CHAPTER I

INTRODUCTION

Land is the most valuable natural resource and provides the base to all the economic activities of human beings. It is inextensible and remains confined within the national boundaries. It is a renewable resource so long as it is used according to its potential. But continuous unplanned and unscientific utilization of land leads to its degradation and takes it to a non-renewable state. Land is the basic resource for production of food; fiber, fruit, fertilizer, fuel and many other essential goods needed to meet human and animal needs. This important resource, therefore, needs to be conserved, utilized and managed most prudently. However, there are serious threats of land deterioration due to ever increasing population pressure and competitive demands.

Land degradation occurs because people in the affected areas are driven by poverty to get as much out of the land as possible in order to sustain. It has very serious impact on rural communities. It starts a vicious spiral of decline in health, the quality of life and life expectancy.

Extent of land degradation

Several definitions of land degradation have been suggested by different scholars and agencies to express the degree of impairment of land potential. In general, land degradation implies temporary partial or thorough deterioration of its physical, chemical and biological aspects. The physical processes, which contribute to land degradation, are mainly water and wind erosion, compaction, crusting and waterlogging. The chemical processes include salinisation, alkalization, acidification, pollution and nutrient depletion. The biological processes, on the other hand, are related to the reduction of organic (humus) matter content in the soil, denudation of vegetation and impairment of activities of microorganisms and fauna. Most of the land suffers from moderate degradation, that is, its agricultural productivity is greatly reduced but it can still be used for agriculture.
Among countries of the region, the People's Republic of China is worst affected in terms of the area of land degradation followed by India and Vietnam\(^1\). Despite massive soil degradation, agricultural yields have steadily increased in the Asia-Pacific region in the last forty years due to the use of improved/high-yielding varieties of seeds; irrigation and increased biochemical inputs. The financial constraints of households contribute to their tendency to let soil degrade in two ways. Firstly, households planting decisions are usually influenced more by the current selling price of their crops than by long-term gains for themselves and society that could be realized from sustainable land use. Secondly, stopping or reversing widespread erosion, this leads to moderate soil degradation, requiring action on a scale beyond the means of a single farm unit.

Even today, a decade after the Brundtland Commission Report, a few countries really implement what was agreed at the UNCED Conference in Rio. The United Nations and countries have spent millions of dollars to agree to the various Conventions on Biodiversity, Desertification, and Global Climate—but in the countries where it matters, there is very little change. "Unsustainable crop yields, unacceptably high rates of soil erosion, deforestation, loss of germplasm diversity, and bewildered households who do not know what to do next to eke out a reasonable standard of living still remain the facts of life in the semi-arid and arid regions of Asia\(^2\)." It can be generalized this for the developing countries of the world and the statement is still true.

"Land Degradation is at the root of all Biophysical and Socio Economic problems of Countries and the sooner countries accept this and attend to it, the better it will be for the World as a whole\(^3\)."

It may be difficult to establish cause and effect relationships that stand the test of scientific scrutiny. But it does point to the fact that human interaction with the land has created in-equilibrium in the global ecosystem. One does not have to search far to determine that many lands are stressed. Our large mono-cultural farms, the network of

\(^1\) ESCAP, state of the Environment in Asia and the Pacific, 1995, Bangkok.


\(^3\) Ibid
roads and concrete buildings which seal the soil surface, the large-scale irrigation systems that alter the hydrology of the catchments, the drainage of swamps, and the emission of green house gases by industries, have cumulatively made this a different world. A healthy, functioning society requires all of these but the difference are that human society has proceeded with tremendous scale of destruction without an estimation of environmental impacts.

The present study is an attempt to identify and assess the extent of distinct categories of wastelands by applying different procedure of digital image processing and also the conventional methods to study the management practises followed in the study area to reclaim them.

**Statement of the problem**

Indira Gandhi Canal Project was introduced in arid northwestern part of Rajasthan to meet the demand for food production against the increasing population growth. Although irrigation enhanced considerably the quantum of food production, it also brought problems such as waterlogging and secondary salinization. Perched water table is developed at low-lying interdunal flats and depressions. Continuous application of surface irrigation at higher frequencies caused a steady rise of water table at the rate of 2.17m per year during 1972-82 (Hooja et al 1995). Due to fluctuations of such artificial water table, secondary salinization appeared around the waterlogged areas. Consequently, vast areas of irrigated agricultural lands have been thrown out of cultivation.

Sri Ganganagar district falls within the project, and its large part forms its command area. This district therefore, has been selected to identify and monitor the wastelands where it has formed more due to human interference rather than due to natural causes. The district was selected mainly, because it is one of the very productive areas of Rajasthan, which has been famous for high yields of wheat, rice and cotton after the inception of Indira Gandhi Nahar Project (IGNP). The canal water has converted the area into a fertile tract. However, in recent years, some parts of the district, especially the areas which are closer to canal, have been facing the problem of waterlogging and secondary salinity due to the seepage from the canal, and unlined Ghaggar depression.
channels due to high water allowance on one hand and the existence of high duny area and the associated scrub lands suffering from wind erosion due to water scarcity on the other.

