INTEGRATED RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURAL LAND USE PLAN IN HISAR DISTRICT USING GEO-INFORMATICS

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY

in

Geography

By

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LOVELY PROFESSIONAL UNIVERSITY

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DECLARATION

I hereby declare that the thesis entitled **"Integrated Resource Management for Sustainable Agricultural Land Use Plan in Hisar District Using Geo-Informatics"** prepared and submitted by me under the supervision and guidance of Dr. Sahab Deen, Assistant Professor in Geography, School of Arts and Languages, Lovely Professional University, Jalandhar, Punjab (India) as per the full requirement for the award of the degree of Doctor of Philosophy (Ph.D.) in Geography is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work that has been submitted for award of any other degree or diploma of any other University.

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CERTIFICATE

This is to certify that the thesis titled **"Integrated Resource Management for Sustainable Agricultural Land Use Plan in Hisar District Using Geo-Informatics"** which is submitted by **Mr. Sandeep Kumar** for the award of degree of Doctor of Philosophy (Ph.D.) in Geography to the Lovely Professional University, Jalandhar, Punjab (India) has been carried out under my supervision and guidance. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the thesis has ever been submitted for any other degree or diploma to any other university. The thesis is fit for the award of Doctor of Philosophy (Ph.D.) degree.

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(Sandeep Kumar)

ABSTRACT

Land and water are critically most important natural resources on which agricultural production depends and whose efficient management is vital for sustainable development of rural areas. Like any other place, the study area is also not free from problem related to natural resources. The area is facing the problem of soil degradation, wind erosion, depletion of underground water, floods, improper use of canal for irrigation, declining trend of per capita availability of land productivity, absence of natural forest and problems caused by green revolution agricultural system. This causes the concern and to combat these problems, the integrated natural resources management holds key to sustainable development of natural resources of the area. To increase the foodgrain production for increasing population, land and water resources have been subjected to great stress and inappropriate land use which has resulted to soils degradation in the district. Today with emphasis on quick production, the optimum balance between the use of land /soil resources and agro-production conditions are disturbed.

Thus, the productivity level of different crops, have either reached plateau or showing declining, trend, despite manifolds increase in fertilizer use and plant protection chemicals. The agriculture system which encompasses the interactions of physical, biological, technical and socio-economic factors, some of which are under human control, for the purpose of producing food, the agro- ecological entity. The agro-ecosystem, therefore, is considered to be in equilibrium with environmental and management factors, which produce a sustained yields. The focus of this research was to achieve objectives such as to describe the harmony between agriculture and ecological environment, the present study has been selected.

Sustainable development may be defined as that meets the needs of present generation without compromising the ability of future generation to meet their own needs. Sustainable development requires a simultaneous progress in the environmental dimension, economic dimension and social dimension. That is, it is improve economic efficiency, protect and restore economical balance and enhance the well being of people. There is often quoted fourth dimension too, the technological dimension. It has been needed new technologies that are more efficient and have lesser impact on environment. Now a day there is a need of integrated planning and management of land and water resources for sustainable development of natural

resources. Modern technologies such as remote sensing, GIS and computing capabilities can be effectively used to improve the efficiency of resources, models their outputs spatially. Existing agricultural production system focuses on intensifying crops yields while ignoring wider implication of changes in agricultural practices on quality of natural resources. Environmental issues including soil and land degradation, damage to water quality and quantity have not been given sufficient prominence. The continuous progress would depend upon more holistic approach that would have focus on health of natural resources base. Remote sensing and GIS has developed into a fast & reliable technology for mapping and management of natural resources and to formulate action plans for their judicious and sustainable use. This prime objective has motivated me to take up this research work and I hope this work will be useful for micro-level planning of the district and implementation of sustainable agricultural land use plan as suggested, which will improve the man-ecological relationship and socio-economic conditions of the area. The current work is based on qualitative and quantitative data for sustainable management of natural resources such as water and soil with the aims to utilize the authentication of present land use in the context of sustainability of agriculture. Thus the novelty of the present research is that the productivity level of different crops is showing a declining trend, despite manifolds increase in fertilizer use and plant protection chemicals. Sustainable agricultural practices fulfil the demand of coming generation and increasing population in respect to the sustainability of natural resources.

The present study has been based on secondary as well as primary source of data. There are secondary source of data which are readily available from the government and private or non-governmental organizations. Such as district census handbook provides detailed information about demographic attributes apart from that state statistical abstract report for economic data.

Based upon visual interpretation of Indian Remote Sensing satellite data at 1:50,000 scale, the maps of various themes were prepared and ground truth verifications were done during field visit. The data on drainage and canal network have been derived from Survey of India topographical maps. The data on depth to water level, ground water quality and socio-economic aspects collected from available sources. All the thematic maps with other ancillary data integrated in a GIS environment to generate locally specific action plan for both land and water resources for sustainable development of area. Apart from all these, the satellite imageries were used to digitize present land use. For analyzing physical landscape SOI toposheet, Three season (Rabi, Kharif and Zaid) IRS-P6 1D LISS – III (2017-18) satellite images were used for mapping of present land use/ land cover. These maps were digitize and demarcated in the GIS environment and after due correction and attributes attachment, final digital maps of different themes were prepared. The land and water resources development plan for sustainable agriculture land use have been prepared using integration techniques various thematic maps in GIS environment.

The study is mainly concerned to develop and suggest sustainable agricultural land use plan for the study area based on soils, cropping pattern, ground water table depth, ground & surface water quality and present land use. Satellite images were used after image rectification and suitable image enhancements technique would be applied to facilitate the delineation and interpretation of different thematic information. Visual interpretation method was used to prepare pre-field interpreted map. The satellite data is interpreted based on photo elements like tone, texture, size, shape, pattern, aspect, association etc. Suitable field samplings were used to assess the interpreted elements and relate with satellite data. The field data collections are aided by GPS in order to locate the ground verification points on the image and for further incorporation of detail. Based on the pre-field interpretation, ground truth verification and available secondary information final maps will be prepared. An extensive use of GIS and remote sensing software's (Arc GIS Desktop 9.3, ERDAS Imagine) was used for analysing the spatial distribution of the various aspects taken up for study. GIS techniques have been used in order to create layers of present land use/ land cover. All these layers are overlayed in Arc GIS 9.3 software and a common or single layer is generated using all above layers through union command. This single layer has all information like soils, water quality & depth, present land use/ land cover for each and every polygon. Based on the layers characteristics such as soil type and texture, physiographic unit, underground water quality, underground water depth, type of present land use and land cover etc. a final recommendation is given to each and every polygon. These layers were put in GIS format to create the database. On the basis of database pre land use recommendation was suggested.

Hisar is one of the leading agriculture district of the state situated in the northwest, whereas 132.89 sq. km area of the district is under wastelands that is 3.34 percentages to the total geographical area of the district. It is also the most intensively cultivated with193% (Statistical Abstract of Haryana, 2017-18) cropping intensity. The population of study area is 1,743,931 persons (Census of India, 2011). Farmers here continue to grow rice- wheat and cotton - wheat as dominant crops due to government incentives and market price ignoring the suitability of soil, water and climatic conditions. The inappropriate land use and introduction of canal irrigation have resulted in soil degradation, soil erosion, salinity / alkalinity and waterlogging, besides nutrient losses as well as depletion of ground water at an alarming rate. The problems of salinity, sodicity and waterlogging have been attributed to irrigation without providing drainage. Salinity and sodicity in 0.56 sq. km area has been created in the highly intensive canal irrigation areas in Hisar-I and Hansi block of the district and 3.80 sq. km area of the district is under the class of seasonal or permanent waterlogged. Water table is falling in the north east zone due to over exploitation of ground water where rice –wheat crop rotation is practiced. It has gone down by of 6.0-7.5 metre in a short span of 10 years and thus, has increased the cost of irrigation. Soil fertility has also been declined here due the constant growing of nutrients exhaustive rice and wheat crops. The above situations, thus, pose serious threats to sustainability of agriculture in this high productive zone of the district.

The overall ground water prospects of the district vary from poor to excellent. The units of alluvial origin have very good to excellent underground water scenarios but on the other hand, ground water prospects in aeolian plain and sand dunal areas are moderate and poor respectively. Alluvial plain with sand have good ground water potential. The ground water quality found in area is good to saline. These include fresh water (38.11 %), sub marginal (40.00) marginal (18.44%) and saline (3.45%). It was observed that adjacent to water body like canal, ponds and river, the sub surface water quality is good. The depth of water table in the study area is 1.5 to >15 meters below ground level (BGL) in various parts. 96 percent of total area falls under the depth zone of 1.5 to >15 meters below ground level during pre monsoon season. Highest depth of water table observed in surrounding Balsamand village.

Surface water resources of the area are available in form of ephemeral river Ghaggar, Bhakhra Canal Network and village ponds. Ghaggar River is main seasonal stream flowing along northern boundary of the study area. In normal condition water flow is very less in this river but during monsoon it becomes very active and many time adjoining areas are flooded by water over flowing the embankments.

Land use and land cover map has been generated by visual interpretation of satellite images of October 2017 and March 2018. The land use of the study area has been broadly categorized into built up land, agriculture, wastelands and water bodies. The landuse statistics reveals that major land use in this area is agriculture, which covers 3877.12 sq. km including double crop, rabi only, kharif only and current fallow class. While double cropped area under agriculture land use constitute 80.89 percent of total area. The study indicated a moderate intensity of cropping of 191.92 percent. The wasteland categories viz. degraded pastures, scrublands and sands comprises of only 3.65 percent of the area. Built-up land use categories occupy 8 percent of total area and rest is covered by water bodies.

The central western alluvial plain of the study area is plasticized by rice-wheat cropping pattern and northern alluvial plain have high intensity of rice wheat and cotton wheat crops. The central plains have suitable conditions of heavy soil and availability of ground and surface water resources. But soils of the northern plain is loamy sand and less suitable for rice cultivation. The south western plain has more dominance of fallows and single cropped area. It is concluded that area under input intensive crops of green revolution has increased at the cost of traditional crops and desi cotton, gram, pulses and millets cropped area have declined significantly.

On the basis of physiographic or land-soil relationship, the soil mapping was carried out up to series level along with associated soils in that particular unit. Physiographically, the study area were divided into mainly aeolian plain and alluvial plain. Further; these units are sub-divided into dunes, partially stabilized, very gently undulating plain, upland, low land and recent flood plain. Total eleven soil series were established in the district and soils are classified taxonomically as per USDA guidelines. The soil types mainly consist of Fine Loamy, Fluventic Haplustepts, Coarse Loamy, Typic Ustipsamments, Fine Loamy, Typic Haplustepts, Coarse Loamy, Nitric Haplustepts, Coarse Loamy, Typic Haplustepts, Coarse Loamy, Typic Ustifluvents, Sandy, Typic Ustipsamments, Fine, Aeric Halaquents and Fine Loamy, Fluventic Haplustepts. The soils of the district have been evaluated for their suitability and sustainability for main agriculture crops and agricultural plantation of land evaluation and soil sustainability status of different crops are also discussed.

The land resource development plan have been prepared by integrating different thematic maps like land use and land cover, physiography, soils, available water holding capacity, ground water quality, underground water table depth, rainfall, irrigation facilities and socio-economic conditions. These thematic maps were analyzed in term of resources potential and limitations individually and jointly. For recommending land resource action plan various decision rules have been formulated. Based on decided rules and integration of all thematic maps, land resources action plan has been explained. For management of agricultural land, the suggested recommendations are agro-horticulture, agro forestry, agro forestry with dry land crops management, double crop, crop diversification with suitable soil conservation measures and agri horticulture with suitable soil conservation measures etc. The management of wastelands includes forest plantation for scrubland, silvipasture for degraded pastures and leveling & dune stabilization for sand dunal areas.

Integrating ground water resources map was prepared using interpolation techniques of collected data from Central Ground Water Board in GIS environment. Water table deepness maps for pre monsoon and post monsoon with water quality and draping of depth to water table map in GIS environment. It shows that 31 percent of area is which lies in north central part of the district has good quality along with good to excellent prospects of ground water. This area has good canal network also. This area is suitable for tube well irrigation. The central part consisting of alluvial plain has very well ground water prospects with marginal quality of water and this sub-surface water depleting due excessive draft of water to irrigate water intensive rice wheat cropping pattern. The measures like diversification of crops with less water consuming water crops and mixing of ground water with canal water are suggested. The south western aeolian plain is suffering from problem of poor quality as well prospects with insufficient canal water supply. Therefore, agro forestry, dry land crops management were recommended for this area.

Due to these input intensive agriculture, the area is suffering from decreasing water table, excessive use of fertilizers and pesticides primary to serious ecological difficulties. The study has exposed that there is serious need for diversification of cropping pattern. The area is also facing another problem of complete absence of natural forest, therefore; there is urgent need of forest plantation on wastelands community land, government land and along with transport network and irrigation channels to restore ecological balance of the area.

For surface water resources management in command areas, the efficient water resources management practices such as sprinklers irrigation, drip irrigation, conjunctive utilize of underground and surface water, mixing of saline water with canal water, growing salt / semi salt tolerant crops, rain water harvesting, lining of canal and water courses have been suggested.

The chief objective of present study is to generate land and water resources sustainable management plan for the study area which is optimally suitable to the topography, climate and creative potential of local resources then the production level has been maintained without decay over time. The recommendations of resource plan have taken into attention present-day technology, resources potential along with terrain and climatic parameters.

The study is divided into eight chapters. The first chapter devoted to introduction part which covered the nature of problem, applicability of present research, review of literature and objectives.

Second chapter deals with geographical background of the study area which comprises of location and extent, administration, physiography, drainage & water bodies, slope, climate, soils, infrastructural development and flora & fauna. Third chapter deals with detailed describe of database and methodology used in present study.

The fourth chapter described evaluation of land resources including land use land cover classification, mapping methodology, distribution, types of land use, cropping pattern for rabi and kharif season and crop rotation with extent and evaluation of present land use pattern.

Fifth chapter discussed the soil resources which include physiographic units, types of soils, soil family, soil texture, soil drainage and available water holding capacity suitability.

Sixth chapter cover the evaluation of water resources and socio-economic aspect of the area. In this chapter underground water table status and quality of underground water were evaluated for pre and post monsoon season. Demographic profile and infrastructural facilities of study area were also discussed.

Seventh chapter deal with development of agricultural land use plan for land and water resources management. This chapter includes integration of different themes in GIS environment carried out and sustainable agricultural land use plan map with different recommendations were formulated for sustainable development of land and water resources.

The last and eighth chapter consists of summary and conclusion of this research work and references have been cited in the end of thesis.

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LIST OF ABBREVIATIONS

AIS-	Automatic Identification System
AWC-	Available Water Holding Capacity
CCS HAU-	Chaudhary Charan Singh Haryana Agricultural University
CGWB-	Central Ground Water Board
CSSRI-	Central Soil Salinity Research Institute
DEM-	Digital Elevation Model
DSS-	Decision Support System
EC-	Electric Conductivity
EMS-	Electromagnetic Spectrum
ERDAS-	Earth Resource Data Analysis System
FAO-	Food and agricultural Organization
FCC –	False Colour Composite
GEF-	Global Environmental Facility
GIS -	Geographical Information System
GPS_-	Global Positioning System
GWP-	Global Water Partnership
ha –	Hectare
HARSAC-	Haryana Space Applications Centre
HLPE-	High Level Panel of Experts on Food
ICAR-	Indian Council of Agricultural Research
IMSD-	Integral Mission for Sustainable Development
INBO-	International Network of Basin Organization
INRM-	Integrated Natural Resource Management
IRS-	Indian Remote Sensing
IWRM-	Integrated Water Resource Management

KM-	Kilometre
LD-	Land Degradation
LISS-	Linear Image Self scanning
LULC-	Land use land cover
LUS-	Land Use System
M-	Metre
MPTS-	Multi Purpose Trees and Scrubs
MSS-	Multi Spectral Scanner
NAPA-	National Adaptation Programme for Action
NATMO-	National Atlas and Thematic Mapping Organization
NBSS-	National Bureau of Soil Survey and Land Use Planning
NGO-	Non Governmental Organization
NIFA-	National Institute of Food and Agriculture
NIR-	Near Infrared
NLCB-	National Land use and Conservation Board
NRCS-CN-	Natural Resources Conservation Service -Curve Number
NRIS-	National Resources Information System
NRSA-	National Remote Sensing Agency
NRSC-	National Remote Sensing Centre
OECD-	Organization for Economic Co-operation and Development
OECD-	Organization for Economic Co-operation and Development
PAN-	Panchromatic
pH -	Potential of Hydrogen
RS-	Remote Sensing
RSC-	Residual Sodium Carbonate
RUSLE-	Revised Universal Soil Loss Equation
SDSS-	Sloan Digital Sky Survey

SEPA-	Scottish Environment Protection Agency
SOI-	Survey of India
SPOT-	Satellite Pour L Observation de la Terre
TM-	Thematic Mapper
UNEP-	United Nation Environmental programme
USDA-	Unite State Department of Agriculture
USGS-	United States Geological Survey
UTM-	Universal Traverse Mercator
WHO-	World Health Organization
WWF-	World Wide Fund for Nature

CHAPTER-1
INTRODUCTION

1.1 NATURE OF PROBLEM

Sustainable development maintain the resources based upon which it depends by emphasizing soil conservations, nutrient recycling, depletion of underground water quality, declining water table and bio diversity. It makes the highest efficient utilization of non renewable resources. United Nations also demarcates the 17 goals of sustainable development in 2016 and its target to achieve each goal till 2030. Sustainable agriculture is the process that uses the natural resources in such a way that may not affect the opportunities or benefits of coming generation to set beneficial use of these resources in the existing agricultural utilization process. Now a day, the difference between need of people of agriculture product and available resources in the world is getting wider. There is a requirement to create and emphasize on latest strategies and planning for accessing sustainability.

Optimal and proper management and utilization of natural resources has very broad for the whole world in common and the developing countries like India in order to attain as these has dealing with a difficult problem over past few decades. The alarming rate of depletion and degradation of water and land resources has been accelerate at an alarming rate in scrutiny of the increasing population pressure. Present environmental issues like desertification, soil degradation & erosion, deforestation and problem of salinization have been corrupted the environment alerting the demand to feed the food for increasing population & development of whole world. Over utilization and misuse of natural resources to meet the expand requirement leads to faulty cropping pattern, decreasing water tables, seeking biodiversity, over fishing in relation to increasing pollution. Stretching the finite natural resources of the world to achieve the basic needs of increasing population growth that is carefully expected 11 billion by 2075, without improving environmental, biological and ecological circumstances is the main challenge which facing the world currently (Navalgund, 2002). The World Bank estimated minimal requirement of 0.5 hectare per capita arable land is required in the world, but our presently available arable for agricultural practices is 0.12 hectare per capita in India and 0.19 hectare per capita in the World. This will further dwindle to only 0.15 hectare by 2100 (Navalgund, 2002). It is appalling to learn that about 75 percent forest of the world cover has shrunk because of cutting & deforestation. Approximately 58 percent of coral reefs are potentially threatened due to disastrous fishing activities, tourist pressure and water pollution. About 65 percent of cropland faced significant degrees of soil erosion/degradation (World Resources, 2015-16). These brainstorming issues cut across the geographical hurdle and transcend boundaries between nations. "According to Global assessment of soil degradation (Global assessment of soil degradation, GLASOD), of the world's 1,900 million hectare of land affected by soil erosion and degradation since last 45 years; The Asia-Pacific regions had the largest area (550 million hectare) (UNEP/ISRIC 1991)." Waterless area of region is under harmed land; and it is approximate 1,320 M populations live in drought prone region (UNEP 2015). The latest appraisal of degradation of soil and depletion in South-East Asia founded that farming output was compact by dilapidation in waterless areas that is 180 M hectare in China. (SEPA 2016), 110 M hectare in India and 62 M hectare in Pakistan are degraded. According to various estimates, that all land less than irrigation has been resulted to salinity, alkalinity and problem of waterlogging. It is understood to be badly disturbing 2 to 3 lac hectares of the global best agricultural land annually.

India is gifted with high deposition of natural resources. However, for its size and population, it is one of most densely populated nations. It faces a multiplicity of troubles ranging commencing increasing population to causes soil erosion and degradation. As per the Census of India 2011, India has 17.5 percent of world's people while India has 2.32 percent geographical area of the world. At present, India has 0.15 hectare per capita arable land and is expected to decrease to 0.09 hectare by 2075. Crop production, which is 205 Million tones today wants to be increases 325 Million tonnes by 2050 to provide food to rising population. Near about 65 percent of the agriculture is rainfed area and is subject to vagaries of the monsoon. In spite of an predictable accessibility of 3000 cubic meter of water per candidate annually, unequal allotment of spatial and temporal dimension is main reason of water shortage in a lot of areas of the earth. Almost 50 percent of annual rainfall is lost because of evaporation and surface run off. The rising utilize of underground water for flood irrigation, lacking applying sufficient recharging system, ha led to water level decreasing and interference of sea water into underground water aquifers.

India has 30.44 percent of world's cattle population (World Cattle Inventory, 2018); placing intense requirement of fodder and overgrazing of grazing lands and forest areas also resulted. Only 21.23 percent of geographical areas of India are under forest cover that is too low against 33 percent prescribed. Area under dense forest is only 50 percent of what it was about fifty years ago.

Conservation of biodiversity is an area of concern. India has long coastline of about 7500 km. A large faction of population lives in coastal areas. Speedily growing industrialization, urbanization and population in coastal regions are creating pressure on wetlands of coastal area, coral reefs and mangroves areas at distressing rate. Himalayan snow cover is showing alarming draw back. India is amongst the mainly exposed group of developing countries suffering from damage due to hazards such as droughts, flood, cyclones landslides, forest fire, earthquakes and locust attacks. India experiences frequent drought adding to its multiplicity of problems. About half of the country is affected by droughts and 40 million hectare is affected by floods. Land sliding is main issues in numerous regions of the Himalayas mountain and Western Ghats. In relation of shrinking per capita land and increasing biotic and abiotic pressure, it is a daunting task to raise food production for the needs of increasing population. In order to remove these problems, it is necessary to adopt methods of development, which reduce disparities among people and nations, alleviates poverty and leads to sustainable development without causing irreversible erosion of natural resources wealth.

Sustainable development may be explained as the requirements of present generation in lack to compromising the facility of upcoming generation to achieve their personal greedy requirements. Sustainable development needs a real-time improvement in three dimensions that are the environmental, economic and social dimensions which improve financial efficiency, protect and re-establish environmental ecological balance and create the well being of human being. There is a fourth dimension also, that is the technological dimension. It is based on latest technologies which are additional capable and have less important impact on natural environment. There are strong linkages, relations and interactions among all above dimensions.

The Earth Summit held at Rio de Janeiro in 1992 discussed the way to have long term financial progress is to link it with environmental shelter, protecting of natural resources and judicious use of land & water resources which is essential for well being of current and future generations. Therefore, there is a need of integrated resource planning and managing of water and land resources for sustainable development for future generation. Modern technologies like geo-informatics can be successfully used to improve the efficiency of land and water resources.

The data from Earth Observation Satellite can provide help to sustainable development by generating continuous and temporal information of natural resources endowment. The synoptic view provided by remote sensing satellite data suggest most suitable method for fast and consistent mapping, monitoring, management and planning of various natural resources in context of space and time. Change or temporal analysis provided by repetitive satellite remote sensing over a variety of temporal and spatial analysis; offer the best economic means of assessing environmental effect of developmental process and evolution of appropriate action plan for initiating sustainable development.

Geographical Information System provides conventional tools to integrate hyper spectral data and different layers in different format for analyzing by multi dimensions. GIS is an effective tool for users by enabling contribution in decision building (Navalgund, 2002).

In addition to mapping, monitoring and planning of the natural resources & environmental parameters and their attempts have also been made in India. In order to integrate all layers of various natural resources carried out from satellite data along with other secondary data in GIS environment to produce locally specific achievement of sustainable development plan of natural resources.

Like any other place, the state of Haryana is also not free from problems related to environmentally sound uses of natural resources. The presence of brackish ground water in most of the central part of the state along with flood irrigation system has further aggravated the problem in the area resulting in soil degradation. The state forms a part of arid and semi arid region therefore the rainfall is scanty. Thus, crops suffer from both deficiency of water and excess of water during the year. Further more; the intensive and monotonous cultivation in the area is damaging the soils by depleting the important nutrients and water table. If this situation is allowed to continue, the soils of the area may suffer irreversible damage and may become unproductive and barren. These problems along with other problems related to management of natural resources in the area are needed to be urgently addressed to, so as to avoid further degradation and also to draw maximum benefits from available resources without compromising the concept of sustainable development.

The green revolution based on exhaustive cropping system of the area led to lowering of water table, gradual depletion of soil fertility, extensive deforestation, soil erosion and soil pollution due to excessive use of agro- chemicals. In current land use system of cotton-wheat or rice-wheat crop rotation system in the area, these four crops yield have reached on its plateau level or are showing declining trends. The water table in tube well irrigated areas is declining due to excessive withdrawal of sub surface water for irrigating the water intensive rice wheat crops.

Situated in the northwest, Hisar is largest agriculturally important district of Haryana having variations in soil, landforms and geology with various types of land & water resources with their management problems. This central and north eastern part of area is being intensively cultivated without taking into account of many natural utilization of aeolian plain which faces problem of depletion of water table and is thus facing many natural physio-climatic constraints as well as man made problems of over utilization of natural resources. The south-western region of the district is made by aeolian plain with sand dunes complex that faces problems of scarcity of water, scanty vegetation cover and partially stabilized sand dunes. Besides these, it is also facing the problems of light texture soils, high infiltration, low organic, carbon and clay contents, poor fertility status, slight to moderate wind erosion and poor quality of sub surface water. Another problem of the area is absence of natural forest cover that is because of adverse physio-climatic conditions and the present intensive agriculture land use pattern, which have left no scope for forest cover. 132.89 square kilometre area of the district is under wastelands that is 3.34 percentages to the whole geographical area of the Hisar district. The district also the most intensively cultivated with 193% (statistical abstract of Haryana, 2017) cropping intensity. It covers 4170.81 square kilometres area with a population of 1,743,931 persons (Census of India, 2011). In the study area farmers are carrying on to grow rice- wheat and cotton - wheat as leading crops because of administration incentives and high market value. As a result they ignore the suitability of soil, water and climatic situation. The non sustainable land use and beginning of canal irrigation have introduced in soil degradation, erosion of soil, problems of salinity & alkalinity and waterlogging, moreover nutrient fatalities as well as falling of underground water table at an alarming rate. Problems of soil salinity, sodicity as well as waterlogging have been credited to irrigation lacking by as long as proper drainage.

Salinity and sodicity in 0.56 sq. km area has been shaped in the extremely exhaustive canal irrigation areas in Hisar-I and Hansi block of the district and 3.80 sq. km area of the district is under the class of seasonal or permanent waterlogged. Under ground water status is falling in the north east region because of over use of underground water where rice–wheat cropping pattern or crop rotation is practiced. It has disappeared downwards by of 6.0-7.5 metre in a little distance of 10 years and thus, has enlarged the price of irrigation. Soil richness has also been declined here because of the steady growing of nutrients comprehensive rice and wheat crops. The above situations, pose staid pressure to sustainability of cultivation in this high productive region of the district.

The brackish ground water table is constantly rising due to seepage of water through canals, irrigation channels and irrigated fields in the inland drainage basin in the saucer shaped topography in south eastern part of the district by creating waterlogging and secondary soil Salinization. To increase the foodgrain production for increasing population, land and water resources have been subjected to great stress and inappropriate land use which has resulted to soils degradation in the district. Today with emphasis on quick production, the optimum balance between the use of land /soil resources and agro-production conditions are disturbed. Thus, the productivity level of different crops, have either reached plateau or showing declining, trend, despite manifolds increase in fertilizer use and plant protection chemicals.

The agriculture system which encompasses the interactions of physical, technical, biological and socio-economic factors, some of which are under human control, for the purpose of producing food and the agro- ecological entity. The agro-ecosystem, therefore, is considered to be in equilibrium with environmental and management factors, which produce a sustained yields.

The existing agricultural production system focuses only on intensifying crop yields while ignoring wider implication of changes in agricultural practices on quality of natural resources. Environmental issues including land degradation, damage to underground water quality and loss of biodiversity have not been given sufficient prominence. The continuous progress will depend upon more holistic approach that would have its focus on health of natural resources base. Information and database of natural resources of the area is essential prerequisite for sustainable landuse plan and management of natural resources.

The current work is based on qualitative and quantitative data for sustainable supervision of natural resources like water and soil with the aims to utilize the authentication of present landuse in the situation of sustainability of agriculture. Thus the novelty of this research is that the productivity level of different crops is showing a declining, trend, despite manifolds increase in fertilizer use and plant protection chemicals. Sustainable agricultural practices fulfil the demand of coming generation and increasing population in respect to the sustainability of natural resources. Looking into these problems and keeping in mind the harmony between agriculture and ecological environment, the present study entitled "**Integrated Resource Management for Sustainable Agricultural Land Use Plan in Hisar District Using Geo-informatics"** has been taken up.

The problems of natural (land and water) resources degradation with their management related problems are briefly given below.

Land resources problems

- Soil degradation due to faulty cropping pattern
- Declining crops productivity or at plateau level.
- Very heavy textured soil in some parts of the study area
- Presence of sand dunes
- Poor soil fertility
- Lack of Soil nutrient
- Increasing Agricultural inputs
- Negligible forest cover

Water resources problems

- Over exploitation of sub-surface water and particularly in the areas where limited good quality water is available
- Poor quality of ground water
- Problem of drought or waterlogging

Management problems

- Faulty cropping system
- Decreasing per-capita availability of agriculture land
- Increasing cost of crop production
- Decreasing productivity
- Lack of timely & up-to-date database on natural resources
- Harmony between agriculture and ecological environment
- Lack of sustainable management.

1.2 OBJECTIVES

The present study is being undertaken with the following objectives:

- To evaluate the utilization of the land resources with reference to natural resource characteristics and land use pattern.
- To examine the sustainability performance of current land use types with reference to land resources.

- To demarcate the potential sites for agricultural production systems and preparation of sustainable agricultural land use plan.

1.3 APPLICABILITY OF PRESENT RESEARCH

Applicability of the present research is for industry as well as society also because agricultural product provides the raw materials for industry. The population of world will be came over eight billion people in 2025 while the agricultural land will remain the same. Highly use of pesticides, non-environmentally sound agricultural techniques and demand of healthy nutrients will become tougher to access for increasing population. Sustainable agriculture is a global level issue because sustainable agriculture is to end the hunger. With an increasing population, the World is facing the problem of hunger and under nutrition. Now a day, global demands of environmental sustainability and sustainable development provide environmental impact assessment for existing natural resources. The present study suggest encouragements for devoting in sustainable agricultural exercises and crop diversification, counting towards agri horticulture and demarcate the potential sites for speculation to equity in food systems comprise infrastructure, technology, markets and technological knowledge.

The present research is also relevant to the needs of the immediate environment because for the sake of development has the worst impact on not just the environment, but also on people. If government policies do not include sustainable development and governments do not take the necessary steps to inculcate a holistic approach toward development, a lot of things can go wrong not only for the economy but also the overall growth of a country. As humans, we have a general tendency to neglect what impact our actions have on the world around us. Development in every sector has to happen but not at the cost of the environment. Some of the biggest pollutants are the agro and chemical industries. Ever wondered how much water do paddy and sugarcane fields consume? It may seem like an economic boost for a few decades, but the environmental damage is permanent because agricultural land use pattern will consume the soil and water resources. Present agricultural practices are based on the monoculture and there is lack of crop diversification. As a result soil and water resources are degraded due to over use of water, lack of water consuming crops and faulty agricultural practices. So, there is no alternate without changing the methods of agricultural practices to conserve the soil and water resources.

1.4 REVIEW OF LITERATURE:

Soil or land is our largely expensive resource, which is dynamic for security of sustainable development without disturbing ecological balance. Excessive use of land & water resources generates considerable changes in the landuse which have aggressive outcome to the natural atmosphere. As the land resources have been individual property of provisions of mankind, the temporal mapping, supervision and monitoring of soil resources became a major compulsory for developmental and supervision of natural resources. In recent years, the spatial pattern and locational phases of land use and land cover has been studied further correctly using remote geo-spatial techniques. Newest technologies similar to Geo-informatics have developed as noteworthy equipment in now a day for management and monitoring of water and land resources. A lot of studies were carried out at international and national stages for inventory of land use/ land cover.

Studies Related to Integrated Natural Resources Management

Balasubramani (2020) discussed watershed related integrated methodology is measured more effective and proper methodology for resource evaluation and execution of different sustainable improvement measures. The current examination expects to show the utilization of geo-informatics tools in arrangement of thorough just like an effective structure for Indian situation to assess soil and water resources designs using a contextual analysis of Andipatti watershed, situated in Theni region of Tamilnadu. The examination used generally remotely detected information for indulgent exterior attributes and area empowered in order to information, for example; soil, precipitation and groundwater information for understanding the sub-surface qualities of the investigation territory. Whole databases had incorporated in a GIS climate to carried out soil efficiency, soil disintegration, surface overflow, potential of groundwater, groundwater superiority, crop land reasonableness, ground water appropriateness for horticulture, assurance of potential-usage list and to draw land use planning techniques.

Ramteke and Sen (2018) discusses accessible regular resources administer the essential advancement of any nation. Among many; land and water resources are most significant that help endurance of people on the earth. Because of quick expansion in populace, these resources are over extended frequently driving exhaustion continually. Lately, geospatial strategies are adequately used for more exact planning and prudent management of land resources. Geospatial technology worried about spatial data about highlights at a spot or, in space, gathered continuously. Geospatial strategies is the blend of Remote Sensing, Geographic Information System, Global Positioning System, map making, and spatial measurements that catch, store, control and investigate to comprehend complex circumstances of climate and take care of the issues for sustainable turn of events. In the examination an endeavour has been made to survey the utilization of geospatial methods in land resource stock, investigation, planning and management. The survey shows that these strategies have tremendous impending and being used in various parts of land resources stock, for example, advanced territory investigation, soil resource stock, land use and land cover planning, wastelands planning, water resources and ecological management.

Mani and Kishore (2018) discussed the organic land resources are profoundly powerless against varieties in atmosphere, soil and geography of various areas, and all these variables require to be investigated on spatio-transient reason for appropriate supervision and arrangement. The serious methods geo-informatics could be of incredible utilize for their appraisal, supervision and observing. The accessibility of remotely detected information from various sensors of different stages with a wide scope of spatio-worldly, radiometric and otherworldly goals made remote sensing as the best wellspring of information for enormous utilization in cultivation and backwoods resource observing. The incorporated use of distantly detected information and GIS has been empower regular resource supervisors and specialists to create supervision plans for an assortment of farming and woods resource management applications.

Report published by Degree of IWRM Implementation (2018) on integrated water resources management. At the lesser ending, 20 percent of nations have started just beginning IWRM techniques. The greatest impact in the national context is that they need to prioritize activities. Water resources supervision circumscribes water deliver for various sectors like agriculture, industry, energy, municipalities, sanitation, wastewater treatment and water-related disaster-risk reduction.

Tengberg and Valencia (2017) discussed meet numerous environmental targets, integrated writing computer programs is getting progressively significant for the global environmental facility. Incorporation of various ecological, societal and financial targets likewise adds to the accomplishment of the sustainable development goals in convenient and practical way. In any case, combination is frequently not very much characterized. Present report accordingly aimed to recognizing key parts of mix and surveying their execution in natural assets management ventures. We distinguish various difficulties and chances of integrated methodologies that should be tended to so as to augment the reactant effect of the GEF during issue determination, venture plan, execution and administration. We feature the requirement for activities to distinguish more clear framework limits and fundamental input systems inside those limits. We suggest a hypothesis of progress for INRM ventures, in which momentary ecological and financial advantages have initially gather at the neighbourhood level. Execution of better INRM advancements and practically at neighbourhood stage could be stretched out in the course of spatial arranging, reinforcing of development frameworks, economically and motivation components in watershed as well as landscape stage to support and upgrade environment administrations at bigger scopes and longer periods of time.

Manna Subhajit, Mishra Abhishek, Daiman Amit, Karwariya Sateesh and Goyal Sandeep (2017) carried out the conceptual integration of land resource management for Khatan Watershed of Chhhatarpur district of Madhya Pardesh. They focused on action research programmme in growing land degradation, sustainability of agricultural, rural communities through locality based planning and management at the watershed scale. They applied image processing technique and pattern recognition to LANDSAT-TM and IRS LISS-III satellite image data to drive various land development and management. They used ERDAS Imagine 9.3 software for image processing and preparing action plan for integration of land resource management. They found the rising pressure on land resource due to increasing human population and micro watershed of Chhatarpur district. They analyzed and suggested that remote sensing data were powerful tools to improve in understanding of groundwater system and land resource management planning.

Central Water Commission Basin Planning and Management Organization, New Delhi (2016) provided guidelines for integrated water resources progress and managing. The organization discussed IWRM's three basic pillars that are Economic's efficiency, sustainability of environment and social equity. The central goal of IWRM is at the river basin level. The importance of IWRM is required as a part could be the leading concept of planning, development and water resource managing. At local level, it is necessity of local resources for optimum use in canal-irrigated regions, augmentation of irrigated region, avoidance of waterlogging and enlargement of productivity.

Duda (2015) discussed the integrated managing of land and water resources based through a combined approach and disjointed conventions at international level. He assumed that require for water withdrawal would raise 40 percent till 2025 for growing world's population requirements. In the present study he also discussed that demand of withdrawal of water creates different global crises like increasing dry lands, ecosystem collapse, deforestation, hydrological functioning imbalances, increasing vulnerability to recurring droughts /floods at global level. He also demarcated and analyzed the role of international conventions like Convention on Biological Diversity, UNFCCC, United Nations Convention to Combat Desertification and United Nations Convention on the Law of the Sea. He analyzed that global water disaster was solvable by entity sub-sectors such as irrigation or town water needs which have been solved previously. The subsistence of connected land-related crisis and the tendency towards transference of government activities can portion and adulterate the ability of community establishment and makes harness stakeholder participation in catchments and basins still additional significant.

Freeman, Duguma and Minang (2015) carried out operationalzing of integrated landscape approach to desire the multiple goal related to both environmental and non environmental process. They introduced about three major landscape approaches

(Conceptual framework approach, principles landscape approach and process landscape approach) which were largely used in literature. They also analyzed the concept of landscape approach in context of multi-functionality, participation, interdisciplinary, sustainability and complexity view. They also suggested that more sectoral landscape approach is provides more realistic choices.

The Global water partnership international framework studied (2015) integrated water resources management in Central and Eastern Europe. This study of GWP was presented in Technical Focus Paper based on the comparative analysis of Integrated Approach to Water Resources Management (IWRM) and European Water Framework Directive. In the present study GWP discussed on water resources management based on water supply, water demand, domestic supply of water and wastage, quality of water, water shortage during drought, problems created by water during floods and contemporary issues related to law or legislation. The departmental report also studied comparative analysis of IWRM and EU WFD on the basis of river basin development, water policies, water pricing and cost recovery. The report also shares the IWRM experiences of Danube river basin, Tisza river basin, Sava river basin, Drin river basin and Dniester river basin at macro regional level. This technical report also analyzed rural development planning, inland navigation and hydropower development in above all river basins.

Zaag and Savenije (2014) valuated principles of Integrated Water Resources Management of Fresh water resources. It is vital to sustain life. It means that water has a lofty need to its users. Practically speaking it is finite in spite of the fact water is a renewable resource. A lot of uses of water were sub-tractable sense that the utilized by people may prevent the use by somebody else.

Petja, Brilliant and Nesamvuni (2014) this study uses geospatial tools to evaluate the farming capability of the Nebo Plateau of Limpopo Province of South Africa. This methodology involves evaluating the reasonableness as far as land, soil and atmosphere that were major factors for agricultural turn of events. The ecological prerequisites of chose crops were examined using Arcview GIS. Different spatial investigation method was used to show and allocate classes of appropriateness dependent on the most significant and yield-restricting boundaries, for example, precipitation, heat and soil attributes. Outcomes demonstrate that territory is possibly reasonable to an assortment of agricultural items where 65 percent of the region is appropriate for development. This was anyway kind of natural as well as climatic limitations, for example, the accessibility of water, enhancement of the condition of the climate, anticipation of soil debasement because of disintegration and compaction, development of soil ripeness by methods for best cultivating and supervision rehearses. The yields were introduced inside a client amicable GIS stage to a superior choice help to advancement organizations and administration. The outcomes likewise assist to give contributions to evaluating money related attainability of cultivating ventures. This investigation thusly underscores the significance of geospatial technologies in illuminating and advancing sustainable agricultural turn of events.

German, Mowo, Amende and Masuki (2012) carried out integrated natural resources management in the highlands area of Eastern Africa. They conducted present study for highland area of Kenya (Areka), Ethopia (Ginch), Tanjania (Lushoto) and Uganda (Kabale and Kapchorwa). They used altitude from mean sea level, population density, enterprises, irrigation, live stock trends, forest / woodlot access and market integration for site attributes parameters and adopted participatory action research techniques for the evaluation of changes in process and strengthens chances of success to characterize the social and biophysical dimension of natural resources management. The analyzed that society based natural resource supervision, participatory watershed executive and adaptive collaboration management were helpful techniques for management of natural resources in above highland areas.

Kushwaha, Satya and Mukhopadhyay (2011) everybody on the planet relies totally upon Earth's ecosystems and the administrations they give, for example, food, water, illness management, atmosphere guideline, profound satisfaction, and stylish happiness. In the course of recent years, people have changed the ecosystems more quickly and widely than in any similar timeframe in mankind's set of experiences, to a great extent to fulfill the quickly developing needs for food, new water, wood, fiber, and fuel of an ever-growing human populace.

Stucki and Smith (2011) studied integrated approach for management of natural resources in relation to catalyzing position of nationwide adaptation programme for accomplishment. The aim of present study is to validate the emerging importance specified for climate change version is regularly catalyzing a move from a center on strategy to applied utilization of integrated approach. To analysis to the NAPA scheme profile was carried out. They compared concept of integrated approach of natural resource management discussed in context of forest landscape restoration. Out of all above five concepts; ecosystem concept having smallest amount differentiate in evaluation to all other four concepts in proportion of project with ecosystem restoration activities during the period 2004 to 2009. They analyzed that in 2009 (42%) of NAPA scheme include ecosystem re-establishment and in 2004 it was 11% on the other hand project profile using minimum one integrated scheme was 33 percent in 2009 in association to the 4 percent in 2004.

Twomlo and Lilja (2010) carried out role of evaluation in integration of natural resource management. The study discussed the principal and practices of integrated natural resources management. They suggest implementation of an integrated approach through learning cycle and addressed four issues stakeholders participation, a system approach to evaluation, timing of the evaluation and iterative approach to investigation.

Sonowal (2008) discussed the integrated methodology and logical managing of natural resources such as soil, water, flora, creature and climate is needed for in general turn of events and continued creation. These characteristic resources can be best used and overseen in a viable and productive way by watershed approach. Some arrangement and advancement mechanism of these essential characteristic resources used in integrated way on watershed premise in north east region had been begun ever since mid seventies. The watershed management incorporates idea of ideal usage of land and water for farming creation just as applied jointly the specialized ability, individuals and the climate into an agreeable circumstance. Both common resources and the financial circumstances of each watershed are to be specified equivalent significance. Integrated executive of normal assets on watershed premise is the correct methodology for sustainable advancement for accomplishing objectives such as food sanctuary, destitution lightening, and government assistance of more fragile segments of the general public.

Carlson and Stelfox (2007) discussed management and planning of resources through integrated approach. They discussed seven fundamental elements of integrated resource management approach such stockholder as collaborations, explicit goals with indicators, analysis of tradeoff, monitoring, dative management, thresholds and zoning. Inclusive, interconnectivity, goal oriented and strategic are essential characteristics of integrated resources management approach. The study is carried out objective related to balance development and conservation.

Chaudhary, Kumar, Roy and Ruhal (2006) have carried out an integrated study for demarcation of underground water potential areas in Sohna and Gurgaon block of Gurgaon district of Haryana state. Author adopted a union/ included method of predictable and remotely sensed methodology for underground water specific site explanation. It were done through integrating various maps such as geomorphology, geology, water table level, water table variation, underground water superiority, soil drainage and slope analysis.

Frost, Campbell, Medina and Usongo (2006) carried out approaches on landscape level for included natural resources management in tropical forest area. The purpose of present study was to developing an integrated approach for managing and conserving of natural resources. They suggested eight guidelines for integrated natural resources management. The study conducted on the based of action research in three districts Malinau District of East Kalimantan, Indonesia; Tri-National de la Sangha, Cameroon and Reserva Extrativista Verde para Sempre, Porto de Moz, Pará State, Brazil. The study of above three forested region were based on the characteristics on which the management of forest approached. The main characteristics of these features are vegetations, physical features, population, settlement, land use, environmental and socio economic concerns and discussed for all three districts.

The Canadian International Development Agency (2005) highlighted Integrated Water Resources Management Plans. The agency discussed many examples about uncontrolled use of scarce water resources and inherently unsustainable. That emphasis not only pivots water resources development but also development of water management for long time sustainable use for next generations. Many countries prefer first priority to the satisfaction of human's basic need of water. In current world 20% human population have not timid water to drink and 50% population have not enough sanitation. The population is facing lacking water needs and sanitation services by 2015. It can be manage by the importance of ecosystem for human development by the help of safeguard of environmental reserve.

A technical report brought forward by HARSAC with collaboration of NRSA, Hyderabad on union/ integrated management of natural resources in Matanhail block of Jhajjar district of Haryana state adopting geo spatial technology. On the basis of natural resources monitoring through dissimilar themes; a final land resource development plan was suggested. Sensor based images utilized as principal data and ancillary data were collected by ground inspection. The final action plan chiefly explained in two parts first is farmland administration and second is wasteland management plan. (NRSARSGISIRISDA/HARYANA /NRM-WR/ROO/ MARCH 05).

Panigrahi, Ray, Sood, Patel, Sharma and Parihar (2004) discussed on Bhatinda of Punjab for monitoring of cropping practices; crop annually cycle and temporal analysis in cropping pattern with respect to satellite data with spatial and non-spatial collected database. Different maps such as cropping pattern as well as crop rotation were composed for different years. The study shows increasing pattern of cropping intensity which were largely because of raise in paddy crop area. The study also shows that boost in region of rice-wheat and cotton-wheat crop cycle at the outlay of millet, gram and mustard crops respectively.

Moriarty, Butterworth and Batchelr (2004) find out Integrated Water Resources Management. Attainment 1.1 billion population with no sufficient water and 2.4 billion were with no proper cleanliness, is obviously concerning much additional than water resources but these contain and play a vital role to in the Watson sub-sector's. IWRM principles are into worldwide water management practice is still required. Information and communication are the skills which are presented in IWRM: the management superior preparation based on a sound and largely based considerate of human need, but it also affects their ability and the limitation obligatory by working with a limited resource.

