level area causing a rise in water table.

4. **Impervious obstruction :-** The subsurface or ground water moving laterally may meet an impervious barriers like rail, road embankment leading to the rise of water table, on the upstream side of the barrier.

5. **Inadequate infilteration :-** When an impervious soil strata exists at a shallow depth below top soil the downward percolation of soil is resisted.

6. **Inadequate surface drainage :-** Stream water or excess irrigation water not finding proper drainage laterally or longitudinally infilterates below continuously bringing in water table higher up.

7. **Excessive rains :-** Excessive rainfall over land creats temporary waterlogging which may persist permanently in poor drainage conditions.

8 **Submergence due to flood :-** In the flood plains or back water zone,land get submerged for long periods by flood water. Grass, weeds and shrubs grow abundantly preventing surface drainage. Finally, it leads to waterlogging.

9. **Irregular flat topography :-** Flat and irregular terrain having contineous rise and depressions suffers from poor drainage resulting in waterlogging.

1.2. ROLE OF IRRIGATION SYSTEM IN WATERLOGGED AREAS :

The problem of waterlogging is bound to occur under any canal system if attention is not paid to proper soil and water management. When an irrigated water is supplied from a reservoir, through canals, part of water is wasted as overflow from canals and part of it is lost by way of seepage from canals. Some portion of the water which applied to the field infiltrates below ground, and the rest of water is lost as excess irrigation water. The water which infiltrates below ground, only a part of it is used by the crops and the rest deeply percolates to ground water-table. Thus as irrigation goes on continuing, it generates excess surface water as well as excess ground water. Unless this excess water is taken out it will cause rise in water table to root zone and eventually affects the crop (Agarwal et al, 1979.). However in a study carried out by Tyagi (1982) in an area of 72,500 hactares, revealed that the contribution to ground water from stagnated rain water is almost as high as that as from applied irrigated water on crop land. Jain (1961) estimated that as high as 71% of water released at the head works can be lost on the way as seepage in canal irrigation system. Similarly, several studies made in the country indicated that the irrigation application efficiencies in general are very poor, where the geohydrlogical and topographical conditions are unfavorable for natural drainage, give a raise to the watertable. There were reports of similar examples of rise in ground water table following introduction of irrigation, like Indra Gandhi canal command area in Rajasthan (Mathur et al, 1982.), Fatewadi command area in

Gujarat (Kalubarme et al, 1984), Mahi Right Bank Canal command area in Gujarat. (Kalubarme et al,1983). Kakrapar irrigation scheme project in south Gujarat (Bapat,1985). Sharada Sahayak command area in Utter pradesh (Ambekar,1986) etc.

1.3 GROUND WATER TABLE :

1. Depth of ground water table causing waterlogging based on soil

The depth of water table that tends to make the soil waterlogged and harmful to plants depends upon the height of capillary meniscus surface rises within 2 feet from ground surface (Gupta, 1962). Waterlogging starts when capillary fringe reaches the root zone of plant. The height of capillary fringe above watertable depends on soil characterestics as follows.

Soil type.	Height of capillary fringe.
Clay soil	3 metre
Sandy loam	2.5 metre
Peat	1.2 metre
Sandy soil	1 metre

2. Critical depth of watertable of causing waterlogging based on crop:

Another consideration is about the crop itself. The lateral and vertical distribution of roots in the soil depends on crop type. Therefore the position of watertable rendering the land waterlogged also depends on the nature of crops as follows.

Sugar cane	30 cm
Rice	60 cm
Gram	90 cm
Wheat	90-125 cm
Fodder	120 cm
Corn/cotton	125 cm
Lucerne	220-250 cm.

3. Desirable depth of water table:

The depth of watertable has been categorised as the following to avoid the problem of waterlogging.

Good	2.1 to 1.8 metre
Fair	1.8 to 1.28 metre
Poor	1.25 to 1.8 metre
Bad	1.25 and rising.

However, the desirable depth of water table for any irrigation command depends upon the type and stage of growth of crops, the texture of soil and quality of ground waters. According to International Land Reclamation Institute, Netherlands, the depth of water table of 1.0 to 1.10 metre in normal cirucumstances is the criteria for areas with good quality ground waters. According to United States Bureau of Reclamation Drainage Manual, a depth of water table of 0.90 to 1.50 metre is considered satisfactory. In coarse and medium textured soils depth of watertable of 0.90 to 1.20 metre should not be exceeded while in fine textured soils water table depth that should not be exceeded except for brief periods has been taken as 1.2 m to 1.5 m in view of high capillary rise for such soils. Ideally, watertable should be kept at a depth of greater than 2 m to maintain a favourable salt balance in root zone. (Hari krishna,1985)

1.4. ASSESSMENT OF WATERLOGGED AREAS :

Generally two types of methods are being used to assess the extent of waterlogging in the irrigation commands.

1. Observation of water table :

Observation of subsoil water table are being carried out since two decades in almost all the major irrigation schemes during pre-monsoon (May) and postmonsoon (November) periods. The water table are being observed from existing open dugwells almost equispaced through out the command area. This is the conventional method used for identifying the existing and extending waterlogged areas.

2. Remote Sensing Technique :

The modern satellite remote sensing technique was proved to be potential tool for identifying, delineating and monitoring of waterlogged areas. Its reliable data, helped to identify the waterlogged areas, which could not be identified by the ground water- table measurements. Moreover the smallest waterlogged area of even 5 hac. on the earth can be identified by remote sensing technique. (Bapat,1985).