**Literature review**

At present, land resources are being exploited at ever faster rate and often without proper assessment of impacts. Consequently, a continuous degradation of land resources has been posing a serious threat to the ecosystem. The warning signals have appeared in specific problems such as landslides, erosion, flood, drought, waterlogging, salinization, sedimentation etc. in many parts of the world and the third world countries are the worst affected ones.

Although wasteland formation is a common problem in various parts of the world leading to different form of land degradation, the magnitude of the problem is high in South Asia due to high population pressure and poverty, over-grazing, deforestation, inappropriate land use, faulty irrigation, and pollution. The estimated area affected by erosion, salinization and waterlogging is increasing every year. Land degradation is caused by complex interactions among physical, biological, social, cultural and economic factors. They affect sustainable development through their inter-relationships. Only adopting integrated program activities with the involvement of local people can minimize Land degradation.

Wastelands are those lands, which are presently lying unused or are not being used to their optimum potential due to some constraints. Such lands can be classified into two broad categories namely culturable and unculturable wastelands. The first one has the potential for the development of agriculture, pasture and afforestation, but is out of use to its optimum potential due to mismanagement. Gullies and ravines, undulating upland with or without scrub, waterlogged or marshy land, shifting cultivation, degraded forest land, degraded pasture and grazing lands, degraded non forest plantation land, stripland sand, mining and industrial wastelands, etc. come under this category. In the second category, barren wastelands are included which cannot be put to any productive use, such as agriculture and forest cover. This category broadly includes barren, rocky, stony sheet rock, snow covered or glacial areas and steep sloping lands. Various studies
have been done on the causes of wasteland formation, mapping, identification and other aspects.

Information is essential for establishing appropriate priorities and effective plans for natural resource management. Remote sensing techniques and data have been increasingly used in identifying the problems in the management of natural resources (Deekshatulu and Hebber, 1991; Jenson et al., 1977; Kudrat et al., 1990, Westins and Freeze, 1976; Rao 1991 and Bhan et al., 1991). There were various study groups which carried out studies on different aspects of wastelands including soil erosion, gully / ravinous lands, saline / alkali lands, waterlogged lands etc. however, very few studies have been carried out which directly highlight wastelands.

The committee on Natural Resources (1961)\(^4\) approved a study on waterlogged, saline and alkaline lands and other types of wastelands in India. The main objective of the study was to collect all the existing information on the occurrence of saline, alkaline and waterlogged lands, examining all the reclamation measures for such lands and to analyze the data available with a view to suggesting policy measures. The economies of reclamation of such areas by the application of different methods were also studied.

Wasteland Survey and Reclamation Committee 1961\(^5\) prepared reports about wastelands for 12 different states of India in 1961. This report deals with the availability and location of wastelands in large sized blocks in different states and measures for their reclamation.

Shafi (1968)\(^6\) has discussed wasteland distribution in India, with particular reference to other uncultivated lands, excluding fallow and fallow other than current fallow, saline soils, waterlogged lands and ravine lands of India. Further, he analyzed the reclamation measures of the above-mentioned categories of wastelands, which were carried out in different parts of the country by the wasteland survey and reclamation committee. He also made the cost – benefit analysis of wastelands.

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\(^4\) Govt. of India, (1961) Report on Location and Utilization of Wastelands in India, WSRC, Ministry of Food and Agriculture

\(^5\) Ibid

\(^6\) Shafi M., (1968), The Problems of Wastelands in India, The Geographer, Special no. XXI, Geographical Society, Aligarh Muslim University, Aligarh.
The work done by Singh (1978) on the economy and geography of agricultural land reclamation in Koil Block of Aligarh district in which she has taken all the 358 villages of the block reflects a new approach in wasteland development. In the first phase, a survey of land classified other than current fallow was conducted to locate the areas where large blocks of land are available for reclamation and resettlement. Maps of every village were collected. The general aspects including relief, drainage, climate, and soil of the area were also studied in detail. Suitable measures for the reclamation, according to the conditions in different areas, estimate of the cost of reclamation the financial assistance and agricultural assistance and the necessary training for the settlers have been suggested. Finally, the author has estimated the economic aspects of such reclamation in terms of the expenditures involved, likely addition to the food grain production, employment and income that would become available to the settlers.

Gupta et al (1998) in their study have made an attempt for identification, categorization, and mapping of degraded lands of Palamu district of Jharkhand (erstwhile Bihar) using remotely sensed data (IRS-IA, false color composite, on 1:50,000 scale). Based on the image characteristics and tonal variation, satellite scenes were visually interpreted for various degradation types and tentative map of degraded lands of the district was prepared. A general traversing of the area was undertaken to verify various categories of degraded lands. The tone and texture of land degradation types were recorded involving 3-tier system, viz., and land use at first level abbreviated by capital alphabet followed by a numerical representing the kind of problem identified and finally severity of problem indicated by a small alphabet. Scattered sample strips were selected and traversed again to cover various landuse types, physiography and degradation categories. A final correlation was established by incorporating the findings of the sample strip analysis, and thus the final map of the area was prepared. Lastly,

7 Singh A.L (1978), Economy and Geography of Agricultural Land Reclamation, New Delhi, B.R. Publishing Corporation
boundaries from the imageries were transferred to the Survey of India topographical maps.