Murthy, Amminedu and Venkateswara (2003) carried out integration of theme wise maps using GIS technology for demarcation of underground water potential sites. Satellite images have been used to recognize ground water potential sites and integrating different theme wise maps into GIS environment. The maps were union after conveying weight factor to recognized features in each theme maps based upon their penetration capacities and ground water potential sites demarcated in Bhamini Modal block of Shrikakulam district, Andhra Pradesh. The present study resulted integration of non spatial data that provides more precise result in ground water potential site recognition.

Arlosoroff (2002) carried out integrated approach for efficient water use in Israel. The author introduces water as largest and cheapest resources of world. The Israel water resources scheme discussed present case study sufficient executive of water. The author analysed that more than 40 percent of the food and agricultural need of the World is produced on irrigated land. On the other hand global population especially urban population is continuously grown at a rapid speed rate. He also discussed that near about 70 percent of water resources are used for irrigation purposes only. The study also discussed instrument of national water resource development and water demand management such as economic policies and pricing, Reuse of sewage effluents, water conservation / improved efficiency, water allocation system for agricultural sector, virtual water policy and water markets. Ground water resources became the most important preliminary instrument of progress in the 20th century. The total aquifers information have been carried out that more than 65 percent of the entirety supply of water of the nation is pumped out from the aquifers.

Mantri, Bhatnagar, Dave, Patel, Mehrotra and Singh (2002) attempted to provide insight to the user in understanding the hydrology of watershed and in developing the water resources in an integrated manner using space technology in Gujarat state. Recognizing the remote sensing & GIS based multi layer spatial data along with conventional data, the water resources of Gujarat state were studied in an integrated manner.

Chaudhary (2002) studied integrated investigation for natural resources adopting remotely sensed and GIS in Kunar basin of Bardhman district of West Bengal state. Writer used updated spatial as well as non-spatial data database of natural resources commencing different satellite images and integration GIS software to outline a relational data base. Finally, it is analysed for the inter-relationship between various planning fundamentals and also projected action plan for problem dominated region and suggested a decision support system for above studied area to make easy the require useful executive for resources at minor level.

Saxena, Rao, Sen, Maikhuri and Semwal (2001) examined sufferers of forest cover, farming output and biodiversity in Khaljhuni village of Almora district in the Himalayan Mountain which are major problem for the sustainable livelihoods. They identified land treatment in a little remote village near to the alpine region. Communities were worried with the financial profit from bamboo and therapeutic variety than the extended profit in tree planting. They found that the broad series in bio-physical and socio economic condition in the Himalaya requirements are supple and environmental reimbursement in term of improvement in soil richness, biodiversity, defensive wrap and carbon confiscation. They suggested that the most excellent option for treatment were the growth of multi-use tree- crop mixed agricultural.

Report published on INRM workshop (2000) introduced techniques of integrated natural resources management that provide techniques of development oriented research. The present study solves the problem of food insecurity, poverty and degraded natural environment with production futon, human well-being and ecosystem functions and provide the framework chart for the functioning of research process. The report discussed about five modified capital assets such as social, natural, physical, human and financial. Remote sensing and GIS techniques are suggested as new tools and methods in management of natural resources management for eco-regional programme.

Rao, Fyzee, Reddy, Reddy, Shankar and Rao (1997) carried out integrated resource mapping for Kamasi block of Banda district of Uttar Pradesh adopting Remote Sensing tools. He suggested different measures such as double cropping, agro forestry, fodder and fuel wood plantation, Silvi pasture in relation to soil conservation procedures.

Ravindran, Kumar, Tiwari, Kudrat, Ravishankar and Bhan (1992) used the digital satellite database to create database on water and land resources for integrated development of Song River, a tributary of Ganga located in Doon valley. The approach consists of preparation of resource maps using the IRS-IA, LISS-II data by digital processing/ visual interpretation and integration of the maps in GIS environment to generate various derivative maps which are useful in identifying problem areas for planning and development. The study suggests the possibility of integration of information on different themes obtained from remote sensing data through GIS for quantitative analysis. The techniques after a dominant tool for the union of multi-layered in sequence for generation of various maps useful for management, development and planning of natural resources.

Odenyo and Pettery (1977) adopted supervised classification of digital images approach and arranged a landuse and land cover map at 1:24, 000 scales adopting 24 categories by using Landsat MSS satellite data. Accuracy of this classification is 85-90% achieved by this approach.

Studies Related to Sustainable Agriculural Management Techniques

Veronica and Rubio (2020) discuss about information management are causing smart farming to enlarge dramatically as information have become vital part in now a days agribusiness to help makers with fundamental dynamic. Important central points demonstrate up with target data procured by sensors with the point of expanding prosperity and manageability. Information determined horticulture, with the support of automated engagements joining counterfeit canny strategies, sets the reason for the sustainable agribusiness of things to come. This study audits the current status of cutting edge ranch management frameworks by returning to each significant advance, from information procurement in crop fields to uneven rate applications, so cultivators could built enhanced choices to set aside cash while securing the climate and changing how food would be delivered to economically coordinate the approaching populace development.

Erunova (2019) discussed preparation of usage of GIS as well as web innovations for territorial cultivation of the Krasnoyarsk domain is thought of. The test cultivation undertaking "Minino", situated close to Krasnoyarsk city, was picked as a pilot venture for this cultivation endeavor, the complete advanced model utilizing geographic data frameworks, remote sensing with mapping information preparing procedures and software is made. A geospatial data set, that contains significant and documented data about farming field, assortments, crops, loam, molecule size conveyance, soil framing rocks, landscape highlights had been shaped. A progression of mechanical computerized cartograms and maps had been made by data on crop revolutions and developed crops are strenuous. Documents of accessible hyper-spectral sensor information of high resolution goal on the careful region are dissected. Therefore, a electronic map of many layers of the agricultural endeavor was made, that contains whole accessible data and can be utilized for demonstrating and gauging crop yields and arranging of agricultural. The created strategies, software and innovative arrangements can turn into a procedural reason for another age of data and systematic frameworks which advancements to help the board choices in the agricultural area.

Marshet, Nigatu and Gebeyehu (2019) discussed about the agriculture assumes an indispensable function in each country economy each country. In this study, they attempted to diagram utilization of remote sensing with spatial data framework in agriculture and common resource management. Utilizations of various remote sensing methods were significant for crop checking, crop situation evaluation and succumbs assessment for supportability of cultivation and characteristic resources. Unearthly data is the significant part of remotely sensed information for crop displaying and it is unequivocally related with overhang boundaries that were the delegate of crop wellbeing and crop development stages. It is one of the viable devices for evaluating and checking the water resources.

FAO, IFAD and UNICEF (2019) Global appetite has been on the ascent, influencing 821 million individuals in 2018. Clashes and weakness which cause individuals to become uprooted have been the principle drivers of food frailty. Climate boundaries have exacerbated the descending winding of food frailty by affecting agricultural efficiency, food creation and regular assets. These have prompted changes in food frameworks and the rise of new difficulties to tending to the pressing necessities of the most defenceless.

Kumar and Hassan (2018) carried out the suitability of agriculture in Haryana using primary and secondary data related to the land use, cropping pattern, irrigation, crop production and inputs for the year 1970-73, 1980-83, 1990-93, 2003-04 and 2013-14. Stratified random sampling method was used for data collection during the survey. Agricultural transformation in Haryana at regional dimension and issue pertaining to agricultural sustainability was studied on the basis of database used.

Meena and Nandal (2018) carried out the issues of sustainability of agricultural in Haryana at district level using primary and secondary data of agricultural practices for the year 1966-67 to 2013-14. On the basis of above database they studies the year wise agricultural production of different crops as well as their input cost also. They also studied the soil fertility and uses of chemical fertilizers in respect to the production and productivity of the principal crops. They find out that area under food grains is 3520 thousand hectare in 1966-67 and it increased to 4400 thousand hectare in 2013-14.

Vipin Kumar (2017) The examinations identified with agriculture become more appropriate for those regions, where agriculture offers in excess of 80% of net gain, also through its immediate development or by its unified works. The point of current examination is to survey the cropping design, crop mix, and crop positioning in Somb stream bowl utilizing geospatial procedures and auxiliary information. Here, cultivation is solitary essential profession and the fundamental wellspring of economy. Just as in excess of 50% of complete specialists are occupied with cultivation and smallholders ranchers, who develop crops utilizing low force practices of land. Subsequently, a logical and orderly examination was profoundly needed to surveying and mapping the crops design of the watershed.

Sudhakar (2016) propounded Sustainable Agriculture Development in India: Issues and Challenges. The study highlighted the provocation and argument in agriculture sector. Indian cultivation is the basis of occupation for about 65% of the rural population manpower in the nation residing in rural areas. The export-oriented production systems are not right when governments are more favored to the supply of domestic demands. Several new technologies break down to suit appropriate in cultivation sector because to insufficient of suitability by the local civilization. The crop output is profoundly dependent on rainwater that is the major causes for the speed of cultivation division in India that weakens due to its dependence to rain.

Roy, Oborne, Zubrcki, Doan and Venema (2011) carried out four case studies on agricultural participation through integrated water resource management in Canada. They carried out study on Okangan Basin Watershed, Lower Souris River Watershed, Yamashka Watershed and Souris river watershed using integrated approach. The chief objectives of the study were to improve and protect water quality, restore and protect fish and wildlife habitat and to improve living and recreational opportunities. They analyzed financial and technical level of different watersheds and also suggest institutional framework for the completions of objectives.

Singh, Prafull and Thakur (2012) carried out study on the land surface cover qualities and their uses are explanation factors in worldwide change. The general public is as of now to the standard of a different upheaval – the in sequence transformation. This rejuvenates huge trajectories and existing, giving novel methodologies to propel the boondocks of past unrests especially individuals of ground resources planning with observing. Semi-bone dry locales are going through serious anxieties because of the joined impacts of developing populace and environmental change. Over the most recent thirty years, the technologies and strategies for remote sensing have advanced altogether. Presently a days remote sensing information, alongside expanded goal from satellite stages, causes these technology to seem ready to improve sway on land resource management activities associated with checking LULC planning and change discovery at different spatial reaches.

Pretty (2008) discussed agricultural sustainability its concept and evidences. The great progress in agricultural and livestock productivity and its determined by highly utilize of fertilizers, irrigation, pesticides and equipment; it would be over optimistic. The present study used new approach to integrate biological and ecological processes. Agro-ecosystems are significantly more basic than ordinary ecosystems and defeat of biological variety that develops crop and farm animals output resulted in the failure of various ecosystem services like nuisance and illness control. This study suggests management of agro ecosystem nutrient cycling and scheme pliability must lead to decorate of productivity in context of sustainability. This is also argued that farmers practicing additional sustainable agro ecosystems were internalizing a lot of agricultural externalities connected with exhaustive agricultural and therefore can be rewarded for efficiently as long as environmental produce and services.

Studies Related to Land use / Land cover, Temporal Changes

Maric, Ivan and Šiljeg (2019) carried out planning for agricultural land use and their management have seen numerous adjustments in previous not many years dependent on multiplication of cutting edge geo-spatial technologies. Such as, one of the novel regions with escalated use of geo-realistic systems with integrated tools is called precise agriculture. With advancement of satellite route and the likelihood to screen agricultural apparatus procedure on the surface, the precise agriculture turns into an instrument for the decline of farming hardware expenses, sustainable farming land, decrease of natural contamination due to agro-synthetics, superior utilize of water assets and bringing down of food costs and. Ranchers in created nations as of now consistently apply precise agriculture because of its various advantages. The objective of this study is showed potential outcomes of applying geo-informatics tools in the improvement of the main period of the precise agriculture framework for the farming home "Bastica" in Croatia. Yield production can be utilized in different pieces of the Western Balkan locale in which agriculture assumes a significant monetary job.

Shanwad, and Patil (2012) assumes a significant function in the financial improvement of Sedam Taluk of Northern Karnataka. Almost 80 percent of the absolute region is useable for cultivation and 76 percent of complete populace is occupied with various farming exercises. Ranchers are reaping solitary crop in cropping year. Portrayal and investigation of watershed was done adopted IRS (PAN) and LISS-III (combined information), and SOI topographical sheets. Geo-referring of the images information and planning of various topical themes such as landuse / land cover, soil, waste, incline and so on were done using assistance of software (ERDAS Imagine and ArcGIS) programming. The consequences of the investigation uncovered that convenient is adequate degree for water collecting structures and soil preservation rehearses in watershed. The farming resource plan incorporates arrangement of substitute landuse rehearses like agriculture, agro-cultivation, agro-ranger service, feed and fuel and dryland cultivation. Information inferred regarding common resources and its geographic circulation was integrated by way of financial information to create resources activity plans.

Sood (2009) a remote sensing-based methodology was practical to examine the effect of changes in cropping framework on the abuse of water assets in two locale specifically Ludhiana in focal Punjab and Muktsar in south-western Punjab. Rice–wheat stayed predominant revolution in Ludhiana as cotton-wheat pivot was supplanted somewhat by rice-wheat in Muktsar inside a range of more than five years from 1998–99 to 2003–04. The performance rice-wheat framework in Ludhiana area has brought about enormous scope underground water misuse as is apparent from the quicker decrease in water table (0.9m) and upper tube-wells thickness (440 for every 1000 ha). Subsequently, almost 60% of the absolute region of Ludhiana region had the underground water depth profundity more noteworthy than 10m and in certain squares, it has reached to a profundity of 22 metre while Muktsar region, comparing ascend in water depth status is 0.2 metre every year and cylinder well thickness is 114 for each 1000 ha. Water system water related with rice development in Ludhiana with bordering zones falling horizontally during the covered paleo-directs of Sutlej profound soil outline and gets collected in the bowl grounds of Muktsar adjacent abutting territories and creates an additional water motion and ensuing ascent in water table depth status, founded at 3 to 7 metre profundity. To limit the hydrological unevenness of Punjab that is proposed to broaden a portion to the territory in focal areas from water concentrated paddy-wheat framework to fewer water escalated cropping pattern.

Report published by Global Water Partnership (GWP) and International Network of Basin Organization (INBO) (2009) discussed by incorporated approach for water resource management in river basins. The study carried out number of transboundary basin between different continents using remote sensing and GIS technology. Africa continent having 59, Asia continent having 59, Europe having 69, North America having 40 and South Africa having 38 transboundary basins. The study analyzed about basin management in context of problems and challenges of water resources. The study discussed about the learning by doing management cycle of planning and implementation and key issues of incorporated water resources managing in basin areas and also suggests about the action plans of technical aspects and practical implementation.

Gautam (2004) brought out a comprehensive land use/ land cover categorization criteria for the country adopting remote sensing satellite data. This classification is easy to understand and covers the concept and the need for land use / land cover theme along with criteria of classification system for mapping the different classes of landuse and land cover at different levels.

Rao, Kumar, Roa and Roa (2003) discussed assessment of land use pattern and geomorphological units of Visakhapatanam urban and industrial region adopting IRS with SPOT satellite images. The geomorphological unit like structure, alluvial and coastal landforms was recognized after due field confirmation. Further, the study of land use pattern was highly relevant and useful for urban, manufacturing and underground water resources assessment in the relations of quick industrial and urbanization progress.

Jayakumar and Arockiassmy (2003) discussed mapping of landuse and land cover and temporal examination in Koli hill area of Eastern Ghats, Tamilnadu adopting remote sensing images. The present study shows that high resolution images (IRS series

LISS-III) based landuse and land cover mapping is especially effective and provide accurate spatial information based on variations in landuse / land cover for number of corrective actions were incorporated that were necessary for most favourable and sustainable uses of land resources.

Hamsen and Nidhumolu (2002) observed landuse preparation for sustainable progress in India adopting Integrated Mission for Sustainable Development project. Methodology adopted in IMSD used under broad definition of land use planning and it prominence have been on preservation of land & water resources. Main purpose is to produce action plan at large scale for water and land resources improvement to be used at micro level. Spatial data base related to land use, soil, hydro-geomorphology, slope, underground water scenario, climate, rainfall, watershed, surface water sources, drainage had been identified by satellite images and conservative methods adopting GIS knowledge, the resource themes are integrated and resulted for received at supervision and action strategy for land and water resources. Author explained feasible constraints and problems of the study and provided suggestion for upgrading of the approach.

Sahu, Pradhan, Mishra and Sundram (2002) have attempted for monitoring the status of different landuse and land cover pattern of Visakhapatanam district of Andhra Pradesh, using IRS-ID (LISS-III) images along toposheets of Survey of India (SOI) and revealed that about 59% of total geographical area of district was used as cropland.

Nagaraju, Poddar, Srivastva and Saxena (2002) carried out the analysis to differentiate and assess land resources of Nanda Khairi watershed in Nagpur, Maharashtra. They discussed for their susceptibility to erosion of soil through geospatial methodology. This study was discussed out with objective to prepare the physiography & soil map with landuse and land cover mapping of the region using LISS-III satellite database. The slope was calculated with facilitate of Survey of India toposheets to characterize, categorize and soils map taking place in special physiographic divisions. The map of soil erosion for the area was organized using universal soil loss equation.

Nagaraja (2002) carried out survey on district level land use/ land cover investigation of 15 agro climatic zones used and it was completed in 1988-89 using IRS-IA, LISS-I data set of Kharif & Rabi season data. This was done on the demand of Planning Commission of India. The requirement for know the real agricultural cropping area.

Rout, Parida and Behra (2000) had categorised the landuse and land cover monitoring of Delhi with nearby NCR area. He used digital image classification that has show 11 classes. It has approved that DIP technique is extremely trustworthy instrument for landuse and land cover categorization in relation to other conservative techniques of survey.

Venkatesan and Manavalan (2000) explained about satellite data based calculation of landuse / land cover surrounding Kalapakkam nuclear location Digital image processing of LISS-III data are conceded out to obtain details of landuse and land cover. The supervised classification of landuse and land cover images gave essential inputs for recognizing the radiological brunt because of authentication/ accretion of radioactive equipment in casing of fortuitous release.

Chaurasia, Loshali, Dhaliwals, Minakshi, Sharma, Kudhart and Tiwari (1996) take-up landuse trajectories examination for agricultural land use managing in Talwandi Sabo region of Punjab adopting multi date remotely sensed mages and completed farming area is declining at the price of random expansion of built up area.

Hooda, Manchanda and Sharma (1992) have digitally classified IRS, LISS-I images for mapping of landuse and land cover of the whole Haryana and prepared maps on 1250,000 scales. Authors finished that net-cropped region are the highest in Jind that is 91.45 percent and lowest in Ambala where net area beneath ground water bodies Ahuja, Manchanda, Sangwan, Goyal and Aggarwal (1992) discussed physiography and soils map by visual explanation of LISS-II satellite data of Bhiwani district. These maps were used as base line information for preparation of action plan for drought management.

Roy and Das (1991) dealt with mapping of forest cover monitoring in Karbi Anglong as well as North Cachar hills region of Assam state by Landsat Multi Spectral Scanner digital image. The categorization precision achieved in study reveals that maps could be dependable on spectral signature.

Narayan, Rao and Gautam (1989) worked on 329 million ha area of Indian Territory with Landsat MSS satellite data on the scale of one ratio ten Lac. They classified wasteland as gullied, salt affected, waterlogged or marshy waterlogged area, rolling upland, land with or without scrub, jhuming or non vegetative forest cover area, sand dunes of desert and coastal sands, barren rocky and area under glacier. The interpretation methodology was depended on concentrated ground observation data with basic awareness of study area. The accuracy of eighty percent to ninety percent has been founded in the recognition wastelands mapping at what time the ground verification when compared.

Gosh (1987) have studied the environment impact of mining in Jharia coal field covering area of 450 square kilometres and demonstrated the importance of remote sensing approches in landuse and land cover study.

Karale, Sheshagiri, Venketaratanam, Malleshwara, and Rao (1985) carried out digital and visual investigation of Landsat images for soil and landuse / land cover monitoring. FCC with linear stretching showed better results as disposition of soil and land use features were better as compared to raw FCC and band ratio products.

Ahuja, Singh and Goyal (1985) used Land sat imagery and aerial photos to map soil of Chautang River of Haryana and delineated the area physiographically with different soils classes using visual image interpretation techniques.

Studies Related to Managgement of Land and Water Resources

Kumari, Sheetal and Biswas (2019) examined the land resource assume an exceptionally indispensable part for the success of any district and its important turn of events and management involves extraordinary worry to the individuals. Appropriate use of land resources to satisfy the prerequisites and expanding request of developing populace is essential. This study highlighted the conceptional incorporation of land resource managing concerning to the activity research program for various sort of agricultural practices of Keolari Block of Seoni District of Madhya Pradesh. Sentinel, Cartosat DEM and Survey of India geographical guide and important optional information were utilized for the investigation territory. Geo-informatics demonstrates as a gainful device for the advancement of consumer inviting for the investigation of soil resources and their properly executive. The activity plan map recommends reasonable land location for different kind of farming counting twofold cropping, agro forestry, agro-cultivation and dry land agriculture. The whole investigation was characterized five classifications profoundly appropriate, exceptionally reasonable, tolerably appropriate, least reasonable and not appropriate. Zone measurement has been produced for various kinds of agriculture rehearse. Usage of the recommended activity plan has been prompt sustainable improvement of the land resources.

Izakovicova (2018) the study presented the integrated way to deal with sustainable management of landuse dependent on the appraisal of landuse and associated land cover trajectories. Landuse changes are adapted by human being exercises creating changes in landscape cover and starting cycles which reason numerous ecological issues that is along these lines critical to decide the drivers and causality of site changes that would after that be able to be invalidated to guarantee management of sustainable landuse. The incorporated landscape investigate approach depends on considerate landscape as a geo-environment with natural, person, social, and verifiable possible. Our point is to characterize the parts of landuse supervision that can direct social turn of events. The proposition for ideal landuse depends on communication among natural assets, spoken to by the gracefully of natural territorial assets and ecological situation just as request spoke to by network requirement for improvement. The contention among the flexibly of natural assets and requests missing appreciation for landscape assets is a significant deciding variable in ecological and human issues. The integrated methodology is determined on reasonable usage of the normal and social verifiable assets, metropolitan turn of events and end of present ecological and financial issues just as the avoidance of novel ones. Multi-measures examination is needed for last ecological dynamic.

Kamble and Chavan (2018) concluded sustainability of Indian agriculture challenges and opportunities. More than half of the population is based on agriculture. It is most important private business in India providing income and employment opportunities.

To examine the current situation of India agriculture at various dimension need to be identified the existing challenges before Indian agriculture sector. The sustainable agriculture development is only way to bypass this problem and further development of production, productivity and profitability of marginal farmers.

Wang, Mang, Cai, Liu, Zhang, Wang and Innes (2016) carried out watershed management is an ever-advancing work on including the management of terrain, water and different assets in a characterized region for environmental, social, and financial issues. In present study, we investigate the accompanying inquiries: What novel apparatuses are accessible with how might they integrated interested in sustainable management of watershed? To tackle these inquiries, they talk about the way toward creating integrated watershed managing procedures for consolidation of versatile management strategies and customary environmental information. They concentrate on the various advantages from reconciliation athwart disciplines and jurisdictional limits, just as joining of mechanical progressions for example, far off detecting, GIS, large information, and staggered social-environmental frameworks investigation, into watershed management procedures. They use three contextual investigations from Canada, Europe and China to survey the achievement and disappointment of integrated watershed managing in tending to various environmental, social, and financial problems in geologically different areas. They close by featuring that upcoming management of watershed should represent environmental change impacts by utilizing innovative headways and comprehensive, cross-disciplinary ways to deal with guarantee watersheds keep on serving their biological, social, and financial capacities. We present three contextual investigations in this paper as an important asset for researchers, asset directors, government offices and different partners planning to improve integrated watershed management systems and all the more proficiently and effectively accomplish natural and financial management destinations.

Report published by High Level panel of expert on Food Security and Nutrition (HLPE) (2016) discussed development of sustainable agricultural based on food safety and nutrition. This study also discuss the role of livestock sector in agricultural development and farming system also include smallholders varied farming system, rustic systems, profitable grazing system, concentrated livestock system and plant based system. The report also analyzed the challenges of intensive livestock farming and discussed environmental, health, social and economic challenges. The author concluded that impacts of demographic changes and economic growth on food security and nutrition. The author suggested the solution for sustainable agricultural development which role and limits of the market, diversification and integration of agriculture and increase the institutions related to agriculture.

Singh and Parihar (2015) carried out challenges of sustainable development in India. Main objective of present study the issues and challenges with status of agriculture sector and trends and to identify the impact of economic reform on Indian agriculture in context to the sustainable agricultural growth. They decided sustainable development on the basis of ecological sustainability, economic sustainability and social sustainability. They find out agricultural production in India under different milestones such as green revolution, ever green revolution, white and yellow revolution, blue revolution and bio technological revolution. They analyzed that new economic policies in 1991 stressed both external and internal reforms. External reforms include the exchange rate, foreign investment, trades and internal reform in area of policies of industrialization, prices, sharing controls and financial reformation in both public and financial sector must decide the future prospect and solution for sustainable agriculture in India.

Arya, Hooda, Dhankar, Kumar, Darshna and Shashikant (2015) developed sustainable land use plan on 1:50000 scale for Jhajjar district of Haryana using LISS- III satellite data. Author used integrated methodology with remote sensing techniques for progress of land use plan on the basis of soils, physiography and ground water depth, quality and land use.

Machender, Ganaboina and Madhu (2014) discussed that sustainable agriculture is the demonstration of cultivating using standards of nature, the investigation of connections among living beings and their current circumstance. Sustainable cultivation fulfil our food, fiber needs, upgrade ecological superiority and the characteristic resource dependent on most effective utilization of non-inexhaustible resources which are on ranch resources, maintain the monetary suitability of homestead activities, improve the personal satisfaction for ranchers and civilization in general. Manageability can be perceived as an ecosystem way to deal with agriculture. Ideal landuse surmises that the most effective utilize of the resource has been resolved based on overviews identifying with land ability and technology of creation and the arrangement outline work has been coordinated to the point that land is actually used for the reason for which it is generally appropriate on sustainable premise. A landuse preparation model has consider the components identifying with the restriction of our resources, its creation abilities and different results of land which the nation will require as far as food crops, fiber, business plantations, green grub, fuel, backwoods cover, and mechanical crude material.

Report published by United Nation Development Programme (2012) entitled "International Guidebook for Environmental Finance Tools: A sectoral approach" studied different case studies in Morocco, Uganda, Peru, Tanzania, Kenya, Philippines, Cambodia, Senegal, Tunisia and China on sustainable agricultural. They analyzed that risky nature of agricultures the main reason of investor and financial institutions not to take interest in investment. There is a urgent need to convert the traditional subsidy model into sustainable agriculture.

Organization for Economic Co-operation and Development (2010) published report on sustainable management of water resources in Agriculture. The study led to an emerging policy approach that derived demand for water on economic, environmental and social dimension. Main objectives of present study are to set up an extensive plan for sustainable managing of water in cultivation. The study also discussed protect ecosystem on agricultural land and improve the water resource efficiency. The study analyzed that water uses for agriculture for the period 1990-92 to 2002-04 has significant yearly unpredictability in agriculture uses. The OECD tendency in agriculture water utilization highlighted major enlargement in Greece, Korea, New Zealand and Turkey. Agriculture measured for 44 percent of total water utilize on the whole in 2002-04, though for eight OECD nations where irrigated farming is significant; share was over 55 percent.

Billib, Bardowicks and Arumí (2009) explained incorporated water resources managing for environmentally sound irrigation at the basin level. The state of art on water management method for sustainable irrigation of semi-arid and arid climatic conditions was discussed. The objective of this publication includes chosen case studies of waterless and semiarid parts in the world but main prominence on Latin America. As a result it was concluded that the concept of IWRM has proved to be hard to impose even though IWRM is now a legal necessity in a few Latin American countries with fine for disobedience.

The National Institute of Food and Agriculture (NIFA, 2009) of United States, Department of Agriculture defines the explanation of sustainable farming. According to NIFA the word sustainable farming is defines as an included system of agri practices having potential cites application that will long life convince our needs enhancing environmental resource. Agricultural economy built the most judicious utilization of resources of non renewable and naturally biological cycles that control the sustain of financial feasibility of ranch operations and improve the status of farmer and society.

Ray, Sood, Das, Panigrahy, Sharma and Parihar (2005) used geographical information system and remotely sensed to identify crop diversification on the source of soil and water needs for different type of crops in Punjab and state level spatial database of different agro-physical parameters with agricultural area resulting by remote sensing images and integrated into GIS environment. Through raster based modelling, the suitable zones were identified for practicing cropping systems. It define that southwest Punjab is appropriate for water conserving crops, whereas northeast Punjab having more rainfall area and excessive drainage must growing maize dominated cropping pattern. Rice could be replaced by maize in middle part of Punjab where the underground water level is falling down.

Meenakshi, Sharma, Kaur and Shally (2005) studied land conversion through satellite images in Ludhiana district. The study exposed change analysis in land use and land cover during the time period from 1970 to 2001; which was resulted as effect of variations in cropping pattern. These variations are discussed on the basis from Statistical Abstract of 1969-70, lRS IG (LISS-I) satellite image of March, 2001.

Rockade, Kundal and Joshi made an attempt an action plan for water resources sustainable development of Sasti watershed of Chandrapur district of Maharashtra adopting geo-spatial technology. Based on soil, drainage, geological, geomorphological, land use & landcover, ground water quality maps & ancillary data and water resources development action plan was prepared in GIS environment. The potential sites and status for ground water misuse and water harvesting are recommended in thought different physical and cultural aspects.

Douthwaite, Ekboir, Twomlow and Keatinge (2004) discussed the idea of included natural resources management by developing evaluation model through implications. They studied that due to the green revolution a few b of crops enhance her productivity but in many cases high yield large production gains at the expense of soil degradation, water depletion, unbalanced bio diversity and non-cultivated area. INRM generate a new agricultural research that meets challenges and opportunities created by green revolution. It provides a sustainable management for production, food security, risk aversion, poverty, welfare of future generation and environmental conservation. The present study investigates evaluation process for management of natural resources which is needed to generate and support INRM for farming system research.

Rumikhani and Saifuddin (2004) investigated the water requirements of major crops grown in Wadi Sirhan, north-western part of Saudi Arabia. The study shows that geo informatics is less time consuming and economical useful techniques for crop demarcation, expansion assessment and crop area evaluation along with agro-climatic analysis to grow effective irrigation uses for environmentally sound agriculture in arid zone.

Vries, Acquay, Molden, Scherr, Valentin and Cofie (2003) studied included land and water executive for food and environment safety measures at global level. Main objective of the study is to increase the ability in five areas such as civilizing food safety, mechanisms to lessen scarcity, ecosystem supplies and services, enhanced interaction among theses areas, legal framework. Food security, poverty reduction, environmental security and legal framework are the main key issues the research. They carried out status of ecosystem in 2000 for global level and also discussed the global pattern of degradation of land and water resources. They suggested that food insecurity is closely associated with poverty. Global and national food supplies are reducing and population are continuously increasing. They analyzed that degradation are light in most of Asia but was serious in South Asia. The study also suggests the policies to stimulate environmental and food security on priorities and approaches based.

Verma, Sharma, Patel, Lohsali and Toor (2000) undertook the study of natural resources development and management for sustainable development of Bhikhi block of Mansa district using remote sensing technology. Satellite data along with aerial photograph were visually interpreted for soil and land use maps and ground water map was prepared by collecting water sample randomly from the study area. All the maps were completed using union command resulted with a resources restriction map and generate action plan map for management and conservation of underutilized area for optimal returns on sustainable basis.

Koecny (1999) presented a short history of development of the tool known as a remote sensing and explains the on-going intensive effort of data processing, interpretation by which scientists are converting the data supplied by whole range of satellite and sensors into information. This information is vitally important for sustainable development which aims at ensuring a safe environment, adequate supply of food, water, fuel and clean air. It is concluded that by stressing the need of multiple missions supplying data that can be fed into integrated information systems.

Manchanda, Kundu and Kumar (1999) used digital sensed data (LISS-II) and GIS techniques intended for sustainable development of Hisar-I and Hisar-II blocks were carried out in HARSAC, Hisar (HARSAC/TR/1/99).

Kumar, Arya, Subrahamanyam, Prasad and Pande (1998) used satellite based data in assessment of soils to develop sustainable land use plan of semi arid area of western Haryana. Maps of soils organized 19 mapping divisions that representing soil association at the level of family. Land and soil resource divisions were examined for their appropriateness for cultivation crops.

According to United Nation (2012) sustainable agriculture should include crop production, number of livestock, forest, pisciculture and aquaculture that improve food production, eliminates hungers and it is financially viable while preserving land, plant and water resources, bio diversity and enhancing flexibility to climate change.

Wrachien (2011) has developed land use planning for sustainable agriculture in reference to Italy. According to the authors; environmentally sound use of the soil and water were form of natural land resources management that recreates natural fertilization of soil. In this view, the term "sustainable land use" is more effective than the term sustainable utilization of soil use. Land which is generally stands for a section of the terrain of earth with all the physical, biological and chemical features which affect the use of the land and water resource.

Studies Related to Land Degrdation and Ecological Impacts

Sujatha (2019) carried out land degradation (LD) is one of the most genuine ecological issue prompting transitory or perpetual decrease in the profitable limit of the land and consequently influences the food security. There is a need to restore debased lands to help sustainable food creation. In the current investigation, an endeavor has been settled on to create choice based methodology for activity plan advancement pointed towards accomplishing provincial level LD impartiality in the territory of Telengana using existing Land Use/Land Cover (LU/LC), LD and slant maps arranged at 1:50,000 scale using Resourcesat-1 LISS-III and Cartosat DEM. After effects of the examination uncovered that water disintegration, salt influenced soils and woodland corruption were the significant class of LD book keeping to 87.7%, 5.3% and 3.6% separately of the complete LD region. Various standard sets were produced for each LD class dependent on different land protection rehearses pushed by provincial and global associations. Afforestation/gulley stopping, shape reviewed bunds, grass cover foundation are the significant activity plans prescribed to decrease the loss of land because of water disintegration and woods debasement.

Reception of such exercises may help re-establishing 76.4% of the territory under LD in the investigation district.

Studies Related to Socio- economic Aspects

Kumar, Vivek and Agrawal (2019) discussed about the urbanization are happening by a quick rate in India. Populace dwelling in metropolitan territories were 11.4 percent as per the Census of India, 1901. This rate has progressively expanded to 31.16 percent as per the Census of India, 2011. The target of that study is to recognize the adjustments in the farming land and its transformation into other landuse categories. To accomplish this target, planning of landuse changes is finished by using geo-informatics tools. This investigation uses satellite pictures alongside field overview and measurable information to distinguish the difference in cultivating land into other LULC category in various tehsils of Allahabad locale. This investigation is done throughout the instance frame of 18 years that goes from 2000 to 2018. This job gives the aspect of development and reduction of farming and open terrain at tehsil level. Landsat images were used in present work that is open access. Landsat pictures of study time for example during 2000 to 2018 are downloaded and afterward pre processed. The preparation tests are gathered among the assistance of ground fact of data. Therefore, distinguishing proof of landuse changes was completed. This would discover the LULC category that is essential answerable for the reduction of farming land. This spatio-fleeting and measurable examination effort has assist with building a support for a sustainable advancement model.

Studies Related to Assesment, Management and Planning of Natural Resources

Sarmah, Kalyanjit and Deka (2018) examined the Decision Support Systems (DSS) give a structure to reconciliation, management, examination lastly graphical introduction of a specific wonders to improve the current dynamic cycle. In the current day setting, the choice emotionally supportive network idea has been reached out to the geographic measurement by incorporating geo-spatial technology. Because of the absence of program to create user well disposed interfaces previously. Rather GIS had been adopted to create and record ground information which was used as contributions for the scientific or manual measurable models. Mainly, GIS autonomously to show maps with contributing consequences of the explanatory models. In the midst of the progressing time a significant part of the examination has been complete on the utilize of GIS in the representation of the consequences of the systematic models. Creating of abuser invites different graphical interface of fusing explanatory model of Geospatial technology that shows the dynamic regions in advanced agricultural management framework. Mechanical or accuracy cultivating, a mix of GIS, GPS collectors, consistent yield sensors, geo-statistics and uneven rate tools is a creative way to deal with training of sustainable farming. The different SDSS utilities examined in this study were management of watershed, crop profitability and strategy choice investigation.

Studies Related to Management of Water Reource

Reddy, Obi and Ramamurthy (2018) discussed the planning of land use is the efficient appraisal of land prospective, options for landuse monetary and social conditions to choose and receive the most excellent landuse choices to accomplish quickened development by sensible supervision of land and water resources. Advance geospatial instruments such as remote sensing, geographic data framework (GIS), and worldwide situating framework (GPS) can be viably utilized in land resource planning and farming land use planning. The reconciliation of geographical information and its consolidated examination can be performed by GIS and basic information base question frameworks to complex investigation and choice emotionally supportive networks for successful management of land resource. The extension and expected uses of geo-spatial tools in stock, planning and supervision of land resources, farming resources overviews, land corruption planning & appraisal, soil dampness assessment, soil fruitfulness planning and appraisal, crop grounds assessment, crop output anticipating, water resources development and administration, improvement of sol resource data framework, advancement of choice emotionally supportive networks, land assessment, crop appropriateness assessment, accuracy agriculture, portrayal of land organization units, improvement of landuse alternatives and potential viewpoints for sustainable landuse development was quickly talked about in the section.

Balasubramani (2018) present investigation exhibits the utilization of geo-spatial tools to assess actual property of semi parched watersheds and discussed a far reaching strategy pertinent somewhere else. The chose Andipatti watershed, situated in Theni area in Tamilnadu also known for agricultural exercises; notwithstanding, heedless arrangement, supervision rehearses and lacking ventures bring about land and water resource debasement. As vast majority of the farming lands in non-industrial nations were like these situation, current investigation is endeavoured as a container to build up a system to survey the soil and water resources prospective, usage intensity and ground reasonableness for farming; and to develop better supervision procedures. The actual attributes of the watershed was contemplated dependent on in order to remotely detected and auxiliary information sources. Topical themes were produced with remote sensing, picture preparing by GIS methods. To portray and evaluate the watershed dependent on soil disintegration and exterior overflow rates, the updated all inclusive soil misfortune condition (RUSLE) and common resources preservation administrations bend number (NRCS-CN) were used.

Kingra, Pavneet and Majumder (2016) examined that agricultural creation systems are profoundly defenceless against varieties in atmosphere, soil and geology of various areas. The serious methods similar to geo-informatics tools can be of incredible use for their assessment and management. Geo-informatics have complex utilization in farming together with crop segregation, crop development checking, crop stock, soil dampness assessment, calculation of crop evapo-happening, site-explicit management, crop land assessment and yield expectation. Opportune and dependable in order on crop land, development situation and yield assessment can be exceptionally useful to the makers, directors and strategy planners for captivating strategic choices with respect to food security, trade and financial effect. Geo-informatics can likewise used viably in land use investigation just as harm appraisal because of dry spell, floods and other extraordinary climate functions An endeavour has been made in the current examination to audit, dissect and assess the most recent information with respect to the utilization of distant sensing methods used for crop observing, crop situation evaluation and output assessment for manageability of cultivation.

Singha (2016) studied land appropriateness concentrate for farming is a significant method in choosing upcoming farming cropping example, arranging and exercises. Terrain reasonableness examination is an evaluation of a region to decide how legitimate or fitting it is for a specific utilization of land in a specific area. Land reasonableness devices had been broadly practical to distinguish improved administration rehearses in farming zones. Soil and scene merits are basic in sort of assessment, actuality that makes particularly intriguing. The reconciliation of RS, GIS, Fuzzy-rationale and utilization of Multi-Criteria assessment utilizing Analytical Hierarchy Process can give a prevalent information base and lead map for chiefs allowing for crop land replacement so as to accomplish better farming creation. A survey was done for various multi criteria examinations to create land reasonableness maps. Fluffy rationale incorporated with Multi-Criteria Evaluation in GIS climate discovered generally appropriate for agricultural crops.

Studies Related to Mapping and Management of Wastelands

Mahdi Saghafi (2017) studies the utilities of remote sensing for mapping salt-affected areas adopting field survey data methods for Kaji Playa lake regions located at South Khorasan province in east of Iran. The fieldwork of the studied area was carried out by soil sample analysis and multi-temporal analysis of Landsat ETM+ data. The fieldwork included measuring the soil salinity and gathering the ground truth for image classification. Field investigations and 31 soil samples collections were carried out and analyzed the values of EC (Electric conductivity/ micromhos per cm) for the bare soil of the plain unit. He resulted that an area with high raster value or high reflectance was delineated as an area affected by salinity problem. Once the areas having high reflectance value were identified, the level of the salinity was determined based on their reflectance value. In the NDSI image, the salt-affected areas are depicted in gray color and can roughly.

Arya, Hooda, Kumar, Ompal and Singh (2014) studied management and mapping of waterlogging and soil salinity in Central Haryana using Geo-informatics and carried out waterlogged and salt affected regions of Central Haryana using LISS-IV, Carto Sat and Radarsat satellite data for the year 2010-11 for rabi and kharif season. Area under different waterlogged and salt affected classes is 109.55 and 63.21 square kilometre respectively. They also developed action plan map and decision support system for waterlogged and salt affected area in relation to the sustainability of environmentally sound agricultural practices.

Arya, Kumar, Arya, Singh and Hooda (2015) carried out change analysis of wastelands in Hisar, Haryana adopting Indian Remote Sensing LISS-III satellite images. They used the visual image interpretation technique. 132.89 sq. km. area was identified under different categories of wastelands that were 3.34 percent of the whole area of district.

Arya, Kumar, Singh, Kumar, Hooda and Arya (2014) carried out change analysis of wastelands with the help of multi-temporal satellite data in waterless zone of Haryana carried out change analysis of wastelands in arid zone (Bhiwani, Rewari, Mahenderagarh & Mewat district of Haryana. Area under waterlogged and marshy land- permanent class is 9.07 sq. km & area under waterlogged and marshy land-permanent is 5.92 sq. km in arid zone of Haryana.

Hooda et al. (2012) carried out all wastelands of Haryana including salt affected area using Indian Remote Sensing LISS-III satellite images. He had used on screen digitization technique for the identification of various types of wastelands using Arc GIS Desktop software. Area under land affected by salinity or alkalinity (moderate) is 66.20 sq. km and area under land affected by salinity or alkalinity (strong) is 19.76 sq. km in Haryana state (HARSAC/TR/03/12).

Hooda et al. (2011) carried out all wastelands of Haryana including waterlogged area using LISS-III satellite data of 2008-09 (both rabi & kharif season). Area under waterlogged and marshy land- permanent class is 18.35 sq. km & area under waterlogged and marshy land- permanent is 30.46 sq. km in Haryana.

Choubey (1997) discussed multi dated IRS, LISS-I satellite images of the year 1988 for delineation of land use and drainage network map with waterlogged area. He also demarcated sensitive area to waterlogging for Tawa river command region of Madhya Pradesh. The resulted that proved with water table depth information and highlighted that 80 square kilometres were affected by the problem of waterlogging and 140 square kilometres area were perceptive to waterlogging in which area the water table is between 0 and 3 meter. Water table could not be identified direct through satellite data clarification, the useable integrative display can crop pressure because to very high water table prone area.

Kalra and Joshi (1997) analyzed Landsat TM & MSS, SPOT and IRS satellite images of April and May months (zaid season), January and February (Rabi season), October (Kharif season) and resulted the potential of multi sensor images for identification of saline soils in arid region of Rajasthan. Images of summer season suggested the highest amount of saline soil. Salinity of soils are mainly due to salty water irrigation and sodic soils due to Residual Sodium Carbonate (RSC). A unusual pattern and tone might be mapping independently by using images of irrigated season or rabi season attached by information of the superiority of water that were used for irrigation. The demarcations among the saline and sodic soils were feasible by the employ of multi season satellite data and the hint given by the crops.

Singh (1994) used Landsat TM and aerial photos images to check the variations in the position of salt affected land of Kanpur region of Uttar Pradesh. During the study satellite images are inflamed on the 1:50000 scales were examined by image enhancement elements to demarcate the salt affected soil. On the basis of colour combination, two types of salt affected soils like highly and moderately saline soil can be illustrious. Strictly saline soils and salt efflorescence on the plain emerge as white tone in that area moderately saline soil seen bluish light green tone.

Rao and Venkataratnam (1991) discussed Landsat satellite data and demarcated highly sodic soils appears as bright white tone having texture as fine while moderately sodic soils appears as lightly white color to dark brown color. They also discussed terrestrial covered with salts adopting remote sensing and also recognized to uncertainty in comparison to slightly saline and non saline soil.

Venkataratnam and Rao (1991) used the spectral approach for demarcation of salt affected soil of Indo Gangetic alluvial plain that analyzed as salt affected soil analyzed to usual sown area. They also discussed comparatively superior spectral reaction in visible & NIR bands. Again highly saline sodic soil was located to have superior spectral reaction as analyzed to moderately saline sodic soil. The vegetative area spoiled the whole spectral reaction outline of salt affected soil particularly in the green and red spectral bands.

Johnston and Barson (1990) discussed distant sensing trajectories in Australia and resulted which unfairness of saline soil was mainly throughout peak vegetative cover.

As per temporal analysis periods the low incomplete vegetation area of salt not identified from areas which WA snaked due to erosion, overgrazing and high ploughing. Another, Sedaris also discussed (1991) that soil salinity was articulated at the last of the rainy or season irrigation when the lands are under fallow or totally bare.

Venkataratnam (1983) discussed temporal Landsat MSS satellite data for mapping of soil salinity in pre and post monsoon in the Punjab State. They completed that the curves of spectral of high and moderately saline soil variation significantly all through the yearly cycle which considerably complicates temporal concerto practice.

and Curtis (1976) find out development of stream in context to stream length, network and the site of water bodies have been mapped from Landsat Multi Spectral Sensor. GIS suggest apparatus for demarcating the problem of waterlogging and drainage. The characteristics in a drainage basin moreover the in sequence on high morphology, occurrence of upper water table status, soil texture and plant anxiety.

Reddy and Obi (2018) investigated watershed as a geo-hydrological region that channels to a typical direct and is measured as a fitting actual unit for characteristic resources assessment, arrangement and supervision. Watershed management infers the level headed usage of soil and water resources in favour of ideal creation among least risk to regular habitat. Watershed prioritization is main part of planning for executions of its turn of events and organization programs. Geo-spatial instruments could be adequately utilized in different parts of incorporated watershed management that incorporates territory investigation, land resource stock, evaluation of soil disintegration, prioritization of watershed, appraisal of land capacity and irrigability, arrangement of landuse and distinguish the basic zones for dealing inside the watershed in favour of arrangement and execution of watershed action plan. Collaboration of geospatial technologies permit to create and get to active geospatial watershed data devoid of troubling the users through convoluted and costly programming. Participatory observing and assessment necessity be a vital piece of integrated watershed management.