2.REMOTE SENSING :

2.1. Definition :

Remote sensing is the science and art of obtaining information about an object area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. (Lillesand, 1987, Sabins, 1978.). This is accomplished by measuring electromagnetic radiation (EMR) emitted or reflected by the object. Remote sensing could be illustrated by common example i.e "Reading" . The eyes acquire the data, which impulses corresponding to the amount of light reflected from the dark and light areas on the page after acquisition of these data. The analysation or interpretation will be carried out by mental computer to enable to explain the dark area on the page as a collection of letters farming words. Beyond this, the words form sentences and interpret the information that the sentences convey.

2.2 Modern remote sensing technology :

sentence not clear

The modern remote sensing technology is being developed the conventional aerial photographs, by acheiving,

* the use of different and extended postion of electromagnetic spectrum
* the development in sensor technology
* the fabrication of different platforms for satellite remote sensing
* the emphasis on the use of multi spectral information
* the advancements in image processing and enhancement techniques and
* the improved image analysis by automated and manual inter pretation.

2.3 Foundamental concepts of remote sensing :

1. Electromagnetic Radiation - Energy Source

Electromagnetic radiation is a dynamic form of energy which is propagated as a wavemotion at a velocity of $C=3*10^{8}$ m/sec. The parameters which characterise a wave motion are wavelenth - λ, frequency - v and velocity - c. The electro magnetic spectrum classifies, according to wavelength, and energy which propagates as electromagnetic wave. (fig.1). The most prevelent unit used to measure wavelength along the spectrum is the micrometer (µ m). A micrometer equals $1*10^{-6}$ m. Since the portions of the electromagnetic spectrum used in remote sensing lie along a contineous characterised by magnitude changes of many powers of 10, the use of logarithmic plots to depict the electromagnetic spectrum is quite common. The visible portion of such a plot is an extremely small one, since the spectral sensitivity of the human eye extends only from about 0.4 µm to approximate 0.7 µm. The color "blue" is ascribed to the approximate range of 0.4 to 0.5 µm, green to 0.5 to 0.6 µm and red to 0.6 to 0.7 µm. Ultraviolet energy adjoins the blue end of the visible portion of the spectrum. Adjoining the red end of the visible region are three different categories of infrared (IR) waves viz. Near IR (from 0.7 to 1.3µm) mid IR (1.3 to 3µm) and thermal IR (beyond 3µm). At much longer wavelengths is the microwave (1 mm to 1 m) portion of the spectrum. Most common sensing systems operate in one or several of the visible, IR or microwave portions of the spectrum. Within the IR portion of the the spectrum, only thermal IR energy is directly related to the sensation of heat.

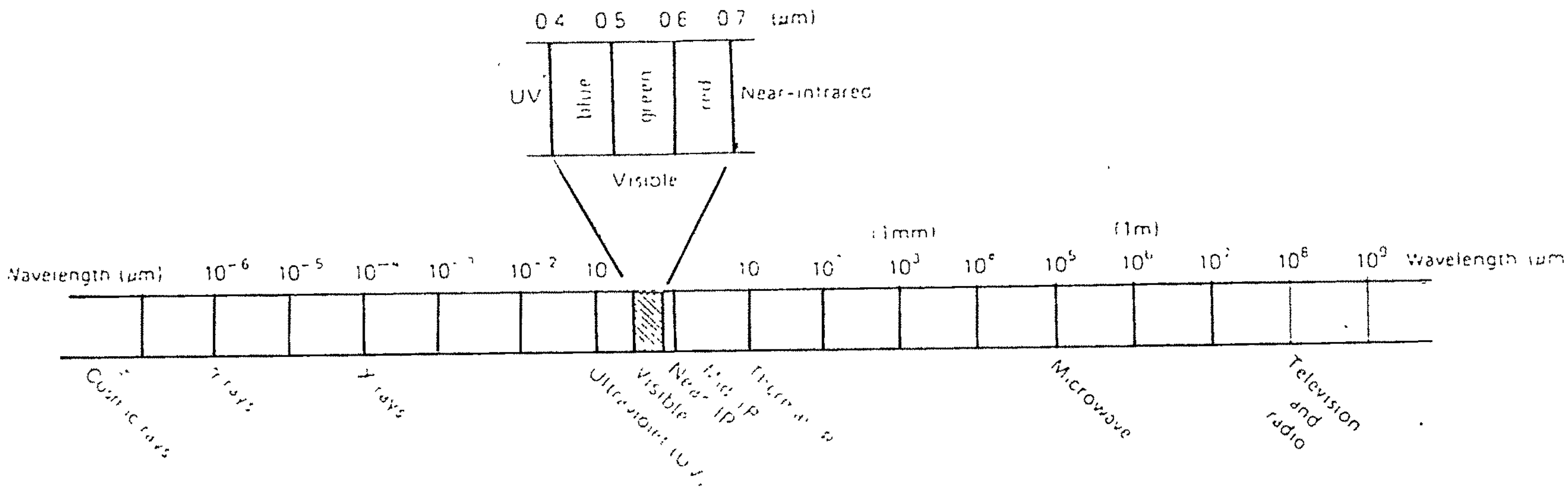

FIG.1. Electromagnetic spectrum.

2. SENSORS

Sensor is a device that gathers energy (EMR or others) converts it into a signal and presents it in a form suitable for obtaining information about the target under investigation. These may be active or passive depending on the source of energy. Active sensors uses their own source of energy to illuminate features of interest, in contrast the passive sensor receive solar electromagnetic energy reflected from the surface or energy emitted by surface itself. These sensors do not have their own source of energy and can not be used during the night time.