Verma et al.,\(^9\) in their study have attempted to map the salt affected areas of Etah, Aligarh, Mainpuri and Mathura districts of Utter Pradesh through remote sensing. Soil salinity / alkalinity are becoming more and more problem for the irrigated agriculture in arid and semi arid climates. Although the dynamics of salt affected soils are understood and soil water management techniques to mitigate the adverse effects which the salt has upon the agricultural input, have been developed, a more elusive problem has been the consistent identification and accurate mapping of the occurrence of salt affected soils. An integrated approach of image interpretation coupled with field studies was followed to map the SAS. The integrated approach consisted of visual interpretation of multi date and multi spectral images. Diapositives of TM bands 6 was enlarged to distinguish the zone of SAS and sandy soils (SS). The soils were grouped into salinity / alkalinity classes based on pH and Ec values as per field manual. In the semi - arid and arid regions the alternate dry and wet conditions encourage the weathering of aluminosilicate mineral providing a steady supply of alkali bicarbonte which accumulates in low lying positions.

Singh (1994)\(^10\) in his study dealt with changes in the extent of salt affected soils in northern India. A large area of barren salt affected soils has been reclaimed in recent years in the Ganges plains of Uttar Pradesh. Increased canal irrigation in the area, on the other hand, is also leading to salinization of new areas. A study was conducted using aerial photographs and Landsat Thematic Mapped (TM) data to monitor change in the status of salt affected soils in the Kanpur district of Uttar Pradesh. The remote sensing technique, with its advantage of repetitive data gathering capability, has been reported to be helpful in monitoring such changes occurring in both time and space and it is possible to monitor the extension or reduction of salt affected soils based on the aerial photographs and Landsat interpretation. However, a reliable soil map is needed to


monitor spatial change over a period of time. Aerial photographs on a 1: 40,000 scale and Landsat TM image enlargements on 1: 5000 scale, where a minimum soil affected area of 2ha could be easily detected and mapped are useful for change detection in the case of large blocks.

Ram et al., (1993) \textsuperscript{11} in their study have attempted monitoring land use changes in the arid parts of Rajasthan. Land- use changes in various parts of arid Rajasthan were identified and mapped on reconnaissance, semi detailed and detailed levels using multidate remotely sensed data, supported with field checks and secondary information. The Resources Survey and Monitoring Division of the Jodhpur – based Central Arid Zone Research Institute was able to monitor the land – use survey mapping. In semi detailed mapping, a district, block, block or sub basin works as a unit and Landsat TM and IRS LISS – II FCCs on 1: 50,000 scale and aerial photographs on 1: 25,000 scale, together with topographical maps on 1: 50,000 scale were used as basic materials. Further, the interpretation was supported with 25 –40 percent field checks and block and village level revenue data on land – use. Remote sensing based land - use studies conducted from time to time in various parts of arid zones on different levels yielded significant results in delineating and mapping land – use changes over time and space; and in pinpointing the potential and problem area. Thus, where on one hand, more and more land has been put into irrigated and dryland farming, by contrast, excessive irrigation, cultivation of sand dunes, and other marginal lands, cutting of trees and shrubs, salinity / sodicity mining activities, lowering of the water table, erosion and deposition hazards, waterlogging and degradation of pasture and forest, have caused desertification. In spite of certain limitations, remote sensing is one of the most powerful tools of the present day for appraising and monitoring natural resources.

Das (1992) in his article has dealt with the mapping and monitoring of wastelands through remote sensing technique. Mapping and monitoring of wastelands through satellite remote sensing provide several advantages over the conventional techniques. Synoptic view of large area is covered on single Landsat imagery to the extent of 34,000-sq. km. (185 x 185 km²). Repetitive coverage enables to monitor the changes in the given area in a relatively short time (every 16 to 18 days) and with two satellites orbiting regularly to access to the data is every 8 days. Relatively low planimetric and image distortions are amenable to correction procedures, which ensure reasonably good accuracy. The method is fast and economical for gross estimates compared to other methods of surveying. The fast monitoring capability of the system provides reliable, near real time and unbiased base line information. Further, methodologies for wastelands mapping and monitoring are depicted, with the help of elements of image interpretation.

Karale (1992), in his study dealt with the application of remote sensing in landuse/landcover mapping. Remote Sensing records response, which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses tone, texture, pattern, shape, size, shadow, site, and association to derive information about landuse activities from what is basically information about land cover. The title 'land use mapping' is quite often applied to remote sensing image classification procedure as a whole, which tend to amalgamate the distinct concept of mapping land use and land cover. Various methods including the one, dispensed by the National Remote Sensing Agency has been described in detail to give a vivid picture of landuse mapping. Lastly, advantages coupled with limitations of mapping landuse/landcover mapping through remote sensing has been dealt.