Balasubramani (2016) evaluate since watershed is an ideal and proficient unit for planning and execution for characteristic resource management program, the current investigation expectations to survey water and terrain resources of watershed of Andipatti for drawing sustainable advancement plans by applying geospatial technologies. Andipatti watershed, which lies in Theni District of Tamil Nadu, is depleted by fleeting feeders of stream Vaigai. About 65% zone of the watershed is used for agricultural purposes, particularly for inundated agriculture (40%). The watershed falls under semi-dry climatic conditions. Since the potential evapotranspiration is consistently more prominent than precipitation (79 cm) for maximum time of the year, the watershed encounters an intense water shortfall (140.5 cm). Because of this, the watershed is much of the time confronted with crop disappointments, at whatever point the precipitation is beneath ordinary. The normal vegetation and agricultural crops everywhere on the watershed need to rely upon earth water sources to repay the water shortage.

Fullen (2011) carried out utilizing biological geo-textiles discussed with Borassus Project and its world level perspectives to contribute in sustainable development and soil conservation Biological geotextiles furnish considerable potential. They analyzed efficiently and economically conserve soil in developing countries that provides evidences in this special issue which sponsor sustainable and environmental sociable agriculture and labour-intensive service. Native plants, leaf fiber or stems have probable method as a soil protection.

Grigg (2008) described the complexity of water decisions and the importance of balancing stakeholder viewpoints. He presented idea how it purpose could be advanced in all countries. In this article, he gave example Latin America for IWRM, where river basin administration was being implemented inside the situation of national IWRM requirement. He offered the element for combination in different category; strategy sector, water sector, administration units, managerial levels, functions of administration discipline and professions, spatial units and parts of supervision.

Jain, Rahore and Sharma (2004) discussed remote sensing and GIS utilities in monitoring & managing of ground water particularly about flood plain management, mapping & management of watersheds, water logging & soil salinity, snow cover monitoring sedimentation of reservoirs etc. Authors concluded that a combination of remote sensing data and powerful software such as GIS gives the water resources managers extremely efficient tool to solve their problems.

Saroha, Chaudhary and Prasad (2003) used remote sensing and GIS methodologies in management of natural resources in Gurgaon district of Haryana state adopting remote sensing images collected information was generated on land use / land cover, geomorphological study, soils, underground water etc. These data were combined with infrastructural data. From these derived databases on land resources, the land resources development, village and agricultural development plans were formulated.

Sjoblom and Rai (2003) carried out management of natural resource in India on the basis of linkage between poverty and natural resource management. They suggested policy and programme for forest management in Orissa state and water resource management for rural water supply. The study evaluated role of Panchayti Raj institutions in administration of natural resources. Main objective of the study is to recover livelihood and well being of the poor through increased access and better management of forest and water resources. The study also suggested proposed programme options for water conservation and management, rural consumption water and cleanliness, building the capacity and understanding the policies connected to integrated water resources supervision. The study also involved risks and killing factors for management of forest and water resources. Strategies and responses to overcome must be outlined in addition to management of resources.

Ngocdam, Tuan and Hanh (2003) applied GIS technology in land resources evaluation in Nam Dong district, Vietnam. Based on UNESCO-FAO land evaluation methods, author have studied soil properties of landscape and identified 196 land units in the area. A data system and map of land resources of district has been prepared using GIS technology.

Kumar, Dhaimodkar and Pande (2002) prepared physiography and soil map from standard FCC (False colour composite) on 1:50000 scale and 13 units were demarcated representing soil association at family and group level. Land resources were examined for their irrigation suitability and land capability.

Mohamed and Saleh (2014) current investigation targeted based on appraisal of manageability factors for farming use by integrated biophysical, monetary feasibility and social agreeableness in the North Sinai region. Environmentally sound agricultural geographically model was created through ArcGIS-10 to distinguish and group the zone, as indicated by manageability level of agricultural use, where the variables of profitability, security, assurance, monetary feasibility, and societal adequacy in the diverse planning units were evaluated. The explored zone is ordered into three distinct classes 1st and 2nd are canvassed in nearly 7 percent of the absolute zone where ground managing rehearses were barely underneath the edge for supportability situated in the northern piece of the examination territory, where manageability esteems are going somewhere in the range of 0.1 to 0.3. The territories described as class 3 don't convene manageability necessities in which the sustainable qualities <0.1.

Kushwaha, Satya & Mukhopadhyay (2010) investigated exhibits the utilization of geo-informatics for planning of sustainable soil and water wealth improvement activity plans for Pathri Rao sub-watershed of Uttarakhand state. IKONOS satellite symbolisms were utilized for itemized landuse/ land cover planning on scale of 1:12500. Different essential and auxiliary information base layers on land use/cover, woods thickness, biodiversity, incline, viewpoint, height, hydro-geomorphology, soil types, soil erosivity and crop appropriateness were produced. The examination likewise thinks about the social, natural and monetary components. A bunch of choice principles was practical and information themes are incorporated in GIS climate for readiness of the logical and sustainable soil and water resources advancement activity strategy for the investigation region. The activity demonstrated a decent degree with geo-spatial methods in integrated watershed advancement arrangement.

Baneş, Adrian and Orboi (2010) discuss that Sustainable advancement is keeping up a sensitive harmony connecting with human necessitate to get better ways of life and sentiment of prosperity on single hand and safeguarding normal resources and environment, on which we and people in the opportunity depend. GIS can be a significant device for helping individuals map out plans for effectively accomplishing management procedures that are sustainable both at nearby and global levels. any nations, aside from our own, have a wealth of geographic information for investigation. GIS is a key device used in appraisal, prioritization, relief, planning, science and preparing. Monetary imbalance, social flimsiness and natural corruption are normal highlights of unsustainable turn of events. Using GIS in sustainable agriculture can prompt extraordinary advantages; particularly for how they can be seen all the way of life they speak to, the dirt which is substances in the dirt, accessibility of water, crop pivot, bothers.

Latest techniques related to Land and Water resources Management

Reed, Vianen, Deakin, Barlow and Sunderland (2016) carried out incorporated landscape techniques for organization social and ecological issues in tropics. They find out poverty, food security, climate change and loss of bio diversity are the major issues in tropic region. They used historical approach to study from learning stage of past and guide to future. They also discussed the terms recognized throughout appraisal referring for some incorporated landscape approach from 1992 to 2014. They defined landscape method as a structure to mix practices and policies for various competing land uses by execution of adaptive and incorporated supervision. They also discussed five key aspect of effective landscape approach. These aspects are evaluates growth, establish good supremacy evolve from cure-all solutions, engage numerous stockholders and embrace lively processes. The study also found barriers to implement the landscape approach such as time lags, expressions confusions, in service silos, interior and outside appointment and monitoring. The study suggests level of applicability of integrated landscape approach in specific sustainable development goals.

Cooper et al. (2006) discussed tools, methods and approaches of natural resources management. They studied that rainfall pattern and heterogeneous distribution of soil leads to frequent sites and growth of crops in the semi arid tropic environment. Highly-managed natural resources produce flows of reimbursement which give the source for maintain and improve of livelihoods, get better the superiority of living, and supply to sustainable expansion and mitigation of shortage. The study is a package of applications of simulation modeling, climate change and forecasting, strategies of adaptation, financial approaches to secure food, present market scenario and investment decision by farmers. It also analyzed practical bnifits in reproduction modeling for minimization of the probable impacts of natural resource management on resource and ecosystem activities. The utilities of remote sensing and GIS scheme for evaluating biophysical variations were used. The study completed adopting GIS based technology for mapping, modeling, surface water runoff monitoring and exploitation of agricultural fallows.

Baltztimo and Fritch (2002) explained structure of geo-informatics as a tool for environmentally improvement through integrated land use plan of China. Main aims of study for monitoring of containing simplified land use and land cover classes that discuss the landuse planning in simple and explicable mode.

Goossens and Van (1996) studied the commencement and last of the rising seasons in the western delta of Nile river. He completed that only single image can be appropriate for acquiring sternly salinized soil.

Metternicht and Zinck (1996) explained their information connected with land inspection and radiometric dimension in the noticeable and NIR wavelengths as major factors distressing the mineralogy and quantity of salt with wetness of soil, soil color and roughness of terrain which in revolve are proscribed by various grouping of salts, soil texture and natural substance contented. Salts prejudiced terrain features involve the soils with and only slight confirmation of the turnout of salt.

Studies Related to Hydro-geomorphological Studies

Babar (2002) attempted to evaluate the ground water potential of various hydro-geomorphological units of Purna River in Parbani district, Maharashtra, India. The study has revealed that satellite remote sensing is most beneficial advanced scientific tool for hydro-geomorphological studies and delineation of ground water prospect zones. Remote sensing inputs coupled with hydrological data are important component for evaluation of suitable sites for ground water development.

Gwande, Srivastva, and Jeyaram (2002) studied geological, geomorphological, hydro-geomorphological and land use / land cover monitoring for Kamthi and neighbouring region of Nagpur district. On the discussed matter, various land use / land cover, geomorphological and lithological units are delineated and mapped. An stab was also been complete to demarcate the region with orientation to underground water prediction into poor, moderate, very good and excellent underground water prospects zones.

Pandey and Nathawat (2002) discussed the analysis on hydro-geomorphological mapping of Yamunanagar district adopting remote sensing technology; the plan of water resources. Author prepared hydro-geomorphological mapping of area and completed the water harvesting structures delineation adopting satellite data on the scale of 1:50000.

Thakur (2001) has undertaken study on GIS application in Uttar Pradesh Bhumi Sudhar Nigam under this project digitization of cadastral map along with various other formats of database connected to underground water and irrigation was being done and transformed into GIS for land reclamation project.

Report published by International Fund for Agricultural Development (2001) on Environmental and Natural Resources Management discussed about the cause and effect relationship between poverty and environmental degradation. Near about 70 percent rural poverty alleviation project are exited in ecologically fragile and marginal environmental and they were fixed the pattern of depletion in the lack of productive resources. The study analyzed in genetic erosion and land and water resources degradation in South and South East Asia, western and Central Africa, Eastern and Southern Africa, Asia and Pacific, Latin America and Caribbean and North America. The study introduced about the global mechanism to link poverty and environment degradation in the wake of Earth Summit 1992.

Toleti, Rao, Chaudhary, Kumar, Yadav, Singh, and Pandey (2000) have studied underground water resources in Gurgoan region of Haryana adopting geospatial techniques. An integrated map was prepared by over laying ground water quality and hydro-geomorphological map and draping on it depth to water level map in ARC/ info GIS environment.

Thomas, Sharma and Sood (1999) conceded out hydro-geomorphology studies with the help of IRS series LISS-II images and assessment of ground water prediction of hydro-geomorphological unit in the Lehragaga block of Punjab state. The geographic divisions recognized in the area were sand with dunes, alluvial plain, palaeochannels and flood plain of Ghaggar river.

Dutta, Sharma, and Radhakrishnana (1997) studied common land resources planning for Nadot block of Sawai Madhopur. Author organized different maps like slope aspect, hydro-geomorphology, soil drainage with watershed, landuse/ land cover, infrastructural map with villages. GIS based included plan was organized for most favourable land use which includes different actions such as soil & water protection, forest security and plantation, silvi pasture and agro horticulture.

Chaudhary, Kumar, Roy and Ruhal (1996) have studied demarcation of underground water potential areas in Sohna block of Gurugram district of Haryana adopting an integrated approach. Authors discussed an incorporated approach of conservative for underground water probable zone marking out. All these completed by union all different themes; geology, geomorphology, lineament density, underground water depth status of underground water level instability, underground water superiority, density of drainage and slope.

Studies Related to Soil Resources

Manchanda, Kundu and Kumar (1999) used LISS-II remote sensed satellite data with GIS were used for the problems of water and soil resource management in Mewat region of Haryana state. Various resource maps for soils, hydro-geomorphology, underground water, soil salinity and waterlogging were generated. Finally a site definite action plan was generated for environmentally sound and sustainable water / land resources management. (HARSAC/TR/25/99).

Chaudhary, Kundu and Kumar (1999) used geospatial tools for the solution of water and soil resources management in Mewat. Different thematic maps soil, hydro-geomorphology, underground water, soil salinity & waterlogging etc. were generated.

Final place definite action plan was generated for sustainable landuse and water resources progress and executive (HARSAC/TR/25/99).

Mougenot, Pouget and Epema (1993) discussed the explanation on nude soil and not direct on plants studies. Information from visible region of EM spectrum with soil reflectance of salty region was institute to be famous. Middle infrared band detailed information related to moisture exists in soil that were generally connected with salt content. The needs of green vegetation / dotted vegetation or highly saline salt region made it probable to straight notice salt exist on the land. They founded the reflectance in visible and IR bands that gave the individuality of the outside are set up to be various from the cover beneath. Field verification and radiometric properties show that the major factors that affect the reflectance are the amount and salt mineralogy, soil wetness, tone and coarseness. Assessment of soil on earth surface ruins beneath the pressure of outside factors as variation of water table and groundwater quality.

Sehgal, Sharma and Karale (1988) used Landsat images in black and white imagery format to produce soil map of Punjab state. MSS band 284 was interpreted single and combine to outline a compound explanation map. The generalization stage was great group of taxonomy. Soils map revealed that about 33 percent of total area of state Punjab which suffer from different soil problems such as soil salinity & sodicity, waterlogging. These lead to conclusions which for fast as well as accurate high level landuse planning with the use of remotely sensed data.

Moulders (1987) discussed that near infrared and middle infrared band provide sensible information on soil moisture and soil salinity. Steven (1992) also complete this through finding near to middle infrared key was the best sign for chlorosis going on in stressed. This latest relation is resistant to colour combination and suggest an suggestion water potential of leaf.

Baber (1982) resulted out that colour infrared remote sensing can point out drainage troubles by soil moisture infiltration or plant anxiety. Low water tables show signs of unboots in exterior moisture which could be detected from microwave emissivity and visible reflectance.

Studies of Different Institutions

UNEP (2012) this distribution might be replicated in entire or to some degree and structure for instructive or without benefit purposes and uncommon consent to the patent owner gave affirmation of the foundation is finished UNEP will value getting duplicate of some distribution which utilizes this distribution like a source. Denial utilization of the distribution might for some other business reason at all without earlier authorization recorded as a hard copy of UNEP. The assignment of geological elements and introduction of the substance thus, don't infer the declaration of any feeling at all with respect to the distributer or the taking an interest associations regarding the legitimate position of every nation, domain or region or in relation to the delimitation of its limits.

Fuller (2010) This WWF preparation paper features the connections between agriculture, global development and natural frameworks and reacts to expanding interest in agriculture in the development sector. We contend that natural frameworks and biodiversity are the stage for agriculture and we talk about the connections between sustainable agriculture and food security, water security and environmental change. Sustainable agriculture needs latest ways to deal with land and water utilization arranging, boosting the capability of little holders and continuing ecosystem forces that support farming and food safety. This is likewise basic to lecture to indefensible utilization and creation designs. Several food and cultivating procedure ought to at last be founded on making sure about the essential basic liberties of sufficient food and great wellbeing, and on lessening the worldwide ecological effects of the food we create and devour.

Department of agriculture and cooperation ministry of agriculture, New Delhi (2010) have discussed National Mission for Sustainable Agriculture “Differential Vulnerability” of varied agricultural systems and the societies involve a amount of environmental, societal and financial factors. Change in agriculture into an environmentally sound sustainable climate flexible manufacture scheme which seeks to the National Mission for Sustainable Agriculture while at the similar time, over utilization of its highest impending and thereby also ensuring food safety, reasonable admission to food resources.

Merem, Edmund and Twumasi (2008) evaluate that Lagos Metropolis arose as solitary of the top urbanizing urban communities in the West Africa. Without customary utilize of geospatial information supervision systems, restricted exertion had been complete to monitor changes in the indigenous habitat in the quickly developing city for strategy making in land organization. This examination explores the geographical ramifications of the fast growth of metropolitan Lagos for land executive using GIS and remote sensing methods.

Singh (2007) This Report, following a point by point examination of status and management situation of natural assets, weaknesses and strengths of the different projects and the future difficulties and objectives, presents new systems, program mediations and strategy alternatives and activities, and budgetary expenses to be embraced in the XI Plan for natural assets management towards the specified.

Gopalan (2002) carried out study on NRIS (National Resources Information System): vision and missions. NRIS, the program visualized as a broad network of GIS based centres covering resource information in spatial data format. The organization encompasses information on natural resources in context to water, land, forest, mineral and soil with socio economic aspects. The integrated of these set of data would aid the conclusion making for process for the efficient resources utilization for suitable development goal of the nation. The study indicates that NRIS has clearly established possibilities of creating satellite database for selected districts and proved its effectiveness for state level conclusion making.

The United Nations Environment Programme (UNEP, 1992) aggravated worldwide supporting decency on the thought of suitable growth. The continuing global mismanagement of earthly resources raises questions about the best way to present information on natural resource to land use planners and how this knowledge can be put to good use. Agriculture which is the chief source for the most of world must increase dramatically to meet the food gaps being observed.

Jenson and Dominque (1988) discussed to take out topographic construction to outline watershed. The DEM based on computer composed drainage line, polygons of watershed. They also linked four-point information and transferred to spatial or vector based GIS format for additional examination. Evaluation among these computer generated parameters and its manually delineated complement usually indicated shut accord.

Anderson (1977) has developed classification criteria that are frequently a matter of cooperation between the enviable and probable. They also assured that there cannot be a unique common classifications pattern for landuse / land cover monitoring but it must be customized as per to need of users. These could be included on outline developed by them.

Barret Nunnally (1974) demonstrated the use of various images for demarcation of various land use / land cover types. He analyzed that no single land use / land cover classification would be adopted with all types of satellite database on different scale.

Research Gap

Main reason to select the present study area is that there is a lot of variation in Hisar district on available physical resources and cultural resources such as soil, under ground water table depth status, under water quality, physiography, current land use, cropping pattern and crop rotation. On the basis of all these variation Hisar district represents the whole Haryana. Therefore; the present study will be used as a pilot project for the whole Haryana state. The farmers of study area spend a lot on inputs for agricultural production because of not environmentally sound technology. On the other hand the study regarding the problems of waterlogging and soil salinity in study area are continuously increasing and agriculture land is converting into wastelands. Brackish ground water table is constantly rising due to seepage of water through canals, irrigation channels and irrigated fields in the inland drainage basin in the saucer shaped topography of the study area and creating the problems of waterlogging and secondary soil salinization. But the problem related to sustainable agriculture is not taken up by any institute or agencies. Keeping this research gap in mind the present study area was taken up to increase the food grain production for increasing population. Land and water resources have been subjected to great stress and inappropriate land use which has resulted to soils degradation in the district.

CHAPTER-2

BRIEF DESCRIPTION OF THE STUDY AREA

Hisar is short form of Hisar-e-Feroza. Hisar word derived from the unique town that is outcomes from the building of a fort by Feroz Shah Tughlaq in 1354 A.D. The study area has rich Harappan sites of Rakhigarhi, Banawali including Rakhishahpur and Rakhikhas and Siswal. Hisar district of the state was founded by Feroz Shah Tuglak and was made as a move forward fort with four giant gates. It is one of the oldest district of joint Haryana and Punjab. District Hisar is major producer of steel and stainless steel. Detailed of the study area is discussed below.

2.1 LOCATION AND EXTENT

The district's position is 28^{o} 53' 45" to 29 ^{o} 49' 15" north latitude and 75 ^{o} 13' 15" to 76^{o} 18' 15" east longitude with an area of 4170.51 square kilometres. It is surrounded by the Haryana districts of Fatehabad and Jind in the northeast and north respectively. The eastern side shares the Rohtak district's border, while the southern side shares the Haryana district's border with Bhiwani. The western side of the district shares its border with the Rajasthan State district of Hanumangarh. The location map of Hisar district is displayed in Figure-1.

2.2 ADMINISTRATION

The district comes under Hisar division and comprises four sub-divisions, six Tehsils, three Sub Tehsils and nine blocks. Detailed of administrative set up of the district is discussed in Table-1.

Table- 1 Administrative Division of Hisar District

Sr. No.	Sub-Division	Tehsil	Sub Tehsil	Block
1	Hisar	Hisar	Balsamand	Adampur
2	Hansi	Adampur	Uklana Mandi	Hansi
3	Barwala	Hansi	Kheri Jalab	Agroha
4	Narnaud	Narnaund		Uklana
5		Barwala		Barwala
6		Bass		Hansi
7				Hisar-I
8				Hisar-II
9				Narnaund

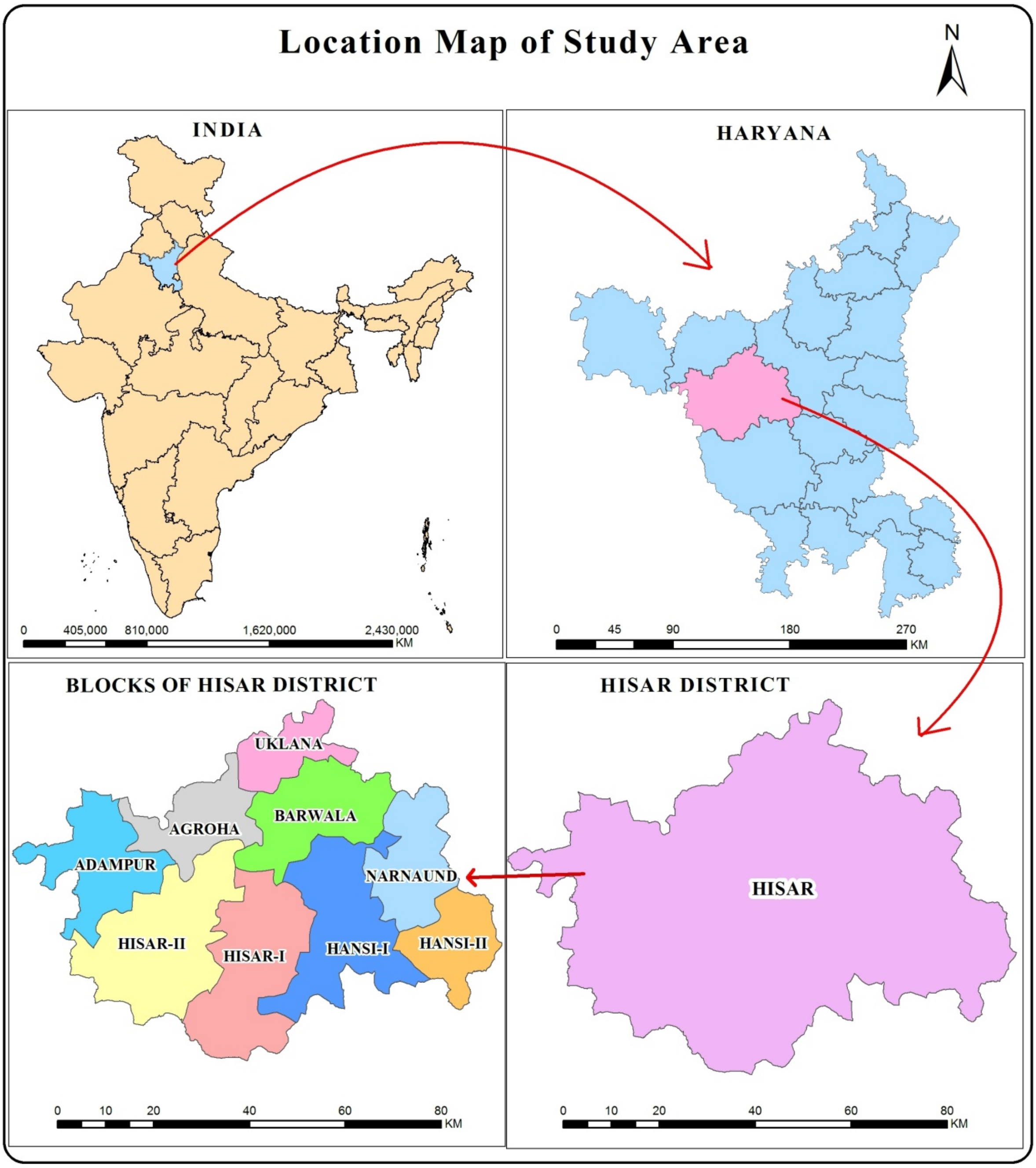


Figure-1

2.3 DEMOGRAPHY

Hisar district is one of the densely populated district of the Haryana. As per Census of India, 2011, the population of the study area was 1743931 from those males and females were 931562 and 812359 persons respectively. The population density is 438 persons per square kilometres. Sex ratio of Hisar district is 872 females per 1000 male while child sex ratio between age group 0 to 6 years is 851 female child as per 1000 male child. Literacy rate of Hisar is 72.89% that was less than the national average of 74.04% and state average 76.6%. On the other hand literacy rate of male is 82.20% and literacy rate of female is 62.25%.

2.4 PHYSIOGRAPHY

Physiographically, the study area consists of alluvial plain, flood plain, aeolian plain and fluvio-aeolian plain in which dune complexes exist. The flood plain which comprises of fluvial deposits has flat to gently sloping strips of land surfaces. This zone demarcates the extent to which water overflows the riverbanks during floods. The fluvio-aeolian plains are spread in western part of the district. This alluvial plain is comparatively low-lying area and occupies major part of the district. It is basically part of Indo-Gangetic plain and created by deposition of sands of river by Sarswati. It is covered by very hard, fine loamy soils and has good ground water potential.

The Aeolian plain comprises sandy plain and scattered dune complexes. These features mainly cover the area adjacent to south western part of the district. Wind action erodes transport and deposit sand particles during long time. The aeolian plains have been further sub divided into plain, very gently undulating dunes and partially stabilized dunes. These dunes are partially stabilized due to human activities and have moderate erosion and are moderately cultivated. These sandy areas are northward extension of sand dunes of Thar Desert of Rajasthan state.

2.5 SLOPE

Slope is an significant parameter from land utilization parameters. It determines overall runoff, land irrigability and land capability. The influence of slope is felt in the form of restraint on cultivation and accessibility. It is very important for plant growth, as it does not only affect the soil formation but also the amount of infiltration. The knowledge and database of slope is of primary concern for landuse planning and policy making. The slope in any area is reflected directly by drainage pattern, density & length, which determine locational suitability of settlement, dam, and reservoirs of all sizes etc. For slope analysis of study area, the Survey of India (SOI) topographical sheets on scales of 1:50,000 having 20 meter interval of contour were used. The general height of the area from mean sea level varies from 203 to 225 metre with a gentle slope towards south western direction. Maximum parts of area the block have nearly level slope class.

2.6 CLIMATE

The climate of the area is famous for its waterlessness and boundaries of hotness with insufficient rainfall and varies arid to semi arid type. It is sub-tropical, monsoonic and continental. The year divided into 4 seasons that are season of cold is followed by season of summer, monsoon and autumn. Sand storms often occur during hot summer season. The incidence of dust storm is highest in June month. The season between July to middle of September is under south west monsoon and from middle September to October constitutes as post monsoon season.

2.6.1. Rainfall: The average annual rainfall in the study area is 307.7 mm that is presented in Table-2. It generally decreases towards north east to south west direction. Near about 65% of the yearly rainfall arrived in rainy season (July to September). Rest of rainfall received in winter season (December to February). In rest of the months, there is no rainfall or a very little rainfall that is because of western disturbances of Mediterranean Sea. There is a lot of variation in annual rainfall among different regions of the study area.

2.6.2 Temperature: There is quick raise in temperature after March. The minimum temperature throughout May and June remains highest and that are hottest month of year. During this period, temperature may raise up to 47^{o} C. Very hot scorching winds are blow in summer season. Pre monsoon in this area arrives in last week of June and there are substantial fall in temperature and the weather became cool during daytime period while nights are warmer than summer season. Because of extra moisture of the monsoon winds nights are often painful. After the arrival of monsoon from the area the temperature begins to falling down. The fall in temperature begins after the month October and rapid drop in night temperature is noteworthy. The winter season is very cool and January is coldest month of year. The long time weather of study area is known as continental type climate. In winter season the study area is affect by cold sea waves and the minimum temperature drops down to about 2 to 3°C occasionally. The irregular fogs also influence the area in cold season.

Table-2 Monthly Average Rainfall in Hisar District

Months	Monthly rainfall average of five Year (2013-2018) in mm	Months	Monthly rainfall average of five Year (2013-2018) in mm
January	4.3	July	55.1
February	13.5	August	75.6
March	3.7	September	71.7
April	7.1	October	2.3
May	18.3	November	4.2
June	29.1	December	7.0
		Total	**291.7**

2.6.3 Humidity: The virtual humidity in early morning usually remains high throughout the monsoon and in the months of non monsoonic (December to February) it is regularly near 70 percent or further. Moisture is reasonably fewer through the respite of the year. Driest region of the district is being in summer period with 30 percent relative humidity in afternoons.

2.6.4 Winds: Winds are usually light in the area among a little intensification strength during monsoon and summer seasons. During the southwest monsoon periods, the winds direction from southwest to west is more ordinary. Easterly and south easterlies wind also rage for few days. During post monsoon season and cold season whilst westerly and south westerlies are more ordinary from southwest or west in early morning time. But summer season winds are frequently from west and north-west directions in the morning.

2.7 SOILS

The main soils in the area varies from loamy to clay loamy in low lying plain, sandy loam to loamy in nearly level plain and sand to loamy sand in aeolian plain. As per the international classification system, these soils area classified into two major orders i.e. Entisols and Inceptisols. The southern part of the district is dotted with sands. The Entisols soils are not fully formed and soils are young that lacks any analytical horizon development and are developed as aeolian and flood plains. The Inceptisols are encountered in alluvial plains. The soils of study area are conventionally discussed as alluvial or aeolian soils which categories under three orders that are Entisols, Inceptisols and Aridisols. Entisols have not fully formed and mature soils which lack any investigative horizon, other than ochricepiped on and developed as flood plains and aeolian part of study area. These soils are classified under Ustipsamments category. These are the majority ordinary soils stirring in the study area that are frequently categories as Haplustepts. Aridisol is typically dry soils that controlled in the south-western and western region of the district that are categories as Camborthids/ Torripsamments. These soils are mainly base saturated, little in electric conductivity and redeemable sodium percentage.

2.8 GEOLOGY

The lndo-Gangetic alluvial plain cover maximum part of the study that is originate from sag of the crust and created contemporaneously with the lift of the Himalayas mountains. These sags or low lying area have been since crammed up by deposits resultant by the rivers & streams of Himalayas mountains and Aravali hills of Pleistocene Era to present. The geology of sub surface region had been a topic of conjecture for extensive instance, as alluvium efficiently conceals the concrete geology floor. The complete of the alluvial relief having relict outlet beds inside which Ghaggar, Drishdawati and Saraswati rivers contain intermittently removed their beds in Holocene Era that protected by aeolian credits in latest past times with mounting dryness. The accurate depth of the alluvium has not well identified but a lot of geophysical and not interest whole data, it differs from 100 meters to 400 meters (Haryana District Gazetteer, Hisar, 2017).

2.9 FLORA & FAUNA

2.9.1 Flora: The district is situated in semi arid region and comprises of xerophytic type of flora. According to recent classification of Forest Survey of India, the forest type in study area comes under tropical thorn forest category. The flora is scanty and sparse and varies according to locality and soil. In moist and irrigated areas common trees are Shisham and Tut. But in sandy area, Jand, Jal, Rohera, Kikar are quite common. Khip and Sarkanda are also frequent in sandy region. The medicinal found in the area are Bansa, Indirain, Aswagandha, Kharnthi, Aak, Bhakra and Datura.

Shrubs found in this area are Hins, Karaunda, Puthanda, Bansa, BaboolKarir etc. The area is facing the problem of complete absence natural forest village common lands and uncultivated fields, tree species are scattered and are of little commercial value. However, these lands have been covered under social forestry but due to overgrazing and unauthorized cutting of trees for fodder and wood these lands have become degraded. With the increase of irrigation and due to land hungriness of Grazing incidence is very heavy in these areas and they are in last stage of retrogression. The village common lands and other lands can be brought under silvi pasture with active cooperation from local rural folks. The social forestry plantation areas are confined along the strips of rail, road, canals and drains vital grasses scattered in the area are Dabh, Dub, Dhaman and Anjan. These are edible fodder grasses which are declining on account of unrestrained grazing grasses in common lands and wastelands are poor in superiority, besides quantitatively also these are inadequate to meet increasing demand fuel the people, such lands are being converted to cultivation.

2.9.2 Fauna: The area is occupied by diverse group of animals, mammals, birds and reptiles. Bander and common languor, Jungle cat, small Indian cinet, the common goose and fox represent the primates. Other small mammals found in the area are Chuchunder, bats, Gilheri, common house rats and Indian hare Chinkara and Black Buck are seen in the region but the digit is very small. Nilgai are common in sandy areas A huge number of pastime birds, birds of economic importance and colourful birds are founded. Out of them some area domestic and found during the year although others are winter visitors. Among pigeons and doves, the Bengal Green Pigeon, Blue Black Pigeon & variety of doves are found in the villages. Dabchik is also a housing bird. Scavenger birds like Kites, Vultures Eagles and Crows etc keep area clear of late animals by feeding on them. A large variety of multi-colored birds add beauty to varied wildife of study area. The national bird of India 'peafowl' is also founded is quite common. Besides, the mammals and birds, the reptiles like a number of snake types, lizards, tortoise, frogs and fishes reside in the area (Hisar District Gazetteer).

2.10 INFRASTRUCTURAL DETAILS

Base map of study area with village boundary with settlements was prepared by collecting the available information from various sources. Most of the linear features were extracted from the topographical sheets. State, district and block boundaries were collected from HARSAC to incorporate in the database. The major infrastructure facilities like transport network, settlements are presented in Figure-2. Study area is a small and relatively isolated residential community. It is commuter settlement with good road & rail links. Total villages are study area is 269 (Statistical Abstract of Haryana, 2016-17). Settlement map of study area with major village name, transport and canal network are displayed in Figure-2.

Transport network is very necessary for linkages to other destination. Expansion of transport facilities helps industrialization and hence enriches social, cultural & political outlook of people of that region. Roads constitute the prime mode of transport besides rail transport in the state. The total road length in Hisar (Statistical Abstract for Road in Haryana, 2016) was 2148 km out of which 243 km is under National Highway, 124 km is under State, 91 km is under Major District road and rest of road length is under village roads or other district roads. There are 2 national highways passing through the study area (NH No 9 and 52). The study area has a good transport network to its adjoining location and to the other state through rail also. All towns and villages are linked to each other and to district headquarter with metalled road. The study area enjoys a good transport system with a quite high frequency of bushes at each location.

2.11 SOCIO ECONOMIC ASPECTS

General scenario

Socio-economic aspect of the area is by product of its location, site, situation, geological structure and available natural resources like soil, forest and water. Development of natural resources be determined by the quality of human resources. Man is also an important resource himself on the earth as well as he is also the dominant utilizer of all other natural resources including biotic and abiotic both. Human interactions with resources over time bring changes in socio-economic conditions. The population, socio-economic structure and natural resources are indissolubly related with scenarios of financial growth and environmental quality. The role of time, space and technology dimension is significant to control large proportion of variations in socio-economic structure of the district. We need to look into broadly demographic features and existing socio-economic situation of the area for environmentally sound development with management of natural resources of any area. To generate action plan for sustainable management of natural resources, the following demographic attributes like existing density, distribution, growth, literacy and working non working population and status of infrastructural facilities like medical educational and transport & communication network have been considered.

The socio-economic profiles of the district were prepared on the source of ancillary data from Census of India 2011 and Statistical Abstract of Haryana (2016-17). As per requirement, these data were processed and put into tabular form that was presented in Table-3. The Hisar City, which is district headquarter of the study area. The administration of town and all its development related works come under municipal committee and state government directly Hisar district administration is concerned.

Table-3 Socio Economic information of Hisar district (2017-18)

Population Density (Per sq. km)	Rural	Urban	Total	Literacy in percentage: Male	Female	Total
	310	3753	438	82.79	62.31	73.24

Size of land Holding (area in hect.)	Below 0.5	0.5-1.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-7.5	7.5-10.0	10.0-20.0	20 & above	Total	Average
	8106	12440	39143	33101	30403	49247	34953	61569	33845	340196	3.25

Total worker (Agriculture) (main+ marginal)	As cultivator			As Agricultural labourer			Industrial workers	Govt. Services & Contract Basis	Agro- Based Industries capacity (in tonn.)	
	Persons	Males	Females	Persons	Males	Females			Capacity of Warehouse	Cold storage
	261120	165785	95335	144213	89883	54330	13,838	23560	441	9

Livestock population	Cattle	Buffaloes	Sheep	Goats	Camels	Total	Poultry
	167573	486057	82098	30959	2836	796810	2372896

Consumption of Fertilizer (in tonnes)	Nitrogenous	Phosphatic	Potassic	Total
	84454	27368	1107	112929

Consumption of Pesticides (in tonnes)	1984-85	1990-91	1995-96	2000-01	2005-06	2010-11	2011-12
	339.77	687.57	604	271	252	420	420

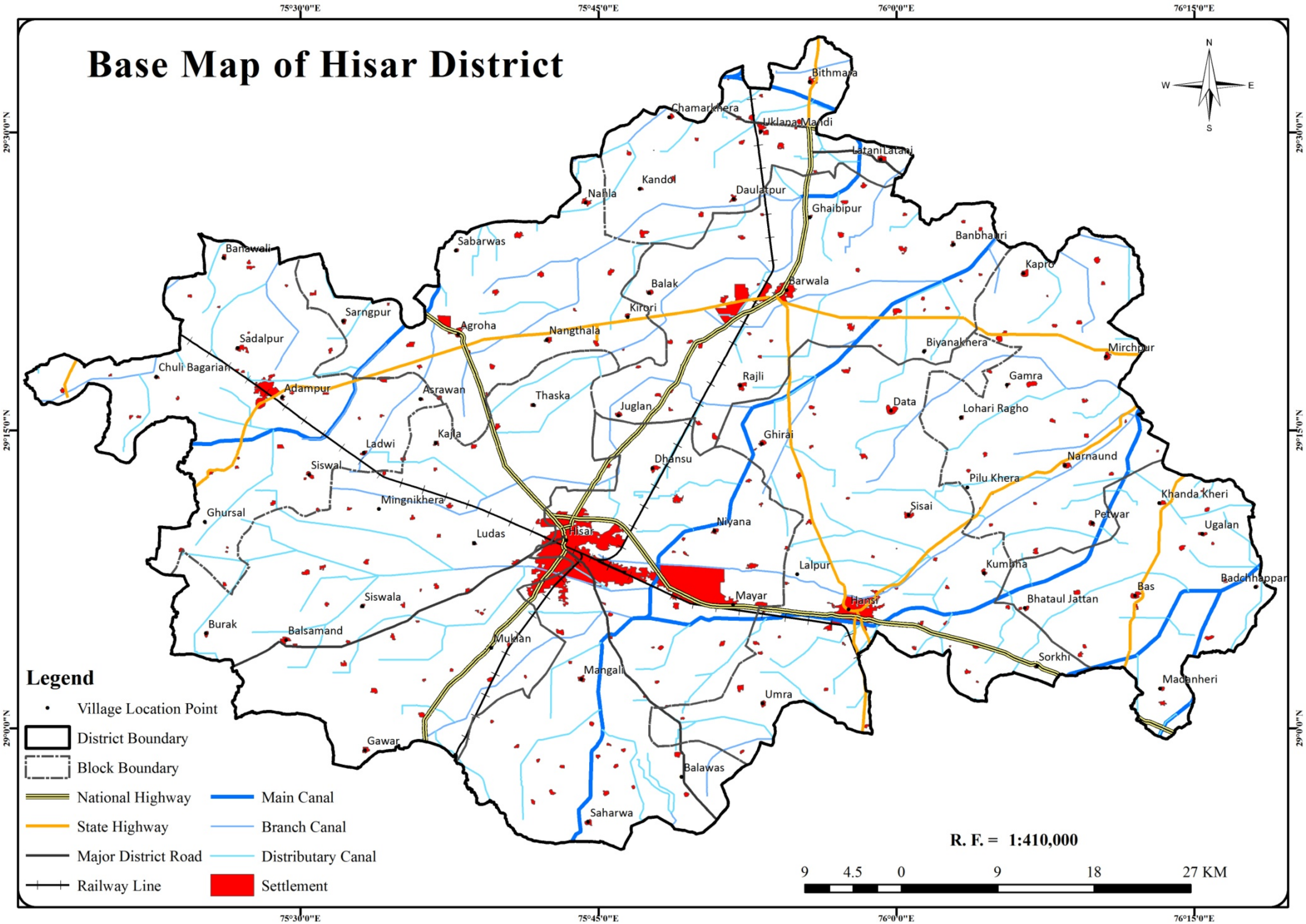
Numbers of tractors	21671

No. of tubewells & pumping sets	Diesel set	Electric set	Total
	19556	11416	30972

No. of electricity connections	Agricultural
	47969

Threshing & harvesting	Straw reaper	Forage harvester
	581	7417

Consumption of Electrical (Lakh KWH) in Agriculture	46,079
% of Irrigation to net sown area (area in hect.)	85.5
Intensity of cropping (%)	193.09
Intensity of irrigation (Gross irrigated area*100/net area) - area in hect.)	202.2



Base Map of Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
W
E
S
Bithmara
Chamarkhera
Uklana Mandi
Latani
Nahla
Kandol
Daulatpur
Ghaibipur
Banbhauri
Sabarwas
Banawali
Kapro
Barwala
Balak
Kirori
Sarngpur
Agroha
Nangthala
Biyanakhera
Mirchpur
Sadalpur
Chuli Bagarian
Adampur
Asrawan
Thaska
Rajli
Gamra
Juglan
Data
Lohari Ragho
Ladwi
Kajla
Ghirai
Siswal
Dhansu
Narnaund
Pilu Khera
Mingnikhera
Khanda Kheri
Sisai
Ghursal
Niyana
Petwar
Ugalan
Hisar
Ludas
Lalpur
Kumbha
Badchhappar
Bas
Siswala
Mayar
Hansi
Bhataul Jattan
Burak
Balsamand
Mukhlan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Village Location Point
District Boundary
Block Boundary
National Highway
State Highway
Major District Road
Railway Line
Main Canal
Branch Canal
Distributary Canal
Settlement
R. F. = 1:410,000
9
4.5
0
9
18
27 KM

Figure-2

CHAPTER-3
DATABASE AND METHODOLOGY

For the conclusion of any research work; data and methodology are necessary to fulfil the research complete. Therefore different types of data were utilized. The data used in current study are discussed below.

3.1 DATABASE:

Diverse types of data was collected and used for the present study like Satellite images, Ancillary data, climatic data and data related to underground water depth & quality are discussed below.

3.1.1 Satellite Data

Indian Remote Sensing satellite Series, LISS-III satellite data for the years 2017-18 was used for interpretation of the existing landuse / land cover, cropping pattern and crop rotation. The projection system and datum for geo-referencing of the satellite images were taken as World Geodetic System 84 and Universal Transverse Mercator projection respectively (UTM). The data was received from Haryana Space Applications Centre (HARSAC), Department of Science and Technology, Government of Haryana. Detail of satellite data used is shown in Table-4.

Table-4 Detail of used satellite data in present study

Satellite	Sensor	Date of Data Acquisition	Season	Spatial Resolution	Spectral Resolution (μm)	Swath
IRS-P6	LISS-III	September, 2017 October, 2017	Kharif	23.5 Metre	0.52-0.59 (G) 0.62-0.68 (R) 0.77-0.86 (NIR) 1.55-1.70 (MIR)	140 Km
		March, 2018	Rabi			

3.1.2 Soil and underground water data

Data associated to soil series and maps were received from HARSAC with their physical and chemical properties. Data related to underground water depth and quality is collected from Central Ground Water Board, Ministry of Water Resources, Government of India.

3.1.3 Ancillary Data

Toposheets of Survey of India were utilized for demarcating locations of rural settlement, transport network, civilizing features, canal irrigation system and demarcation of towns/ urban areas. Climatic data, available literature, maps and reports were received, consulted and used relevant. Other sources of data were Census of India 2011, District Gazetteer and Statistical Abstract of Haryana (2017-18).

3.2 SOFTWARE USED

3.2.1 ERDAS Imagine 9.3

ERDAS is a software related to digital image processing. It is Lica-Geosystems software functions include having with functions like viewing, altering and analyzing satellite images. ERDAS Imagine is intended mainly at geospatial data handling, preparation, display and enhancement of satellite images. It provides tools for the users to perform the various operations.

In this study ERDAS Imagine software used for importing, satellite data rectification, classification, mosaic and geo-referencing. This software is also used for Layer stacking, liner feature extraction, generation and processing workflow and import & export of data at a wide verity and scale.

3.2.2 ArcGIS 9.3

Arc GIS Desktop 9.3 includes a complement of union applications to carry out GIS operations, from uncomplicated to multiple, mapping, monitoring, geographic investigation, data restriction and data management, digitization and integration. This software used to clip and map composition**.**

3.2.3 Geomatica 10.3

Geomatica has developed Geomatica software that after a signal integrated environment for remote sensing and GIS with cartography and web development tools. Geomatica10.3 software is used for the purpose of image processing. Geomatica10.3 has a number of features ortho-rectifications of images. The software has the strong classification tools and better interpretability and hence used for the present study.

3.2.4 MS Office 2007

For the present study, Microsoft Office 2007 was used for report generation and graphical presentation of data.

3.3 METHODOLOGY

Initially base map of the district was developed from toposheets of Survey of India and placed over geo-referenced LISS-III (False Color Composite) satellite image; the visual interpretation was carried out using on screen digitization techniques. On the basis of satellite image description like tone, texture shape, color, associations etc; the different land use /land cover units were delineated. The available geological maps, information were also consulted in elevating the geomorphological information. During the interpretation of satellite data somewhere some doubtful objects were demarcated and the same were noted for field verification published literature and other relevant. The ground verification was completed based on encoded pre-field interpretation cross plan and unsure units were verified in the field. The corrections were incorporated while finalizing the land use / land cover map. Every effort were made for verification of all the geomorphic units during field visit in order to improve the correctness. After digitization and error removal, attributes were attached to various land use units. Maps of pattern and rotation of crops and layers of the study area were collected from HARSAC which was generated using Geometica 10.3 software adopting ISODATA (Iterative Self-Organizing Data Analysis Technique) techniques and unsupervised classification approach (Digital Image Interpretation). Soil series map & layer were also collected from HARSAC with physical and chemical properties information. On the basis of chemical and physical properties different soil maps like soil family, soil group, soil sub groups, soil drainage, soil texture and available water holding capacity maps were generated using ArcGIS 9.3 software.

After that; on the basis data acquired from Central Ground Water Board; underground water depth maps for pre and post monsoon (2015) were generated using interpolation and isopleths techniques adopting Arc Info software. Like that using same techniques on the basis of electric conductivity (EC) underground water quality maps for the study area was also prepared.

Finally, legend was prepared which reveals the different soil layers, different classes of underground water depth and quality layers and classes of land use & land cover layer. Coding system be developed for integration of different thematic layers which was presented in Table-5.