1. Types of sensors

(i) Return beam vidicon (RBV)

RBV do not contain film, but instead their images are exposed by a shutter device and stored on a photosensitive surface within each camera. This surface is then scanned in raster form by an internal electron beam to produce a video signals just as in a terrestrial television camera. RBV images have greatest inherent cartographic fidelity than these acquired by MSS. Reseau grid on RBV images halps in geometric correction of the images to high accuracy.

(ii) MSS (Multi Spectral Scanner)

This sensor covers 185 km swath with resolution of 79 m in four spectral bands, as follows.

0.5-0.6 µm (green)- Movement of sediment landen water and delineation of sholow water areas.

B5 0.6-0.7 µm (red)- Cultural features discrimination of vegetation type.

B6 0.7-0.8 µm (IR)- Vegetation boundary between land and water, land forms

B7 0.8-1.1 µm (IR)- Penetration of atmospheric haze, vegetation, boundary between land and water, land forms.

IFOV (Instantaneous field of view) gives resolution cell of approximately 79m on a side. Total field of view scanned is 11.56 degree. The mirror oscillates once every 73 milliseconds. Six contineous lines are scanned simultaneously with each mirror oscillation. Four arrays of six detectors give analog signals and are converted to digital form by an onboard A to D converter. A digital number ranging 0-63 (6 binary digits) is used for this purpose. These data are than scaled to other ranges during ground based preprocessing. Bands 4,5 and 6 are scaled to the range 0-127 and band 7 is scaled to 0-63. MSS scans each line from west to east with the southward motion of a space craft providing along back progression of scan lines. Each frame covers 185*185 sq.km, area with 10% end lap between successive scenes. A nominal scene consists of 2340 scan lines with 3240 pixels/line or about 7,581,600 pixels per channel.

(iii)TM Thematic Mapper

Landsat 4 and 5 are having an advanced multispectral scanner called the thematic mapper. The TM is a NASA experimental sensor.

It is designed to provide 30m resolution, except for 120m resolution in the thermal infrared bands. This can be used for generating classified images (thematic map) using spectral pattern recognition techniques. The TM is having seven channel scanner designed to maximise vegetative analysis, capabilities for agricultural applications. Digital output data range is 256 levels (8 binary digits) which gives very good contrast and sharp images.

Spectral bands

TM-1. 0.45 to 0.52 µm. Coastal water mapping, soil/vegetation differentiation, deciduous/coniferous differentiation.

TM-2. 0.52 to 0.60 µm. Green reflectance by healthy vegetation.

TM-3. 0.63 to 0.69 µm. Chlorophyll absorption for plant species differentiation, emphasizes contrast between vegetation and nonvegetation features as well as contrast with vegetation classes.

TM-4. 0.76 to 0.90 µm. Responsive to amounts of vegetation biomass present in a scene, emphasize soil crop and land water contrasts.

TM.5. 1.55 to 1.75 µm. Vegetation moisture measurements.

TM.6 10.40 to 12.50 µm. Plant heat stress management, other thermal mapping.

TM.7 2.08 to 2.35 µm. Hydrothermal mapping, discrimination of rock formations.

iv). High resolution visible Imaging system.(HRV)

This is a push-broom scanner used on board SPOT satellite. There are two identical system HRV-1 and HRV-2 any one of which can be tilted to +27° to produce stereoscopic images, scene size is 60x60 km, each HRV is designed to operate in panchromatic and multispectral modes. Spacial resolution is 10 metres for panchromatic (B/W) and 20 metres for multispectral mode, radiometric resolution, digital output data range, is 256 lavels.

Panchromotic mode (B/W) (PA)	0.51-0.73 μm.
Multispeetral mode (XS)	0.50-0.59 μm.
	0.61-0.68 μm.
	0.79-0.89 μm.

Panchromatic mode uses 6000 detectors and there are 3000 detectors for each band in multispectral mode. Thus giving 6000 pixels and 6000 scan lines per image for panchromatic and 3000 pixels x 3000 scanlines for multispectral data.

(v).Linear Imaging self scanning system

Two push-broom scanner Liss-I of 72.50 metre spatial resolution and Liss-II of 36.25 metre spatial resolution are used on board IRS-1A. satellite. Each camera system images in four spectral bands in visible and NIR regions.

Band1.	0.45-0.52 μm.
2.	0.52-0.60 μm.
3.	0.62-0.69 μm.
4.	0.77-0.86 μm.

The reflected energy sensed for each picture element by the detector is quantised into 128 Levels (Radiometric resolution).

Ground swath for image obtained by LISS-I camera is 148.5km and for LISS-II camera it is 74.2 km. There are 4 LISS-II scenes in one LISS-I scene.

LISS-I and LISS-II uses four arrays of 2048 total scan lines in one scene.

3. Platforms of Remote Sensing

Platform is a stage to mount the cameras or sensor to acquire the information about earth surface. Platforms may be classified as.

1. Ground based platforms:-

The ground based remote sensing system for earth resources studies are mainly used for collecting the ground truth or for laboratory simulation studies.

2. Air borne plat forms :-

These are commonly used as remote sensing platforms for obtaining photographs and different scanners digital data eg. Air crafts.