Raina (1994)\textsuperscript{14} in her Study makes an effort to identify and map areas affected by various degradation processes in Jalore and Ahor districts (Western Rajasthan) with the aid of Landsat TM imagery data of 1988 and ground truth verification. In arid and semi-arid region satellite data have been found useful for mapping degraded lands. The criteria laid out by the U.N. Conference on Desertification (FAO, 1983 and Oldeman \textit{et al.}, 1990) with some modifications were adopted for mapping the area degraded due to different kinds of land degradation processes. These criteria suggested that vulnerability of land to degradation should be assessed upon consideration of climate, terrain, soil, and vegetation condition. Three types of degraded lands were mainly encountered in the study area, viz; area subjected to wind erosion (W), area subjected to water erosion (V) and area subjected to salinization and alkalinization (S).

The degree to which soil has been degraded were estimated in relation to changes in agricultural suitability in case of cultivated lands and in relation to its biotic functions in case of pastures and forest soil either due to overgrazing or removal of vegetation for domestic use.

The execution of irrigation projects without the provision of adequate drainage system has disrupted the equilibrium between the ground water recharge and discharge resulting in accretions to the ground water table in the command area in India. The Tawa command area faces the problem of waterlogging resulting from over irrigation and seepage from canal. Choubey (1997)\textsuperscript{15} attempted to delineate waterlogged areas in this command using IRS-1A LISS-I data. A landuse/landcover map was prepared depicting irrigated cropland, shrub land, forest and standing water areas. Waterlogged areas were delineated on the basis of indicators such as high soil moisture, standing water and perennial vegetation. The presence of high soil moisture and shallow standing water is indicated by bluish tone on FCC. Perennial vegetation could be identified from its characteristics pink or red tones. The study was further supported by field checks.


the commissioning of Tawa irrigation project in 1975, there was a general rise in ground water table. The arming community observed waterlogging due to seepage in 1978 over an area of 50 ha and by 1982 the problem had spread to an area of 200 ha (Annual progress report, ZARS, 1989-90). Density slicing is a useful technique to delineate the waterlogged area. Selection of gray value range based on field information such as topography (low-lying areas); soil moisture and vegetation may help in the identification of sensitive areas for waterlogging. It was suggested that periodic assessment of waterlogging using remotely sensed data should be carried out at regular intervals.

Kalra et al (1997)16 in their study delineated the salt affected soils in arid Rajasthan with the help of multi sensor data. In the arid part of Rajasthan the salt affected soils are of common occurrence. The Landsat (MSS and TM), SPOT (PLA and MLA) and IRS (LISS-II) images of the crop free period (April, May), rainfed crop (October) and rabi irrigated crop (January, February), have been evaluated for their capability of mapping (I) primarily salt affected soils; (slightly moderately and severely), (II) saline water irrigated saline soils, (III) sodic water irrigated sodic soils and (IV) salt affected soils due to tank seepage in the arid Rajasthan. Field checking of the identified units of the salt affected soils was conducted. Soil samples from the representative sites were collected and analyzed for pH and Electric Conductivity in 1:2 soil water suspensions. Samples of saline sodic ground water used for irrigation were also collected and analyzed. Thus a mixed approach based on image characteristics on satellite imagery, pH and EC of soils, the quality of irrigation water and cropping pattern was adopted for delineating different types of salt affected soils.

In their study Sugumaran et al., (1994)17 have made an attempt to delineate different categories of wastelands at micro level in Matar taluka of Kheda district based on digital remote sensing. The chemical characteristics of these soils have also been

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studied, which can aid in taking reclamation measures. The digital data was classified following supervised classified algorithm. Three types of wastelands namely waterlogged, pasture / grazing and salt affected lands could be identified and mapped, and the area statistics for these wasteland categories were generated at taluka level. The study reveals that digital data can be used to map various types of wastelands at micro level. The spatial distribution and soil nature of these lands can serve as the base for the implementation of various reclamation measures and afforestation program.

Visual interpretation or digital analyses of satellite data are of unique importance in mapping different types of salt affected soils. These require, however, an understanding of the spectral response in different region of electromagnetic spectrum. The spectral reflectance of a typical soilscape though specific may vary according to the surface conditions modified by factors like ploughing, erosion and salinity. Kalra and Joshi (1997)\(^\text{18}\) in their study analyzed the spectral reflectance characteristics of natural and anthropogenic salt affected soils. Occurring in southeastern arid Rajasthan under field conditions and their relationship with soil characteristics reported. The findings provided important clues for interpretation of satellite data for delineation and categorization of various types of salt affected soils.

Saini et al., (1999)\(^\text{19}\) have studied the nature, extent and spatial distribution of degraded lands in Puruliya district with ultimate objective of providing location specific database for district level planning to rehabilitate such lands. The study was organized in three phases comprising pre – field interpretation, ground truthing, and post – field interpretation. The IRS – IB LISS – II data of March and December 1994 were interpreted to extract information on various land degradation types and their categories. Five land degradation types viz. Water erosion (We), Waterlogging (Wl), rock quarries (Rq), brick kiln (Bk) and industrial effluents (Ie) could be identified and delineated with


fair degree of accuracy with the help of the image. Though the objective of providing specific information on degraded lands of the district has been successfully achieved in this study, detailed information with regard to their characterization at micro level is essential before taking up various reclamation and management program to rehabilitate such lands.