Table-5 Codification of different thematic Layers for integration

Soils		Underground Water Depth		Water Quality			Land Use/ Land Cover Categories	
Soils Series	Code	Range in Metre	Code	Electric Conductivity (uS/cm)	Code	Class	Code	Class
Bas	1	0-1.5	1	0-2000	F	Fresh	DC	Double Crop
Bichpari	2	1.5-5	2	2000-4000	SM	Sub-marginal	R	Rabi Only
Dabra	3	5-10	3	4000-6000	M	Marginal	K	Kharif Only
Dhingsra	4	10-15	4	>6000	S	Saline	CF	Current Fellow
Fatehpuri	5	>15	5				F	Forest
Gangwa	6						SC	Scrub Land (Open & Dense)
Jaundli Khurd	7						P	Plantation
Kanala	8						DP	Degraded pasture
Kharia	9						BU	Built-up
Niyana	10						SD	Sands Dunes
Ratia	11						W	Waterbody Canal/ River
Habitation Mask	H						SL	Salt Affected
Waterbody Mask	W						WL	Wetland

So, the methodology includes the preparation thematic maps of different layers. These thematic maps on 1:50,000 scale like physiography, soil family, soil group, soil sub-groups, soil texture, soil drainage, available water holding capacity map, constraints and potentials of soils, present land use / land cover map, kharif / rabi cropping pattern, underground water depth and quality etc. were generated or reformatted and integration of all above layers was done in GIS mode and the jobs of error removal topology building and attribute attachment were carried out. After that final integrated map having information of all theses thematic layers was generated using ArcGIS 9.3 software. A number of polygons were created in this integrated map. Each polygon was given appropriate land use recommendations based on the characters derived from resource integration in a table form. Finally a common map for different land use recommendations was prepared by combining the similar units of recommendations at one place. Ground checking of maps was also done and recommendations were modified based on the discussion with farmers and ground observations wherever required. Later on, a final action plan was prepared. Detailed methodology is discussed below.

3.3.1 Input Data

Two seasons Resource Sat, LISS-III satellite images for kharif, rabi and zaid for 2017 and 2018 were used for rabi & kharif cropping pattern, crop rotation and current landuse / land cover. Underground water superiority, underground water table depth data received from Central Ground Water Board was used to prepare water table maps for pre & post monsoon and water quality map. Soil series maps and layer were used to prepare different soil based maps. All these layers are on 1:50,000 scales.

3.3.2 Input Data Preparation

The Resource Sat, LISS- III sensor satellite data were geo-referenced and rectified using image to image geo-referencing methods. Water quality and depth data was received in Microsoft excel format (.xlsx) and converted to geodatabase format for preparation of maps.

3.3.3 Approach

A document containing codification system for interpretation explaining the detailed methodology and layers characteristics was prepared and used by all the work. The methodology flow chart (Figure-3) shows the details about methodology. The codification system is presented in Table-5.

3.3.4 Image Interpretation

Based on the visual image interpretation properties such as texture, tone, pattern, shape, size, location and association adopting on screen visual digitization of remotely sensed data was carried out. Keys of interpretation were generated for different themes like soils texture, land use & land cover, kharif / rabi cropping pattern, crop rotation, water quality and underground water depth. Those interpretation "keys" designed the basic pattern for delineation of the satellite images. Different thematic layers with their categories were delineated. A unique layer of the villages (settlement) with their attributes and network of roads were also generated. All of above maps are inserted in GIS system and database was created. The projection system and datum of the satellite images were taken as World Geodetic System 84 and UTM projection respectively. ERDAS Imagine 9.3 used for geo-referencing of satellite data, ArcGIS Desktop 9.3 used for creation of vector layer of different themes, digitization, integration, map composition and planning and Geometia 10.3 used for digital image analysis.

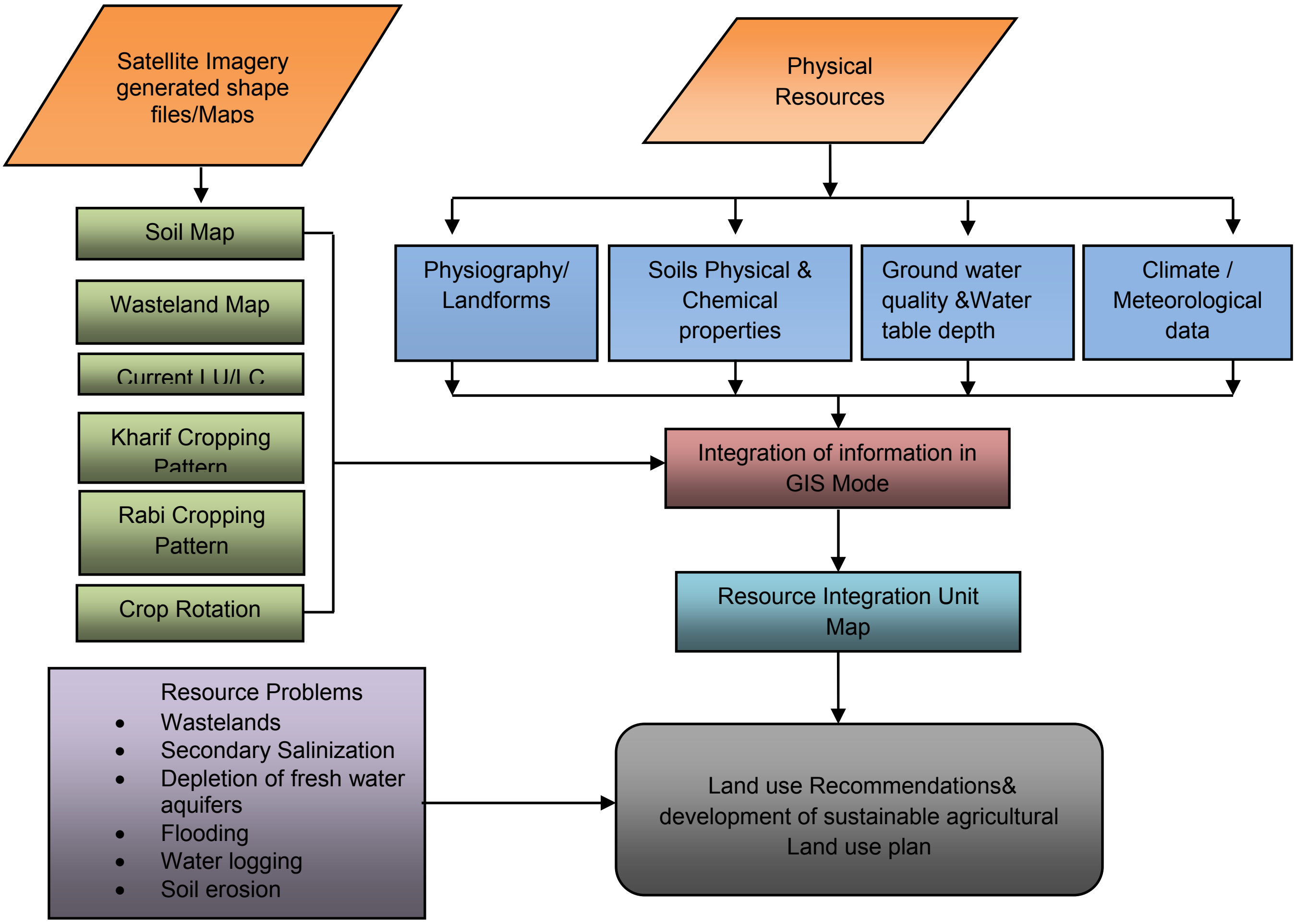


Figure-3 Detailed Methodology Flow Chart

3.3.5 Ground Verification

Due to variability of different layers and suggested recommendations in study area, field verification in the study area was collected with ground photographs and GPS locations. The doubtful area founded in the pre interpretation maps were checked during the field visits and the pre interpreted maps were updated by ground verification. After the updation of layers final attributes were attached with shapefiles.

3.3.6 Geo-database creation

All these layers are overlayed in ArcGIS desktop 9.3 software and a common or single layer is generated using all above layers through union command. This single layer has all information like soils, water quality & depth, present landuse / land cover for each and every polygon. Based on all these layers description such as soil type and texture, physiographic unit, underground water quality, underground water depth, types of present land use and land cover etc. a final recommendation is given to each and every polygon and recommendations are suggested. These layers were put in GIS format to built the geo-database. Database is organized using above discussed different layers and union layer also generated in GIS format. On the basis of database pre land use recommendation was suggested.

3.3.7 Recommendations Assurance Mechanism

Each and every suggested land use recommendation was presented and discussed before expert.

3.3.8 Sustainable agricultural action plan map

Final sustainable land use plan was prepared for study area based on discussion and suggestions given by experts.

3.3.9 Spatial statistics generation

Area of each and every suggested land use recommendation was calculated for study area.

CHAPTER-4
EVALUATION OF PRESENT LAND RESOURCES

4.1 LAND USE/ LAND COVER MAPPING

4.1.1 General scenario

Natural resources may be defined as conditions and raw materials which man uses to meet his need and improve his net worth. It follows from the definition that the supply of natural resources is not a matter of fixed quantity but rather which became greater and more varied with every scientific & technological advances taking place at the hands of people engaged in this pursuit in human society. The natural resources of the earth in such as air, land, water, and natural vegetation are original blessing of the nature.

Presently earth's land and water resources constitute a fairly finite resource base upon which increasing population has been placing greater & greater demands. It has been estimated that as little as 30 percent of land surface of earth is actually suitable for cultivation, 10 percent of which is currently being cultivated with another 20 percent to be brought into cultivation if required. Other 70 percent is regarded as being unsuitable for cultivation due to different reasons (Duddin, 1990).

In India, total area under cropland in 2011 was 159.7 million hectare with density of population 382 persons per square kilometres. In Haryana state as per latest available information, out of total area of 4.4 million ha the net shown area (3.4 million hectare) covers 82 percent followed by land put to non-agricultural utilization (0.29 million hectare) amounting to 6.5 percent and land under current fallow (0.17 million hectare) constitute 4.2 percent of the district.

The state of Haryana is one of the most intensively cultivated and irrigated region of the India. About 80% of total geographical area is under agriculture. It is required to protect from dangers of degradation. It is therefore necessary to conduct scientific surveys to utilize the finite natural resources on sustainable basis through appropriate land use planning.

From the above discussion it is clear that spatial distribution on landuse / land cover in digital maps with respective statistical values is very important for spatial management, planning and use of land resources for forest, agriculture, degraded pasture, urbanization, industry, land with scrub, different environmental studies as well as their financial production. Now a day, population are increasing at an alarming rate and in that context man-land ratio is decreasing that creating the difficulty of soil and land degradation. So the requirement for sustainable consumption of land and water resources assumes a lot superior significance in present days. The outline draft on National Land Use Policy and Planning related to optimum landuse utilization and formation of National Landuse Conservation Board (NLCB, 1995) purely suggest the concern of government. More, with present insertion that agriculture planning in the every nation must be based on agro climatic regions; the primary require is to contain inclusive in order to spatial arrangement of land user, predominantly on the availability of land for agriculture for food grain crop.

Periodically land use catalog survey has been needed, to make existing information on type, spatial arrangement, areal coverage, location, rate and changing pattern of each group of land use /land cover. Planning of up to date information, exact as well as consistent information of land use / land cover for a region on constant basis is only probable by latest technology like remote sensing technique on spatial and temporal valuable basis.

Even though conservative land use data existing in thematic maps statistical table and charts are insufficient and do not give an updated information on temporal land use outline in respect to their changing types. However, organizational effort in updation of reports, maps and numerical data by SOI, NATMO, NBSS & LUS, AIS & LUS, Ministry of Agricultural, State Land Use Board are remarkable. The Indian understanding on utilize of satellite images of landuse / land cover spatial and temporal examination derives from studies worked at NRSA in collaboration with different state and centre government agencies.

4.1.2 Meaning and concept of land use:

Land use refers as activity of human beings with different uses, that are completed on land surface while land cover is discussed for "natural flora, water bodies, soils, non-natural cover and other consequential due to land renovation" but both land use as well as land cover are intimately inter related to each other and are not jointly restricted from each other. These are compatible as previous is indirect based on land cover on appropriate signals (Nagaraja, 2002).

Classification: As per spatio-temporal change and huge demand on obtain ability in sequence on landuse / land cover is becomes necessary to contain a criterion categorization system criteria, exact definition of landuse /land cover and its different categories, unique procedure of data acquisition and mapping on different scale at state and national level. United States Geological Survey (USGS) made first attempt for devising a landuse and land cover criteria of categorization scheme used with remote sensing images in 1970. The concepts and structure of land use and land cover are still valid and followed also.

Anderson (1971) put certain guidelines about criteria for landuse / land cover criteria system adopting remotely sensed images and important among them are that applicability over large area, facility to use different season of data, interpretation accuracy of land use classes should be at least 85 to 95 percent and aggregation of categories must be possible.

Anderson (1976) stated that there is not any perfect categorization of land use and land cover and there are hug stand points in categorization process also. The procedure and tends to be choosy, even an impartial geometric method is used. He tried to expand a categorization scheme for land use through remote sensing data which were satisfied the requirement of multiple users and definite strategy of standards for assessment initial were recognized. The land use/ land cover classification presented by him could be related to system for classification capacity, susceptibility to certain management performs.

Further in Indian context, understanding the requirement for an updated countrywide land use and land cover map by different agencies in the nation, as a foreword, land use and land cover categorization systems were developed by National Remote Sensing Agencies, Department of Space, captivating into deliberation the present land use categorization used by NATMO, Ministry of Agricultural Revenue Department, AIS & LUS and details attainable from satellite data. The basic structure of this classification was taken from USGS system.

The classification system used in present study is basically modified version of Anderson etc. al (1976) and cover up to level-III classification The legend has been prepared after due consultation of literature on land use and land cover and on the basis of the landuse and land cover category available in the study area (Table-6) This classification basically is modification of national level classification (NRSA, 1989) of land use / land cover which has taken into account of local classes present in command area. This classification is helpful in assessing the present land use of all categories available in the area to know the present status on short and long term basis.

4.1.3 Database:

The essential primary data used in present study was LISS-III sensor images (False Colour Composite) for September–October 2017 and March 2018 (for kharif and rabi both seasons). Ground truth process establish an important database in remote sensing due to it upturn the interpretation correctness and consistency of remotely sensed images through allowing confirmation of construed information and by complementing it with data which could not be acquired directly by satellite data.

4.1.4 Methodology

Methodology is created for visual image interpretation of IRS, standard FCC of rabi & kharif season for recognition and demarcation of different land use and land cover categories. Satellite data interpretation is explained as "the skill of investigative image for the intention identifying the objects as exterior features and judging their consequence". Image understanding is compound process of physical as well as cultural activities occurring in recent past of time. The arrangement begins with recognition and recognition of imagery and later on its capacities. Images are after that careful in term of data, particularly non graphic and lastly deductions are completed. These are aspects of image understanding such as finding, appreciation & find out, analysis, categorization, presumption and idolization and the elements of image appearances like tone or colour, size, pattern, texture, shape, association and location are basic instrument by which visual analysis of satellite imageries is carried out. Step by step procedure followed is given below:

I. Pre-interpretation field visit was carried out (reconnaissance survey) along with Satellite data, Survey of India topographical maps and ancillary data for getting information about land cover classes, crop rotation, crop types etc.
II. The base map is generated and arranged on 1:50000 scale using Survey of India topographical maps & LISS-III satellite data selecting prominent features like railway line, major road network, water bodies, settlement and major canal network.
III. Based on image analysis elements such as color, shape, size, association, texture etc; Rabi period images were visually interpreted by using software (ArcGIS Desktop 9.3.) After that recognition & delineation of crop lands during kharif season, from corresponding LISS-III imagery. The ordinary areas occupying under both rabi & kharif crops is demarcated as double cropped area. The area without the crops developed throughout Kharif/ rabi season and under double crop is discussed as fallow lands. The former classes of landuse and land cover were also delineated from both period data while delineating different landuse and land cover classes numerical number was assigned to them. This has helped in better separation of interpreted classes and also simplified the process of shift of thematic information on to base map.
IV. On screen digitization methodology and techniques were utilized to recognize various landuse and land cover categories adopting techniques of visual image interpretation using ArcGIS 9.3 software. After that, all suspicious areas were marked and scheduled for field visit confirmation. The field traverse program was made to cover maximum doubtful areas in field in one go. It was well ensured that traverse plan for field visit was planned in such a way that as many land use/ land cover categories as probable, apart from suspicious

regions can also be cross correlated. After that, all field details entered on pre-field interpreted map for post ground truth correction and modification.

V. After completed of ground verification, the required correction and modification were completed for landuse and land cover borders and classes were completed. Before, finalizations of maps again rechecking and crosschecking were completed where ever probable to make sure higher correctness and consistency of information. Further processes such as error removal, topology building and attribute attachments were carried out. The area of various units was quantified.

VI. This final map was composed using ArcGIS 9.3 software.

Different kinds of landuse / land cover categories found in the district & their associated features/ characteristics/ problems are described in following section. The landuse / land cover map displayed in Figure-4 and area under various landuse and land cover categories is given in Table-6.

4.1.5 Land Use/Land Cover Types

4.1.5.1 Built up Land

It is well-explained as habitat residential in lake of non-agricultural utilization that has been cover of buildings, network of communication and transportation, utilization in context with water, greenery and unoccupied land. All the human finished construction covering the terrain is involved in this category. These human settlements are containing of residential, transport/ communication, industrial, commercial and service provider area. Together, cities, towns and village habitat are incorporated in this class. On the imagery, the physical size of built up land (due to sprawl) and the connectivity with transport network can be used as surrogates to distinguish urban from rural. Rabi season images give accurate information of built up area. These areas show in dark bluish in core and bluish in periphery with irregular and discontinuous scattered shape & coarse mottled texture. Often built up land with maximum concentration of building appear in dark in the center & dull tone in surrounding because being less building. The pattern is of these settlements are contiguous to non-contiguous as well as clustered to scattered.

It founded on all types of surface amidst of crop land, wasteland and in association with linear features like railway lines, roads and canals etc. The satellite data from October to March month are suitable for delineating built-up land and network of transport. The transport network of railways and roads were mapped from LISS-III satellite images and Survey of India Toposheets. Transport network appears in dark bluish to grey and red (where ever the vegetation occurs in parallel of road) in colour. Railway lines appear on imagery narrow width with smooth turnings and connectivity with settlements. Total area under built up category is 126.90 sq. km. The built up land urban category occupies 75.26 square kilometres which is 1.81 % of total geographical area while built-up rural class occupies 51.64 square kilometres area that was 1.24% of total geographical area. Geographically distribution of landuse / land cover categories is presented in Figure-4.

4.1.5 .2 Agricultural Land

It is explained as first and foremost used of land for cultivation and food creation, fiber production, business use and horticulture crops. It involve land used in crops both irrigated and un-irrigated land, uncultivated land and plantation. The irrigated farming areas are those in which these crops are grownup by manmade distribution and utilities from water to land to excite or create conceivable the growth of crops. It includes standing areas under command areas of reservoir, tanks, wells and canal system in country. Un-irrigated agricultural lands used for growing crops where the crops are grown with the help of rain water.

Crop Land: It involves those areas with existing crops as on the engagement of data acquisition. Croplands are sub divided as Kharif, rabi, doubled cropped and current fallow. The area under rabi and kharif as well as double cropped has been calculated and is given in Table-6. Multi temporal data and contextual interaction help in discrimination of agriculture land from other categories that are dominated by vegetative community. The tonal contrast of different crops differ from dark red to red tone which depends upon spectral reflectance of the particular crop, height of the crops or healthy or infected, nature of surface soil. Spatial extent of different crops is in size & shape, texture for mature stage of crops and coarse texture for early stage of growth of crops. It is contiguous for irrigated area and non-contiguous for un-irrigated fields. The cropped areas are situated mainly in alluvial plains, sandy areas, culture able wastelands and inter-dunal valleys.

Rabi: Rabi crop season includes those crops that are grown during months of October to April. In this season, wheat, mustard, bengal gram, and fodder crops are raised in study area. The wheat, mustard and fodder crops are associated with good irrigated areas. Bengal gram is grown in dry sandy south western part of the district. Area under rabi crop is 174.27 square kilometers, that makes about 4.18% of total study area. The rabi crop is raised in all parts of study area the is covered by alluvial plain, flood plain where the fresh ground water for irrigation available.

Kharif: Kharif includes all standing agricultural crops during April-May to October months. It coincides with southwest monsoon season. The major crops grown are rice, cotton as commercial crops in irrigated areas and bajra, guar and millets as food grain as well as fodder crops in dry un-irrigated sandy areas in Adampur and Hisar-II block. The Kharif crop constitutes 177.76 square kilometers which is4.26 percent of total area. Intensity of rice crop is in Uklana and Hansi block because of good soil and availability of canal water and marginal quality ground water.

Double Cropped Area: Areas under this category include standing crops during both seasons. The double cropped class has 80.79 percent to total study area, which spread over 3371.11 sq. km. These areas are situated in flood plain and alluvial plain of the study area. These areas have canal irrigation network as well as tubewells. Under doubled cropped area, the wheat and fodder crops in rabi season and rice, cotton and fodder crops are raised during kharif season.

Fallow Land: These lands basically explained as farming land that is used for farming of crop but for the short term allowed to rest and these are non-cropped for one or all season but that time is less than one year. This area is predominantly those that are founded vacant of crops at that time of image acquisition of both rabi and kharif seasons. Its tone is yellow whitish to greenish blue on imagery contingent on the ground conditions. Sandy areas signify light tone and alluvial & clay soils with dark tone. Its size is small with regular shape and non-contiguous in irrigated areas and in un-irrigated fields size is large and contiguous and irregular shape. Due to absence of crop cover, the texture is generally medium to smooth. It may be found amidst agricultural cropland-as harvested agriculture fields. These are the areas, which are prone to soil erosion particularly in dunal areas. The total area covered by fallow land is 155.64 square kilometers, which is 3.73 percent lo total area. It is found that fallow lands are spread all over the area in small patches. But the intensity and concentration of fallow lands is more in south eastern aeolian plain and south western part of the area. The reason for keeping fallow land is non-availability of good quality underground water and sufficient canal water for irrigation, lands but often they appear similar to that of certain wasteland classes.

4.1.5.3 Wastelands

Wastelands are explained as tainted areas that could be taken under vegetation cover through judicious works and that are presently in utilization. These lands are declining because of requires of suitable soil and water conservation measures or on explanation of natural reasons, Wastelands could result from inbuilt/ compulsory disabilities, as location, environmental, chemical or financial or management constraints. Wastelands are divided into culturable wastelands and un-culturable wastelands. Culturable wastelands are capable of or have the probable for progress of green cover and are not being used because of various constraint of changing degree. Development of culturable wastelands have been contingent on the land ability defined by physical factors like relief, soils, soil depth, physio-chemical characteristics of soil, soil qualities, climate and present land use ownership pattern. Uncultivable wastelands are lands that can't be established for vegetative cover and are designated as Cultivable wastelands, comprises of following categories in the area.

Degraded Pasture/ Grazing Land: This class are non forest areas, mostly found in surrounded area of village Panchayat lands and associated with village surroundings. These areas are covered with natural grasses, bushes and shrub or with scattered trees often used to feed the cattle and which has become degraded because lack of water and soil conservation and faulty management measures. It is observed that most of grazing lands are now in the degraded conditions because of over grazing and management over the ages and they are in last stage of retrogression. These lands appear in light brown to light red tone, varying size with uneven shapes, texture from coarse to mottled and contiguous to non contiguous in pattern. These lands founded in Panchayat common lands located at surrounding of villages. The grazing lands are spread over 128.85 square kilometres which is 3.09% of the total geographical area.

Scrub Land: These lands are undulant in nature, degradationally prone and such lands may be open or dense scrub cover. These lands occupy topographical higher location but exclude hilly terrain. But in present investigation scrub cover, even in plain area and in sandy class are involved an mapped under this category. These scrub lands are extent in alluvial plain, Aeolian plain and distributed throughout the area. These lands appears in light yellow to brown. Where ever, the occurrence of scrubs are more, reddish tinge perform in patches &dots, varying size, with uneven and non continuous shapes, coarse to mottled texture. Total area under this category is amounted to 17.51 square kilometres, which constitute 0.42 percent of total study area.

These lands has been degraded due to inadequate soil & moisture preservation measures and such lands need immediate protection from biotic interferences with immense felling of plants & small shrubs for fuel, fodder & timber to meet the needs natives. These are the lands which are not suitable or are less suitable agricultural use and from which more benefit can be derived by afforestation and pasture development.

Sand dunes: Sandy wastelands are those, which have stabilized to unstabilized accumulation of sand in situ or transported predominantly by aeolian activity fluvial process. In present analysis, the sand dunes partially stabilized to stabilize nature, barren sandy plain and adjoining inter dunal areas which are not fully under agricultural use due to physical and climatic constraints have also been mapped under this category. Most of sand dunes wasteland is largely founded in south and eastern part of the district. Sandy wastelands appear in colour as bright white to light yellow with light reddish color (subject to vegetation cover), that were vary in size with regular to irregular shapes, texture from smooth to mottled, pattern is contiguous and linear. This category covers 5.09 square kilometres area that covers 0.12 percent of total geographical area. The main problems of sand are light textured, high permeability, low organic carbon and clay contents, poor fertility status, slight to moderate wind erosion and poor quality of ground water.

Salt affected land: Lands exaggerated by salinity or alkalinity had additional soluble salts or high negotiable sodium. Salinity is produced by waterlogging that creates capillary action rise throughout exciting climatic situations separation salt deposit on the surface. This category covers 0.38 square kilometres area.

4.1.5.4 Water Bodies

Water bodies include area of external water stored in shape of lakes, ponds and tank or curving as a streams, rivers and canal. These are clearly identified on satellite data in blue colour.

Rivers/ Streams/ Canals: River is naturally course of water graceful on the ground surface along fixed channels. It may be seasonal or perennial. Canals are manmade inland waterways constructed for irrigation/ drainage/ navigation. But in the district canals are used only for irrigation and domestic/ industrial uses. As far as canal network is concerned, the major distributary is western Yamuna canal and Bhakhra canal. The area of canal network was quantified by taking length & breadth of canals, which were taken from irrigation department, Ghaggar River appears in light blue black to black tone, with narrow to wide in size, irregular and sinuous pattern, smooth texture, contiguous to non linear in pattern. In canal network, only major canals appear in blue black tone, long and narrow with regular shape and continuous pattern.

Ponds Tanks/ Lakes: It is man made or natural bounded water bodies with planned flow of water. Ponds And tank are smaller in size. Reserved lakes are larger than tanks & ponds but in study area these lakes does not exist. In present analysis, the ponds found in villages are basically natural low lands or digressional areas which collect the rain water village area and these are used for domestic, animal drinking and bathing purpose, On the other hand, tanks are constructed by public health department for supplying drinking water to rural & urban areas. These lined tanks exist in almost all villages and urban areas. Generally, the size of these ponds and tanks is small and appear on imagery as small dots. These water bodies seem in blue black to black tone, small in size with regular to irregular shapes smooth texture, non contiguous and dispersed in pattern. The total area occupied by this category is 5.86 square kilometres that makes 0.14 percent of total study area.

Table-6 Details of different land use classes

Land use Level-I	Area in Sq. km	Land use Level-II	Area in Sq. Km	Percentage to Total Geographical Area
Built up	126.90	Builtup Urban	75.26	1.80
		Builtup Rural	51.64	1.24
Agricultural Land	3878.78	Double Crop	3371.11	80.83
		Current Fallow	155.64	3.73
		Kharif only	177.76	4.26
		Rabi only	174.27	4.18
Forest	4.93	Forest	4.93	0.12
Plantation	3.27	Plantation	3.27	0.08
Wastelands	152.43	Degraded Pasture & grazing land	128.85	3.09
		Scrub land	17.51	0.42
		Sand Dunes	5.09	0.12
		Salt affected land	0.38	0.01
		Wet land	0.60	0.01
Waterbody	5.86	Waterbody	5.86	0.14
Total	4170.51	Total	4170.51	100.00

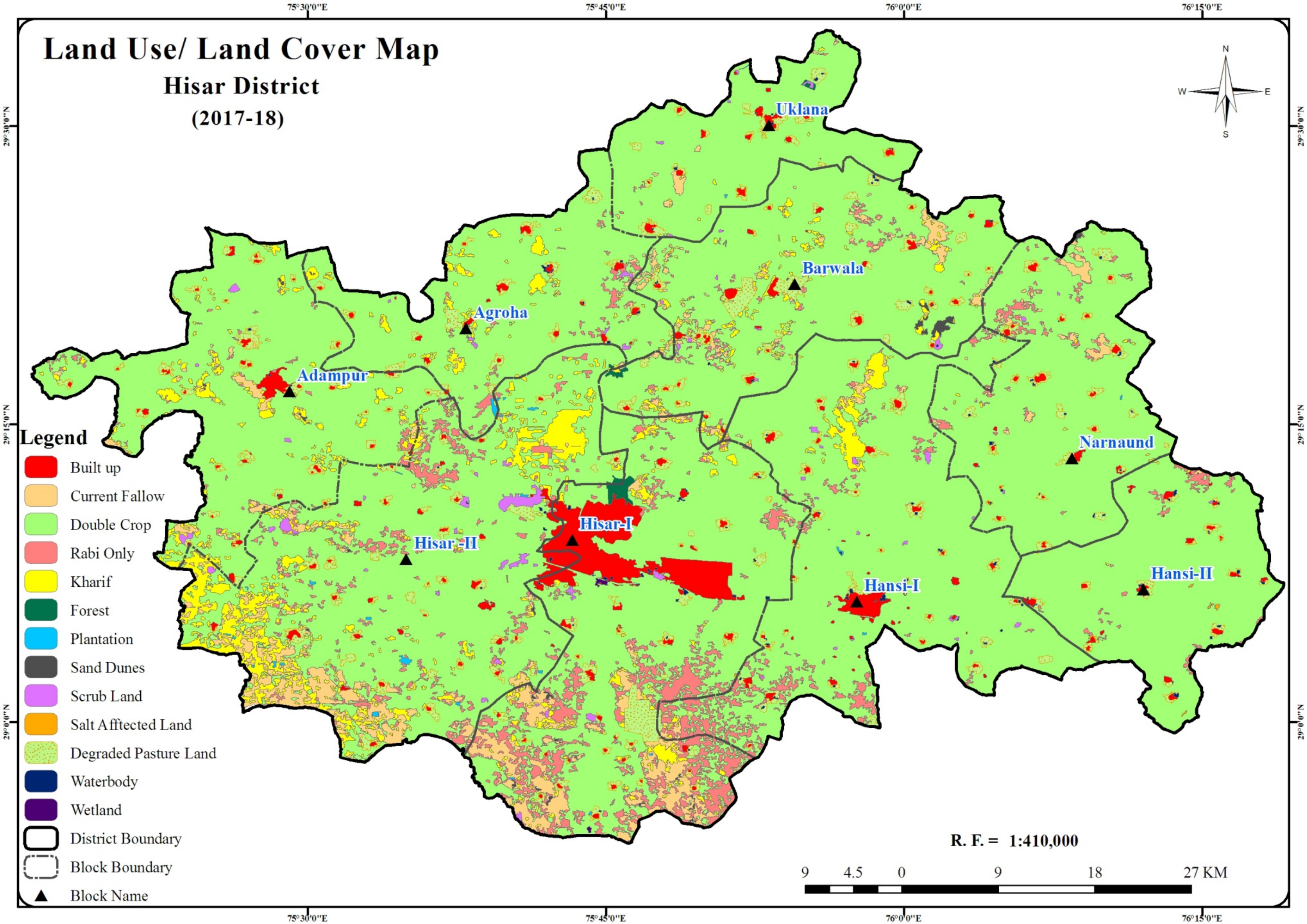

Land Use/ Land Cover Map
Hisar District
(2017-18)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
W
E
Uklana
Barwala
Agroha
Adampur
Narnaund
Hisar-I
Hisar -II
Hansi-I
Hansi-II
Legend
Built up
Current Fallow
Double Crop
Rabi Only
Kharif
Forest
Plantation
Sand Dunes
Scrub Land
Salt Affected Land
Degraded Pasture Land
Waterbody
Wetland
District Boundary
Block Boundary
Block Name
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-4

4.1.6 Evaluation of Present land use

The study demonstrates that remote sensing skill can be adapted to map and monitor land use/ land cover details rapidly at different scale. This provides additional accurate and consistent accurate information than any other conventional data sources. This technology not only provides information of land use pattern, change with its extent & nature but also evaluate the consequences of change in the land use and how the people are responding to land use change.

Agriculture is main economic activity in this area. It is one of most cultivated intensively and irrigated district of the state, because nearly 92.96 percent of its geographical area. The kharif & rabi crops occupy an area of 4.26 percent and 4.15 percent respectively of total geographical area. Only 3.73 percent remained fallow due to shortage of canal water and absence of sub surface water or rainfall. Rest 80.78 percent of total area consists of doubled cropped. It is observed that major part of area (northern and central part) is under the impact of green revolution land use pattern and main crops grown are like wheat, rice and cotton.

The green revolution rice wheat crop rotation is mainly grown in flood plain, alluvial plain and alluvia plains with sand cover where both, the canal water and ground water available with good quality and quantity. These crops use high yielding variety seeds which are accompanied by high doses of fertilizers, agricultural chemicals (insecticide, pesticide and fungicides) and farm machinery. These inputs were preceded by improvement in irrigation water supply (augmentation of canal water supply and facilities for pumping ground water). It is a whole scale change that increased the production of wheat and rice many folds but the cotton production was not increased on desired direction in the area. Better and assured crop production led the farmer to increase the area under these two water intensive crops at the expense of oilseeds, pulses and millet crops.

The exhaustive land use pattern practiced in the district is basically exhaustive utilize of available water which has affect its quality and quantity. This non scientific land use pattern leads to non-judicious exploitation of aquifers. Other environmental problems which have come up with faulty land use & cropping pattern are loss of soil fertility, pollution of soils & underground water because of excessive use of chemical fertilizers and agro chemicals. Thus the green revolution land use and cropping pattern has created situation which imposes no restriction on the excessive use of inputs without taking into account of the environmental problems related to soil and water resources. Now, questions have been raised about sustainability of these agricultural practices.

The crops raised in aeolian plains are mustard, gram, bajra, gawar and wheat also where the assured water for irrigation is available. Due to physical and climatic constraints, this area can not be put under intensive cropping pattern and is more suitable for plantation or agro-forestry practices. The region is suffering from the scarcity of canal water as well as sub- surface water of good quality and quantity. The mixing of fresh water of canal with poor quality of underground water is done to minimize unfavourable consequence of saline water and to increase the supply of water for irrigating the heat and cotton crops. The occurrence of sand, dune complexes, wastelands, fallow and single crop particularly the kharif crop is more in this area. The sprinkler and drip irrigation methods should be stimulated to decrease over all irrigation water desires of the area.

The complete absence of natural forest in the area is another problem of existing se pattern. The expansion of cultivated land is basically at the cost of other land uses and particularly natural vegetation. The intensive agricultural land use pattern needs the some proportion of natural vegetation cover, to maintain ecological balance. To increase vegetation cover, the sandy waste scrublands, marginal fallow land and degraded pasture land should be brought under forest plantation.

The built up land consists of mainly rural settlements as there are urban settlements named Hisar, Hansi, Adampur, Uklana, Agroha and Barwala. Area covered by transport network falls also under this unit. The large area under this class is accredited to enlarge in population, households and related needs like infrastructure and public amenities. The total 3.66 percent area of district is laying waste in form of sand dunes, scrubland with or without scrubs and degraded pasture grazing lands. Most of these areas are located in aeolian plain and adjacent to villages. The water bodies land use category constitutes mainly canal, village ponds and tanks. These water bodies cover 5.86 square kilometres.

4.2 EVALUATION OF PRESENT CROPPING PATTERN & CROP ROTATION

Crop rotation is the preparation of producing a chain of various types of crops in a particular region in successive seasons. A customary aspect of crop rotation is the replacement of nitrogen during the utilize of green fertilizer in order with cereals and other crops. The crops selection and their types is to be made conditional on the soil and rainfall condition in a particular area. The insensitive crops and variations with smaller period should be select to escape drought of different concentrations. There are wide variations which differ location to location as per water availability in dryland area.

4.2.1 Evaluation of kharif cropping pattern

Rabi and Kharif are the main two cropping seasons in the study area. Kharif crop season starts in May-June and continues upto September- October. Analysis of remote sensing (RS) and other ancillary data reflected that Paddy, Sugarcane, Cotton, Bajra / Other minor crops are sown during Kharif season in the study area. Minor and non-contiguous crops are not separable and clubbed in to other crops category. Cotton is evenly dominated in northern & central part of the district. Bajra, Jowar and Guar crops concentrated in dryland and sandy regions of the study area. Sugarcane crops are mainly located in Hansi and Narnaund block. South western part of study area occupies some fellow land also due to the lack of rainfall or irrigation facility. Remote Sensing estimates showed that the Cotton, Sugarcane, Rice and Bajra/Jowar/Guar and other crops occupied 1660.20, 0.53, 773.83 and 280.33 square kilometres area correspondingly discussed in Table-7. Spatial distribution of kharif cropping pattern is shown in Figure-5.

Table-7 Aerial Extent of Kharif crops

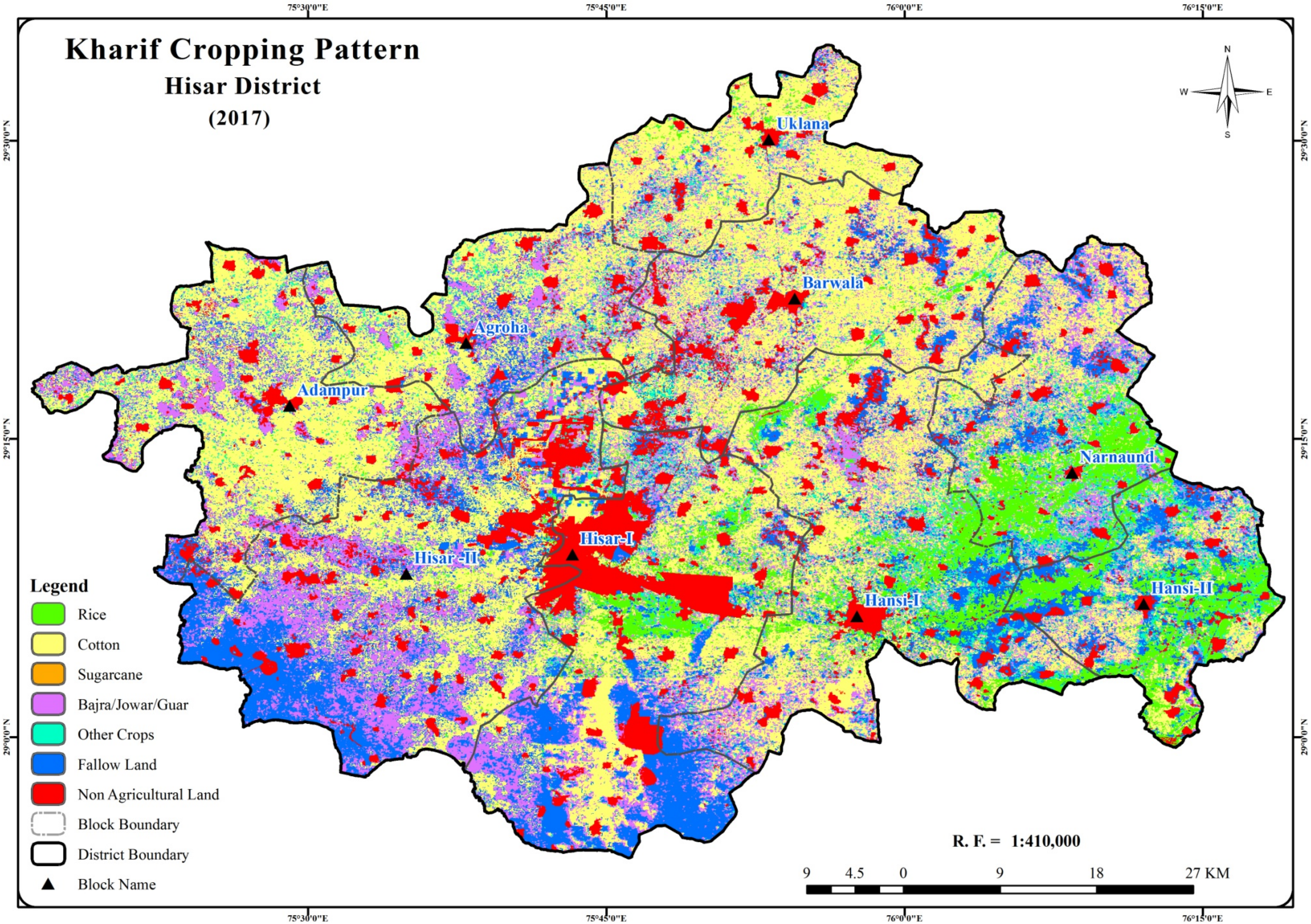
Crops	Area in square kilometres	Percentage to total Area of the district
Rice	326.51	7.83
Cotton	1660.20	39.81
Sugarcane	0.53	0.01
Bajra/Jowar/Guar	773.83	18.55
Other crops	280.33	6.72
Fallow Land	643.13	15.42
Non Agricultural	485.98	11.65
Total	4170.51	100.00

4.2.2 Evaluation of rabi cropping pattern

Rabi season is the most important season in study area in which maximum area is cultivated. Wheat is the dominant crop of rabi season followed by mustard in the study area. Mustard is sown in those areas having coarse texture soils and scarcity of water. Map of rabi cropping of the district was generated using satellite data of the particular season. It is apparent through the Table-8 & Figure-6 that crop of wheat is evenly spread evenly distributed in study area except south western part of the district. Wheat crop covers 2131.25 square kilometres area, followed by mustard (686.32 square kilometres) and pulses (146.67 square kilometres). Mustard and Gram crops are concentrated in south western and southern upland sandy parts of the district.

Table-8 Aerial extent of Rabi crops

Crops	Area in square kilometres	Percentage to total area of the district
Wheat	2131.25	51.10
Sugarcane	0.53	0.01
Pulses	146.67	3.52
Mustard	686.32	16.46
Other crops	126.44	3.03
Fallow Land	585.41	14.04
Non Agricultural	493.90	11.84
Total	4170.51	100.00



Kharif Cropping Pattern
Hisar District
(2017)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
W
E
S
Uklana
Barwala
Agroha
Adampur
Narnaund
Hisar-I
Hisar -II
Hansi-I
Hansi-II
Legend
Rice
Cotton
Sugarcane
Bajra/Jowar/Guar
Other Crops
Fallow Land
Non Agricultural Land
Block Boundary
District Boundary
Block Name
R. F. = 1:410,000
9
4.5
0
9
18
27 KM

Figure- 5

4.2.3 Evaluation of crop rotation

The crop rotation is rising a sequence of various crops in the particular region in sequential seasons. Analysis of cropping pattern maps of different seasons indicate that study area has the main crop rotations of Cotton-Wheat, Rice-Wheat, Bajra/Jowar/Guar-wheat and minor rotation. Cotton-wheat crop rotation occupies maximum area that is 1847.91 sq. km. followed by fallow -wheat which occupies 1237.33 sq. km area. Crop rotation of the district with their areal extent is discussed in Table-9. Cotton-wheat rotation is evenly distributed in whole study area except south western and southern part of the district where Fallow-Fallow/other Crops-gram/mustard rotation is more prominent. The spatial distribution of crop rotation is shown in Figure-7.

Table-9 Aerial extent of different crop rotation

Crops rotation	Area in square kilometres	Percentage to total area of the district
Rice-Wheat	292.59	7.02
Cotton –Wheat	1237.33	29.67
Sugarcane based	0.53	0.01
Rice-other crops	6.29	0.15
Other crops –Wheat	173.48	4.16
Cotton- other crops	53.57	1.28
Bajra/Jowar/Guar-Wheat	267.26	6.41
Rice-Fallow	6.81	0.16
Bajra/Jowar/Guar- Fallow	214.89	5.15
Cotton – Fallow	119.93	2.88
Fallow – Wheat	160.75	3.85
Minor Rotation	983.44	23.58
Non Agricultural	653.64	15.66
Total	4170.51	100.00

4.2.4 Authentication of cropping pattern with Statistical Abstract of Haryana, 2018-19

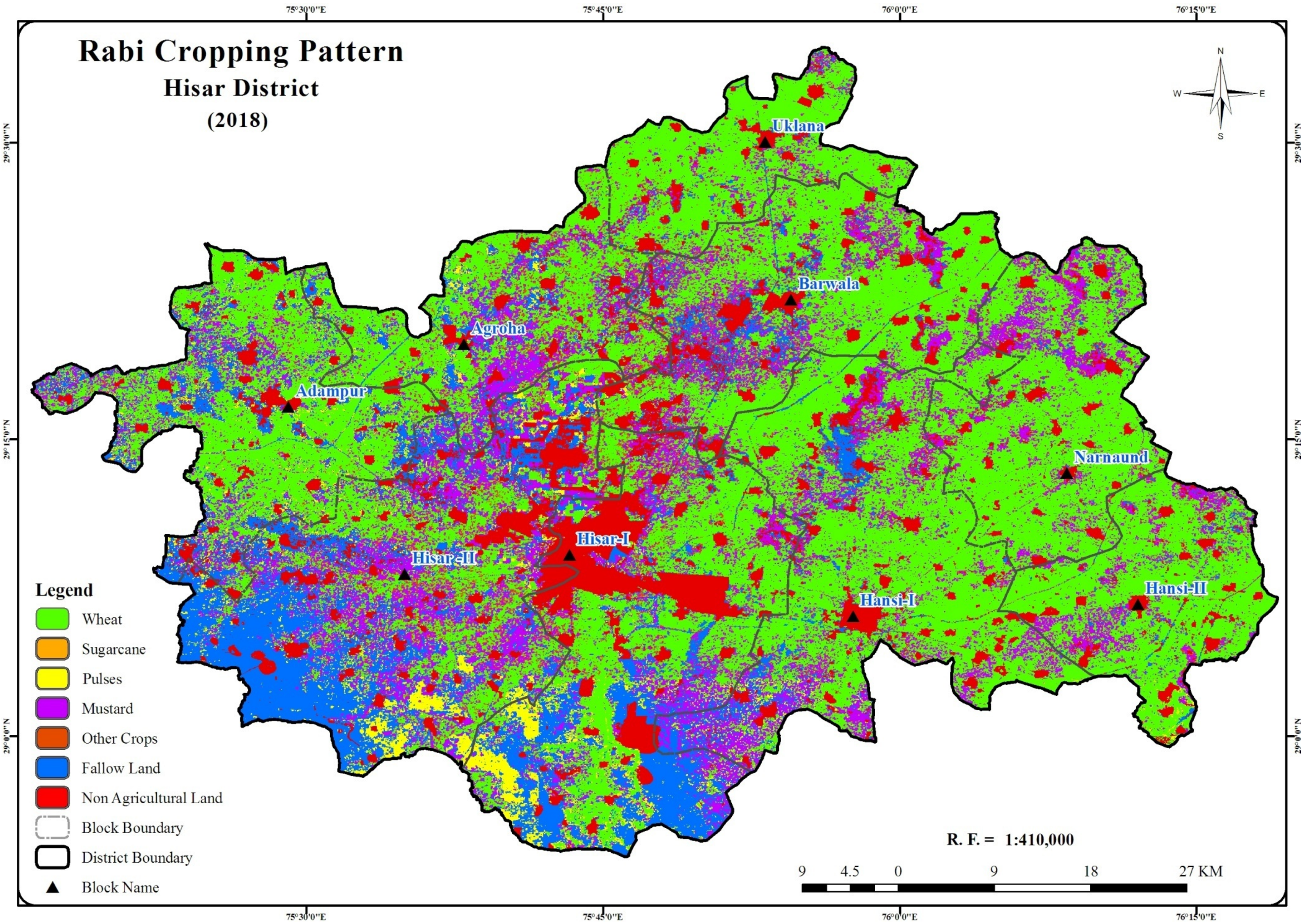
As per the Statistical Abstract of Haryana, 2018-19 the major crops sown in the study area are rice, cotton, and bajra/ guar/jowar and in rabi season are wheat, mustard, gram, pulses and barley. Area under different crops of rabi and kharif season as per the record of Statistical Abstract of Haryana, 2018-19 is presented in Table-10.