3. Space-borne platforms :-

Platforms in space are not affected by the earth atmosphere. These platforms are freely moving in their orbits around the earth and entire earth or any part of the earth can be covered at specified intervals. The coverage mainly depends on the orbit of the satellite depending on their altitude and orbit these platforms may divided in two categories.

a). Geostationary satellites

An equatorial west to east satellite orbiting the earth at an altitude of 35,000 km at which altitude it makes one resolution in 24 hours synchronous with the earth's rotation. These platforms are covering over the same place and give contineous near hemi-spheric coverage over the same area day and night. These are mainly used for communication and weather monitoring viz. GOES, METEOSAT, INTELSAT, INSAT satellites.

b). Sun-synchronous satellite

An earth satellite orbit in which the orbital plane is near polar and the altitude such that the satellite passes over all places. On earth having the same latitude twice in each orbit at the same local sun time. Through these satellites the entire globe is covered on regular basis and gives repetitive coverage on periodic basis. All the remote sensing resources satellites may be grouped in this category. Few of these satellites are LANDSAT, SPOT, IRS-1A, NOAA, SEASAT, TIROS, HCMM, SKYLAB, SPACE SHUTTLE etc. The salient features of various remotesensing resources satellites are tabulated in table-1.

2.4. Remote Sensing Resources Satellite

1. Landsat System:- (Earth resources technology satellite-ERTS)

So far five landsat satellites have been launched by NASA,

Table 1 : The salient features of various remote sensing resources satellites.

Features	LANDSAT 1, 2, 3	LANDSAT 4, 5	SPOT	IRS-1A
Nature	Sun - synchronous			
Altitude (Kms)	919	705	832	904
Orbital period (minutes)	103.3	99	101	103.2
Inclination (degrees)	99	98.2	98.7	99
Temporal resolutions(days)	18	16	26	22
Revolution	251	233	369	307
Equatorial crossing (A.M.)	09:30	09:30	10:30	10:00
Sensors	RBV,MSS	MSS,TM	HRV	LISS-I LISS-II
Coverage	Entire globe1 except polar regions.			

USA in circular polar orbits and they have delivered very useful data for resource management. Landsat satellites were designed to demonstrate the feasibility of mapping and monitoring earth surface featurcs from space.

Satellite	Altitude(km)	Operation period	Sensors
Landsat-1	917	July 1972-January 1978	MSS,RBV,DCP
Landsat-2	917	January 1975-July 1983	MSS,RBV,DCP
Landsat-3	915	March 1978-March 1983	MSS,RBV,DCP
Landsat-4	705	July 1982-October 1983	MSS,TM,DCP
Landsat-5	705	March 1984 -Operational	MSS,TM,DCP.

Landsat satellites are sun-synchronus and capable of covering the entire earth, except for the polar regions. They complete one revolution of earth in 103 minutes, resulting 14 orbits per day. The successive orbits are about 2760 km. apart at the equator. Because the sensors aboard the satellite image only a 185 km swath, there are large gaps in image coverage between successive orbit on a givin day. However, with each new day satellite orbit progresses slightly westword having an overlap over the coverage of the previous day. The entire earth is covered with in 18 days for Landsats 1,2 and 3 and with in 16 days for 4 and 5. Thus repetitive coverage of same area is possible after 18 or 16 days with same area coverage 20 times/year.

2.4.2. Indian Remote sensing satellite-1 A (IRS-1A):-

ISRO has successfully developed and utilized a variety of the sensors operating in visible infrared and microwave regions of the electromagnetic spectrum. This led to initiate of satellites. The first of the IRS series termed IRS-1A, is carrying remote sensing payloads operating in the visible and near IR regions. The future satellites are expected to carry the other regions of electromagnetic spectrum including the microwaves.(George Joseph, 1985).

The priniciple components of the mission are.

* A three axis stabilised polar sun synchrous satellite with multi spectral sensors.
* A ground based data reception, recording and processing systems for multi spectral data.
* Ground systems for the in orbit satellite control including the tracking the network with associated supporting system.
* Hardware/Software elements for the generation of user oriented data products. Data analysis (NRSA,1988).

The IRS camera is based on the concept of "push broom scanning" using Linear Imaging Self Scanning sensors (LISS)..two different camera were designed for IRS-1A, one with 72 m resolution (LISS-I) and the other with 36m (LISS II). The resolution of 36 m of LISS-II can be compared to TM on board of Landsat. LISS-I has a swath of 148 km and LISS-II cameras give a combined swath of 145 km.

2.4.2(1). Push broom scanner technique :

The push broom scanning is the technique of using the forward motion of the satellite platform to sweep a linear array of detectros oriented perpendicular to the ground track, across a scene being imaged, (fig.2). One array is typically used for each spectral bands. The satellite motion provides coverage in the direction of scan and electronic sampling of the detectors in the cross track dimension provides the orthogonal scan components for an average. The detector array is sampled at appropriate rate advantages in using the push broom scanning machanism. First of all the complex machanical moving parts is an optical machanical scanner (as in MSS) are eliminated. Secondly, this approach allows the photon flux from the scene to be integrated during the time required for the Instantaneous field of view (IFOV) to advance the dimension of one resolution element on the ground, this result in an increase of the signal generated and stored at each detector position, thus resuloting in letter signal to noise ratio.

Besides this the datas collected from the French satellite 'SPOT' are also widely used for natural resource studies.