Singh (1962)\(^\text{20}\) dealt with the problem of cultivable waste and the reclamation measures. The author holds that the large area of cultivable waste is marked on the Vindhyan plateau due to the fact that the slopes of the hilly tracks are either barren or too steep for profitable cropping. Secondly, the soil cover over waste stretches of upland is very shallow exceeding nowhere 5' in thickness with frequent outcropping of rocks. The author has discussed three types of land under cultivable wastes namely (1) garden (2) fallow (3) scrub jungles and then made a comparative study of the general land use pattern in this region between the period of 1880 and 1958.

**Scope and rationale of the study**

The scope of the study is limited to wasteland mapping, monitoring and management at the village level based primarily on the primary data sources. Land is always in the constant flux due to transformation resulting from natural processes and human activities. The change in human activities is very dynamic and rapid. There are two factors behind the formation of wastelands, viz: natural and anthropogenic.

In case of Sri Ganganagar district, we find 4 different types of wastelands, such as, waterlogged area, areas affected with salinity; land with or without scrubs and sandy areas. The main purpose is first to identify and map these areas followed by to find out their causes of formation and to provide concrete action plans for reclamation.

This is assumed that the development projects providing irrigation are not neutral to land degradation. Further in the sandy terrain of Sri Ganganagar district much of the

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\(^{20}\) Singh, B. (1962), Distribution of culturable waste and possibility for its reclamation in Chakia, Banaras, National Geographic Journal of India, Vol.8 (1)
wastelands could be put under productive use through proper management strategy. Therefore, implementation of proper management practices along with contemporary technology will stimulate positive changes in physical/natural characters of wastelands. This would further enhance more economic return of land.

**Objectives**

1. Identification and mapping of Wastelands in Sri Ganganagar district at sample village cluster level.
2. To study changes in Wasteland categories over period of time and its trends therein.
3. Micro-level evaluation of different categories of wastelands, i.e. land affected by salinity/alkalinity, waterlogging, land with or without scrub, sand etc.
4. To examine the role of management practices, bringing about change in physical/natural environment.
5. To evaluate strategy for wasteland reclamation and suggestion of action plans.
6. To evaluate the success/failure of the wasteland reclamation strategy introduced in the district.

**Research question**

1. What have been the temporal changes, their causes in the wasteland and other landuse categories?

2. What is the nature and extent of land degradation in the district? How far this can be attributed to development of irrigation in this dry tract?

3. What are the physical characteristics of these degraded lands?

4. Whether the landuse and wasteland development policies have been successful in the district?

5. What has been the reclamation strategy already introduced and how have the households benefited?
GANGANAGAR DISTRICT
(as viewed by WiFS)
22nd November 2000

Fig 1.2
Data base

Three types of data have been used in the study.

- Satellite data, here it is important to mention that the minimum delineation unit taken was 3mm x 3mm on the scale of 1:50,000, which represent 150m x 150m or 2.25 hectare area on the ground. The data use for Rabi and Kharif season for the study is given in table 1.1.

Table 1.1
Satellite data used in wasteland mapping

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<th>Season</th>
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</tbody>
</table>

- Survey of India toposheet and other collateral data
- Socio economic data from census, revenue records, and other published and unpublished documents

SOI Toposheet of 1:50,000 scale to be used to draw various features for base map, viz., district boundary, taluk/block boundary, roads and railways. Some of these features were suitably modified / update based on situation during satellite data of over pass. Other collateral data, such as landuse, cropping pattern, etc were collected from...
respective line departments. The District Census Handbook (DCH) (1991) and revenue maps were used for drawing village boundaries and encoding village code and name.

Methodology

Digital analysis of IRS IC/ID LISS III was performed using Max. Likelihood algorithm. Two season data were used to avoid any misclassification and aggregation. Extensive ground truth testing was carried out first to take training sets for supervised classification and then to interpret false color composite (FCC’s) and classified images in relation to ground features. The methodology followed is follows;

The methodology followed for generating wasteland data base of the district is as under:

Generating grid base: The regional referencing scheme i.e., grid base is generated or the district consisting of latitude and longitude of 5’minutes interval using software GRID BASES. It is a polyconic projection with central meridian covering more than $1^0 \times 1^0$ area.

Scanning of maps: The toposheets containing features like roads, railways, administrative boundaries etc. and scanned in the line/gray level mode and gray level threshold of 150 to 200 depending upon the medium used for preparing the layer. An EASI routine was written to convert these scanned files into data base files of image processing environment.

Registration of scanned maps and satellite data with grid base: The SOI maps were registered with the vector of grid base and subsequently, the satellite data of both the seasons were prepared using EASI/ PACE /ERDAS image processing software. Village maps were registered and projected in ARC/INFO.

Supervised classification of satellite data of wasteland categories: Mapping of wastelands using visual interpretation technique has been carried out by several workers,
like Mehta et al., (1988)\textsuperscript{21} in Bhavnagar, Gandhinagar, and Shetrunji districts of Gujarat and Rao et al \textsuperscript{22} (1991) in parts of Vishakhapatnam in Andhra Pradesh. However digital remote sensing analysis technique has been followed to a limited extent for mapping wastelands. Venkataraman (1983)\textsuperscript{23} has classified the degraded lands using Landsat digital for Sangrur district of Punjab.