Table 10 Area under major crops of rabio and kharif season (Statistical Abstract of Haryana 2018-19)

Kharif Season crops		Rabi Season Crops	
Crops	Area in sq. km.	Crops	Area in sq. km.
Rice	700	Wheat	2240
Cotton	1516	Mustard	677
Bajra/Guar/ Jowar	740	Gram	73
		Pulses	174
		Barley	27

As per Statistical Abstract of Haryana, 2018-19; area under wheat crop is 2240 sq km while as per IRS LISS III satellite based map collected from HARSAC showed that 2131 sq km is under wheat crop and 27 sq km area is under barley crop in rabi season.Other major crop in rabi season is mustard that occupies 677 sq km area as per Statistical Abstract of Haryana, 2018-19 and 686 sq. km area as per IRS LISS III satellite based study. Pulses crops sown in 174 sq km area as per Statistical Abstract of Haryana, 2018-19 and 146 sq. km area as per IRS LISS III satellite based study.

Like that cotton is major dominant crop in kharif season; as per IRS LISS III satellite based study this crop sown in 1660 sq km area and as per Statistical Abstract of Haryana, 2018-19 cotton crop sown in 1516 sq km area while rice crop sown in 700 sq km area as per Statistical Abstract of Haryana, 2018-19 and as per IRS LISS III satellite based study rice crop sown in 326 sq km area. Other dominant crops are dry farming or low water requiring crops (bajra, moong and guar) that sown in 740 sq km area as per Statistical Abstract of Haryana, 2018-19 and in 773.83 sq km area as per IRS LISS III satellite based study. The comparative study of cropping pattern and rotaton analysed that except rice crop variation in area of all crops in rabi and kharif season as per Statistical Abstract of Haryana, 2018-19 and IRS LISS III satellite bases study are same. IRS LISS III satellite based study is conducted through spectral signature of different crops and unsupervised classification techniques using Geometica software but the Statistical Abstract of Haryana, 2018-19 is based on primary survey conducted by Haryana Revenue Department.



Rabi Cropping Pattern
Hisar District
(2018)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
W
E
S
Uklana
Barwala
Agroha
Adampur
Narnaund
Hisar-I
Hisar-II
Hansi-I
Hansi-II
Legend
Wheat
Sugarcane
Pulses
Mustard
Other Crops
Fallow Land
Non Agricultural Land
Block Boundary
District Boundary
Block Name
R. F. = 1:410,000
9
4.5
0
9
18
27 KM

Figure- 6

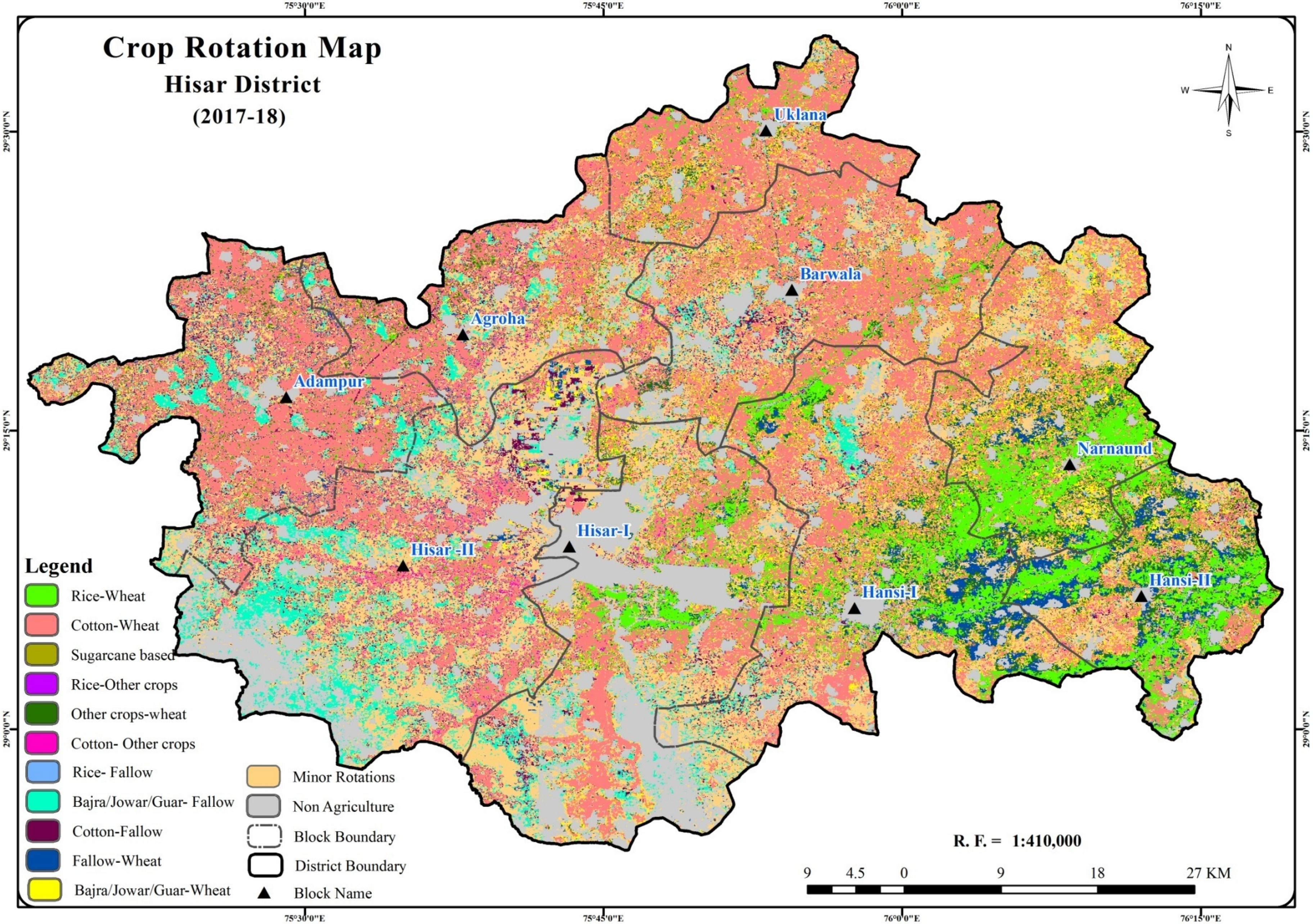

Crop Rotation Map
Hisar District
(2017-18)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Uklana
Barwala
Agroha
Adampur
Narnaund
Hisar-I
Hisar -II
Hansi-I
Hansi-II
Legend
Rice-Wheat
Cotton-Wheat
Sugarcane based
Rice-Other crops
Other crops-wheat
Cotton- Other crops
Rice- Fallow
Bajra/Jowar/Guar- Fallow
Cotton-Fallow
Fallow-Wheat
Bajra/Jowar/Guar-Wheat
Minor Rotations
Non Agriculture
Block Boundary
District Boundary
Block Name
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-7

CHAPTER-5

EVALUATION OF SOIL RESIOURCES

5.1 INTRODUCTION TO SOIL MAPPING

Soils are the very important non-renewable natural resources which are the base of all activities monitoring output of cultivation. The possible production of soil varies with its productive ability and inherent limitation. It is an active living scheme shaped from mutual result of climate, plants, soil, vegetation, fauna and secure on rocks and parent matter. Its correct husbandry is necessary for both sustained agriculture output and avoidance of soil degradation. The constant biotic population creates pressure on land to meet our growing demand of food, fodder, fuel fiber has resulted in deteriorating land and soil resources health. There would be a stable and nonstop degradation of farming land because of soil erosion and reduction of nutrient and consequential loss of soil effectiveness. Yearly, approximately 5354 M Tonnes of soils is vanished by soil erosion by water (The Hindu, 26 Nov. 2010, New Delhi). Due to, shifting cultivation, problems of water logging and salinization or alkalization soils of India nearly 9.38 million hectare area is affected by soils salinity out of which 5.5 million hectare are saline containing coastal saline land also and 3.88 million hectare is affected by alkali soils.(CSSRI, Karnal 2000).

The soils in Haryana are developed on alluvium in plain, on detrital & alluvium material in northern sub mountains tracks, as aeolian material in extreme western on alluvium caped by aeolian deposits in southern part of state. Inceptisols, the most dominant soils occupying about 58 % are followed by Entisols 28 %, Aridisols 9% and Alifisols 5% only Basically, soils over 43% of total geographical area are fine loamy, over 34% coarse loamy and rest 23% are sandy soils. One third of state's soil suffers from degradation of one or other kind e one fifth of total area of state is suffering from water and wind erosion. The problem of salinity and sodicity manifests in another 10% area and 3% of area in susceptible to flooding and water logging, while stonnivers affects nearly one percent of area. Hills and rocky outcrops make another 2 percent unfit for general cultivation (Kuhad, 1998).

The major part of state comes under low nitrogen, medium phosphorus a potassium category. With the present rate of population growth, the pressure on soil is increasing and degradation is taking place at fast rate (Kuhad, 1998). Therefore, there is an urgent need to arrest, check and reverse the process of soil degradation. Thus, comprehensive information about soils is required for better landuse planning, proper supervision and development of land resources.

This situation, call for comprehensive data base about different soils and their nature, extent, physio-chemical characteristics and limitations. This information can be provided by soil survey where each soil survey unit can be described in term of its characteristics and presented in the form of a map. Thus soil survey has been approved out by conventional approach. They are not only slow, time consuming and tedious but also very difficult and impractical for remote and inaccessible terrain. The use of aerial photos and satellite images since mid sixties accelerated soil mapping to some extent overcoming some of limitations of conventional ground surveys. This was further accelerated with the advent ot space borne data in narrow discrete spectral bands enabling soil scientist to map fairly large areas on repetitive basis.

Literature review shows that satellite images obtained by sensor such as Landsat TM/ MSS, SPOT and Indian remote sensing satellite series were being engaged for mapping of soils resources at various scales extending from 1:250000 scale to 1: 50000. In recent years, the recent generation of remote sensing satellites series like Landsat TM, Resource Sat and SPOT series were launched with excellent spectral, spatial and radio metrical resolution which allowed to map the soil at 1:50000 scale in relation of soil series. The studies completed with LISS-III and LISS-IV sensors data have shown the trend of quick development and extensive suitability of remote sensing utilities of soil resources. The technique has been employed successfully in India and abroad for mapping of soils (Saxena, Kumar and Arya, 1998; Ahuja et. al., 2001; Goyal et. al., 2001).

Hisar is the major and main agriculturally potential regions of Haryana having large differentiation in soils, landforms and land degradation-desertification, wind erosion, waterlogging, soil salinity/ alkalinity, soil fertility etc. This soil map and soil work of study area is taken from Haryana Space Applications Centre, CCS HAU Campus, Hisar (Arya et al, 2002). For identifying and mapping different kinds of soils and their problems, the soil survey through the application of remote sensing technique has been planned.

5.2 PHYSIOGRAPHY OF SOIL UNITS

Physiography or landform-soil relationship has been established by several workers in various parts of the country (Dhir and Kolarkar, 1977; Pande et al. 1990 and Sawhney et al., 2000). Physiography of soils units found in the area is mainly aeolian plain and Alluvial or flood plain. These physiographic unit and sub units are described below. The district is approximately level along with slight slopes except the region near the sand dunes or tibba. Common incline of the surface towards north-east to south-west direction and then the slope changes towards west. Hisar district contains mainly three physiographic units that are Chautang flood plain, older alluvial plain and aeolian plain. Other three sub-units arising in study area are plains, sand mound, old basin or channel. Western part and south-western parts of the district were affected by covering of sand dunes of Aeolian activity, sandy plains and interdunal regions. The area under various physiographic units is discussed in Table-11 and spatial arrangement of different physiographical unit is displayed in Figure-8. The Physiography map of soil series of the district is shown in Figure-8.

1. Aeolian Plain
2. Alluvial and Flood plain

5.2.1 Aeolian Plain

This plain is undulating in topography and occurs mainly in south eastern part of the district. These plains are covered with aeolian sand transported from the adjacent state Rajasthan. Some area of this class also scattered in eastern and central part of the district. The aeolian plain have been again divided into dunes, partially stabilized plain, interdunal aeolian plain and very gently undulating.

Dunes, Partially Stabilized: Sand dunes are scattered throughout the aeolian plain, which occurs mainly in the Hisar-II, Adampur, Barwala and Agroha blocks of the district. These dunes a partially stabilized due to human activities. Partially stabilized dunes are gently undulating, having moderate erosion and are marginally to moderately undulating cultivated. These sand dunes appear as light tone, coarse texture with diffused large parceling on satellite imagery. The soils of these sand dunes are excessively drained and sand to loamy sand texture. Taxonomically, these soils are placed under Typic Ustipsamments (Bichpari and Kharia series). Some patches of these dunes are also occurring in flood plain also particularly north of the district.

Plain, Very Gently Undulating: This is an aeolian plain with very gentle undulating topography. It appears as mixed light-red tone, medium texture and with diffused medium parcelling on imagery comprises of rolling sandy plain with the presence of scattered partially stabilized dunes. The soils of these areas are somewhat excessively drained and sand or loamy sand to sandy loam texture. Taxonomically, all these soils are placed under Typic Ustipsamments (Bichpari and Kharia series) occurring in association with fine Aeric Halaquents (Niyana Series). This unit is situated in Chamar Khera (Uklana block) and Ugalan (Hansi-II block) and Pillu Khera (Narnaund block).

5.2.2 Alluvial and Flood Plain

The Ghaggar River flowing from east to west in the Fatehabad district and northern part of the district forms the Ghaggar flood plain. Areas under this part of the plain are moderate to intensively cultivated due to favourable moisture and soils conditions. The Ghaggar flood plain also comprises of upland, nearly level and low land. These sub units, in relation to soils are described as under upland, nearly level: It forms the sub units of Ghaggar flood plain. These are differentiated on the imagery by mixed light red tone, fine texture a moderately distinct small parcelling. The soils in the unit are well drained sandy loam to loam/ silt loam in texture. Taxonomically, these soils are placed under coarse loamy/ fine loamy, Typic Haplustepts (Dabra, Fatehpuri, Gangwa and Kanala series). This unit is spread in Uklana block, northern part study area and adjacent area of Hisar city. These plains are classified as nearly level alluvial plain.

Flood Plain: These subunits, comprising of undulating topography and occurring along the bank of Ghaggar River, appear as light reddish tone and diffused parceling on imagery. This area falls in central part of the district. The soils of this unit are stratified having lithological discontinuity and lack of pedogenic development. Taxonomically, these soils are fine loamy, coarse loamy, Fluventic Haplustepts (Ratia series).

Table-11Area under different physiographical units

Physiography	Area in square kilometres	Percentage to total area of the district
Gently sloping Aeolian plain with stablised and interdunal plains	259.08	6.21
Gently to moderately sloping interdunal aeolian plains	394.95	9.47
Nearly level Fluvio-aeolian plain	714.32	17.13
Nearly level alluvial plain	839.79	20.14
Nearly level plains over Fluvio-aeolian plains	50.77	1.22
Nearly level to very gentle sloping alluvial plain	55.24	1.32
Very gentle sloping recent flood plains	1298.27	31.13
Very gently sloping interdunal aeolian plain	410.56	9.84
Habitation mask	146.59	3.51
Waterbodies	0.93	0.02
Grand Total	4170.51	100.00

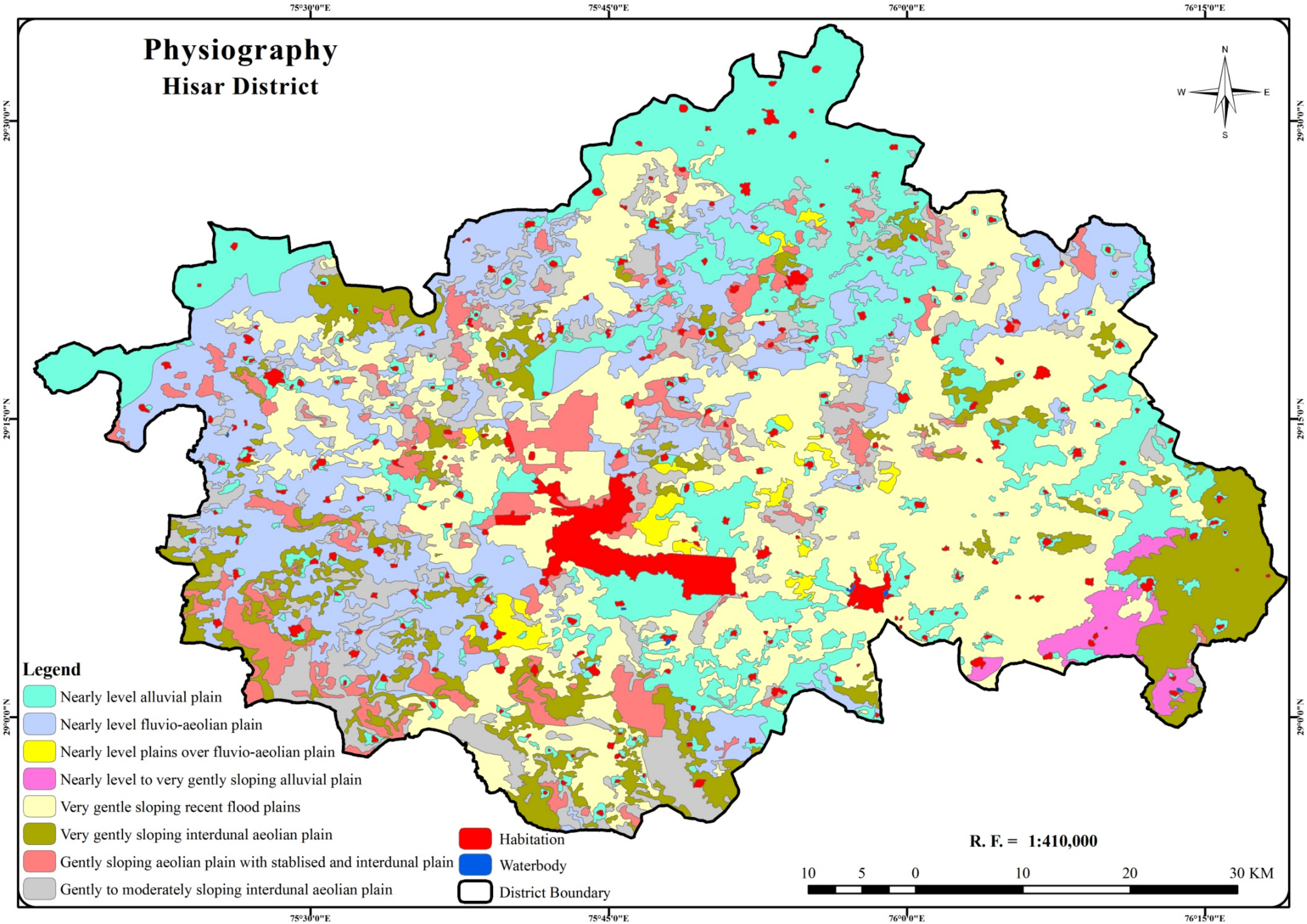

Physiography
Hisar District
N
S
E
W
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
Legend
Nearly level alluvial plain
Nearly level fluvio-aeolian plain
Nearly level plains over fluvio-aeolian plain
Nearly level to very gently sloping alluvial plain
Very gentle sloping recent flood plains
Very gently sloping interdunal aeolian plain
Gently sloping aeolian plain with stablised and interdunal plain
Gently to moderately sloping interdunal aeolian plain
Habitation
Waterbody
District Boundary
R. F. = 1:410,000
10 5 0 10 20 30 KM

Figure-8

5.3 TYPES OF SOILS

Eleven soil series were identified in the study area and these soils are categorised as per Soil Taxonomy discussed in Table -12. Brief explanation of each soil series is discussed below:

5.3.1 Kharia Soil Series

Kharia series is associated of the mixed, hyperthermic family of Typic Ustipsamments (Entisol). These are recent soils profile without any pedogenic activity. The soils are very deep, light textured throughout the profile. They have yellow, non- saline, non-sodic, sandy, A horizon and brownish yellow sand to loamy sand C horizon. This series is distributed in whole district. These soils occur on undulating partially stabilized sand dunes and mainly associated with Bichpari series. The soils are excessively drained with very rapid permeability.

5.3.2 Bichpari Soil Series

Bichpari series is also associate of mixed, Hyperthermic, Entisol's family of Typic Ustipsamments. These are recent soils profile having undulating topography. The soils are very deep, light textured throughout the profile. They have yellow, sandy, A horizon and brownish yellow sand to loamy sand C horizon. This series is founded scattered patches in eastern and central part of the district. These soils occur on gently to moderately sloping interdunal aeolian plains. The soils are well drained with low to medium water holding capacity.

5.3.3 Ratia Soil Series

Ratia series is having the mixed, hyperthermic family of Fluventic Haplustepts (Inceptisol). These are more developed soil than Entisols with very gentle sloping recent deep flood plain. They have sandy loam to sandy clay to clay loam texture with medium available water holding capacity. This series is largely situated in central and western portion of the district. These soil series having good permeability of water and are associated with Bas series. The soils are well drained.

5.3.4 Bas Soil Series

Ratia series is also having the mixed, hyperthermic family of Fluventic Haplustepts (Inceptisol). The soils are very deep and have initiated the pedogenic activities with nearly level to gentle sloping. These soils are very potential for agricultural purpose. These are located in Hansi-I in Bas, Madanheri and Sorkhi villages. These soils are situated in upland nearly level plain and having clay loam to sandy clay loam medium texture. This soils have properties of moderately well drained and medium to high water holding capacity.

5.3.5 Fatehpuri Soil Series

Fatehpuri series is also associated with mixed, hyperthermic family of Typic Haplustepts. The soils are very deep and well drained. These soils have dark brown, moderate to strongly alkaline, silt loam B horizon. These soils are mainly lies in Uklana block and Banwali village of Adampur block. The series is related to Kanala, Dabra and Gangwa series. The soils having average water holding capacity with good permeability.

5.3.6 Kanala Soil Series

Kanala series is also a member of the mixed, hyperthermic family of Typic Haplustepts, nearly level alluvial plain. The soils are very deep with good permeability. These soils are potential for agricultural purpose and having slightly heavy texture. These soils occur in Nangthla, Kirori, eastern sided area Balak village. These are well drained with medium to high water holding capacity.

5.3.7 Dabra Soil Series

Dabra series having mixed, hyperthermic, sandy loam to clay loam classified as Typic Haplustepts (Inceptisol). These soils are slightly sodic or saline with very high water holding capacity. This series is situated adjacent to region of Hisar city and Niyana, Umra and eastern sided area of Narnaund village. This soil series has developed on channel courses, levees and recent & active flood plains. This series is clay to sandy loam and imperfectly drained.

5.3.8 Gangwa Soil Series

Gangwa series having mixed, hyperthermic, sandy loam to clay loam classified as Typic Haplustepts (Inceptisol). These type of soils are brown, loamy sand, mildly alkaline A horizon, brown to dark yellowish brown having stratified layers of sand loam/loamy sand/ silty clay loam C horizon. Gangwa series is located in small scattered patch in central part of the district. These soil series is fine loamy and well drained with medium water holding capacity.

5.3.9 Jundli Khurd Soil Series

This series having mixed calcareous, hyperthermic, coarse loamy classified as Typic Ustifluvents (Entisol). These types of soils are deep and well drained. This series is located in small scattered patch in whole part of the district and mainly founded in Hansi-I block. These soil series have high water holding capacity.

5.3.10 Dhingsara Soil Series

Gangwa series having mixed calcareous, hyperthermic, deep, coarse lomay classified as Nitric Haplustepts (Inceptisol). These soils are potential for agricultural purpose but some reclamation measures are required. This series is mainly located in Hisar – II, Adampur and Barwala blocks. Small scattered patch also founded in north eastern part of the district. These soil series have good permeability and medium water holding capacity.

5.3.11 Niyana Soil Series

Niyana series having mixed calcareous, hyperthermic, deep, fine classified as Aeric Halaquents. These soils are potential for agricultural purpose but some reclamation measures are required. This series is mainly located between Petwar and Khanda Kheri villages and eastern side of Pillu Khera village. Single patch also founded in southern side of Hisar city. These soil series are moderately saline or sodic type, with low permeability and very high water holding capacity. Spatial arrangement of different soil series is presented in Figure-9.

Table-12 Description of various soil series with respective area, physiographic unit, taxonomy and soil series important characteristics

Soil Series	**Physiography**	**Soil Taxonomy**	**Major Characteristics**	**Area in square kilometres**
Bas	Nearly level to very gentle sloping alluvial plain	Fine Loamy, Fluventic Haplustepts	Mixed non calcareous hyperthermic, deep, moderately well drained, medium to high AWC, few fine iron concretions, very potential for agriculture and good permeability.	55.24
Bichpari	Gentle to moderately sloping interdunal aeolian plain	Coarse Loamy, Typic Ustipsamments	Mixed non calcareous hyperthermic, deep, well drained, medium to high AWC, moderate to high permeability and low fertile soil.	394.95
Dabra	Nearly level alluvial plain	Fine Loamy, Typic Haplustepts	Mixed calcareous hyperthermic, deep, Imperfectly drained, very high AWC, very low permeability, slightly sodic/ saline soil and potential for agriculture.	333.68
Dhingasra	Nearly level fluvio-aeolian plain	Coarse Loamy, Nitric Haplustepts	Mixed calcareous hyperthermic, deep, well drained, medium AWC, good permeability, moderately sodic/ saline soil and potential for agriculture but need some reclamation measures.	714.39
Fatehpuri	Nearly level alluvial plain	Fine Loamy, Typic Haplustepts	Mixed calcareous hyperthermic, deep, moderately well drained, medium AWC, good permeability, slightly light texture soil and potential for agriculture.	389.38
Gangwa	Nearly level plain over fluvio –aeolian plains	Coarse Loamy, Typic Haplustepts	Mixed calcareous hyperthermic, deep, well drained, medium AWC, good permeability, moderately sodic/ saline soil and potential for agriculture but need some reclamation measures.	50.77
Jaundli Khurd	Very gentle sloping interdunal aeolian plain	Coarse Loamy, Typic Ustifluvents	Mixed calcareous hyperthermic, deep, well drained, high AWC, good permeability, slightly waterlogging/ flooding and undulating topography.	410.57
Kanala	Nearly level alluvial plain	Fine Loamy, Typic Haplustepts	Mixed calcareous hyperthermic, deep, moderately well drained, medium to high AWC, good permeability, slightly heavy texture soil and potential for agriculture.	53.05
Kharia	Gently sloping aeolian plain with stabilised and interdunal plains	Sandy, Typic Ustipsamments	Mixed non calcareous hyperthermic, deep, excessively drained, very low AWC, high permeability, sandy texture soil and low fertility.	259.08
Niyana	Nearly level alluvial plain	Fine, Aeric Halaquents	Mixed calcareous hyperthermic, deep, poorly drained, very high AWC, low permeability, heavy texture soil, moderately saline /sodic soil and waterlogging.	63.68
Ratia	Very gentle sloping recent flood plains	Fine Loamy, Fluventic Haplustepts	Mixed calcareous hyperthermic, deep, well drained, medium AWC, good permeability, slightly and very potential for agriculture.	1298.27
Habitation	-	-	-	146.52
Waterbody	-	-	-	0.93
Total				4170.51

Soil explanation as family wise is displayed in Figure -10 and soil sub group allotment is displayed in Figure-11 correspondingly. Area under different soil family classes is presented in Table-13 and area under different soil sub group class is Table-14.

Table-13 Area under different soil family classes

Soil Family	Area in Square Kilometres	Percentage to Total Study Area
Coarse Loamy Natric Haplustepts	714.39	17.13
Coarse Loamy Typic Haplustepts	50.77	1.22
Coarse Loamy Typic Ustifluvents	410.56	9.84
Coarse Loamy Typic Ustipsamments	394.95	9.47
Fine Aeric Halaquents	63.68	1.53
Fine Loamy Fluventic Haplustepts	1353.50	32.45
Fine Loamy Typic Haplustepts	723.56	17.35
Fine Typic Haplustepts	53.02	1.27
Sandy Typic Ustipsamments	259.08	6.21
Habitation	146.06	3.50
Waterbody Mask	0.93	0.02
Total	4170.51	100.00

Table-14 Area under different soil sub group class

Soil sub group	Area in square Kilometres	Percentage to Total Study Area
Aeric Halaquents	63.68	1.53
Fluventic Haplustepts	1353.50	32.45
Natric Haplustepts	714.39	17.13
Typic Haplustepts	826.88	19.83
Typic Ustifluvents	410.56	9.84
Typic Ustipsamments	654.03	15.68
Waterbody	0.93	0.02
Habitation Mask	146.53	3.51
Total	4170.51	100.00

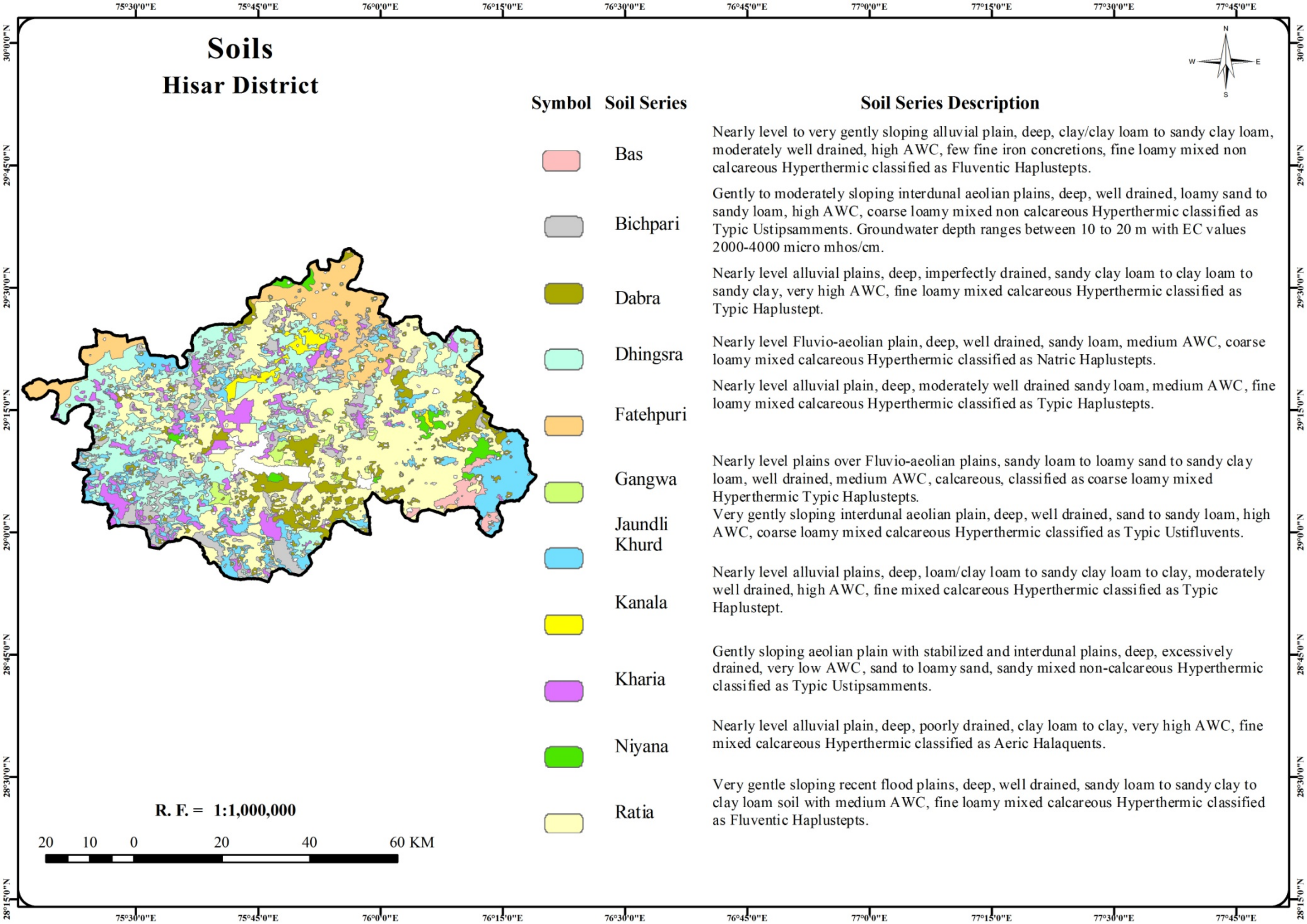

Soils
Hisar District
Symbol
Soil Series
Soil Series Description
Bas
Nearly level to very gently sloping alluvial plain, deep, clay/clay loam to sandy clay loam, moderately well drained, high AWC, few fine iron concretions, fine loamy mixed non calcareous Hyperthermic classified as Fluventic Haplustepts.
Bichpari
Gently to moderately sloping interdunal aeolian plains, deep, well drained, loamy sand to sandy loam, high AWC, coarse loamy mixed non calcareous Hyperthermic classified as Typic Ustipsamments. Groundwater depth ranges between 10 to 20 m with EC values 2000-4000 micro mhos/cm.
Dabra
Nearly level alluvial plains, deep, imperfectly drained, sandy clay loam to clay loam to sandy clay, very high AWC, fine loamy mixed calcareous Hyperthermic classified as Typic Haplustept.
Dhingsra
Nearly level Fluvio-aeolian plain, deep, well drained, sandy loam, medium AWC, coarse loamy mixed calcareous Hyperthermic classified as Natric Haplustepts.
Fatehpuri
Nearly level alluvial plain, deep, moderately well drained sandy loam, medium AWC, fine loamy mixed calcareous Hyperthermic classified as Typic Haplustepts.
Gangwa
Nearly level plains over Fluvio-aeolian plains, sandy loam to loamy sand to sandy clay loam, well drained, medium AWC, calcareous, classified as coarse loamy mixed Hyperthermic Typic Haplustepts.
Jaundli Khurd
Very gently sloping interdunal aeolian plain, deep, well drained, sand to sandy loam, high AWC, coarse loamy mixed calcareous Hyperthermic classified as Typic Ustifluvents.
Kanala
Nearly level alluvial plains, deep, loam/clay loam to sandy clay loam to clay, moderately well drained, high AWC, fine mixed calcareous Hyperthermic classified as Typic Haplustept.
Kharia
Gently sloping aeolian plain with stabilized and interdunal plains, deep, excessively drained, very low AWC, sand to loamy sand, sandy mixed non-calcareous Hyperthermic classified as Typic Ustipsamments.
Niyana
Nearly level alluvial plain, deep, poorly drained, clay loam to clay, very high AWC, fine mixed calcareous Hyperthermic classified as Aeric Halaquents.
Ratia
Very gentle sloping recent flood plains, deep, well drained, sandy loam to sandy clay to clay loam soil with medium AWC, fine loamy mixed calcareous Hyperthermic classified as Fluventic Haplustepts.
R. F. = 1:1,000,000
20 10 0 20 40 60 KM

Figure-9

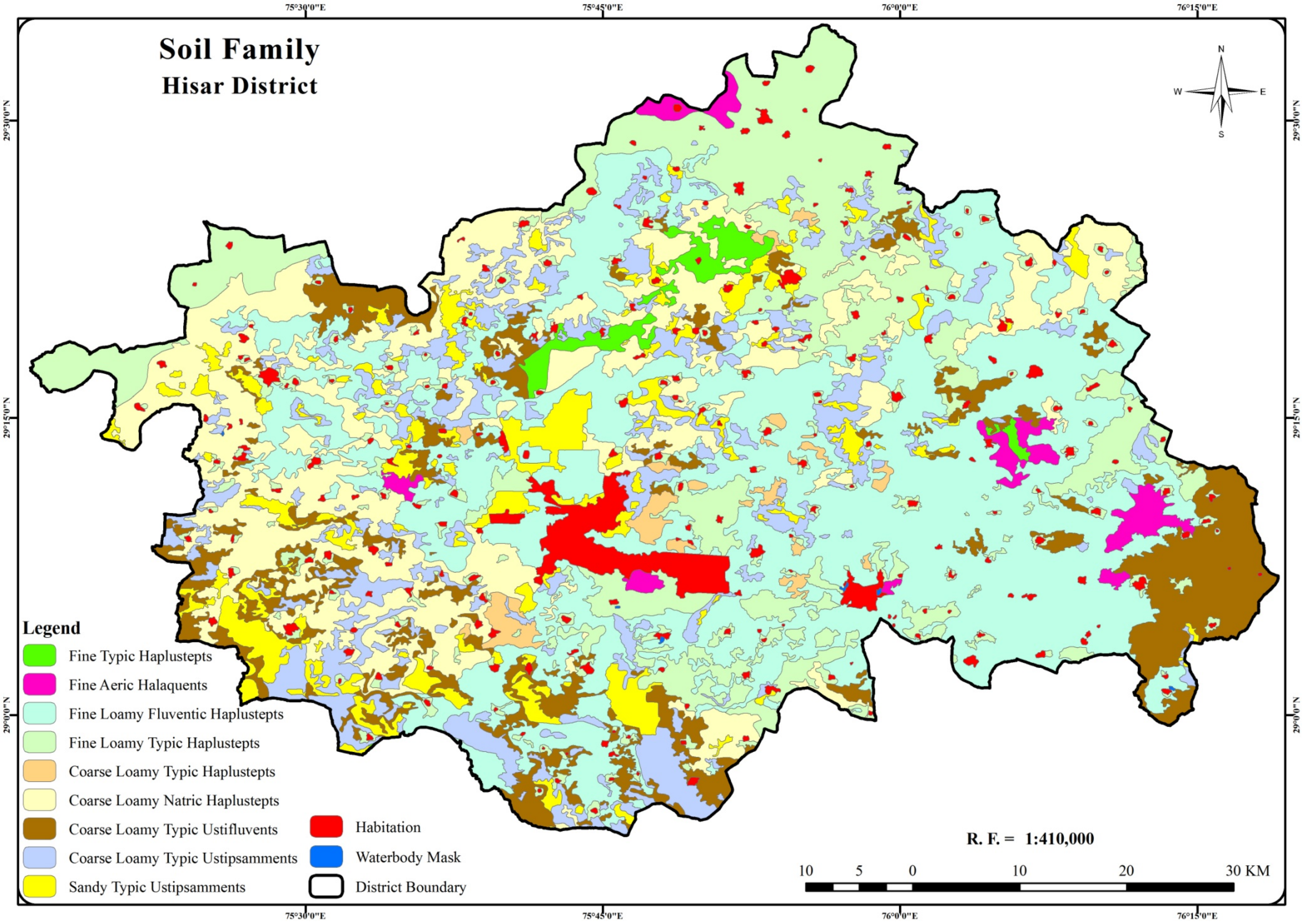
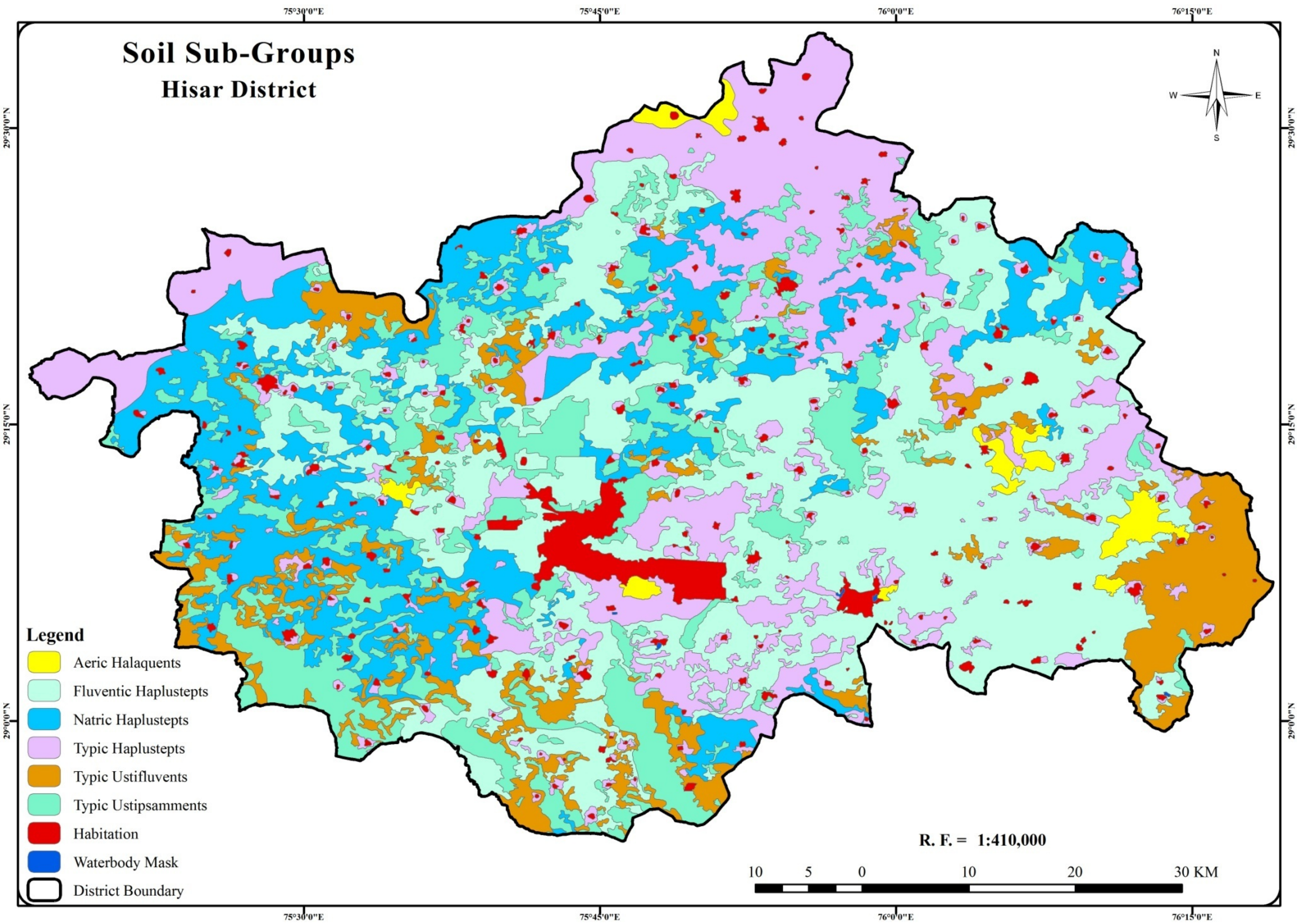

Soil Family
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Legend
Fine Typic Haplustepts
Fine Aeric Halaquents
Fine Loamy Fluventic Haplustepts
Fine Loamy Typic Haplustepts
Coarse Loamy Typic Haplustepts
Coarse Loamy Natric Haplustepts
Coarse Loamy Typic Ustifluvents
Coarse Loamy Typic Ustipsamments
Sandy Typic Ustipsamments
Habitation
Waterbody Mask
District Boundary
R. F. = 1:410,000
10 5 0 10 20 30 KM

Figure-10



Soil Sub-Groups
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Legend
Aeric Halaquents
Fluventic Haplustepts
Natric Haplustepts
Typic Haplustepts
Typic Ustifluvents
Typic Ustipsamments
Habitation
Waterbody Mask
District Boundary
R. F. = 1:410,000
10 5 0 10 20 30 KM

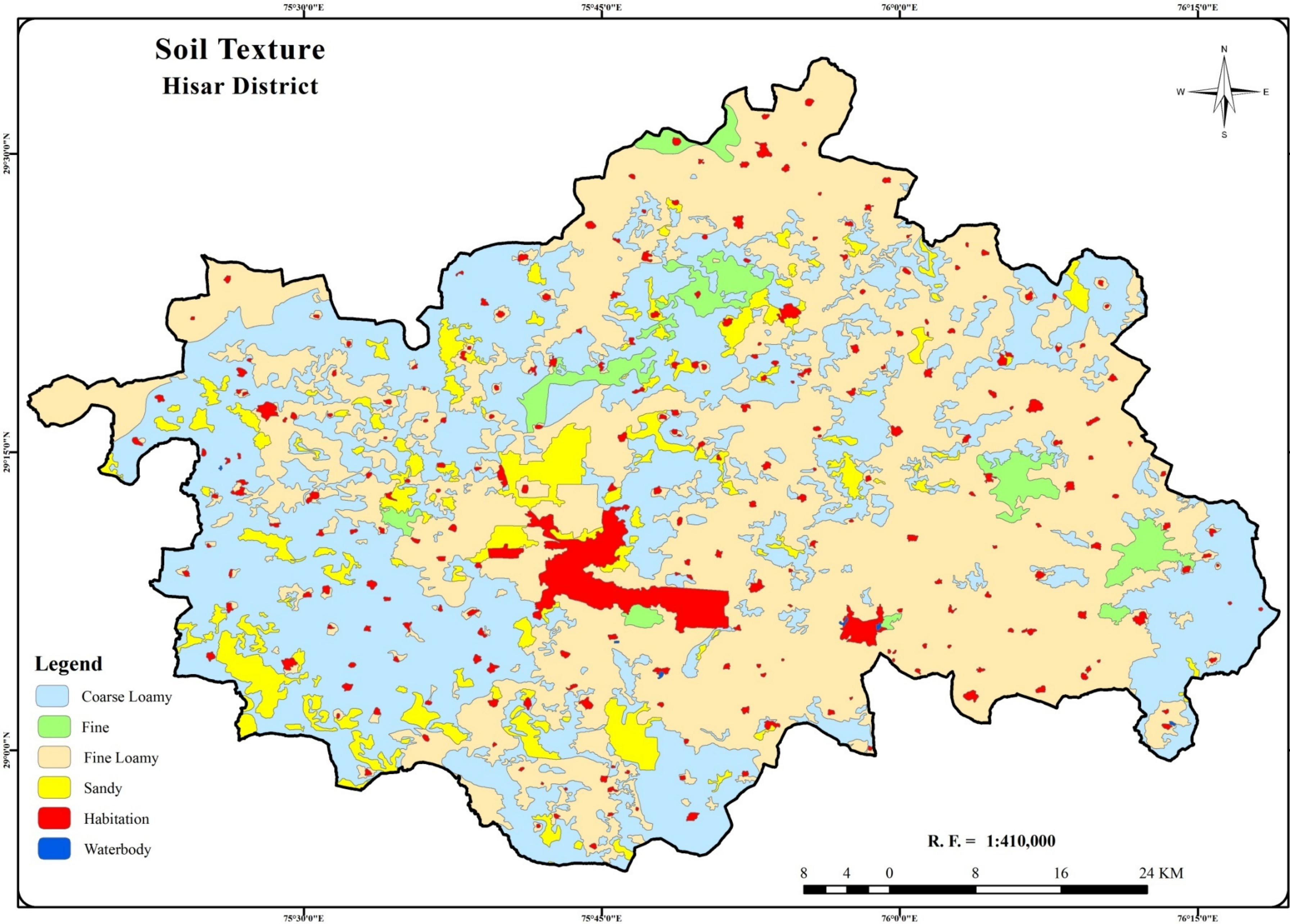
Figure-11

5.4 SOIL TEXTURE

Soil texture elaborates soil properties that are base of crop output and ground management. Texture based category of a soil is determined by the proportion of clay, sand and silt. A soil texture map of the district was generated based on chemical and physical properties of soil collected from HARSAC. It was observed that different soil texture family classes like Coarse loamy, Fine loamy, Fine and Sandy are there in the study area. Fine loamy category occupies 2076.56 square kilometres area that is 49.79 percent of the study area. Mainly this class is observed in eastern part of the district in blocks namely Narnaund, Uklana, Hansi-I, Hansi-II and Hisar-I. Second major class is coarse loamy that occupies 1570.67 square kilometres area which is 37.66 percent of the study area. This category is observed in western part of the district in Adampur, Hisar-II and Agroha blocks. Third main class is sandy which covers 259.08 square kilometres area that is 6.21 % of study area and founded in scattered patches in whole district. Other class is fine which covers 2.80 square kilometres. Spatial arrangement of soil texture is presented in Figure-12 and areal variation of different classes of soil texture is discussed in Table-15.