2.5. Analytical Process of Remote Sensing

The remote sensing involves two basic processes viz Data Acquisition and Data Interpretation (fig.3)

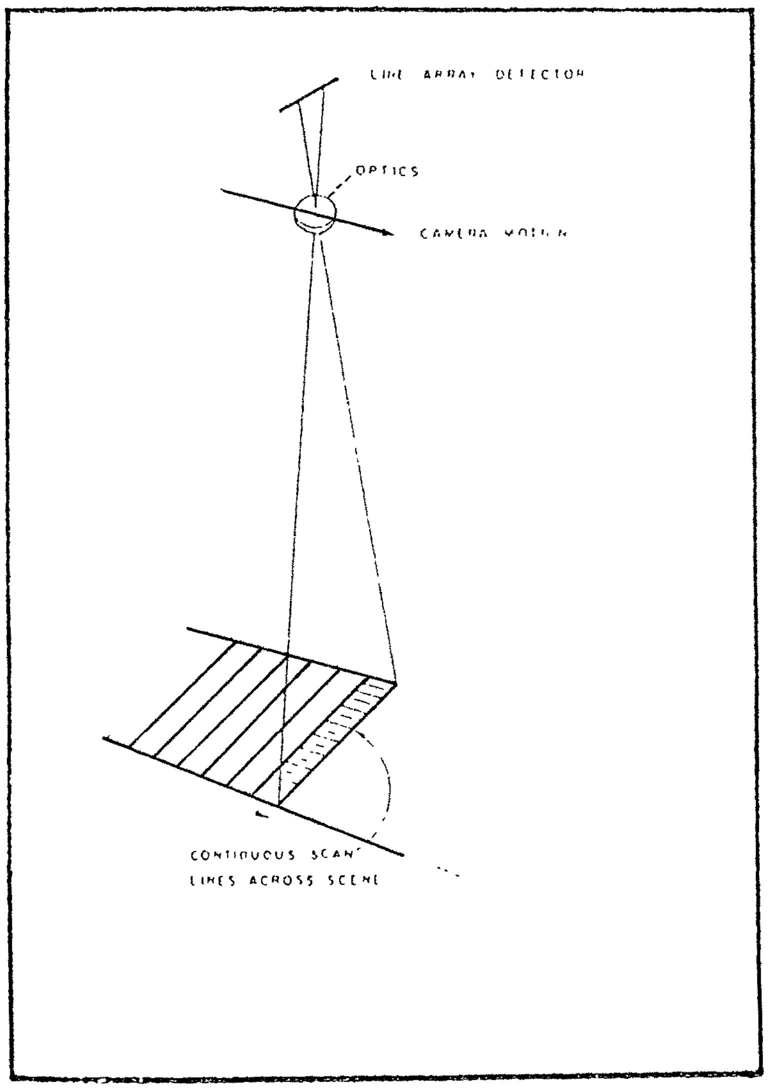

FIG.2. Pushbroom concept of IRS-1A.

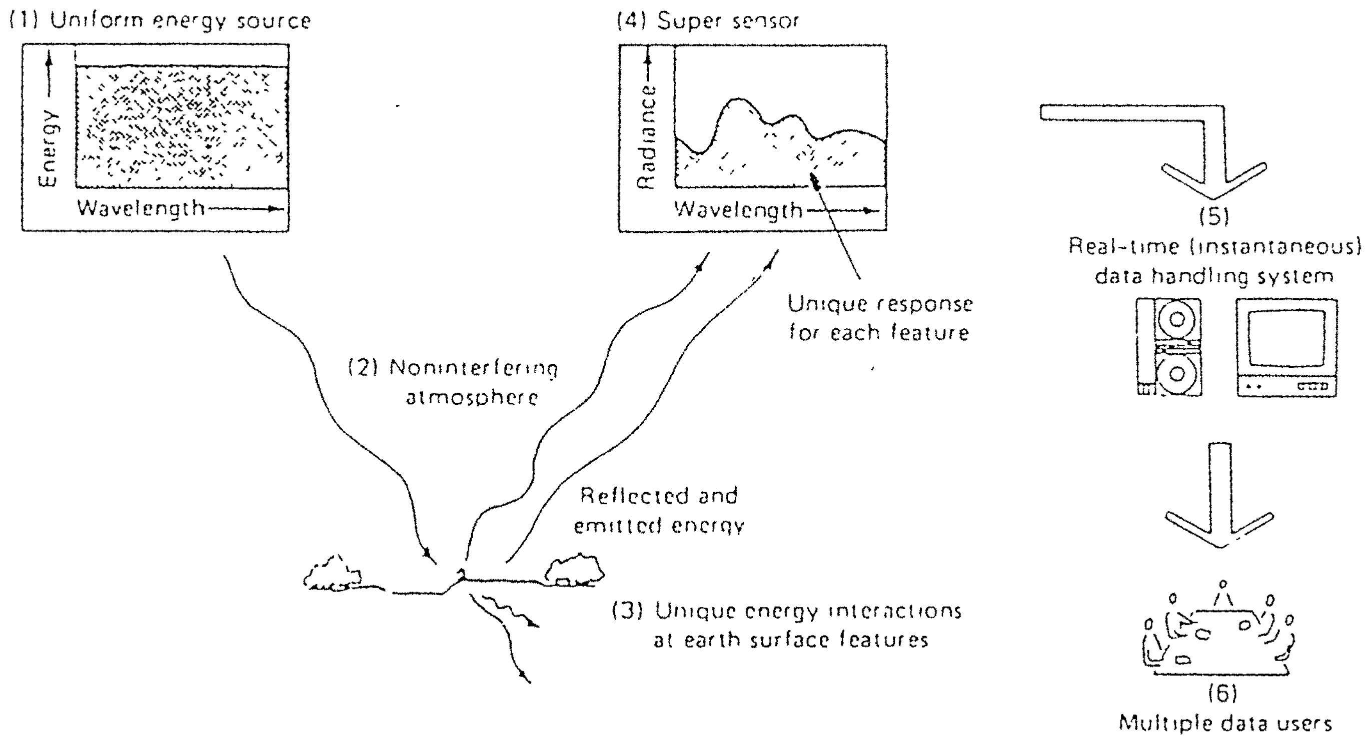

Fig 3. Remote Sensing System.