In this classification scheme the operator, in a process known as ‘training the classifier’; provides information about the pixel classes. Based on ground information the operator will know which classes some of the areas of the image correspond to extract the sample values (for example mean, variance) the classification algorithm can then assign class probabilities to all the remaining pixels in the image.

There are several algorithms to result in supervised classification. Classifiers that make use of the statistical distribution of the training samples are known parametric classifier is ‘maximum likelihood’. This assumes that each class has a multivariate normal distribution; this means that the distance from the cluster centroid, calculated in terms of the variance in each band, can be used as a measure of the probability that the pixel belongs in that class. To classify the image is located in features space and the maximum likelihood distance to each of the class centroid is calculated.

The classification involves following activities;


\textsuperscript{22} Rao, D P NC Gautam and B Shahi (1991), IRS IA Application for wasteland mapping, current Sci.61 (3,4): 192-193

After pre-field examination of satellite data training sites for different categories of wastelands were identified and ground truth was performed to cover these sites.

Both the season’s data (rabi and kharif) were classified separately and referential refinement was performed with respect to each other.

Aggregation of refined results was done to club both seasons’ information into a single output channel.

To check the accuracy of classification the bitmaps for different wasteland categories were overlaid on the FCC. Discrepancy, if any, the previous step were repeated.

Creation of masks: On line mask was created for different cultural features, forest boundaries and watersheds in vector existing environment of EASI/PACE. Besides, the mask for major settlement were made and stored in graphic segment.

Vector data base creation: This includes;

Conversion of raster image format to vector data in GIS environment: The raster image of wasteland map from EASI/PACE/ERDAS was converted into ARC/INFO, compatible format using ERDASWRIT function of XPACE. The .gis file is then subjected to gridding and followed by vectorization. The polygon features of wasteland were checked for attribute values in the grid code item. For cultural features, digitized in the vector-editing module of EASIPACE/ERDAS was transformed into ARC/INFO format using VECWRIT and GENERATE functions.

Error correction of existing vector layer: The uncorrected vector layer, viz., administrative boundaries, watersheds and cultural features were edited in ARC EDIT environment to remove errors such as dangle nodes, overshoots, undershoots etc. and subjected to clean and build for creation of topology. Edge matching was performed for the village boundary maps with district/block boundary.

Labeling of arcs and polygons as per wasteland guidelines: As coverages, viz., state, district, blocks, villages, roads and railways were assigned proper types values in
corresponding item. Similarly, polygon coverage, such as village overage was labeled for village code, block/block code, and village names. Similarly, watersheds were labeled for watershed code. Annotation coverage also was prepared showing major settlements, roads, railways, state, district and country.

**Overlaying and map finalization:** Single appended coverage from individual line features coverage was generated having all the line features with respective line attributes. Similarly, the annotation coverage were overlaid on the wasteland map and saved as a single coverage.

**Statistics generation:** Statistics was generated using MLR function of XPACE, after sieving the classified wasteland map with 5 pixels, which is equivalent to 0.25 ha.

**Plotter output generation:** The customized softcopy for plotter output for showing different wasteland categories, overlaid various cultural features along with heading, legend, toposheet incidence, linear scale and north arrow was generated.

**Monitoring**

For the monitoring purpose three toposheets namely 44 G/12, 44 G/15 and 44 G/12 were used, to study changes in the different wastelands category found in the study area, viz., sand areas, waterlogged areas, areas affected by salinity / alkalinity and scrub lands. Selection of these toposheets was based on the satellite imageries of Sri Ganganagar. Further, different wasteland categories along with other landuses were traced and scanned. The scanned maps were brought into ARCINFO environment for geo-referencing and clearing of dangle nodes. Further, attributes were fed for each polygon to create coverages.

**Change detection**

The already existing coverages corresponding to those toposheets for 1997 along with the coverages made from the toposheets were written into Grid format. Here combitorial operation CAND was used to study change detection
Sampling

- Sample of cluster villages representing different categories of wastelands was chosen based on satellite imagery interpretation.
- Selecting villages, which are highly affected and where wasteland reclamation, has been undertaken.
- Selecting households, which have adopted the strategy of wasteland reclamation.

Methodology for empirical survey

First of all various categories of wastelands viz., sandy area, scrubland, area affected by waterlogging and salinity were identified on the LISS III imagery of Sri Ganganagar district. Village map was prepared for the entire district, which was overlaid on the classified image, to identify the problem villages. The eight sample villages representing the different categories of wastelands were identified from the three-sample toposheets nos.44D/13, 44G/12 and 44G/15 from the blocks of Suratgarh and Gharsana.

Further, questionnaire (Appendix I) was prepared to study various aspects of wasteland formation, besides, studying the soil characteristics, cropping pattern, irrigation pattern, and management practises etc. All this was done by interviewing the households coupled with personal observations. Stratified random sampling technique was adopted for selection of households, nevertheless the three economic classes, small households (1 to 5ha.) medium (5 to 15 ha.) and large households (above 15 ha.) on the basis of landholdings.