Table-15 Texture wise soil classification and their respective area

Type of Soil Texture	Area in square Kilometres	Percentage to total study area of the district
Fine	116.74	2.80
Coarse Loamy	1570.67	37.66
Fine Loamy	2076.56	49.79
Sandy	259.08	6.21
Habitation Mask	146.53	3.51
Waterbody	0.93	0.02
Total	4170.51	100.00



Soil Texture
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Legend
Coarse Loamy
Fine
Fine Loamy
Sandy
Habitation
Waterbody
R. F. = 1:410,000
8 4 0 8 16 24 KM

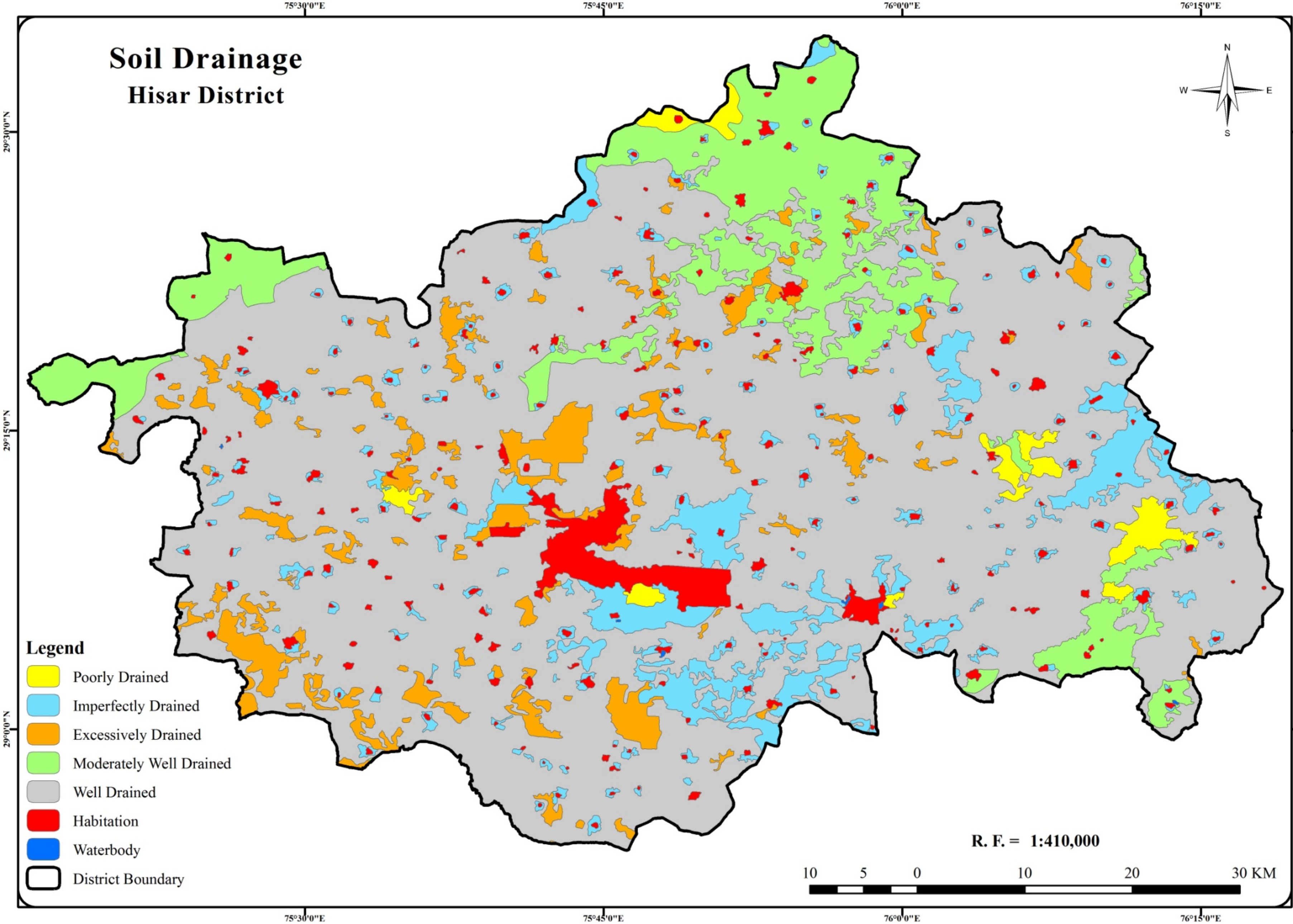
Figure-12

5.5 SOIL DRAINAGE

The natural processes through which water travel throughout or transversely the soil because of gravity. Soil drainage could define that which types of plant and vegetation develop most excellent in any area. Many of soils require good drainage to increase or tolerate the production or to accomplish water supplies (Haroun, 2004). Poor drainage pattern explained that is largely set up in water-logged regions could often be identified by investigating the soil texture or color. It conquered by longer ages of diffusion and dipping situation. 2868.94 square kilometres area of the district is under well drained class which was 68.79 % of the study area. This class occurs mostly in whole district. Other major category is moderately well drained that occupies 497.67 sq. km. area and mostly founded in Uklana block of the district. Other classes are imperfectly drained, excessively drained and poorly drained that covers 33.68, 259.08 and 63.68 sq. km area respectively. Detailed information of concerning area and spatial understanding are displayed in Table-16 and Figure-13 accordingly.

Table-16 Area under different class of Soil Drainage

Types of Soil Drainage	Area in Square Kilometres	Percentage to Total Study Area
Poorly Drained	63.68	1.53
Imperfectly Drained	333.68	8.00
Excessively Drained	259.08	6.21
Moderately Well Drained	497.67	11.93
Well Drained	2868.94	68.79
Waterbody	0.93	0.02
Habitation Mask	146.52	3.51
Total	4170.51	100.00



Soil Drainage
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
W
E
Legend
Poorly Drained
Imperfectly Drained
Excessively Drained
Moderately Well Drained
Well Drained
Habitation
Waterbody
District Boundary
R. F. = 1:410,000
10 5 0 10 20 30 KM

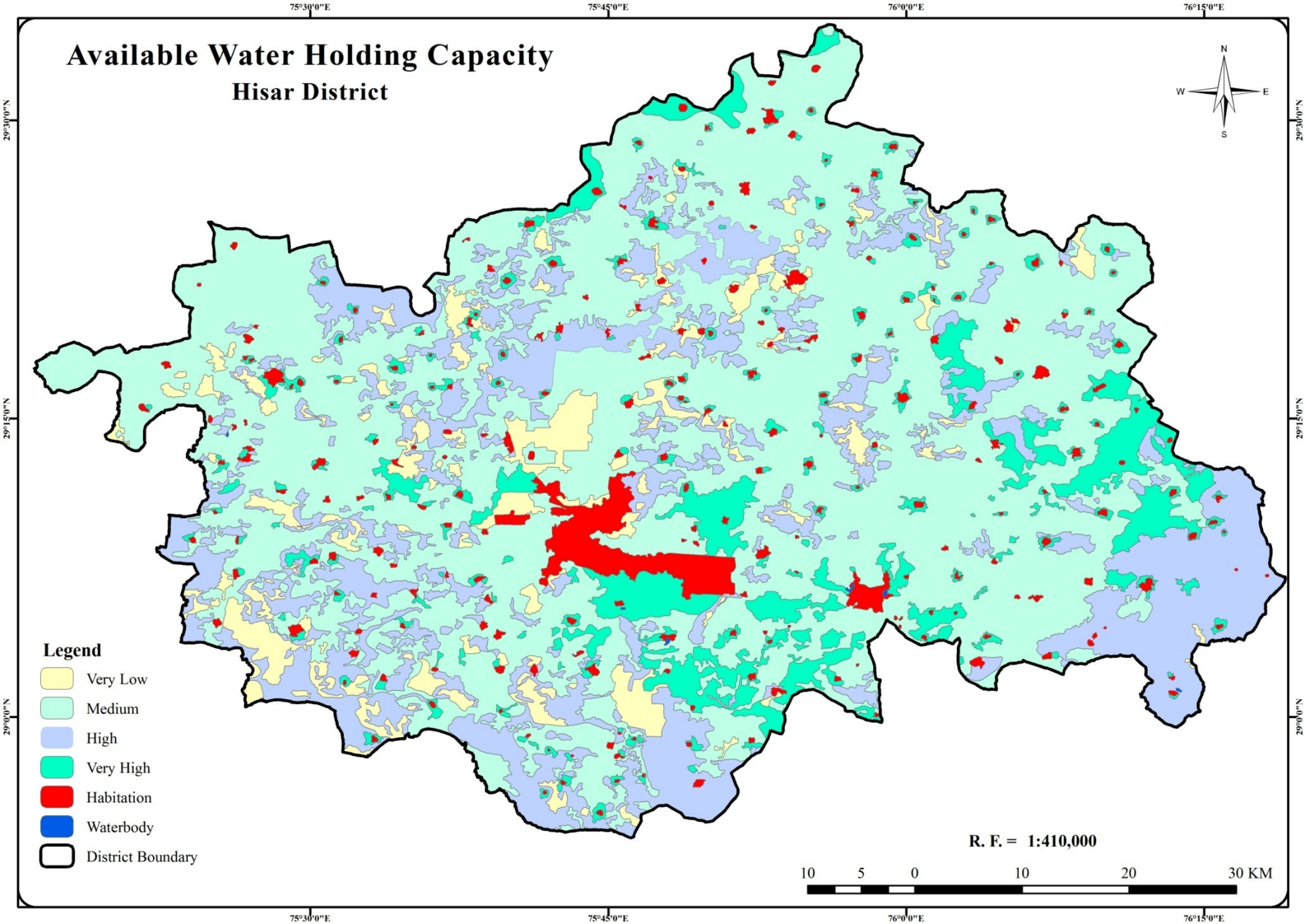
Figure-13

5.6 AVAILABLE WATER HOLDING CAPACITY OF DIFFERENT SOILS

The water holding capacity of the soils is a very significant agronomic property. Soils that carry large quantities of water are less likely to avoid nutrient sufferers or soil-applied insecticides. This is because textured soils with imperfect holding of water volume reached the saturation point much earlier than the soil with high water holding potential of the clay loamy textures due to a sandy loam. Soils are saturated by the solution process with all the excess water and few of the contaminants and nutrients that are leached downwards into the soil profile. The study area of 2452.81 square kilometres has a medium water holding capacity of soil that was 58.81 percent of the district's total geographical area. The maximum area of the district is covered in this class. Other classes defined in the district are very high AWC (397.83) and very low AWC (259.08). The region of usable water holding capacity under the different soil groups is addressed in Table-17 and presented in Figure-14.

Table-17 Area under different class of soil water holding capacity

AWC Class	Area in square kilometres	Percentage to Total Study Area
Very high	397.83	9.54
High	913.80	21.91
Medium	2452.81	58.81
Very low	259.08	6.21
Habitation	146.06	3.50
Waterbody Mask	0.93	0.02
Total	4170.51	100.00



Available Water Holding Capacity
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Legend
Very Low
Medium
High
Very High
Habitation
Waterbody
District Boundary
R. F. = 1:410,000
10
5
0
10
20
30 KM

Figure-14

CHAPTER-6

EVALUATION OF WATER RESIOURCES

6.1 UNDERGROUND WATER TABLE DEPTH STATUS

Ground water depth information also plays a big role in assessing the present landuse and suggesting alternate landuse of the area. The data of ground water depth was collected from Central Ground Water Cell, Haryana. On the basis of collected data underground water depth map for pre monsoon and post monsoon (2015) were generated adopting interpolation techniques in ArcGIS 9.3 software. As per their criteria, it is categorized into five classes; Less than 1.5 Metre, 1.5 to 5 metre, 5 to 10 metre, 10 to 15 metre and more than 15 metre. Pre-monsoon water table depth status is shown in Table -18 and post- monsoon water table status is shown in Table-19. It is clear from both tables that about fifty eight to sixty percent of the study area falls under 5-10 metre depth followed by 10-15 metre. The depth which is considered critical and falls under waterlogged category (Pre monsoon) is between 0-1.5 metre and covers an area of 8.76 square kilometres. This class founded near Sabarwas and Sarangpur villages adjacent to Fatehabad district. Underground water table depth maps for pre and post monsoon was presented in Figure-15 and Figure-16.

Table-18 Pre-Monsoon water table depth status with areal extent

Depth Range in Metre	Area in Square Kilometres	Percentage to Total Study Area
0-1.5	8.76	0.21
1.5-5	561.91	13.47
5-10	2510.83	60.20
10-15	958.49	22.98
>15	130.52	3.13
Total	4170.51	100.00

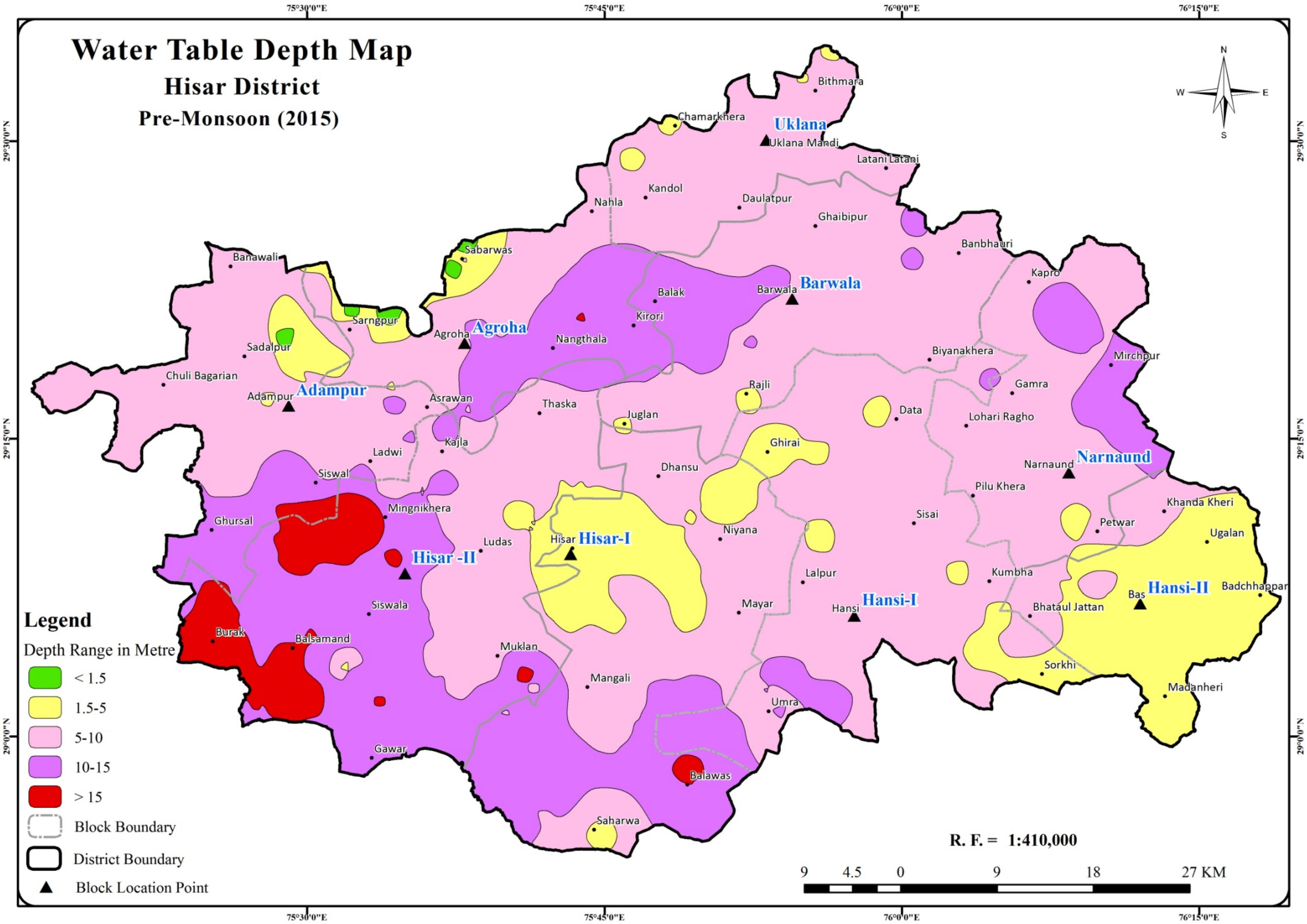
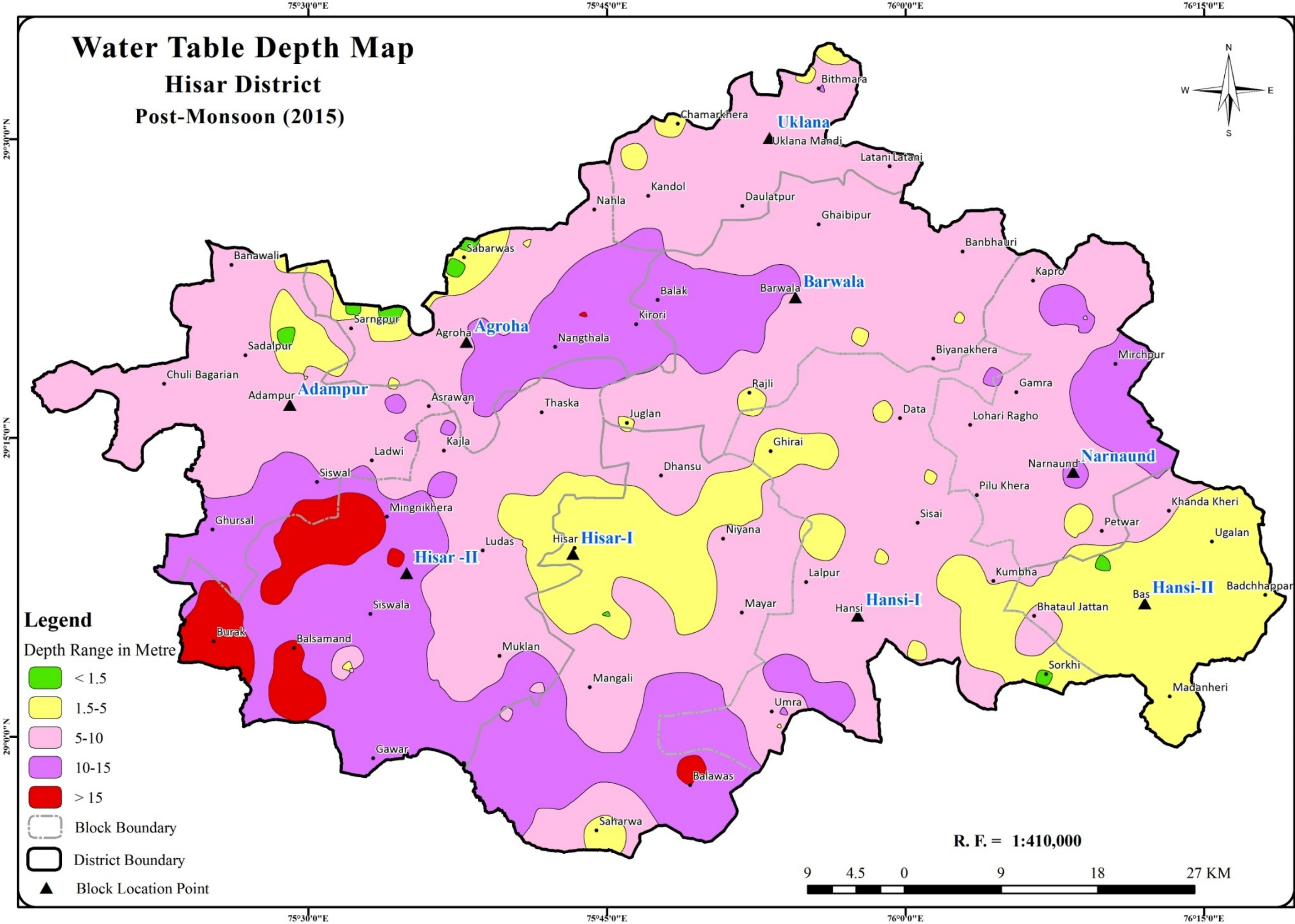

Water Table Depth Map
Hisar District
Pre-Monsoon (2015)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Bithmara
Chamarkhera
Uklana
Uklana Mandi
Latani Latani
Kandol
Nahla
Daulatpur
Ghaibipur
Banbhauri
Sabarwas
Banawali
Kapro
Barwala
Balak
Kirori
Sarngpur
Agroha
Nangthala
Sadalpur
Biyanakhera
Mirchpur
Chuli Bagarian
Adampur
Asrawan
Thaska
Rajli
Gamra
Juglan
Data
Lohari Ragho
Kajla
Ghirai
Ladwi
Dhansu
Narnaund
Siswal
Pilu Khera
Mingnikhera
Khanda Kheri
Ghursal
Niyana
Sisai
Petwar
Ludas
Hisar
Hisar-I
Ugalan
Hisar -II
Kumbha
Lalpur
Badchhappar
Bas
Hansi-II
Siswala
Mayar
Hansi
Hansi-I
Bhataul Jattan
Burak
Balsamand
Muklan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Depth Range in Metre
< 1.5
1.5-5
5-10
10-15
> 15
Block Boundary
District Boundary
Block Location Point
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-15



Water Table Depth Map
Hisar District
Post-Monsoon (2015)
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Uklana
Barwala
Agroha
Adampur
Narnaund
Hisar-I
Hisar -II
Hansi-I
Hansi-II
Bithmara
Chamarkhera
Uklana Mandi
Latani Latani
Kandol
Nahla
Daulatpur
Ghaibipur
Banbhauri
Sabarwas
Banawali
Kapro
Balak
Kirori
Sarngpur
Sadalpur
Nangthala
Biyanakhera
Mirchpur
Chuli Bagarian
Gamra
Rajli
Asrawan
Thaska
Juglan
Data
Lohari Ragho
Ladwi
Kajla
Ghirai
Siswal
Dhansu
Narnaund
Pilu Khera
Mingnikhera
Khanda Kheri
Ghursal
Sisai
Petwar
Niyana
Ludas
Ugalan
Kumbha
Lalpur
Siswala
Mayar
Bas
Badchhappar
Hansi
Bhataul Jattan
Burak
Balsamand
Muklan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Depth Range in Metre
< 1.5
1.5-5
5-10
10-15
> 15
Block Boundary
District Boundary
Block Location Point
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-16

Table-19 Post-Monsoon water table depth status and areal extent

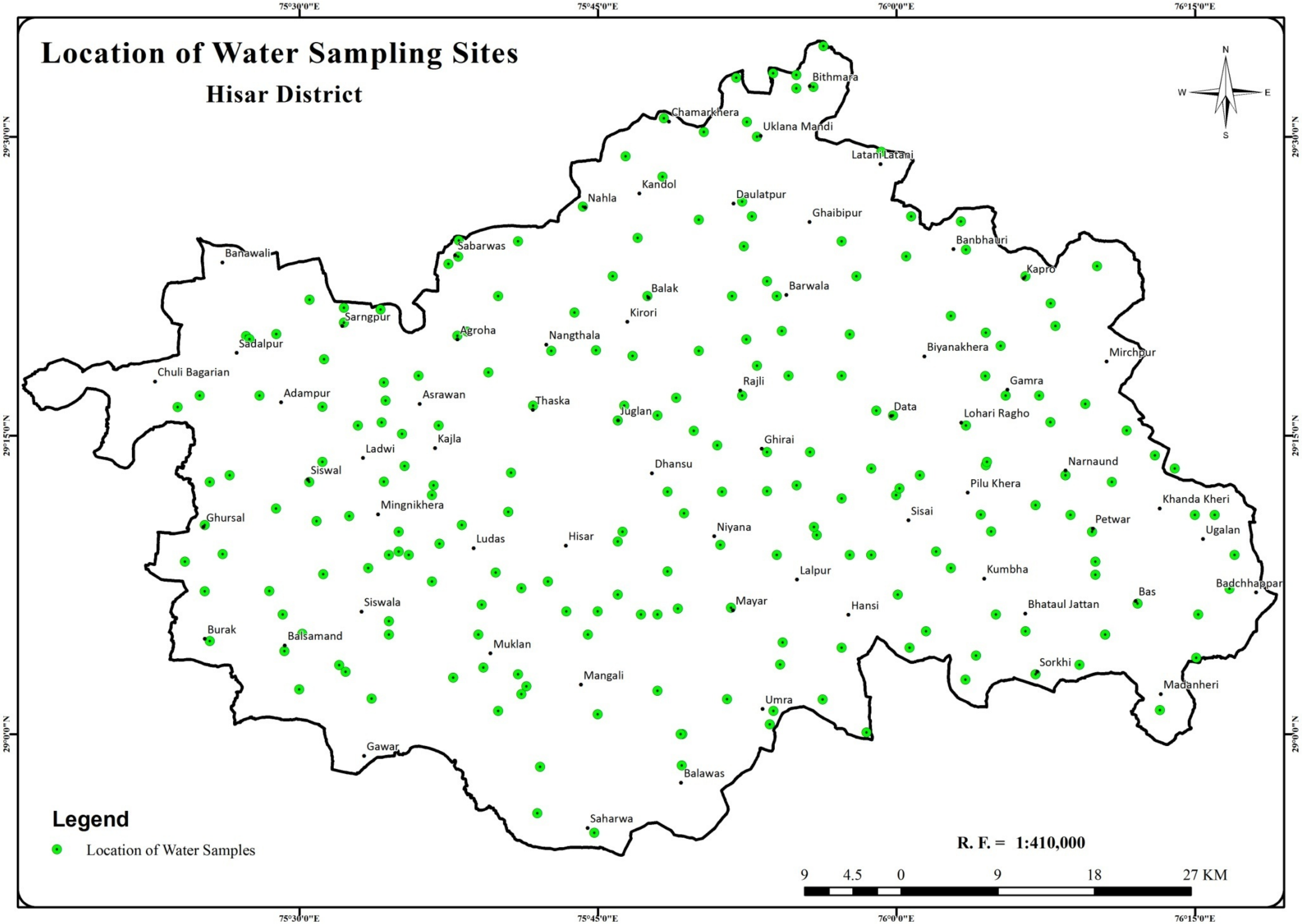
Depth Range in Metre	Area in Square Kilometres	Percentage to Total Study Area
0-1.5	12.03	0.29
1.5-5	675.11	16.19
5-10	2417.37	57.96
10-15	942.54	22.60
>15	123.46	2.96
Total	4170.51	100.00

6.2 WATER QUALITY STATUS

Underground water defines water available in the saturation zone that is parted from the surface of earth by permeable zone of aeration**.** The underground water quality investigation in study area included laboratory analysis of water samples. Detailed of total 225 water samples were received from Ground Water Cell, Haryana. These water samples of underground wells, tube wells & hand pumps were collected along with their GPS locations and analyzed for their chemical properties like EC (dS/m), pH, Ca+Mg (me/L), CO3, HCO3 (me/L) and Residual Sodium Carbonate (RSC). The location sites of water samples are shown in Figure-17. 1589.42 square kilometres area of the study area is under fresh quality while 1668.34 square kilometres area is under sub marginal class. 769.03 square kilometres area under marginal class and 143.72 square kilometres area is under saline class (Table-20). Water quality map is presented in Figure-18.

Table-20 Underground water quality status and areal extent

Description	Quality	Area	Percentage to total Geographical Area
0-2000	Fresh	1589.42	38.11
2000-4000	Sub Marginal	1668.34	40.00
4000-6000	Marginal	769.03	18.44
>6000	Saline	143.72	3.45
Total		4170.51	100.00



75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
Location of Water Sampling Sites
Hisar District
N
W
E
S
Bithmara
Chamarkhera
Uklana Mandi
Latani
Kandol
Nahla
Daulatpur
Ghaibipur
Banawali
Sabarwas
Banbhauri
Kapro
Balak
Barwala
Sarngpur
Kirori
Agroha
Nangthala
Sadalpur
Biyanakhera
Mirchpur
Chuli Bagarian
Rajli
Gamra
Adampur
Asrawan
Thaska
Juglan
Data
Lohari Ragho
Ladwi
Kajla
Ghirai
Siswal
Dhansu
Narnaund
Pilu Khera
Mingnikhera
Khanda Kheri
Ghursal
Sisai
Petwar
Niyana
Ugalan
Ludas
Hisar
Lalpur
Kumbha
Badchhappar
Siswala
Mayar
Hansi
Bas
Bhataul Jattan
Burak
Balsamand
Muklan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Location of Water Samples
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-17

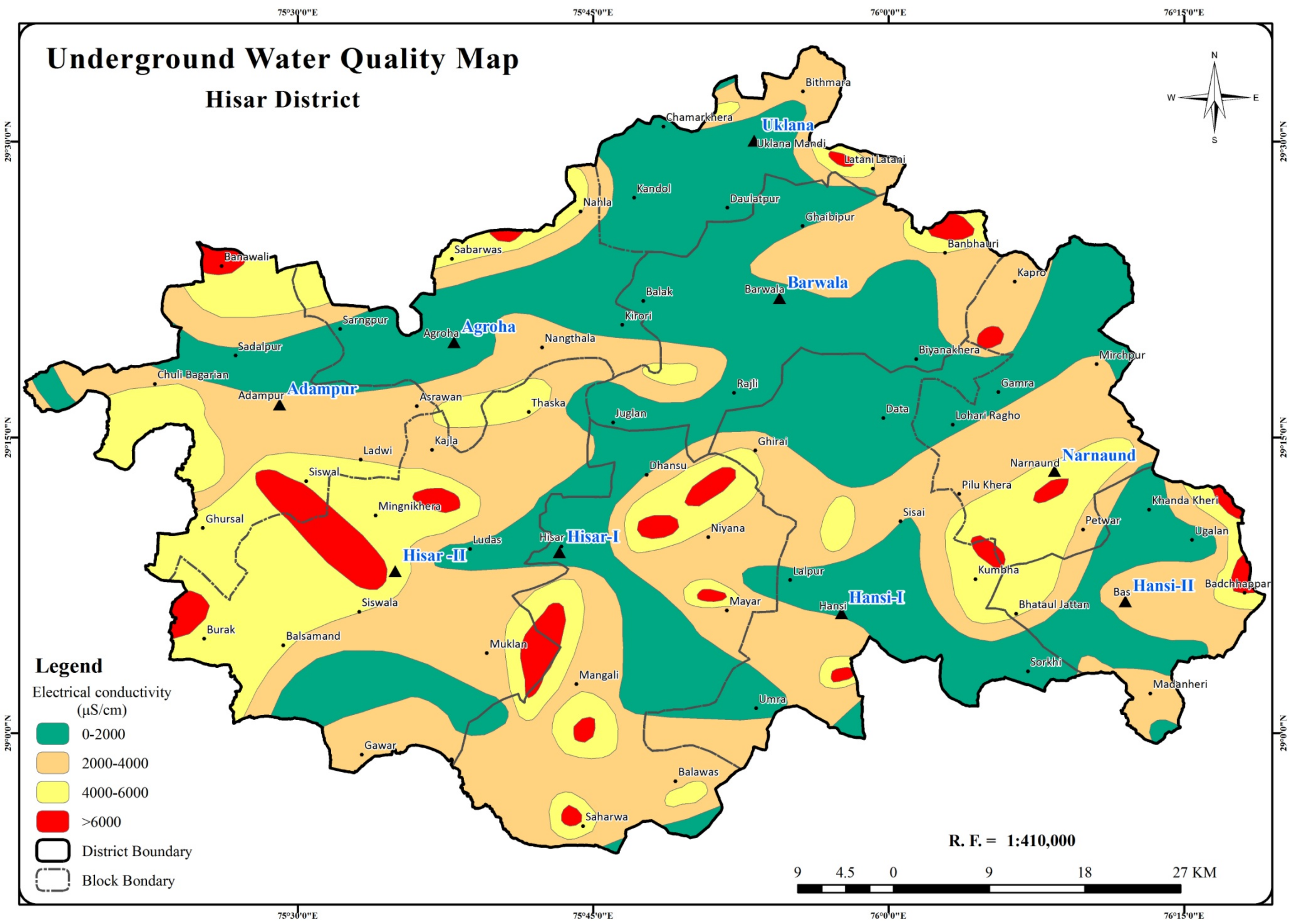
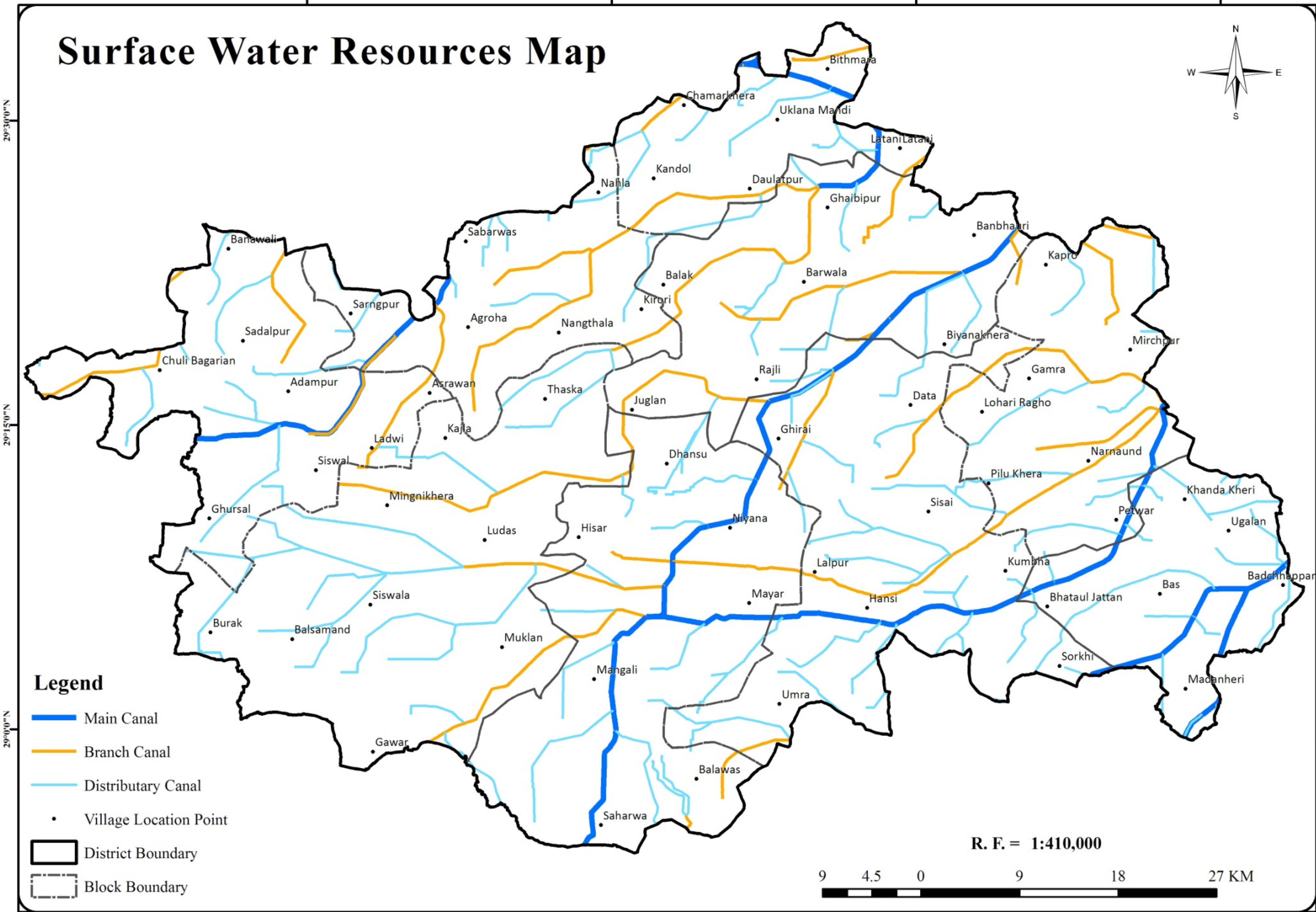

Underground Water Quality Map
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Bithmara
Chamarkhera
Uklana
Uklana Mandi
Latani Latani
Kandol
Nahla
Daulatpur
Ghaibipur
Banbhauri
Sabarwas
Banawali
Kapro
Balak
Barwala
Barwala
Sarngpur
Agroha
Agroha
Kirori
Nangthala
Sadalpur
Biyanakhera
Mirchpur
Chuli Bagarian
Gamra
Rajli
Adampur
Adampur
Asrawan
Thaska
Data
Juglan
Lohari Ragho
Kajla
Ghirai
Ladwi
Narnaund
Narnaund
Dhansu
Siswal
Pilu Khera
Mingnikhera
Khanda Kheri
Sisai
Ghursal
Niyana
Petwar
Ludas
Hisar
Hisar-I
Ugalan
Hisar -II
Kumbha
Lalpur
Badchhappar
Bas
Hansi-II
Hansi
Hansi-I
Siswala
Mayar
Bhataul Jattan
Burak
Balsamand
Muklan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Electrical conductivity (µS/cm)
0-2000
2000-4000
4000-6000
>6000
District Boundary
Block Bondary
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-18

6.3 SURFACE WATER RESOURCES

Hisar district is an alluvial plain of Indo-Gangetic drainage basin. There is no permanent river in the district but northern part of the district falls under Ghagghar River Doab. As per irrigation purpose, Hisar district was categories into five regions; namely Barani (low rain area where rainfed dry farming is trained), Bagar (dry sandy tract of land on the area of border of Rajasthan). Nahri (canal irrigated), Nalli (productive prairie tract) and Rangoi tract (irrigated by the Rangoi canal built for the reason of transportation flood waters of Ghagghar river to dry areas).

The study area have also canal network. Western Yamuna and Bhakra canals are two major canals that provide water for irrigation in most of the region of the study area with their distributaries, minors and sub minors. The surveyed topography forms of a region and water divide between old Drishdawati and Ghaggar. Chautang river (Drishdawati) area is wiped out and is vast crammed channel course is in use by the Hansi branch of the Western Yamuna Canal. Throughout the monsoons season a lot of seasonal streams overflow the adjacent parts of the side broken up Ghaggar flood plain. A number of small natural ponds/ tanks exist in almost all villages and these are basically low lying digressional areas and are used for domestic animals bathing and drinking purposes. These ponds are fed by rainwater during monsoon season. Maximum irrigated area in the study area is done by canals due to brackish underground water. However, some regions of the study area have fresh underground water and tubewell are the main source of irrigation. Details of surface water resources is displayed in Figure-19.



Surface Water Resources Map
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
E
W
Bithmara
Chamarkhera
Uklana Mandi
LataniLatani
Kandol
Nahla
Daulatpur
Ghaibipur
Sabarwas
Banbhauri
Banawali
Kapro
Balak
Barwala
Sarngpur
Kirori
Agroha
Nangthala
Sadalpur
Biyanakhera
Mirchpur
Chuli Bagarian
Rajli
Gamra
Adampur
Asrawan
Thaska
Juglan
Data
Lohari Ragho
Kajla
Ghirai
Ladwi
Narnaund
Siswal
Dhansu
Pilu Khera
Mingnikhera
Khanda Kheri
Sisai
Ghursal
Petwar
Niyana
Hisar
Ugalan
Ludas
Lalpur
Kumbha
Badchhappar
Bas
Mayar
Siswala
Hansi
Bhataul Jattan
Burak
Balsamand
Muklan
Sorkhi
Mangali
Madanheri
Umra
Gawar
Balawas
Saharwa
Legend
Main Canal
Branch Canal
Distributary Canal
Village Location Point
District Boundary
Block Boundary
R. F. = 1:410,000
9 4.5 0 9 18 27 KM

Figure-19

CHAPTER 7

DEVELOPMENT OF AGRICULTURAL LAND USE PLAN

7.1 INTEGRATED PLAN FOR LAND RESOURCES DEVELOPMENT

Land resources are limited and consequently their optimal utilization, improvement and executive plays the causal position in their satisfying utilize and civilization. Land resources will be preserved as solitary, renewable and inter-generational thing and it has to be observed as major resource at national level for all economical, societal and governmental contemplations. Planning of integrated agricultural land resources improvement plan targets at prime, eco-friendly, feasible & integrated land use in relation to corresponding water consumption and it should not only be technically feasible but also economically viable and practically implementable. As a pre-requisite of many preparation and implementation of an action plan for the creation of land resources with a constant and temporary assessment of the status of land resources at local and national level, using GIS and remote sensing technologies of inventory of natural resources be used with data storage in computer aided software.

The objectives of present study is to create action plan for sustainable agricultural land use, which must be optimally suitable to study area and to production possible of local resources thus this stage of production is sustained over their waning over time. The recommended practices of action plan must take into reflection latest technology, resources, climatic and terrain parameters.

Various thematic maps like land use and land cover, soils family, soil sub group , soil texture, soil available water holding capacity map, water quality and depth, cropping pattern and rotation coupled with socio-economic and agro-climatic data were integrated to suggest suitable combinations of practices for various agricultural land use parcels. In formulation of action plan remaining landuse and land cover and wastelands have been taken as basis for assessing the present land use and to suggest alternative landuse suitability. The major part of the district is under agricultural practices; hence action plan is also suggested for overall development of agriculture on the long term basis. For sustainable production the following criteria should be fulfilled.

- The land use should be based on land capability with scope to increase the invention.
- The farm production practices must be diversified, allocating the risk of failure and financial return.
- It must decrease the risk of soil degradation and re-establish the efficiency of degraded lands.
- It should minimize the difficulties of environmental degradation.

Based on study of land use, soils, ground water, rainfall, cropping pattern, socio-economic data and with surface irrigation facilities available in the area, the package of practices have been recommended for sustainable development in the area. The basis of the development packages are the following.

7.1.1 Study of different theme and maps

The study of separate thematic maps has carried out to make spatial valuation of relative disparities of resources probable and range of terrain situations. All the parameters (resource units) in respect of each theme like soil, water quality, water depth and land use / land cover is listed to analyze and understand the peculiar problem of the area like soil degradation, condition of ground water depth & quality, wastelands and floods in quick look.

7.1.2 Data Analysis and integration

The main objective of present study is to produce integrated land resources action plan of the area. The methodology adopted consists of following:
First individual thematic layers were studied and then all thematic layers (Soil series, landuse / land cover, underground water depth and water quality) were integrated using union command of ArcGIS desktop 9.3 software and different combinations were generated. Integrated map is presented in Figure-20 and the combinations are presented in Figure-21. Further, the decision rules for integrated land resource development plan have been developed and further culminating into generation of draft action plan. This land resource plan was evaluated by experts and on the basis of this evaluation and recommended suggestions of these experts; the final land resource action plan was formulated. These steps are discussed below in detail.