1. Data acquisition

Data acquisition involves following steps.

* Source of electromagnetic energy (sun/self emission)
* Transmission of the energy from the source to the surface of the earth-absorption, scattering.
* Interaction of energy from the surface to the remote sensor.
* Sensor data output.

Subsequently the data is transmitted, processed and get ready in the from of pictorial or digital for analysis.

2. Data Interpretation:-

Image interpretation is defined as the act of examining images for the purpose of identifying objects and judging their significance.

Elements of Image interpretation:-

Imagery represents energy reflected, emitted or transmitted from any part of the EMR spectrum and is recorded in many shapes, size and scales. The fallowing elements of photographic interpretation are regarded as being of general significance.

1 **Shape:-** Numerous components of the environment can be identified with reasonable certainty merely by their shapes or forms.

2. **Size:-** In many cases the lengths, widths ,heights, areas and/or volumes of imaged objects are significant.

3.**Tone**:- Different objects emit or reflect different wavelangths and intensities of radiant energy. Such differences may be recorded as variations of picture tone.

4. **Shadow**:- Shadow are especially useful in geomorphological studies where micro-relief features may be easier to detect under conditions of low angled solar illumination than when the sun is high in the sky. However deep shadow in areas of complex detail may obscure significant features.

5. **Pattern**- Relative arrangements of both natural and cultural features are quite common, which is useful for the mapping and analysis of relatively complex features.

6.**Texture**:- This is an important element closely associated with tone in the sense that it is the quality which permits two areas of the same overall tone to be differentiated on the basis of microtonal patterns. Common taxtures in image include smooth, rippled, mottled, lineated and irregular. This element more often invoked as the basis for a subdivision of categories.

7. Site:- At an advanced stage in interpretation, procedure, the location of objects with respect to terrain features of other objects may be helpful in defining the identification and classification of certain picture contents.

Besides these Resolution, Association are also used as a significant elements for image interpretation.

Two basic methods are used to study the images in visual interpretation, viz. Fishing expedition, examination of each and every object, so as not to miss anything and logical search, quick scanning and intensive study selectively. The activities in imageinterpretation sequence includes detection, recognition and identification, analysis, deduction, classification, idealization, accuracy determination with field varyfication which again includes prefield, field visit during interpretation for doubtful cases and post field study.

2.6. Digital Analysis:-

Digital image processing is the numerical manipulation of digital images and includes preprocessing enhancement of classification with the aid of computer. Preprocessing rafers to the initial processing of the raw data to calibrate the radiometry, correct geometric distortion and remove noise image enhancement produces a new enhance image which may be easier to interpret than the original image.

i) Image classification :- Image classification carries the digital image processing a step further and attempts to raplace the visual interpretation step with quantitatine decission making. The output of classification, there fore, is a the matic map in which each pixel has been classified into one of the several themes.

ii) Image enhancement :-Image enchancement techniques improve the quality of an image as percieved by a human. These techniques are most useful because many satellite image when examined on a colour display give inadequate information for image interpretation. The contrast stretch, density slicing, edge enchancement, and spatial filtering are the more commonly used techniques. Besides these, multispectral ratios are also useful. This type of processing can remove temporally or spatially-varying gain and bias factors, suppress radiance variations arising from topographic slope and aspect and enhance radiance differences between soils and vegetation

3. REMOTE SENSING IN THE DELINEATION OF WATERLOGGED AREAS:-

Identification of the object can be made based on their spectral reflectence as it is dipicted in the figure 4 for soil, vegetation for water. The changes in the reflectivity of the soil, according with its moisture content paved the way to use remote sensing technique to identify delineate and map the waterlogged areas. Reflectivity of the soil decreases with increasing moisture content, tends to be independent of wavelength. Thus the waterlogged areas are characterised by dark tone in black and white image and blue colour in False Colour Composite (FCC) (Aggarwal and Mishra,1987; Bajbai,1989). The acheivement of mapping the high soil moisture and surface salt deposites in perched water table and associted salinity by Tinney et al (1974) has been landable.Later, the location of the high water table in a part of the irrigation district in Kansas state (U.S.A) using both Landsat images and aerial photographs has given an accuracy of 91% when correlated with ground truth survey by measuring the water table depth. (Ryland et al 1974). Added to this regular