Personal observation of the affected areas was also made by collecting soil samples at varying depths viz., 15cm and 30 cm to check the electrical conductivity (Ec or salinity) and alkalinity (>8 pH) which was measured by taking 1:2 soil water ratio, (Seth 1967)\textsuperscript{24} in the Agricultural Research Station: Sri Ganganagar. Altogether 220 soil samples were collected. Further, 20 water samples were collected to measure the extent of salinity /alkalinity in soil and water. Electrical conductivity (EC) and pH were

\textsuperscript{24} Seth, S.P. (1967), Indices for diagnosis of alkalinity and salinity in soil of Rajasthan canal area, Journal of Indian Society of Soil science 15:93
measured of the sample soils in the "Agricultural Research station: Sri Ganganagar". Waterlogging was recorded by personal observation of the farms.

Further, chi-square test was conducted to study the relationship between variables to find out the extent of relationship. Cross tabulation followed by correlation analysis was done to study the nature of relationship between two variables.

Geographical personality of the study area

Sri Ganganagar is one of the western most districts of Rajasthan adjacent to Pakistan in the west. The district is situated in the northern most region of the state bounded by Haryana in the north; Hanumangarh district in the east and Bikaner district lies in the south. The district lies between 28°5' and 30°30'N lat. And 72°30'E and 74°30'E long and is covered by SOI Toposheet no. 44C/16, 44D/9, 44D/13, 44D/14, 44F/12, 44F/16, 44G/2, 44G/3, 44G/4, 44G/5, 44G/6, 44G/7, 44G/8, 44G/9, 44G/10, 44G/11, 44G/12, 44G/13, 44G/14, 44G/15, 44G/16, 44H/1, 44H/24,4H/3, 44H/5, 44H/9, 44H13, 44K/1, 44K2, 44K/3, 44K/4, 44K/5 and 44I/1.

The total area of the district is 10962 sq. km with a population of 991,759 persons spreads out 3,019 villages, 53.22 percent of the total population is male and 46.78 percent female. Decennial population growth during 1981-91 was 29.20 percent. Population density is only 127 person / sq. km, which is slightly less than the state’s average. Literacy rate is poor among women (26.39%) whereas among male, it is 55.29% with an overall literacy of 41.82%.

Geological characteristics

Except for few isolated patches of recent calcareous and sandy sediments associated with gypsite, the area is covered with wind borne sand. It is revealed that the oldest rock in the area belongs to Aravalli super group that includes phyllite, shale and quartz veins. These are overlain by the rocks of the Upper Vindhyan which are entirely made up of pale to pale red, fine and medium grained compact sandstone and silt stone seen in the dug wells near Dalenan, Jaitsisar, Pichgarain and many other places. The wind borne sand of recent to sub recent period is mainly made up of quartz with minor...
biotic and magnetite. Gypsum rich beds are found in shallow depressions surrounded by sand dunes.

**Physiography**

The whole of a district is a plain covered with thick layer of wind blown sand except in the extreme south. It displays a general slope towards the west. Generally, the sand dunes are 4-5 metres high except in southwestern part where they are more intensely developed attaining sometimes a height of 10-15 metres in height. The general height of the district varies from 168 to 227m above MSL. Ghaggar, which is an ephemeral river, flows from NE to SW, which sometimes gets flooded during monsoon.

**Climate**

The climate of the district is marked by with large variation of temperature, extreme dryness and scanty rainfall. The mean maximum and minimum temperature are 43.03°C and 5.05°C respectively. Mean annual rainfall is 254 mm with a coefficient of variation (CV) of 50% and probable maximum precipitation of 45 cm. Large variations in rainfall are found in one traverse in SE to NW direction. The mean annual potential evapo-transpiration is about 1650 mm. The average wind speed for the entire year works out to be 6.7 kmph, which exceeds to 20 km/h during May.

**Agriculture**

The principal agricultural crops in the district are rice, jowar, bajra, maize, wheat, barley, pigeon pea, gram, sesame, mustard, groundnut and cotton. Cotton is the dominant crop during kharif season, and during rabi, mustard is the most important crop.

**Cropping pattern**

The district is endowed with fertile soil and is well drained with moisture retaining characteristics, which is very much helpful for the production of food and cash crops. The *Nehri* type of soil is available in canal command area, while the soils of unirrigated lands are termed as *Nali, Rohi* and *Dahara*. Rabi crops are sown in *Nali* types of soil on which rain waters during monsoons leaves moisture while *Rohi* is less
CROP MAP OF GANGANAGAR
RAPESEED & MUSTARD
(as on 22nd November 2000)

Fig 1.4
CROP MAP OF GANGANAGAR
COTTON
(as on 22nd September 2000)

Fig 1.5
CROP MAP OF GANGANAGAR
WHEAT
(as on 22nd November 2000)

Fig 1.6
fertile and *Dahara* is the uncultivated barren land with sand dunes. The remaining parts of the district, which is outside the canal command area, have *Pala*, *Non pala* and *banjar* types of soils.