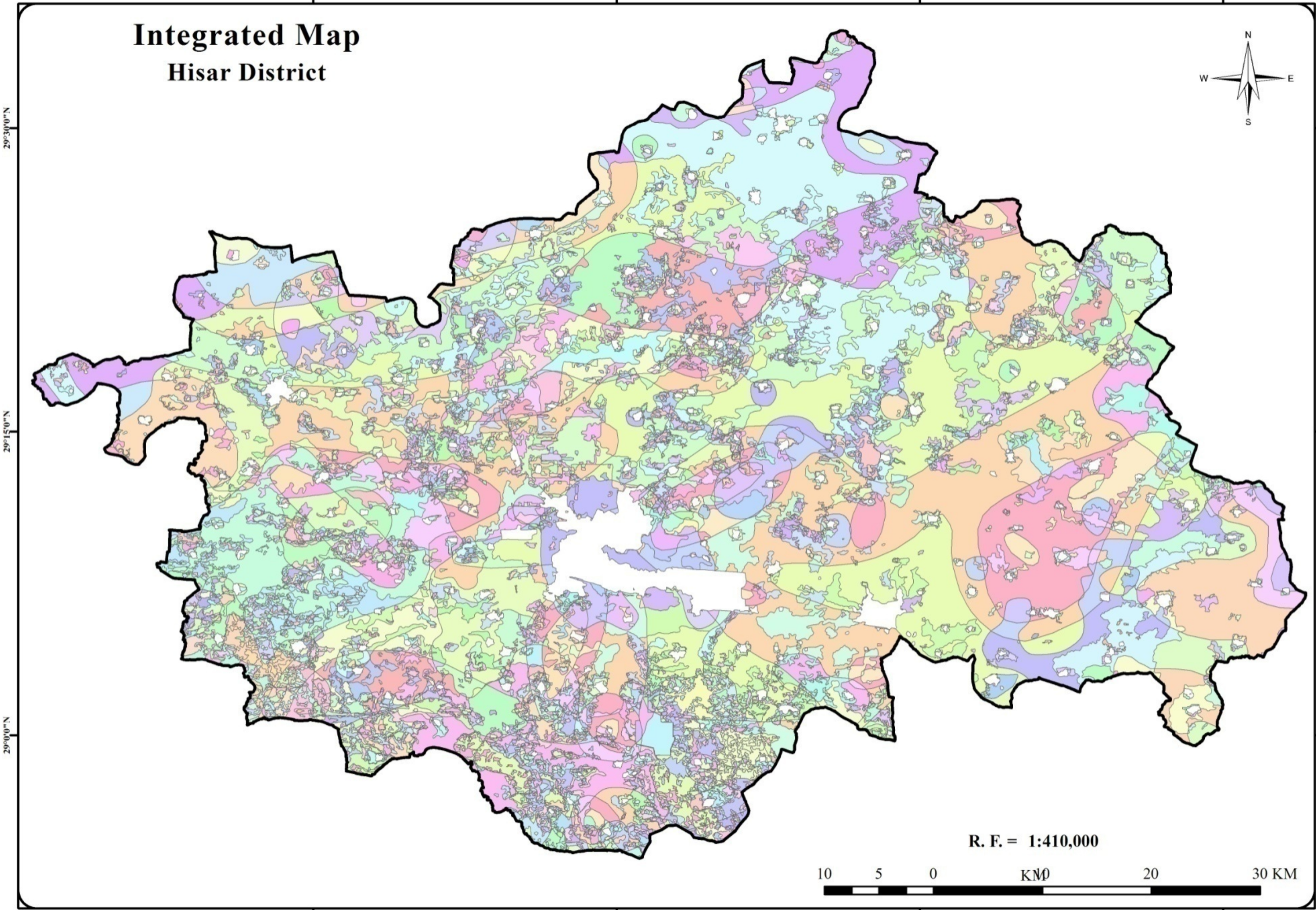
7.1.3 Study of Different Thematic Maps in Combinations:

The study of thematic maps in grouping is addition of preceding step, where in natural and reasonable organization of restrictions of each single layers with all other layers were studied. This organization investigation helps in superior considerate of reason and consequence in context of problem/limits but also conceivable that exists in the district. All these thematic layers were studied in combinations to each with all. All these combinations were discussed and explained in Table-21.

7.1.4 Development of decision rules for action plan

Under this step, field visit was conducted for a number of observations covering the complete area with various types of landforms, soils, underground water prospects & quality, rainfall conditions, availability of canal irrigation and current land use. All the spot observations were marked on 1:50000 scale Survey of India topographical sheets. At apiece mark, the land characteristics were taken into consideration and verified as mapped in relevant thematic maps along with current landuse. A no of site situation like irrigation facilities, present cropping pattern which were not shown in theme maps were also noted taken into account whereas recommending alternative landuse practices with innovative attentions such as misuse of ground water, opportunity of adopting more effective irrigation scheme, water management and all other site development practices through water and soil preservation measures.

Apart from these, the factors like accessibility of improved variety of crops, plant, grasses and shrubs, advantage of interdependency of crops, livestock and other observes such as integrated farming system were also taken into considerations. Finally, based upon all these observations, decision rules were formulated as shown in Table-22.



Integrated Map
Hisar District
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
29°30'0"N
29°15'0"N
29°0'0"N
N
S
W
E
R. F. = 1:410,000
10 5 0 10 20 30 KM
KM

Figure-20

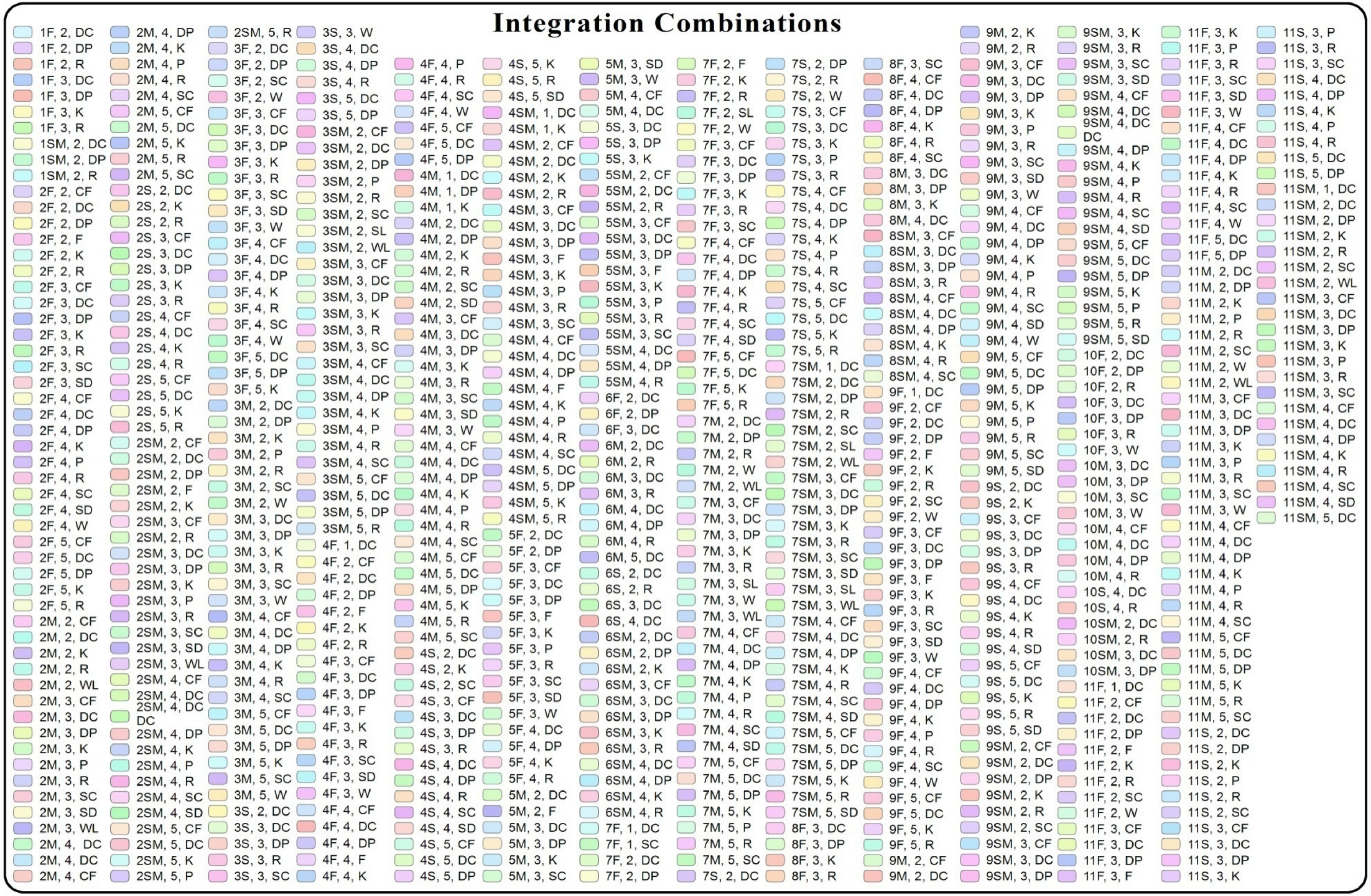

Integration Combinations
1F, 2, DC
1F, 2, DP
1F, 2, R
1F, 3, DC
1F, 3, DP
1F, 3, K
1F, 3, R
1SM, 2, DC
1SM, 2, DP
1SM, 2, R
2F, 2, CF
2F, 2, DC
2F, 2, DP
2F, 2, F
2F, 2, K
2F, 2, R
2F, 3, CF
2F, 3, DC
2F, 3, DP
2F, 3, K
2F, 3, R
2F, 3, SC
2F, 3, SD
2F, 4, CF
2F, 4, DC
2F, 4, DP
2F, 4, K
2F, 4, P
2F, 4, R
2F, 4, SC
2F, 4, SD
2F, 4, W
2F, 5, CF
2F, 5, DC
2F, 5, DP
2F, 5, K
2F, 5, R
2M, 2, CF
2M, 2, DC
2M, 2, K
2M, 2, R
2M, 2, WL
2M, 3, CF
2M, 3, DC
2M, 3, DP
2M, 3, K
2M, 3, P
2M, 3, R
2M, 3, SC
2M, 3, SD
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Figure-21

7.1.5 Preparation of Draft Action Plan:

The action plan was prepared using decision supporting rules by digitizing all thematic maps and putting them in ARC/info GIS Desktop 9.3 environment. All the individual thematic maps were then integrated (overlaying) one by one and then final integrated map was prepared along with parameters of different thematic maps. As per assessment rules, a short discussion was complete on utility and sustainability of current land use pattern particularly in context of agricultural construction and quality of ecosystem. Later on, the suitability of these existing practices were examined and various alternative land use activities like agro horticulture, agro forestry, agro forestry with improved dry land crops management, double crop, silvi pasture, levelling & dune stabilization etc. have been considered. For recommending these package & practices, the basic research activity of CCS, HAU, Hisar (Rabi & Kharif Faslon Ki Samagra Sifarasen, HAU, Hisar) and ICAR with latest technologies in the district of agriculture research and development were considered. The socio-economic conditions of the area were also taken into account while suggesting land resource action plan.

7.1.6 Finalization of action plan

The draft action plan was put before the scientists of CCSHAU, Hisar, HARSAC, Hisar, and expert of district administration for critical evaluation and to make viable and feasible recommendations. The valuable suggestions of the experts were incorporated in final action plan. Based upon these suggestions and keeping in view the better ecological conditions with optimal and sustainable production of land resources, the final sustainable agricultural land use plan map of the district was prepared and displayed in Figure-21. Complete information of all these recommendations is addressed in Table-21. The area under various land resources development activities is given in Table-22.

Final sustainable agricultural land use plan is also prepared for all nine blocks of Hisar district and area under different agricultural land use recommendations were also calculated at block level. Final sustainable agricultural land use plan maps for different blocks is presented in Figure-23 to Figure-31 and area wise distribution of different land use recommendations in various blocks was presented in Table-23.

Table-21 Details of sustainable agricultural land use recommendations

Mapping Unit	Soil Series	Soil Series Description	Constraints	Potentials	Cropping pattern & Land use / land cover	Recommendation
1	Bas	Nearly level to very gently sloping alluvial plain, deep, clay/clay loam to sandy clay loam, moderately well drained, medium to high AWC, few fine iron concretions, fine loamy mixed non calcareous hyperthermic classified as Fluventic Haplustepts.	●Slightly waterlogging	●Agriculturally very potential soils ●Good permeability ●Goodwater holding capacity ●Medium texture ●Fresh groundwater ●Ground water depth 3-10 m	**Rice-Wheat & Cotton-Wheat Crop rotation**	
					DC 2F, 3F,2SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measures
					K 3F	Agro Forestry
					R 2F	Agro Forestry
					DP 2F,3F,2SM	Social / Community forestry /MPTS

2	**Bichpari**	Gently to moderately sloping interdunal aeolian plains, deep, well drained, loamy sand to sandy laom, medium to high AWC, coarse loamy mixed non calcareous hyperthermic classified as Typic Ustipsamments.	●Undulating topography ●Slightly light texture Soils ●Groundwater quality sub-marginal ●Groundwater depth 10-20 m ●Low fertile soils ●Low to medium water holding capacity	●Moderate to high permeability	**Cotton -Wheat & Guar Wheat-Crop rotation**	
					DC 2F,3F,4F, 2SM,3SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measures
					4SM,5SM	Agro Forestry
					5F	Double crop having low water requiring crops
					3M,4M,5M,3S,4S,5S	Agro Forestry with salt tolerant tree species
					2M,2S	Saline aquaculture on embankment plantation
					DP 2F,3F,4F,5F,2SM,3SM 4SM	Afforestation/ Silvi pasture with soil & water conservation measures

					3M,4M,3S	Social / Community forestry /MPTS
					R 2F,3F,4F,5F,2SM, 3SM, 4SM,5SM	Agri Horticulture
					2M,2S	Agro forestry with eucalyptus plantation
					3M,4M,3S,4S	Agro Forestry
					5M, 5S	Horticulture plantation with drip irrigation
					F 2F ,2SM	Conservation of forest
					CF 2F, 3F, 4F, 5F,2SM,3SM,4SM,5SM	Agri Horticulture
					2M	Agro forestry with bio drainage
					3M,4M,5M	Agro forestry

					3S, 4S,5S	Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water/ tank purifier
					K 2F ,3F,4F	Pulses/ oilseed crops
					2SM,3SM	Agri Horticulture
					5F,4SM,5SM	Double crop having water conserving crops
					2M,2S	Agri Horticulture with eucalyptus plantation on field boundary
					3M,4M,3S,4S	Agro forestry with dry farming
					5M,5S	Horticulture plantation with drip irrigation
					SC 3F,4F	Horticulture plantation for Panchayat income or on contract

					3SM,4SM	Horticulture plantation with drip irrigation
					3M,4M,5M	Afforestation/ Silvi pasture with soil & water conservation measures
					SD 3F,4F	Double crop after leveling or Double crop with sprinkler irrigation
					3SM,4SM	Agri horticulture after levelling
					3M	Agro forestry after land levelling
					P 4F,3SM, 4SM, 5SM	Existing system adopting good management practices with soil and water conservation measures
					3M,4M	Existing system with salt tolerant plantation

					WL 2M	Saline aquaculture with embankment plantation
					3SM ,3M	Bio drainage
					W 4F	Pisciculture
3	**Dabra**	Nearly level alluvial plains, deep, imperfectly drained, sandy clay loam to clay loam to sandy clay, very high AWC, fine loamy mixed calcareous hyperthermic classified as Typic Haplustept.	●Very low permeability ●Slightly sodic/saline soils ●Groundwater quality sub-marginal ●Groundwater depth 3-10 m	●Agriculturally potential soils ●Very high water holding capacity	**Cotton-Wheat & Rice-Wheat Crop rotation**	
					DC 2F,3F,4F,2SM, 3SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					5F	Double crop having water conserving crops
					4SM,5SM	Agri horticulture with crop diversification required
					2M,2S	Salt tolerant forest plantation / bio drainage
					3M,4M,5M -	Agri-horticulture with mixing of tubewell and canal water

					3S,4S,5S	Agro Forestry
					DP 2F,2SM,2M	Clone eucalyptus on embankment plantation
					3F, 4F,5F,3SM, 4SM, 5SM	Silvi Pasture with soil and water conservation measures
					3M,4M,5M,3S,4S,5S	Social and community forestry/MPTS
					CF 3F,4F,2SM,3SM,4SM,5SM	Agri-Horticulture
					4M,5M	Agro Forestry
					K 3F,4F,3SM,4SM	Agri-Horticulture
					5F	Double crop having water conserving crops
					2M	Clone eucalyptus plantation on filed boundary
					3M,4M,5M	Agro Forestry
					R 3F,4F,2SM,3SM	Agri-Horticulture

					3M,4M	Agro Forestry
					4SM,5SM	Double crop having water conserving crops
					2M	Clone eucalyptus plantation on filed boundary
					3S,4S	Agro Forestry
					SC 2F,3F,4F,2SM,3SM,4SM	Horticulture Plantation for Panchayat income or on contract
					2M	Bio drainage/ Aquaculture/ saline aquaculture
					3M,4M,5M,3S	Afforestation/ Silvi pasture with soil & water conservation measures
					SD 3F	Double crop after land levelling or Double crop with sprinkler irrigation

					P 2M,2SM, 4SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					SL 2SM	Bio drainage/ Saline Aquaculture
					WL 2SM	Bio drainage
					W 2F,3F,4F	Pisciculture
					2M,3M,5M,3S	Saline Aquaculture
4	**Dhingasra**	Nearly level Fluvio-aeolian plain, deep, well drained, sandy loam, medium AWC, coarse loamy	●Moderately saline/sodic soils ●Groundwater quality fresh to marginal	●Agriculturally potential soils but needs some reclamation measures	**Cotton-Wheat Crop rotation**	
					DC 1F,1SM	Double crop with clone eucalyptus plantation on field boundary

		mixed calcareous hyperthermic classified as Natric Haplustepts.		●Groundwater depth 10-20 m ●Good permeability	2F,3F,4F,2SM,3SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					5F	Double crop having low water requiring crops
					1M,2M	Clone eucalyptus plantation with embankment
					4SM,5SM ,5M	Horticulture plantation with drip irrigation
					3M,4M	Agri horticulture
					2S,3S,4S,5S	Agro forestry with salt tolerant tree species
					DP 2F,3F,4F,5F,3SM,4SM, 5SM	Horticulture plantation/ Silvi pasture

					1M,2M	Bio drainage/ aquaculture/ saline aquaculture
					3M,4M,5M,3S,4S,5S	Social / Community forestry / MPTS
					R 2F,3F,4F,	Agri horticulture
					2SM,3SM,4SM,5SM,3M,4M,5M	Agro Forestry
					2M	Clone eucalyptus plantation on filed boundary
					3S,4S,5S	Agro Forestry / forest plantation
					K 2F,1SM,2SM	Double crop with clone eucalyptus plantation on field boundary
					3F,4F	Double crop with soil and water conservation measure
					3SM,4SM,3M,4M	Agri-horticulture

					1M,2M,2S	Saline aquaculture with embankment plantation
					5SM, 5M	Horticulture plantation with drip irrigation
					5S	Agro Forestry
					CF 2F,3F,4F	Double crop with soil and water conservation measure
					2SM,3SM,4SM	Agri-horticulture
					5F	Double crop having water conserving crops
					3M,4M,5M	Agri-horticulture
					3S,5S	Agro Forestry
					SC 3F,4F,3SM,4SM	Horticulture plantation for Panchayat income or on contract

					2M,2S	Bio drainage/ aquaculture/ saline aquaculture
					3M,4M,5M,4S	Afforestation/ Silvi pasture with soil and water conservation measure
					F 2F,3F,4F, 3SM,4SM	Conservation of forest with gap filling
					SD 3F	Double crop after levelling or double crop with sprinkler irrigation
					2M,3M,4S,5S	Agro forestry after land levelling
					P 4F,4M,3SM,4SM	Existing system adopting good management practices with soil and water conservation measure
					W 3F, 4F, 3M	Pisciculture

5	**Fatehpuri**	Nearly level alluvial plain, deep, moderately well drained sandy loam, medium AWC, fine loamy mixed calcareous hyperthermic classified as Typic Haplustepts.	●Slightly light soil texture ●Groundwater quality sub-marginal	●Agriculturally good land ●Good permeability ●Average water holding capacity ●Groundwater depth 10-20 m	**Cotton-Wheat & Rice-Wheat Crop rotation**	
					DC 2F,3F,4F,2SM,3SM,4SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					2M,3M,4M	Agri-horticulture
					3S	Agro Forestry
					DP 2F,3F,4F,3SM,4SM	Horticulture plantation for Panchayat income or on contract
					3M,3S	Social / Community forestry/MPTS
					K 3F,4F	Double crop with soil and water conservation measure
					3SM	Agri-horticulture
					3M,3S	Agro Forestry

					R 3F,4F	Double crop with soil and water conservation measure
					2SM,3SM,4SM	Agri-horticulture
					CF 3F,2SM,3SM	Agri- horticulture with crop diversification required
					4M	Agro Forestry with dry farming
					P 3F,3SM,3M	Existing system adopting good management practices with soil and water conservation measure
					F 3F,3SM	Conservation of forest with gap filling
					SC 3F,3SM	Horticulture plantation for Panchayat income or on contract
					3M	Afforestation/ Silvi pasture with soil & water conservation measures

					SD 3F	Double crop after land levelling or Double crop with sprinkler irrigation
					3M	Agri horticulture after levelling
					W 3F,3M	Pisciculture
6	**Gangwa**	Nearly level plains over Fluvio-aeolian plains, sandy loam to loamy sand to sandy clay loam, well drained, medium AWC, calcareous, classified as coarse loamy mixed hyperthermic Typic Haplustepts.	●Moderately saline/sodic soils ●Groundwater quality fresh to saline	●Agriculturally potential soils but needs some reclamation measures ●Groundwater depth 10-20 m ●Good permeability	**Cotton-Wheat land & Other crop-Wheat Crop rotation**	
					DC 2F,3F,2SM,3SM,4SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					2M,2S	Bio drainage/ Saline Aquaculture
					3M,4M,5M	Agri-horticulture with mixing of tubewell and canal water
					3S,4S	Agro Forestry

					DP 2F,2SM,3SM,4SM	Horticulture plantation for Panchayat income or on contract
					4M	Social / Community forestry/MPTS
					CF 3SM	Agri-horticulture
					R 3SM,4SM.3M	Agri- horticulture
					2M,2S	Agri- horticulture with salt tolerant species plants
					3M,4M	Agro Forestry
					K 2SM,3SM,4SM	Agro Forestry
7	**Jundli Khurd**	Very gently sloping interdunal aeolian plain, deep, well drained, sand to sandy loam, high	●Undulating topography ●Sandy texture ●Slight waterlogging/flo	●Average water holding capacity ●Good permeability ●Groundwater	**Cotton-Wheat Crop rotation**	
					DC 1F,1SM	Double crop with clone eucalyptus plantation on field boundary

		AWC, coarse loamy mixed calcareous hyperthermic classified as Typic Ustifluvents.	oding ●Sub-marginal groundwater	depth 10-20 m	2F,3F,4F,2SM,3SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					5F	Double crop having low water requiring crops
					2M,2S	Salt tolerant forest plantation / Bio Drainage
					4SM,5SM	Horticulture plantation with drip irrigation
					3M,4M,5M	Agri horticulture
					3S,4S,5S	Agro Forestry with salt tolerant tree species
					DP 2F,3F,4F,2SM,3SM, 4SM, 5SM	Horticulture plantation / Silvi pasture
					2M,3M,4M,5M,2S,4S	Social / Community forestry /MPTS

					R 2F,3F,4F,5F	Double crop with crop diversification
					3SM,4SM,5SM	Agri horticulture
					2SM,2M,2S	Agri horticulture with salt tolerant tree species
					3M,4M,5M,3S,4S,5S	Agro Forestry
					K 2F,3F,4F,5F	Double crop with crop diversification
					3SM,4SM,5SM,3M,4M,5M	Agri horticulture
					3S,4S,5S	Agro Forestry
					CF 3F,4F,5F	Double crop with crop diversification
					3M,4M,5M,3SM,4SM,5SM	Agri horticulture with salt tolerant tree species
					3S,4S,5S	Agro Forestry
					SC 1F	Excess fresh water potential zone for pipelines
					2SM	Bio drainage

					3F,4F,3SM,4SM	Horticulture plantation / Afforestation
					4M,5M,4S	Afforestation/ Silvi pasture with soil & water conservation measures
					F 2F	Conservation of forest with gap filling
					SL 2F,2SM ,3SM,3M	Salt tolerant forest plantation / Bio Drainage
					SD 4F,3SM,4SM	Double crop after levelling or Double crop with sprinkler irrigation
					5SM	Double crop having low water requiring crops after levelling
					4M	Agro Forestry
					WL 2M,3M,2SM,3SM	Salt tolerant forest plantation / Bio Drainage

					P 4M,5M,3S,4S	Existing system adopting good management practices with soil and water conservation measure
					W 2F,2M,2S	Pisciculture
8	**Kanala**	Nearly level alluvial plains, deep, loam/clay loam to sandy clay loam to clay, moderately well drained, medium to high AWC, fine mixed calcareous hyperthermic classified as Typic	●Slightly heavy texture soils ●Groundwater quality sub-marginal	●Agriculturally potential soils ●Good permeability ●Good water holding capacity ●Groundwater depth 3-10 m ●Fresh groundwater	**Rice-Wheat & Cotton-Wheat Crop rotation**	
					DC 3F,4F,3FM,4FM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					3M,4M	Agro Forestry
					DP 3F,4F,3FM,4FM	Horticulture plantation for panchayat income or on contract

		Haplustept.			3M	Social / Community forestry/ MPTS
					R 3F,4F,3SM,4SM	Agri horticulture
					K 3F,4F,4SM	Agri horticulture
					3M	Agro Forestry
					CF 4F,3SM, 4SM	Agri horticulture
					SC 3F,4F,4SM	Horticulture plantation/ Afforestation
9	**Kharia**	Gently sloping aeolian plain with stabilized and interdunal plains, deep, excessively drained, very low AWC, sand to loamy sand, sandy mixed non-calcareous hyperthermic	●Gently sloping undulating topography ●High permeability ●Very low water holding capacity ●Sandy textured soils ●Low fertility ●Groundwater	●Groundwater depth 10-20 m	**Guar -Wheat & Other Crop-Wheat Crop rotation**	
					DC 1F,2F,2SM	Double crop with clone eucalyptus plantation on field boundary
					3F,4F,3SM,4SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure

		classified as Typic Ustipsamments.	quality sub-marginal		5F,5SM	Double crop having water conserving crops
					2M,2S	Bio drainage /Aquaculture/ saline aquaculture
					3M,4M,5M	Agri horticulture
					3S,4S,5S	Agro Forestry
					DP 2F,3F,4F, 2SM, 3SM	Horticulture plantation for panchayat income or on contract
					4SM,5SM	Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
					3M,4M,5M,3S	Social / Community forestry /MPTS
					K 2F,3F,4F,5F,2SM, 3SM,4SM, 5SM	Agri-horticulture
					2M,2S	Salt tolerant forest plantation/ bio drainage

					3M,4M,5M,4S,5S	Agro Forestry
					R 2F,3F,4F,5F,2SM, 3SM, 4SM,5SM	Agri-horticulture
					2M	Salt tolerant forest plantation/ bio drainage
					3M,4M,5M,3S,4S,5S	Agro Forestry
					CF 2F,3F,4F,5F,2SM, 3SM, 4SM,5SM	Agri-horticulture
					2M	Salt tolerant forest plantation/ bio drainage
					3M,4M,5M,3S,4S,5S	Agro Forestry
					P 4F,3M,4M,5M,4SM,5SM	Existing system adopting good management practices with soil and water conservation measure
					F 2F,3F	Conservation of forest with gap filling
					SC 2F,3F,4F	Horticultural plantation / Silvi pasture

					2SM,3SM,4SM	Horticulture plantation with drip irrigation
					3M,4M,5M	Afforestation/ Silvi pasture with soil & water conservation measures
					SD 3F,3SM,4SM	Double crop after land levelling or double crop with sprinkler irrigation
					5SM,3M,4M,5M	Agri horticulture after levelling
					4S,5S	Agro Forestry
10	**Niyana**	Nearly level alluvial plain, deep, poorly drained, clay loam to clay, very high AWC, fine mixed calcareous Hyperthermic classified as Aeric	●Low permeability ●Heavy textured soils ●Waterlogging ●Moderately saline/sodic soils ●Marginal to	●High water holding capacity	**Rice-Wheat Crop rotation**	
					DC 2F,3F,2SM,3SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure
					3M,4M	Agri-horticulture
					4S	Agro Forestry

		Halaquents.	saline groundwater ●Groundwater depth 3-10 m		DP 2F,3F,3SM	Horticulture plantation for panchayat income or on contract
					3M,4M	Social / Community forestry / MPTS
					R 2F,3F,2SM	Agri-horticulture
					4M,4S	Agro Forestry
					SC 3M	Afforestation/Silvi pasture with soil & water conservation measures
					CF 4M	Agro Forestry
					W 2F,3F,4F,3M	Pisciculture
11	**Ratia**	Very gentle sloping recent flood plains, deep, well drained, sandy loam to sandy clay to clay loam soil with medium AWC, fine	●Slightly heavy textured soils ●Occasionally flooded for short duration	●Very potential soils ●Good water holding capacity ●Good permeability ●Fresh	**Rice-Wheat & Cotton-Wheat Crop rotation**	
					DC 3F,4F,3SM,4SM	Existing cropping system adopting good agriculture management practices with soil and water conservation measure

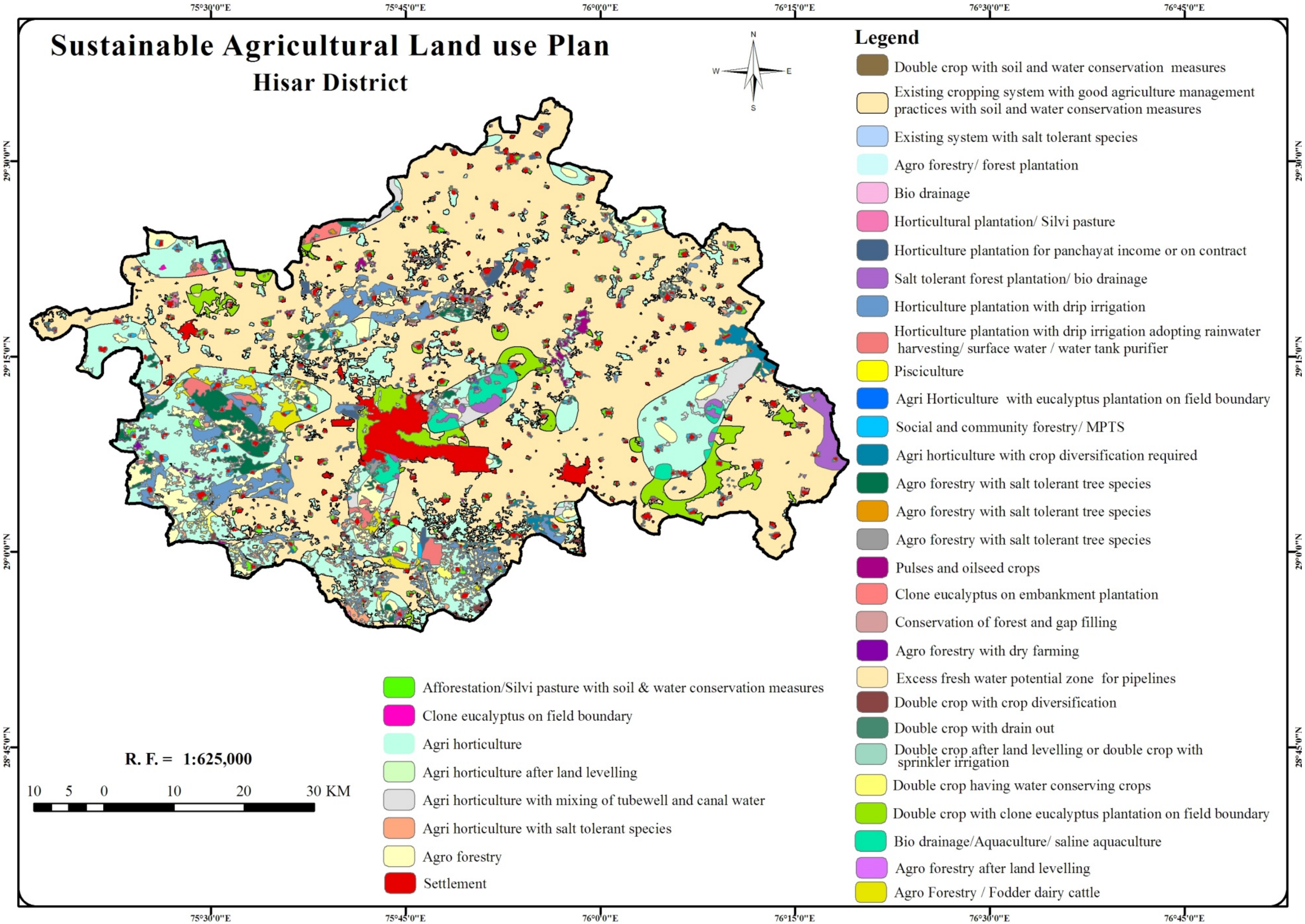
		loamy mixed calcareous hyperthermic classified as Fluventic Haplustepts.		groundwater ●Groundwater depth 10-20 m	4M	Agro Forestry / Fodder dairy cattle
					1F	Excess fresh water potential zone for pipelines
					1SM	Double crop with drain out
					5M,4S,5S	Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
					2F,2SM	Double crop with clone eucalyptus plantation on field boundary
					5F,5SM	Double crop having water conserving crops
					2M,2S	Bio drainage/ Aquaculture/ saline aquaculture
					3M	Agri-horticulture
					3S	Agro Forestry

					DP 2F,3F,4F,5F	Horticulture plantation for panchayat income or on contract
					3M,4M,5M,3S,4S,5S, 3SM,4SM	Social / Community forestry / MPTS
					2SM,2M,2S,3S	Bio drainage/ Aquaculture/ saline aquaculture
					R 2F,3F,4F,2SM, 3SM,4SM	Agri-horticulture
					2M,3M,4M,5M,2S,3S,4S	Agro Forestry
					K 2F,3F,4F,2SM, 3SM, 4SM	Agri-horticulture
					2M,3M,4M,5M,2S,3S,4S	Agro Forestry
					CF 2F,3F,4F, 3SM, 4SM, 3M, 4M,5M,3S	Agri-horticulture
					F 2F,3F	Conservation of forest and gap filling

					P 3F,2M,3M,4M,2S,3S,4S, 3SM	Existing system adopting good management practices with soil and water conservation
					SC 2F, 3F,4F,2SM,3SM,	Horticulture plantation for Panchayat income or on contract
					2M,3M,4M,5M,2S,3S	Afforestation/Silvi pasture with soil & water conservation measures
					SD 3F, 4SM	Double crop after land levelling or Double crop with sprinkler irrigation
					WL 2SM,2M	Bio drainage
					W 2F,3F,4F,2M,3M,4M	Pisciculture

Table-22 Area under different land use recommendation

Code	Recommendation	Area in square kilometre	% to Total area of district
1	Afforestation/Silvi pasture with soil & water conservation measures	37.84	0.95
2	Clone eucalyptus on field boundary	0.91	0.02
3	Agri horticulture	700.83	17.58
4	Agri horticulture after land levelling	1.38	0.03
5	Agri horticulture with mixing of tubewell and canal water	50.28	1.26
6	Agri horticulture with salt tolerant species	24.48	0.61
7	Agro forestry	183.57	4.60
8	Agro Forestry / Fodder dairy cattle	30.16	0.76
9	Agro forestry after land levelling	0.18	0.00
10	Agro forestry with dry farming	5.99	0.15
11	Excess fresh water potential zone for pipelines	0.47	0.01
12	Bio drainage/Aquaculture/ saline aquaculture	44.45	1.11
13	Clone eucalyptus on embankment plantation	16.31	0.41
14	Conservation of forest and gap filling	2.19	0.05
15	Double crop after land levelling or double crop with sprinkler irrigation	3.39	0.08
16	Double crop having water conserving crops	17.13	0.43
17	Double crop with clone eucalyptus plantation on field boundary	123.92	3.11
18	Double crop with crop diversification	10.56	0.26
19	Double crop with drain out	0.02	0.00
20	Double crop with soil and water conservation measures	7.86	0.20
21	Existing cropping system with good agriculture management practices with soil and water conservation measures	2340.57	58.70
22	Existing system with salt tolerant species	0.14	0.00
23	Agro forestry/ forest plantation	1.23	0.03
24	Bio drainage	0.33	0.01
25	Horticultural plantation/ Silvi pasture	11.04	0.28
26	Horticulture plantation for panchayat income or on contract	30.68	0.77
27	Salt tolerant forest plantation/ bio drainage	40.49	1.02
28	Horticulture plantation with drip irrigation	119.98	3.01
29	Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier	24.52	0.61
30	Pisciculture	2.27	0.06
31	Agri Horticulture with eucalyptus plantation on field boundary	1.13	0.03
32	Social and community forestry/ MPTS	22.26	0.56
33	Agri horticulture with crop diversification required	28.82	0.72
34	Agro forestry with salt tolerant tree species	77.68	1.95
35	Saline aquaculture on embankment plantation	1.37	0.03
36	Agro forestry with bio drainage	6.44	0.16
37	Pulses and oilseed crops	16.76	0.42
Grand Total		3987.64	100.00



Sustainable Agricultural Land use Plan
Hisar District
N
W
E
S
Legend
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Existing system with salt tolerant species
Agro forestry/ forest plantation
Bio drainage
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Salt tolerant forest plantation/ bio drainage
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Agri Horticulture with eucalyptus plantation on field boundary
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with salt tolerant tree species
Agro forestry with salt tolerant tree species
Pulses and oilseed crops
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Agro forestry with dry farming
Excess fresh water potential zone for pipelines
Double crop with crop diversification
Double crop with drain out
Double crop after land levelling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Bio drainage/Aquaculture/ saline aquaculture
Agro forestry after land levelling
Agro Forestry / Fodder dairy cattle
Afforestation/Silvi pasture with soil & water conservation measures
Clone eucalyptus on field boundary
Agri horticulture
Agri horticulture after land levelling
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Settlement
R. F. = 1:625,000
10 5 0 10 20 30 KM
75°30'0"E
75°45'0"E
76°0'0"E
76°15'0"E
76°30'0"E
76°45'0"E
29°30'0"N
29°15'0"N
29°0'0"N
28°45'0"N

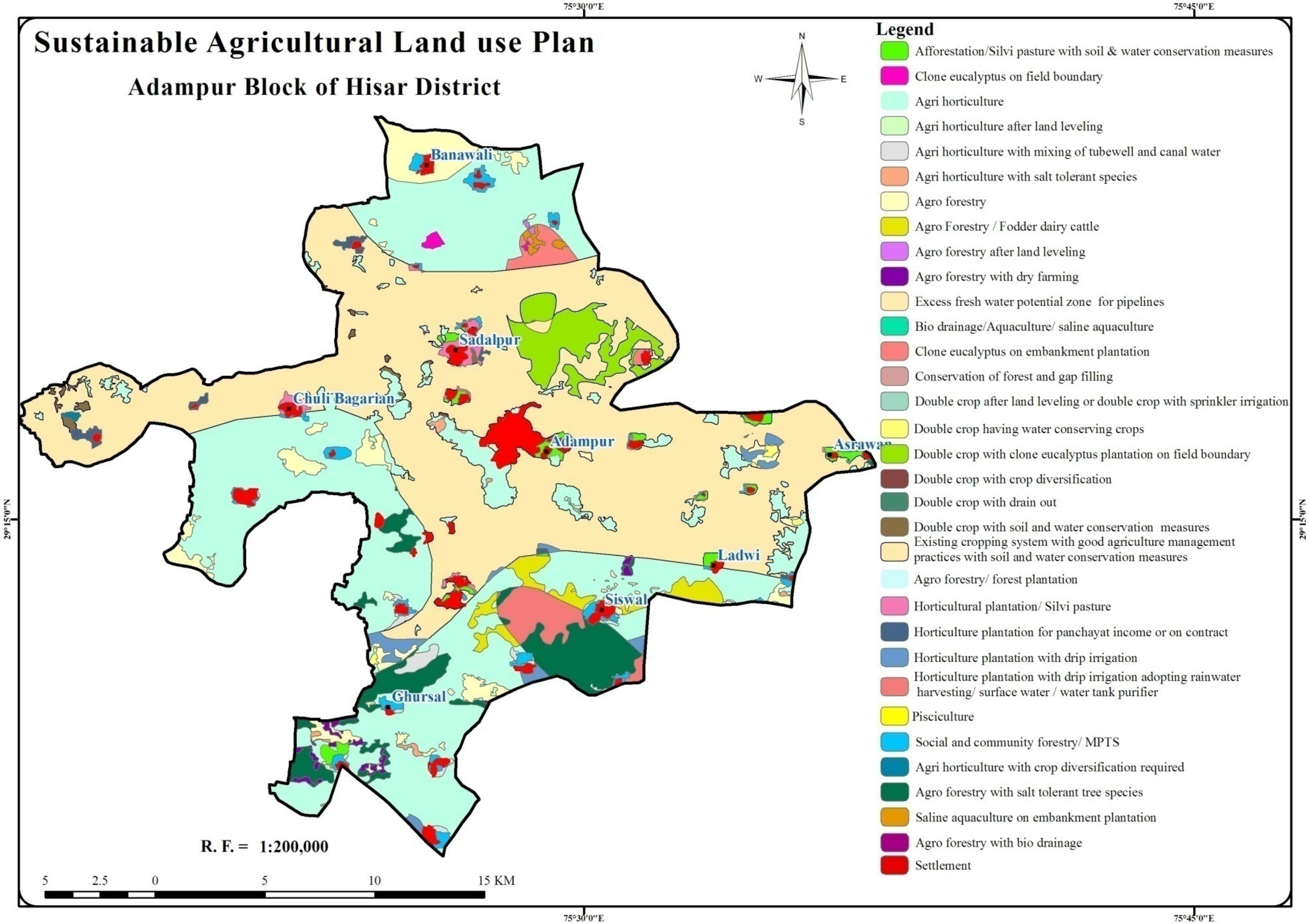
Figure-22

Table-23 Block wise distribution of different land use recommendation
(Area in sq. km)

Block Name / Recommendations	Adampur	Agroha	Barwala	Hansi-I	Hansi-II	Hisar-I	Hisar -II	Narnaund	Uklana	Recommendations wise total
Afforestation/Silvi pasture with soil & water conservation measures	3.63	3.66	5.26	4.85	0.15	5.72	5.27	4.15	5.16	**37.84**
Clone eucalyptus on field boundary	0.54				0.01	0.15	0.21			**0.91**
Agri horticulture	143.39	25.84	36.62	63.68	22.76	134.57	179.93	57.43	36.62	**700.83**
Agri horticulture after land levelling	0.25					0.95	0.18			**1.38**
Agri horticulture with mixing of tubewell and canal water	2.18	8.51	0.27	2.76	0.30	8.43	6.34	21.21	0.27	**50.28**
Agri horticulture with salt tolerant species	0.80		1.24	0.78	1.02	9.59	8.60	1.21	1.24	**24.48**
Agro forestry	17.92	11.39	11.06	11.05	0.35	29.11	81.24	10.05	11.39	**183.57**
Agro Forestry / Fodder dairy cattle	6.08	0.23		0.58		8.21	15.03	0.03		**30.16**
Agro forestry after land levelling	0.12	0.05					0.02			**0.18**
Agro forestry with dry farming	1.58	0.91	0.31			0.81	2.02	0.07	0.30	**5.99**
Excess fresh water potential zone for pipelines	0.42	0.05								**0.47**
Bio drainage/Aquaculture/ saline aquaculture	0.02	0.62	0.08	7.51	2.06	30.61	0.13	3.34	0.08	**44.45**
Clone eucalyptus on embankment plantation	2.96	8.42	0.60	1.35	1.40	1.05			0.54	**16.31**

Conservation of forest and gap filling	0.00		0.77		0.01	0.52	0.29		0.59	**2.19**
Double crop after land levelling or double crop with sprinkler irrigation	0.06		1.15			0.45	0.00	0.42	1.30	**3.39**
Double crop having water conserving crops	0.55	0.52	0.13	2.20		5.20	8.35	0.06	0.13	**17.13**
Double crop with clone eucalyptus plantation on field boundary	12.60	7.39	2.96	38.10	25.14	20.88	11.52	2.37	2.96	**123.92**
Double crop with crop diversification	0.05	0.51	0.97	1.10	0.05	3.32	2.19	1.41	0.97	**10.56**
Double crop with drain out	0.02									**0.02**
Double crop with soil and water conservation measures	1.37	0.38	2.45	0.39		0.05	0.36	0.39	2.45	**7.86**
Existing cropping system with good agriculture management practices with soil and water conservation measures	197.12	200.53	330.58	401.31	189.07	223.39	227.30	221.69	349.58	**2340.57**
Existing system with salt tolerant species		0.08					0.06			**0.14**
Agro forestry/ forest plantation	0.08						0.59	0.56		**1.23**
Bio drainage						0.33				**0.33**
Horticultural plantation/ Silvi pasture	2.01	1.28	1.45	0.73	0.51	1.37	1.35	0.92	1.42	**11.04**
Horticulture plantation for panchayat income or on contract	1.64	3.03	7.02	3.16	0.11	2.08	5.25	0.87	7.52	**30.68**

Salt tolerant forest plantation/ bio drainage		0.52		0.18	25.39	10.90		3.51		**40.49**
Horticulture plantation with drip irrigation	3.78	22.81	4.16	11.97		13.19	57.92	1.99	4.15	**119.98**
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier	6.06	0.14	0.36	0.75		7.43	9.41		0.36	**24.52**
Pisciculture	0.00	0.26	0.36	0.33	0.39	0.23	0.17	0.18	0.36	**2.27**
Agri Horticulture with eucalyptus plantation on field boundary		0.03		0.08		1.01				**1.13**
Social and community forestry/ MPTS	4.57	2.41	0.94	1.78	1.38	3.01	4.71	2.53	0.94	**22.26**
Agri horticulture with crop diversification required	0.20	0.38	0.56	8.86	0.81	1.65	1.98	13.82	0.56	**28.82**
Agro forestry with salt tolerant tree species	17.50	7.06	3.58	0.57	0.33	6.92	36.09	1.95	3.68	**77.68**
Saline aquaculture on embankment plantation	0.61	0.71				0.05				**1.37**
Agro forestry with bio drainage		0.31		0.98		5.15		0.00		**6.44**
Pulses and oilseed crops	0.01	2.81	2.45	6.49	0.10	1.16	1.55	0.14	2.05	**16.76**
Block Wise Total	**428.13**	**310.83**	**415.35**	**571.52**	**271.33**	**537.47**	**668.05**	**350.32**	**434.64**	**3987.64**



Sustainable Agricultural Land use Plan
Adampur Block of Hisar District
75°30'0"E
75°45'0"E
29°15'0"N
N
S
E
W
Banawali
Sadalpur
Chuli Bagarian
Adampur
Asrawan
Ladwi
Siswal
Ghursal
R. F. = 1:200,000
5 2.5 0 5 10 15 KM
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Clone eucalyptus on field boundary
Agri horticulture
Agri horticulture after land leveling
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Agro Forestry / Fodder dairy cattle
Agro forestry after land leveling
Agro forestry with dry farming
Excess fresh water potential zone for pipelines
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Double crop after land leveling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with drain out
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Agro forestry/ forest plantation
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Saline aquaculture on embankment plantation
Agro forestry with bio drainage
Settlement