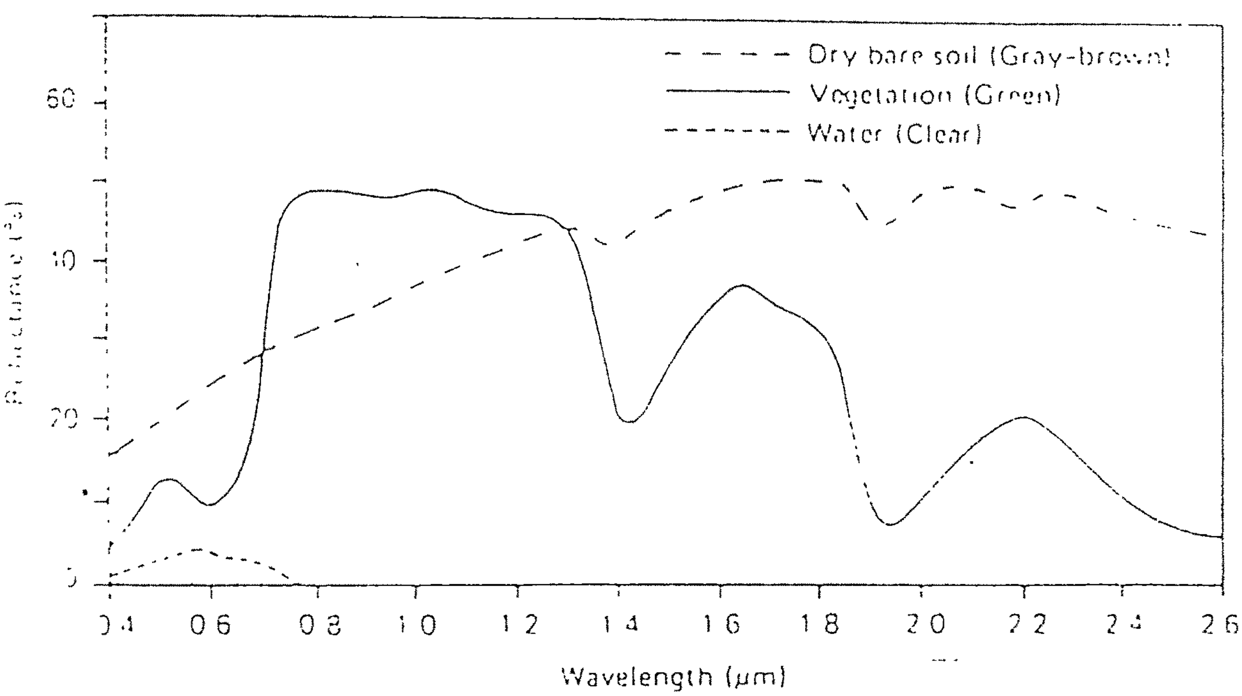

FIG. 4. Spectral reflectance curves for Vegetation, Soil and Water.

monitoring of water bodies, estimation of irrigated lands has also been progressed. (Naik et al 1978, Heller and Johnson, 1979, Tinney et al 1979, Thiruvengadachari, 1981). In India Mistry and Purohit (1982) studied the environmental impact of Ukai-command project using the data from conventional sources. Venkataratnam has proved the possible of delineation of the low lying area, prone to waterlogging during monsoon season, from their dark tone in the false colour image and low reflectance values than other soil association (Venkataratnam, 1980 and 1983) latar in 1984, he has further delineated the waterlogging employing dry season imagery by the same characterestics (Venkataratnam,1984) Murthy et al 1983 also has delineated the waterlogged areas due to the high water table with bad drainage in land evaluation and classification of agriculture land studies. In this study, waterlogged areas have been identified not only by the dark tone, but also by the presence of perennial vegetation like eucalyptus used for dewatering measures.

Kalubarme et al(1983) has attempted an intensive study in identification, delineation and monitoring of waterlogged areas by using multidate, multispectral and multiseasonal Landsat imagary. ~~From the year~~ 1972 to 1977. They first started to study the waterlogged araes in different categories depending on the direct image characters and indirect measures associated with waterlogged areas, like perennial vegetation in Mahi Right Bank Canal command area Gujarat. From their studies, it has been revealed that the remote sensing technique can help to identify a smallest waterlogged area of even 5 ha. on the earth. The same study has been carried out in Fatwadi commands in 1984 and Kakrapar in 1985 to prove the above (Sahaiet al1984, Bapat,1985). The same scientists in 1985 have studied the impact of canal irrigation on the ecology and environment of Vkai-Kakrapar command area with special reference to waterlogging and salinity as well as changes in the cropping pattern. the waterlogged areas have been identified on the basis of high soil moisture shallow standing water and vegetational cover. The delineated waterlogged areas have excellent correlation with hydroisobath data available from irrigation dept., Govt. of Gujarat.

In 1988, Singh et al have delineated waterlogged areas by visual interpretation technique into four categories viz. waterlogged areas, along stream banks, Isolated/ponded waterlogged areas, Wet lands with vegetation and Permanent waterlogged land in Etah district of Uttar Pradesh.

Sahaet al(1988) have processed the digital data of Landsat TM for various contrast enhancement such as the principle component analysis (PC), n-space spectral indices such as Soil Brightness Index (SBI), Soil Wetness Index (WI) and supervised classification etc. to delineate the salt affected and waterlogged areas in Aligarh district of U.P at 90% accuracy level. The advantage of n-space spectral indices such as SBI, to identify the salt affected areas, has been brought out by the above study.

The wastelands especially the waterlogged and salt affected soils in Aligarh district by using the Landsat TM CCT data and processes such as map to image rectification, selection of suitable spectral bands (based upon the spectral response) etc. reveales that out of six TM bands the spectral separability of all waterlands can be possible in bands 2,3,4,5 and 7 (Saha et al,1990) Spectral separatibility of waterlogged/marshy lands is poor in bands 1 and 2 because of almost similar spectral responses of remote sensing technique has been found to be superior to the conventional methods to monitor the waterlogged areas because of their synoptic viewing, repetetive coverage and cost effictive basis more over the waterlogged areas which has not been identified by the ground water table measurements can be identified by remote sensing techniques (Bapat,1985)

4.IMPACT OF WATERLOGGING WITH VEGETATION :-

Waterlogging had a deliterious effect on the growth of plants. It usually reduces both shoot and root growth in agricultural crops like Barley, Wheat, Zea mays,**Capsicum annuum**,etc.(Belford*et al* 1980,Suh*et al* 1987 Kono *et al*1988, Davies and Hillman 1988). It also adversly affected the germination of the seeds by affecting the various metabolic activities (Paul and Mukherji, 1977). The morphology of the plants was also altered by waterlogging leading to wider leaves (Zea) and decreased apical dominance as proved in Amaranthus (Hoehler *et al*, 1976).