Cultivation of commercial crops such as cotton and sugarcane is very much favored because these crops fetch attractive prices. Amongst food crops, wheat and gram are the most preferred ones. A Regional Research Station for field crops and a Horticulture Research Station for fruit and vegetables crops are functioning at Sri Ganganagar. In August 1956 the Suratgarh Mechanized Farm was set up at Suratgarh which was later re-named as ‘Central State Farm in collaboration with the then USSR. It is the biggest farm of its kind in whole of Asia.

**Irrigation**

A total area of 1,145,376 ha. in the district was irrigated during 1988-89, as compared to 9,2849 ha. during 1980-81. Similarly, the net irrigated area was 751058 ha. in 1988-89 against 652023 ha. during 1980-81. The net irrigated area was 46.26 percent of the net sown area during 1988-89.

Canals are the principal source of irrigation as about 99.6 percent of gross irrigated area was irrigated through Indira Gandhi canal (IGNP), Gang Canal and Bhakhra multiple project.

The natural lakes and tanks exist in the district, however, an artificial lake known as Telwara jheel formed in the Ghaggar bed. Source wise data regarding gross and net irrigated area during 1988-89 is given in the following table.

**Table 1.2**

**Source wise data for gross and net irrigated area in Sri Ganganagar**

1988-89

<table>
<thead>
<tr>
<th>Source</th>
<th>Gross irrigated area</th>
<th>Net irrigated area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well and Tubewell</td>
<td>4,495</td>
<td>2,747</td>
</tr>
<tr>
<td>Canals</td>
<td>1,140,881</td>
<td>7,48,331</td>
</tr>
<tr>
<td>Total</td>
<td>1,145,376</td>
<td>7,51,078</td>
</tr>
</tbody>
</table>

Forest and vegetation

Due to adverse climatic conditions, such as scarcity of surface water, unsuitability of soil etc, no forest worth the name existed in the district. Efforts, however, are made to preserve the meager tree growth and for planting of new trees. After the advent of Indira Gandhi canal, some increase has been registered in the trees and plantations.

Species like Shisham (Dalbergia sissoo), Mulberry and Eucalyptus are planted along the banks of canal. Protected forest areas extend in several hectares of Shisham plantation. Along the Rajasthan canal, the plantation consists of babul (Acacia arabica), shishum and khejri (Prosopis cineraria). Other important trees found in the district are Kikar (Prosopis juliflora), Neem (Azadirachta indica), Karir or Kair (Capparis aphylla).

The vegetation on sand dunes is Phog (Calligonum polygonoides), Bui (Aerna tomentosa), Ak (Clotropis procera), Bawli (Acacia jacquemontii), Kheemp (Leptadenia spartium) etc.

Watersheds

Six watersheds and one basin cover Sri Ganganagar district. The area falls under 2 different water resource region viz., Indus drainage (1) and ephemeral drainage of western Rajasthan (6)*. In Indus region, the basin is Sutlej, whereas in region (6) the basin has its extent from Rohtali to Ambala in the east and Sri Ganganagar in the west. A small portion in the south of the district falls in the basin (6c) and covers Jaisalmer, Bikaner and Churu districts. The sub catchment of Sutlej is defined as IAIA. The hierarchy of the watersheds as per Watershed Atlas of India (1:1 million scales) of All India Soil and Landuse Survey is as follows;
Road and Rail Network of Ganganagar

- Roads
- Railway

Fig 1.8
Image Characteristics of Sand Dunes in Ganganagar
(as on 8th May 1995 LISS II)
Fig. 1.9
Hierarchy of watersheds

*These are the codes of watersheds mentioned in AUS & LUS Watershed Atlas of India (1:1 million), Dept of Agriculture & Co-operation, MOA, N Delhi

Transport network

The district is well served by roads and railways. Bikaner-Bhatinda broad gauge railway passes through the southeastern part of the district. Anupgarh, Raisinghnagar, Karanpur and Sri Ganganagar are well connected with Surat-garh by meter gauge railway. Major roads include NH 15 and State highway 3.

In order to cater to the marketing needs of the agriculturists the erstwhile state government took up the work of construction of pathways and roads, which connected the block headquarters with market town, but most of them were suitable only for bullock carts as these were fair weather roads. A few municipalities for connecting the respective towns with the railway station constructed metalled roads. With the introduction of the fast moving vehicles more road construction were taken in hand. The
district is connected with the categories of roads viz.; state highways, major district roads and other district roads and village roads.

**Chapter scheme**

The entire study has been divided into six chapters, which are in the following order:

Chapter I: deals with introduction of the study including literature survey objectives, database, and methodology research questions and organization of the study.

Chapter II: deals with the overview of planning management and policies introduced in the district and evaluation of their success/failure and suggestion of action plans.

Chapter III: deals with the identification and mapping of wastelands in Sri Ganganagar district and sample village cluster level based on three toposheets extracted from the study area.

Chapter IV: deals with monitoring change detection of different categories of wastelands and cropland and causes of their growth in three samples.

Chapter V: This chapter deals with the empirical study, based on the primary survey of eight villages, by studying the farm management practices of 248 sample households.

Chapter VI: This chapter deals with an overall analysis of the study and summary and conclusion.