4.1 Causes of waterlogging injury

The waterlogging condition, brings about the anearobic condition of the soil substratum completely altering the metabolism of plants. Thus in contrast to the normal aerobic reaction which yields water as given in eq.(1) the anaerobic reactions differ as in the equations 2 to 6.

$O_2 + 2H^+ - 4$ Electrons --- $2H_2O$ ....(1)

$NO_3^- + 2H^+ + 2$ Electrons --- $H_2O + NO_2^-$
(further reduced to N_2O or N_2) ....(2)

$MNO_2 + 4H^+ + 2$ Electrons --- $MN^{++} + 2H_2O$ ....(3)

$Fe(OH)_3 + 3H^+ + 1$ Electron --- $Fe^{++} + 3H_2O$ ....(4)

$SO_4^{--} + 10H^+ + 8$ Electrons --- $H_2S + 4H_2O$.....(5)

$CO_2 + 8H^+ + 8$ Electrons --- $CH_4 + 2H_2O$.............(6)

Anaerobiosis of the soil results in the loss of nitrate from the soil as gaseous N_2O or N_2 (denitrification) and the accumulation of phyto toxic substances such as H_2S and high concentrations of soluble $Fe_2 +$ and Mn_2^+ ions. The anaerobic decomposition of soil organic matter also releases a variety of toxic organic chemicals (especially carboxylic acids) and a number of hydrocarbons including the gaseous plant growth regulator, ethylene (Ponnamperuma,1972 Grable,1966; Waldrenet al 1987),thus many investigators attribute waterlogging damage more to the changes in the concentration of solutes in the soil water than to the direct effect of an inadequate supply of oxygen to the roots. Depletion of nitrate, calcium, potassium and phosphores has been found to occur in the waterlogged soil (Ponnamperuma,1922; Willis, 1963, Trough and Drew,1980). Hence by increasing the levels of the availability of in waterlogged nutrients in waterlogged soil the inhibition in the growth and yield has been ameliorated in some crops. (Khera and Singh, 1975, Biswas and Mahapatra, 1980, Mayer et al,1987, Hodgson and Macleod,1988) etc. Influence of organic matter on the growth of plants has been found to ameliorate the stress effects. However in waterlogged soil, the high organic matter always has been associated with high concentration of toxic exchangeable iron and manganese.(Jones,1973). On the contrary the organic matter is found to be a good source of nitrogen for plants and it also influences the uptake of potassium (Jones.1975 a) and phosphorus (Jones 1975 b) in the waterlogged soil.

Of the many physical and chemical characteristrics of waterlogged soils which can limit plant growth,lack of oxygen is the primary,but not necessarily the most important, problem. This is because many wet land species appear to be able to avoid anoxia in their root cells by transporting oxygen from shoot to root. In these species oxygen diffusion through roots is facilitated by the presence of aerenchyma, by inducing new adventitious roots as in maize. Thus the screening of tolerant species can be very useful in ameliorating the waterlogged lands. (Through and Drew, 1980)

5. SIGNIFICANCE AND OBJECTIVES OF THE STUDY

The day by day degradation of soil in the study area Khambhat taluka due to the waterlogging and salinity was evident by the studies of earlier works (NRSA 1986, Nayak et al 1987, Bhagwat, 1989). The earlier studies, revealed that the problem arose due to the unlimited use of canal water under inadequate drainage and the frequent cultivation of crop, which needs stagnant water leading to waterlogging and consequently salinization of surface soil by evoporation leading to partial or complete crop failures, mitigating the benefits of irrigation potential developed at a huge cost. It has been studied that by proper management of water and soil badance it is possible to bring the degraded land for optimum utilization or atleast to prevent the further deterioration of soil to acheive this the reliable information and regular monitor of the area found to be useful. Hence the detailed study has been carried out with the following objectives.

1. To identify, delineate, map and to monitor the various waterlogged areas, with the help of visual image interpretation technique, in remotely sensed multispectral, multiseasonal and multitemporal images from the satellite viz., Landsat MSS/TM and IRS-1A.

2. To make a detailed study of waterlogged areas at village level by superimposing the interpreted data on the cadestral map of taluka with village bounderies at the scale of 1:250,000 and 1:50,000.

3. To find out the accuracy level of remote sensing technique in delineating waterlogged land by carrying out a detailed ground truth survey of the study area to correlate the satellite information.

4. To study the degree of deterioration of land in the area by mapping the vegetational status by using multiseasonal and multidate images.

5. To attempt the improvement in the presentation of results by various digital analysis using the LISS-II CCT data. To study the feasibility of IRS spectral bands to generate different indices, and band ratios, for improving the interpretation of waterlogged areas.

6. To find the impact of various waterlogged soils on vetation, by carrying out phytosociological study of the area.

7. To attempt to grow crops either which requires less application of water, to prevent the further degradation of soil or which could tolerant under waterlogging condition and

8. To ameliorate the waterlogging effect on crop by improving the availability of the nutrient by the application of biological and chemical treatments to the plants growing under waterlogging condition.

9. To recommend the possibilities of remedial measures to be taken for the proper management of the land on existing condition for reclamation and improvement of affected soils as well as conservation of non-affected areas.