Figure-23

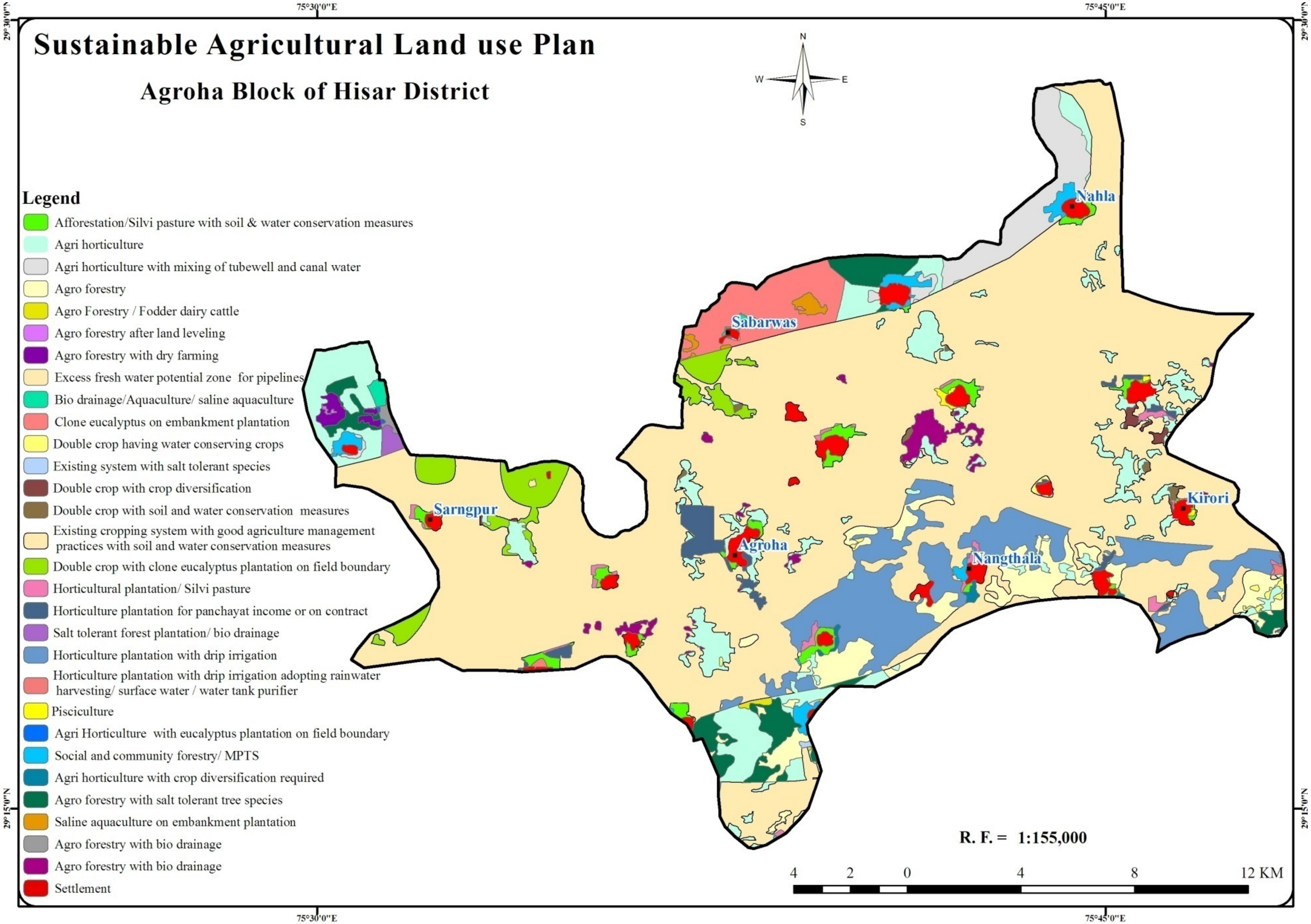
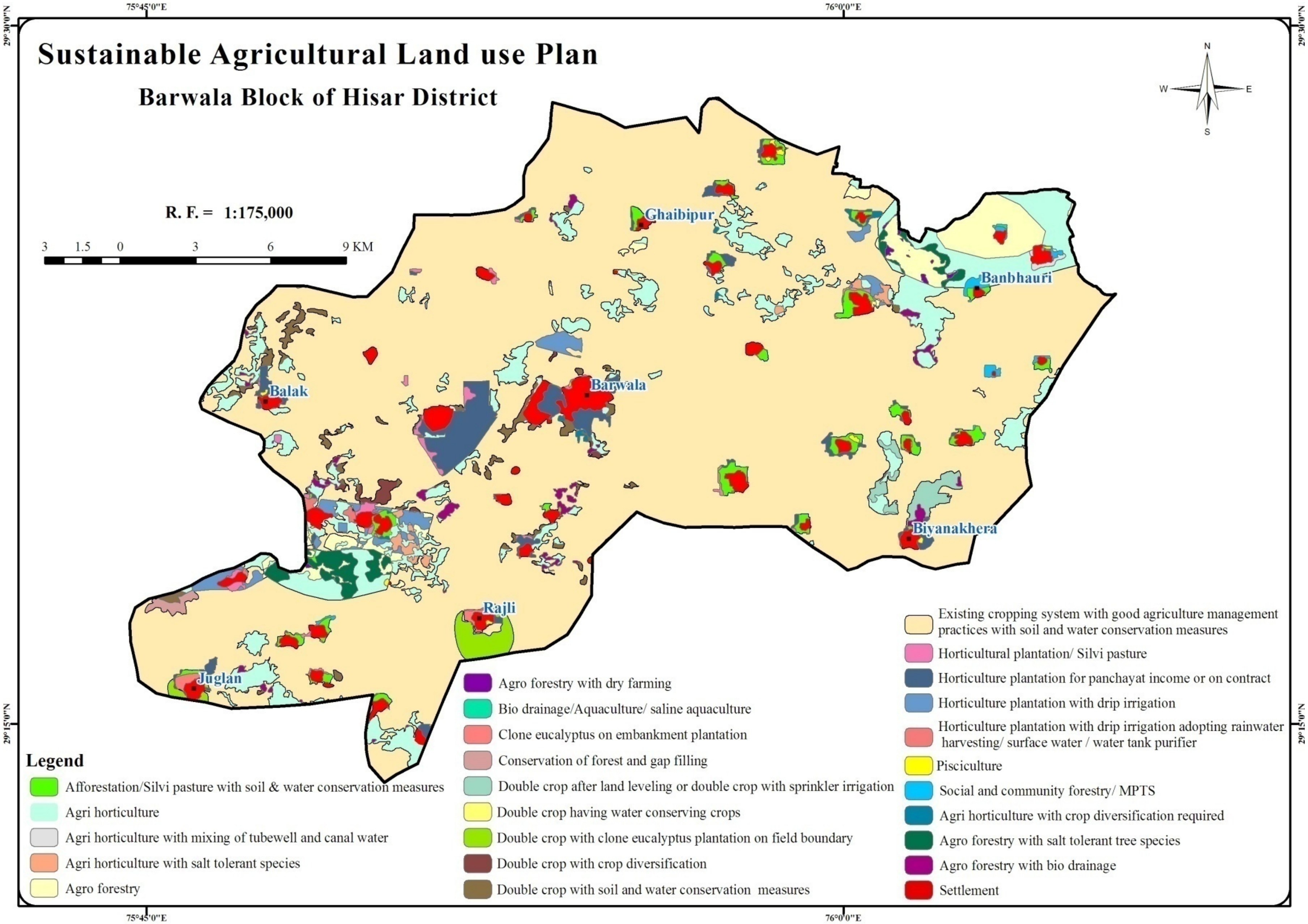

Sustainable Agricultural Land use Plan
Agroha Block of Hisar District
N
S
E
W
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Agri horticulture
Agri horticulture with mixing of tubewell and canal water
Agro forestry
Agro Forestry / Fodder dairy cattle
Agro forestry after land leveling
Agro forestry with dry farming
Excess fresh water potential zone for pipelines
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Double crop having water conserving crops
Existing system with salt tolerant species
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Double crop with clone eucalyptus plantation on field boundary
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Salt tolerant forest plantation/ bio drainage
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Agri Horticulture with eucalyptus plantation on field boundary
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Saline aquaculture on embankment plantation
Agro forestry with bio drainage
Agro forestry with bio drainage
Settlement
Nahla
Sabarwas
Sarngpur
Agroha
Nangthala
Kirori
R. F. = 1:155,000
4 2 0 4 8 12 KM
75°30'0"E
75°45'0"E
29°30'0"N
29°15'0"N

Figure-24



75°45'0"E
76°0'0"E
29°30'0"N
29°15'0"N
Sustainable Agricultural Land use Plan
Barwala Block of Hisar District
R. F. = 1:175,000
3 1.5 0 3 6 9 KM
N
W
E
S
Ghaibipur
Banbhauri
Balak
Barwala
Biyanakhera
Rajli
Juglan
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Agri horticulture
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Agro forestry with dry farming
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Double crop after land leveling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with bio drainage
Settlement

Figure-25

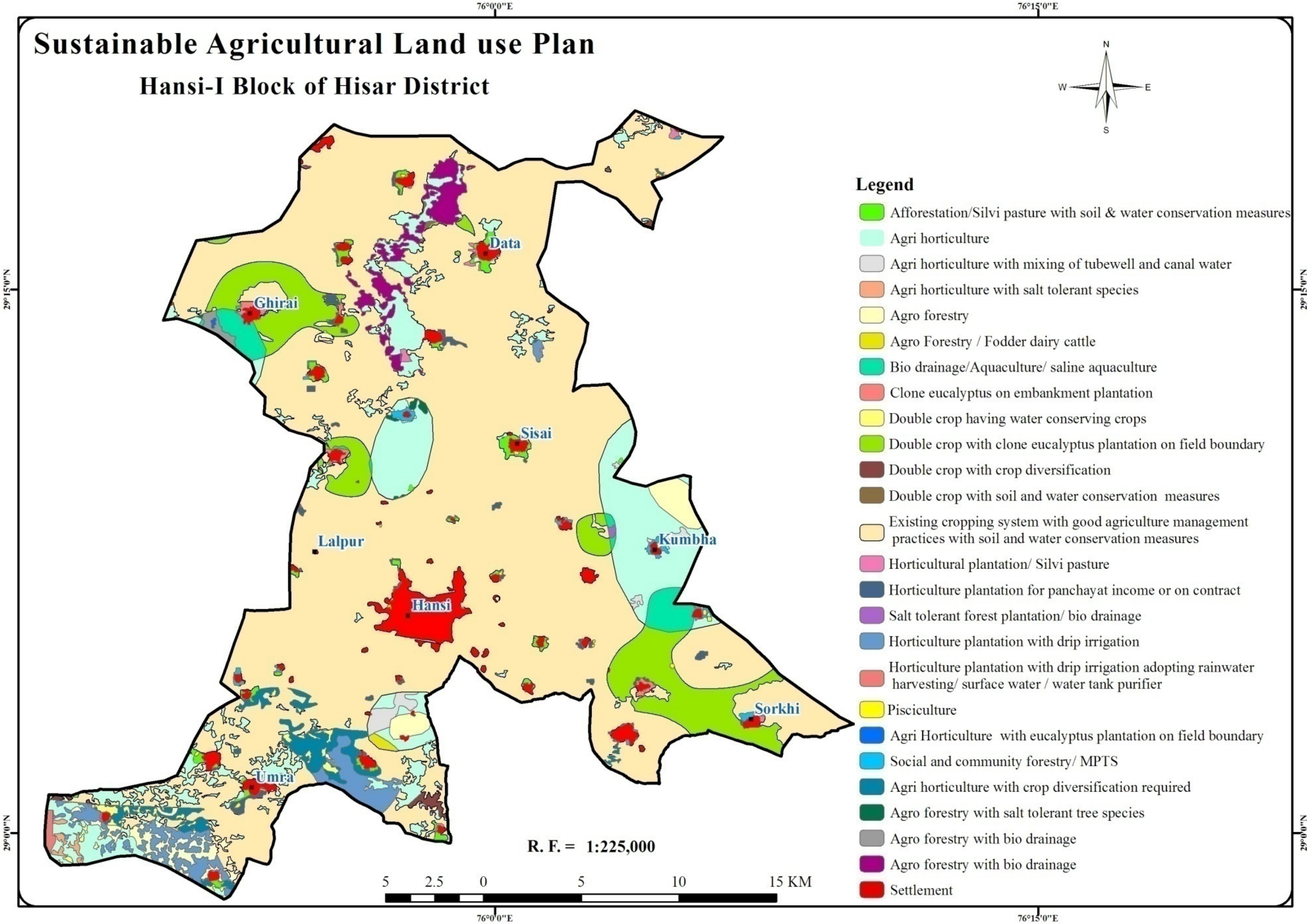
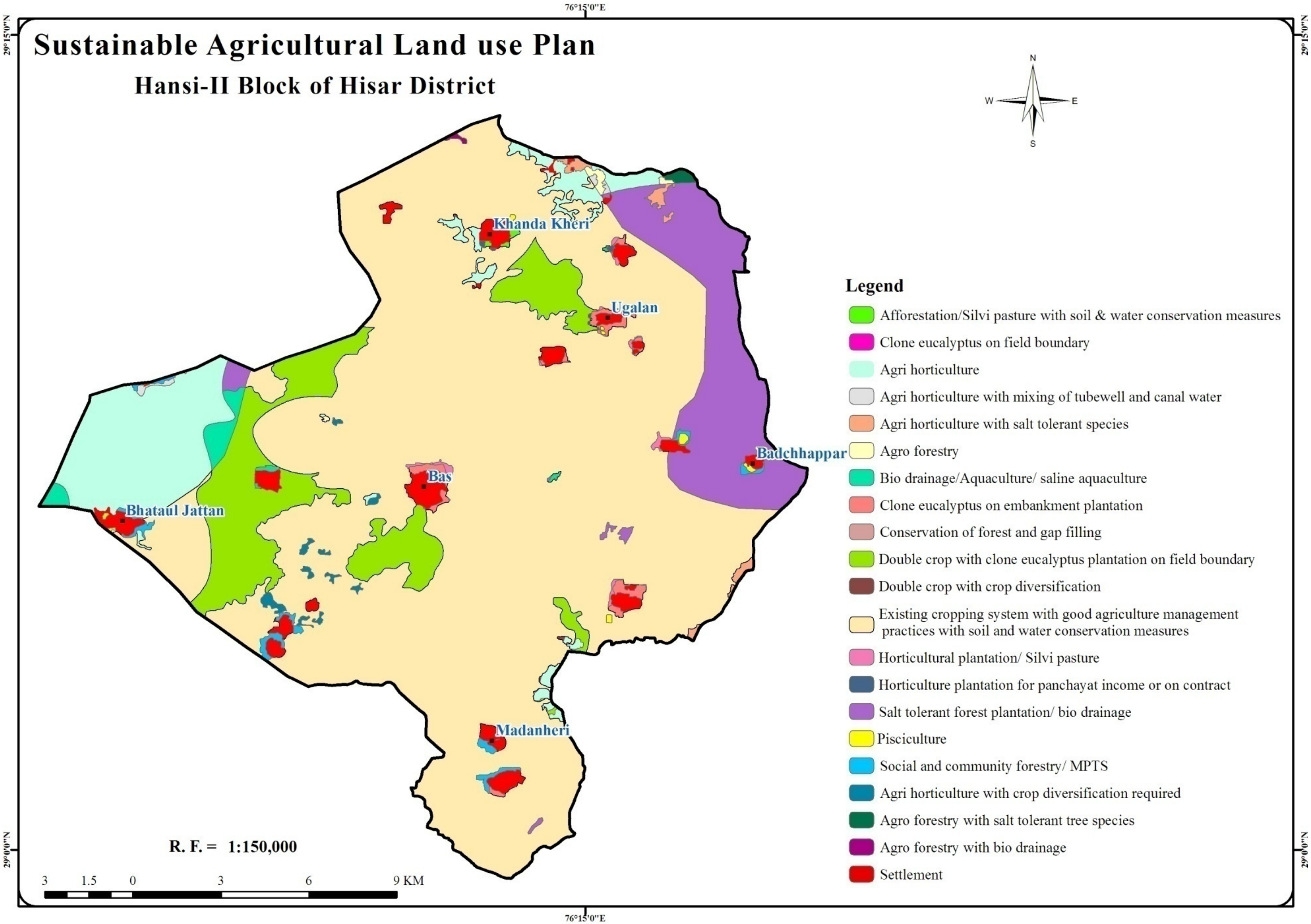
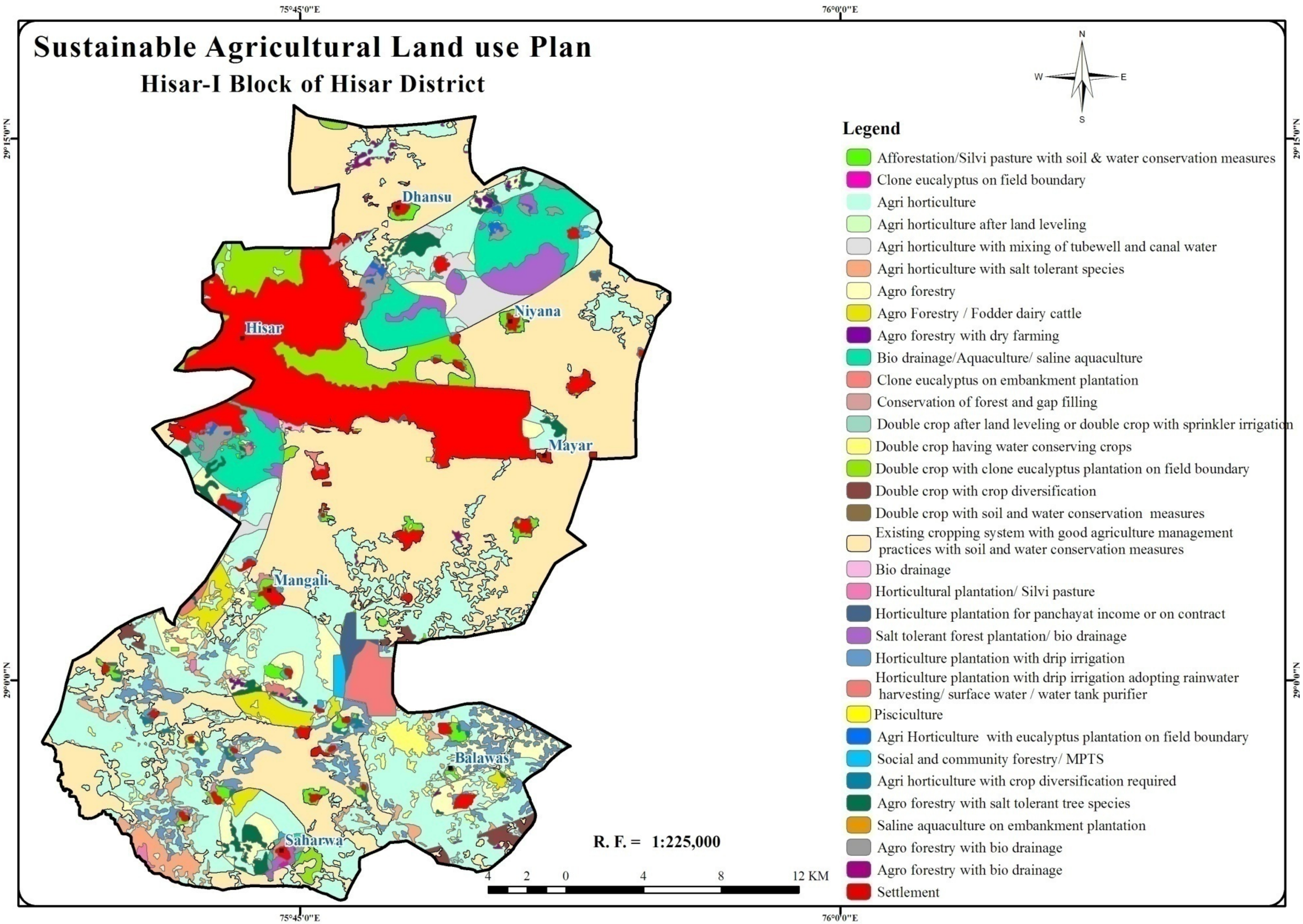

Sustainable Agricultural Land use Plan
Hansi-I Block of Hisar District
76°0'0"E
76°15'0"E
29°15'0"N
29°0'0"N
N
S
E
W
Data
Ghirai
Sisai
Lalpur
Kumbha
Hansi
Sorkhi
Umra
R. F. = 1:225,000
5 2.5 0 5 10 15 KM
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Agri horticulture
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Agro Forestry / Fodder dairy cattle
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Salt tolerant forest plantation/ bio drainage
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Agri Horticulture with eucalyptus plantation on field boundary
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with bio drainage
Agro forestry with bio drainage
Settlement

Figure-26



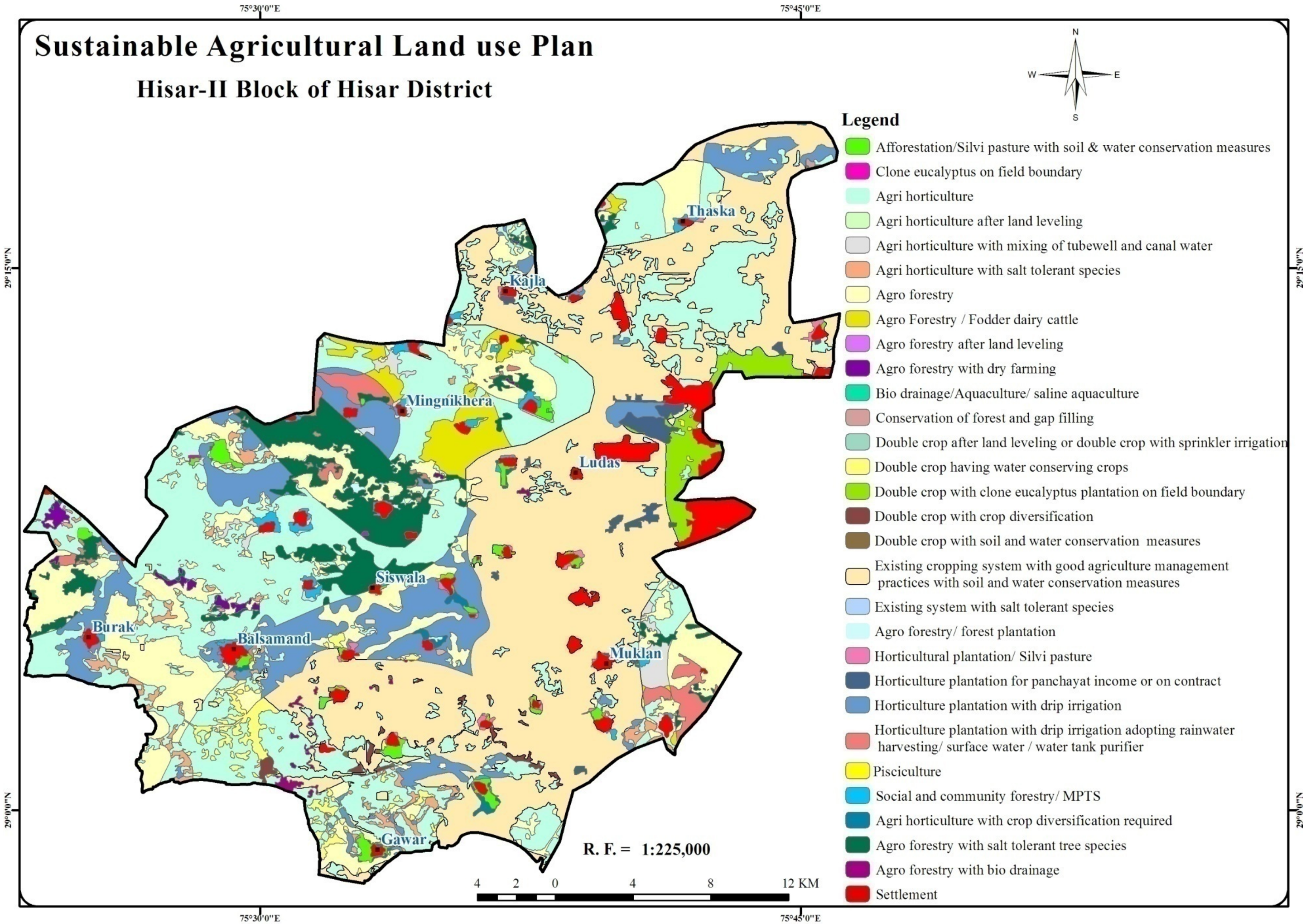
76°15'0"E
29°15'0"N
29°0'0"N
Sustainable Agricultural Land use Plan
Hansi-II Block of Hisar District
N
W
E
S
Khanda Kheri
Ugalan
Badchhappar
Bas
Bhataul Jattan
Madanheri
R. F. = 1:150,000
3 1.5 0 3 6 9 KM
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Clone eucalyptus on field boundary
Agri horticulture
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Existing cropping system with good agriculture management practices with soil and water conservation measures
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Salt tolerant forest plantation/ bio drainage
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with bio drainage
Settlement

Figure-27



Sustainable Agricultural Land use Plan
Hisar-I Block of Hisar District
75°45'0"E
76°0'0"E
29°15'0"N
29°0'0"N
N
S
E
W
Dhansu
Hisar
Niyana
Mayar
Mangali
Balawas
Saharwa
R. F. = 1:225,000
4 2 0 4 8 12 KM
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Clone eucalyptus on field boundary
Agri horticulture
Agri horticulture after land leveling
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Agro Forestry / Fodder dairy cattle
Agro forestry with dry farming
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Double crop after land leveling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Bio drainage
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Salt tolerant forest plantation/ bio drainage
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Agri Horticulture with eucalyptus plantation on field boundary
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Saline aquaculture on embankment plantation
Agro forestry with bio drainage
Agro forestry with bio drainage
Settlement

Figure-28



75°30'0"E
75°45'0"E
29°15'0"N
29°0'0"N
Sustainable Agricultural Land use Plan
Hisar-II Block of Hisar District
N
S
E
W
Thaska
Kajla
Mingnikhera
Ludas
Siswala
Burak
Balsamand
Muklan
Gawar
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Clone eucalyptus on field boundary
Agri horticulture
Agri horticulture after land leveling
Agri horticulture with mixing of tubewell and canal water
Agri horticulture with salt tolerant species
Agro forestry
Agro Forestry / Fodder dairy cattle
Agro forestry after land leveling
Agro forestry with dry farming
Bio drainage/Aquaculture/ saline aquaculture
Conservation of forest and gap filling
Double crop after land leveling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Existing system with salt tolerant species
Agro forestry/ forest plantation
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Horticulture plantation with drip irrigation
Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with bio drainage
Settlement
R. F. = 1:225,000
4 2 0 4 8 12 KM

Figure-29

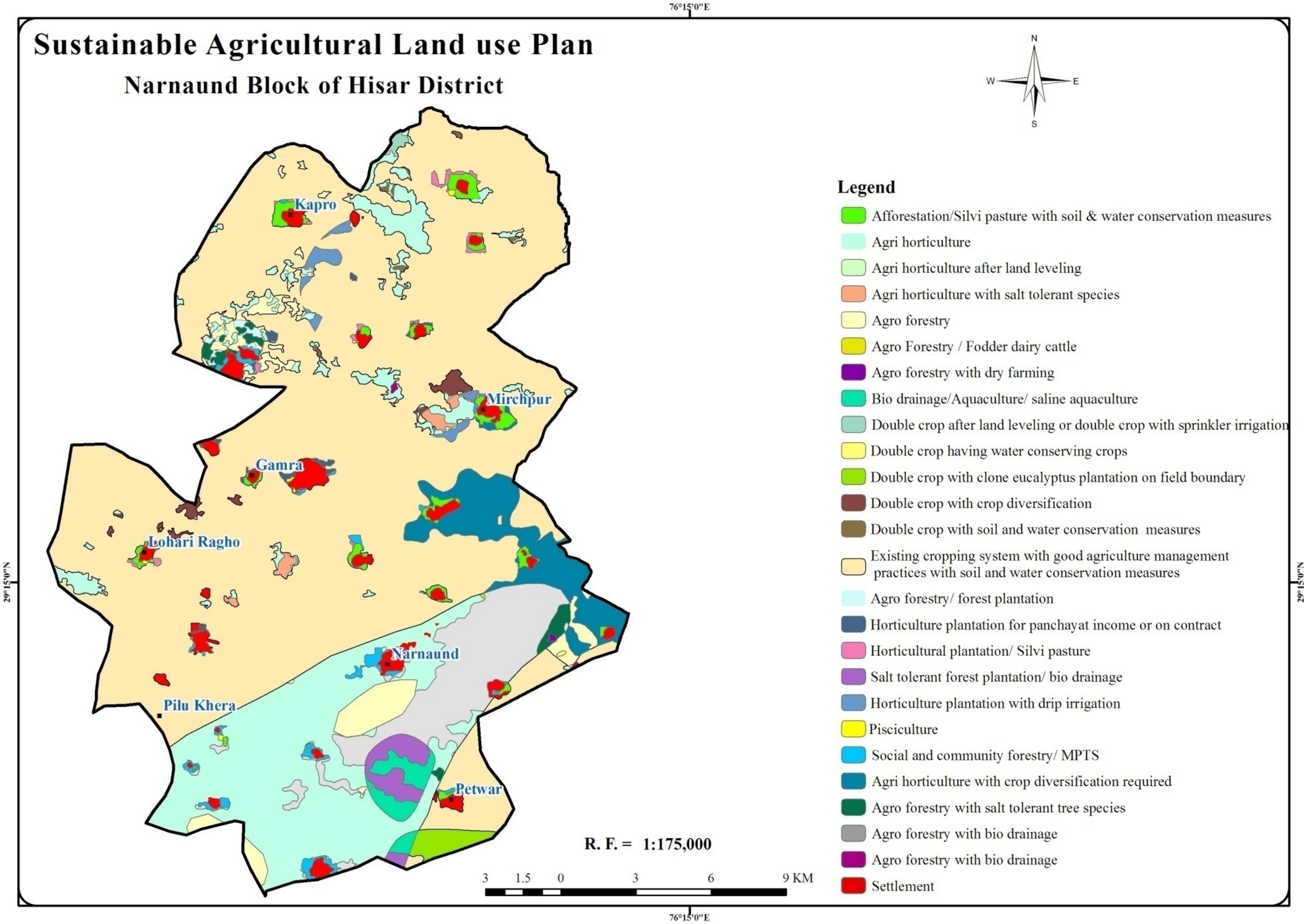

76°15'0"E
Sustainable Agricultural Land use Plan
Narnaund Block of Hisar District
N
W
E
S
Kapro
Mirchpur
Gamra
Lohari Ragho
Narnaund
Pilu Khera
Petwar
29°15'0"N
Legend
Afforestation/Silvi pasture with soil & water conservation measures
Agri horticulture
Agri horticulture after land leveling
Agri horticulture with salt tolerant species
Agro forestry
Agro Forestry / Fodder dairy cattle
Agro forestry with dry farming
Bio drainage/Aquaculture/ saline aquaculture
Double crop after land leveling or double crop with sprinkler irrigation
Double crop having water conserving crops
Double crop with clone eucalyptus plantation on field boundary
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Agro forestry/ forest plantation
Horticulture plantation for panchayat income or on contract
Horticultural plantation/ Silvi pasture
Salt tolerant forest plantation/ bio drainage
Horticulture plantation with drip irrigation
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with salt tolerant tree species
Agro forestry with bio drainage
Agro forestry with bio drainage
Settlement
R. F. = 1:175,000
3 1.5 0 3 6 9 KM

Figure-30

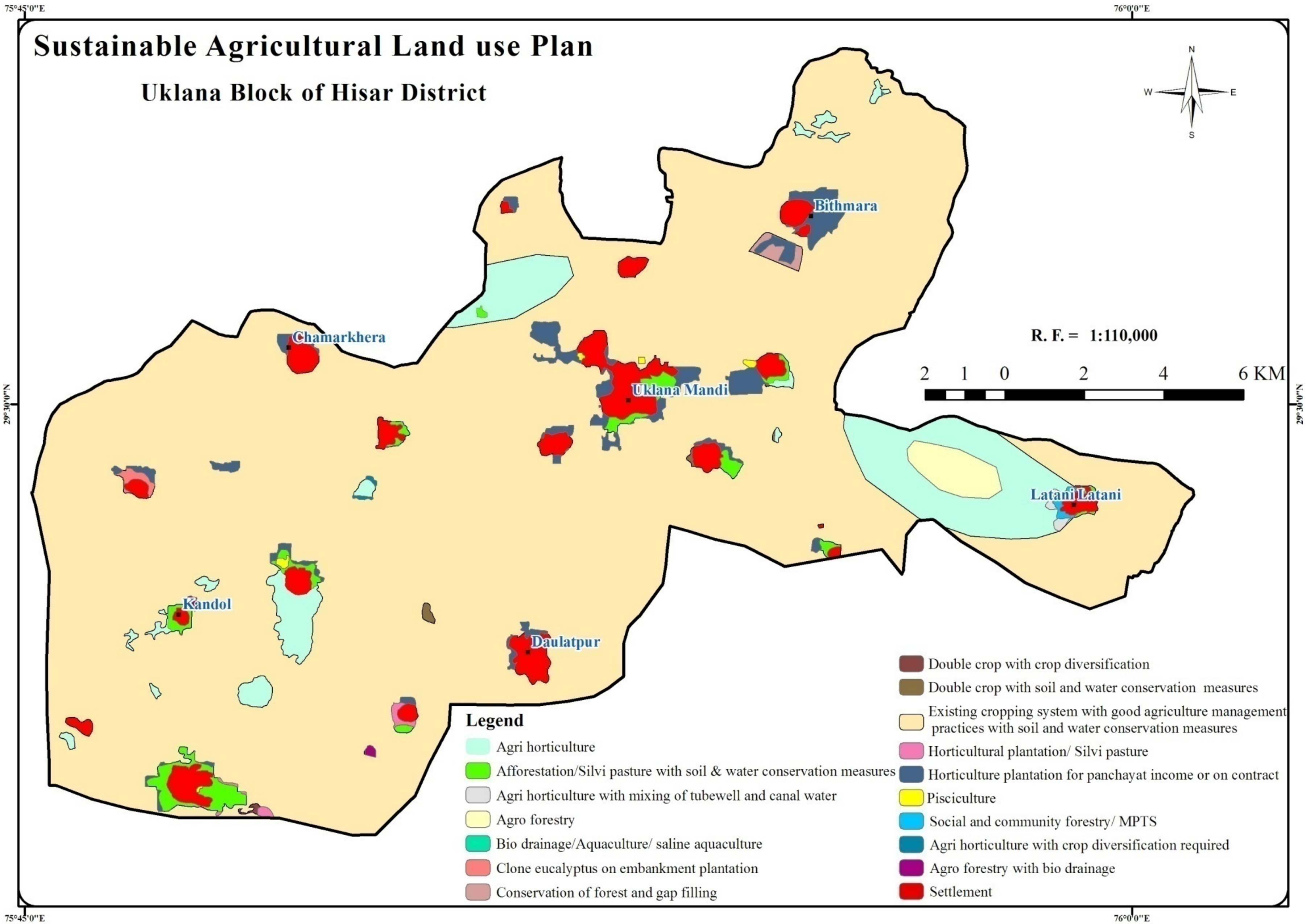

Sustainable Agricultural Land use Plan
Uklana Block of Hisar District
75°45'0"E
76°0'0"E
29°30'0"N
N
W
E
S
R. F. = 1:110,000
2 1 0 2 4 6 KM
Bithmara
Chamarkhera
Uklana Mandi
Latani Latani
Kandol
Daulatpur
Legend
Agri horticulture
Afforestation/Silvi pasture with soil & water conservation measures
Agri horticulture with mixing of tubewell and canal water
Agro forestry
Bio drainage/Aquaculture/ saline aquaculture
Clone eucalyptus on embankment plantation
Conservation of forest and gap filling
Double crop with crop diversification
Double crop with soil and water conservation measures
Existing cropping system with good agriculture management practices with soil and water conservation measures
Horticultural plantation/ Silvi pasture
Horticulture plantation for panchayat income or on contract
Pisciculture
Social and community forestry/ MPTS
Agri horticulture with crop diversification required
Agro forestry with bio drainage
Settlement

Figure-31

7.2 RECOMMENDATIONS

The recommendations of the action plan for the area are described under following heads and sub heads.

7.2.1 Management of Agricultural Lands

Agricultural land resources management has emerged as one of most important issue to improve agricultural productivity and sustainability through protection and rational consumption of our natural resources base like water, soil, vegetation, livestock and genetic diversity. Unfortunately, the agricultural development efforts in the area have over exploited the natural resources without due of long term sustainability. The consequences have been disastrous in form soil degradation drought, floods, lowering of water table and complete deforestation. In order to bring sustainability of agriculture, it is essential long term planning is to be done for rational use of natural resources. This situation calls for integrated approach which entails integrated studies of resources potential, resources limitations, physical setup, socio-economic conditions and technical know-how appropriate to the area.

Agri horticulture: The agricultural land have been continuously overused with faulty management practices and subjected to various processes of degradation. In addition to these problems, the harsh semi arid climatic conditions make the crop production risky, uneconomical and non-remunerative. These conditions can also lead to severe imbalances in ecosystem of area in long duration. Therefore, the assumption of new innovative substitute cropping system like agri horticulture is better option than existing land use system. The agri horticulture can be reasonably practiced in the area of low and unreliable rainfall with lengthy dry curse and area with reasonable fertility status or in soils with low water retention capacity. However, most of the patches recommended for this activity occur in canal command areas.

Agri horticulture is basically growing fruit plants with agriculture crops. The growing of fruit trees with agriculture crops would be helpful in restoring efficiency of agriculture land because the presence of tree plantation prevents the erosion of soil, improve fertility of soil and increase the moisture holding capacity of soils. Hence the term of well-judged management of trees/plant and crops results in most favourable use of water and soil resources, which eventually lead to justifiable agriculture production. The horticulture plantation component of agro horticulture improves the economic conditions of the farmer and resource base of the area. It will not only give higher income to farmer but also provide more employment to the farmers during off season when crops are not cultivated. Total area suggested under this activity is 806.92 sq. km that was 20.23% of the total recommended area including agri horticulture, agri horticulture after land levelling, agri horticulture with mixing of tubewell and canal water, agri horticulture with crop diversification required, agri horticulture with eucalyptus plantation on field boundary and agri horticulture with salt tolerant species.

The suitable crops and their varieties matching with rainfall pattern and on the basis available ground and surface water resources of the area and soil moisture conditions have to be selected. The kharif season crops and their variety recommended for Bajra BJ-104 and HHB-67, for Gwar G-375 and 365, for Mung S-8 and S-9 and for Moth T-23 & T-18 (HARSACITR/26/1999). The Rabi season crops which are suitable for agro horticulture i.e. for wheat WH-2009, 147, 157, 283, 542 and 533, for barley Ratna, Vijay and RD-57, for Oil seed crops RH-30, AH-819, Th-68 and Sangam (toria) etc.

Horticultural plantation: Horticulture plantation is also another option for farmers of the areas, which are recommended for agri horticulture. Horticultural plantation is a practice or cultivation of fruit crops and trees and is efficient alternate land use system. The fruit trees have been better suited for arid as well as semi arid climatic areas which perform better in extremes of soil and climatic conditions, than arable crops. Planting horticultural trees have been found to be beneficial in improving the natural resources base of area and economically viable for agriculturalists. Fruit plants have deep root system and thus have the capacity to pull water from bottomless layers of soil profile. Some of the fruit tree crops recommended for the area is Ber, Guava, Pomegranate, Kinnu, Papaya, Peach and Amla. CCS Haryana Agricultural University, Hisar has found these fruit trees suitable for this area. Besides survival resilience in harsh climatic conditions these fruit crops utilization of off-season rainfall that was otherwise run waste. The dried twigs and branches can also be is useful source of fuel wood. Drip irrigation system is better suited for horticulture plantation. Additional approach for irrigation could be channeling of water from surroundings in bowl shaped pits around plants.

Horticultural plantation provide employment opportunity whole year in comparison to annual crops' seasonal employment. Economically, well managed tree crops give better return than traditional field crops from same piece of land. Another advantage of fruit trees are that they provide green fodder for animals and dried branched can be used for firewood. The fruit tree play vital role in preventing the malnutrition prevalent in rural areas. Recommendation related to horticulture plantation (including Horticultural plantation/ Silvi pasture, Horticulture plantation for panchayat income or on contract, Horticulture plantation with drip irrigation, Horticulture plantation with drip irrigation adopting rainwater harvesting/ surface water / water tank purifier) occupied 186.22 square kilometers area that was 4.67% of the total recommended area.

Agroforestry: Agroforestry system is a practice of mixed farming developed over centuries but this term is very recent and new. Traditionally, agroforestry has been practiced by farmers of arid and semi arid climatic zones of India. Agroforestry is combined surname of land use system and technology, which denotes the addition of yearly crops with persistent trees on farm for the profit of agriculture. To decrease the necessity on forest for fuel, fodder, wooden and fruits, the requirement of agroforestry system is a matter of prime concern for agricultural scientist. Overall goal of agroforestry is to found such a supportable land management system as it could recover the current system quantitatively and qualitatively, decrease environmental injury, financially and ecologically required, essentially practicable and socially tolerable to the farmer.

This system make available to the people timber, fruit, firewood, fodder for which they conventionally depend on forests and it also maintain soil fertility through reutilizing of nutrients and prevents soil erosion. It improves the soil structure and help to maintain high infiltration rate and water holding capacity. Agroforestry prevents standing crops from natural hazards like storm, winds and scorching heat and thus makes the climate more hospitable. The tree plantations also in dry areas also conserve soil moisture and there the agricultural production. Since, the system is labour rigorous, this generate service opportunities for rural people.

Special emphasis is given upon for establishing the plants on bunds of cropped areas. Tree culture also provides adequate supplies of fuel wood to villagers, so that cow dung, which is brunt on large scale for cooking and making bricks, is saved for farmyard manures. Further, the integration of fodder trees in the program also provide much needed top feed for sustenance of livestock during lean periods.

Agroforestry no doubt plays an important role in food production system (tree integration with farm lands), in energy production system (browse, grazing and trees), in livestock production system (browse, grazing and forest plantation grazing system). Moreover agroforestry system is more suitable for poor farmers who have fewer number of prospecting in adopting high cost technology. Agroforestry scheme involves careful selection of both crop and plant types if a valuable production system is to be attained.

The growth of trees is not be hampered when planted wide so that inter space is available for growing agricultural crops. They should posses self-pruning properties and also able to tolerate relatively high incidence of pruning.

The tree species suggested for agro forestry plantation in the area are Prosopis cineraria (Jand), Acacia senegal (Kumat), Tecomellaundulata (Rohida), Ailanthus excelsa (UllooNeem), Dalbergiasisoo (Shisham), Phyllanthusofficinalis (Amla) and Azardichtaindica (Neem). These trees do not compete with agricultural crops to any appreciable extent. Like Khejri tree is attributed to high amount of leaf litter it adds to soil thereby increases soil organic matter and nitrogen content. Further, it increases availability of micro nutrients, moisture availability, woody perennials that enrich the ecosystem and thereby increased the food production system. Rohida tree also holds maximum moisture in soil profile. Both trees Jand and Rohida regenerate naturally. Wheat, Barely, Mustard, Jai, Gram Sunflower, sugarcane Maize, Jowar Guar, Till, Ragietc, are suitable crops for agroforestry system in both rabi and kharif seasons (HARSAC/TR01/92). This activity covers 227.57 sq. km that was 5.71% of total recommended area. Agro forestry activity involve Agro Forestry / Fodder dairy cattle, Agro forestry after land levelling, Agro forestry with dry farming, Agro forestry/ forest plantation, Agro forestry with salt tolerant tree species and Agro forestry with bio drainage.

Agroforestry with Improved Dry Land Crops Management: Aeolian plains of study area have large number of patches of fallow lands, which are suitable for agroforestry with improved dry land crops management. Agroforestry is growing of tree species with suitable crops for sustainable land management and has already been described exhaustively in the previous section. The improved dry land crops management is discussed here. The dry land crops are cultivated in area where rainfall is low and its distribution is very erratic and most of the time precipitation is less than evapotranspiration. More than eighty percent of rainfall is received in 15 to 20 days period in the area. Moisture availability is major problem and it affects successful crop production because of either low rainfall or its uneven distribution. Other problems of these areas are light textured soils with poor fertility and low moisture retention capacity.

Based on existing land use and cover of land conditions the fallow lands have been suggested for alternative land use of agroforestry with dry land crops management. For sustainable crop production in these sandy areas some measure of conservation with suitable crop species are recommended. For conservation deep ploughing before onset of monsoon, dust & stubble mulching, use of compost and organic manures help in soil moisture conservation and create a favourable conditions for crop growth. Intercropping and mixed cropping pattern in dry land/ rainfed areas have been found more beneficial and stable as compared to single cropping pattern. Inclusion of shallow and deep rooted crops in the system gives better utilization of available moisture as in intercropping and sole cropping; the water losses are the same. Suitable intercropping system is bajra+arhar, bajra+moong, maize+arhar, maize+urad, barley+gram, barley+mustard and wheat+gram.

The short duration variety with deep rooted and drought resistant crops are better adapted to dry land conditions. Other desirable conditions for better production are like early showing variety crops, optimum plant population with weed & pest management. Under rabi crops for Wheat HD-2009, for Mustard RH-30, for Barley Ratna, Vijay, Jyoti, DL-88, HDL-95 and for Raya BR-30, T-53 and T-62 varieties are recommended. Under Kharif crops, for Bajra HHB-56, 60, 67 and 68, for Guar HG-75 and 375, for Moong Asha, S-8, and S-9, for Urad T-9 and 18 are recommended for study area (HARSACTR/07/98).

Double crop with crop diversification: This activity is recommended for the area, which is double cropped and situated in alluvial plains of central part of the district. The total area recommended for this category is 10.56 sq. km. The soils of the area are fine loamy Aridic Haplustepts and ground water quality available varies from marginal to good. Most of the irrigation is practiced with tube wells. However the area is also blessed with canal network to supplement the well irrigation. As per field observations during both rabi and kharif seasons and discussion with District Agricultural Department clearly indicates that rice wheat crop rotation dominates the area. The presence of other crops is very less except few patches of fodder and cotton crop. Though, rice wheat crop rotation is most popular and it gives better return, but it has inherent problems of adverse agro-ecological consequences. These crops are associated with high use in term pesticides, insecticides and water. The practice of monoculture has crop diversification and pushed the other cereals crops with pulses and oilseeds to marginal areas. This is responsible for stagnation of production pulses and oilseeds in long run.

In addition to these problems, green revolution high yielding crop rotation has led to soil degradation in the form loss of soil fertility, soil and underground water pollution because excessive use of agro-chemicals. Indiscriminate use of these resulted into adverse effects on micro- organism and environment and further area is suffering from low organic matter. The pudding of the soils for rice crop also affect the progress of wheat crop resulting rice and its cultivation rescinds the soil arrangement by creating sub surface solid pan.

Allowing for the negative agro-ecological influences of the cropping arrangement, a suitable crop diversification plan with soil conservation measures is essential for sustainable agriculture development. Various crops suggested for diversification are desi Cotton, Pulses, Maize, Oilseeds, Pearl-Millet, Sugarcane, Wheat, Fruit orchards, Vegetables and Fodder crops. Most of these crops are low water consuming crops that will help in reducing the fast depleting ground water. The diversification will also help in maintaining soil fertility through leguminous crops and encouraging microbial activity with sustaining of physio- chemical prosperities. It will help in reducing the agro-ecological difficulties and parallelly also preserve soil productivity. The soils of the area are very fine textured and bulk density is very less. Therefore, sand should be added and ploughing may be followed by it. Other soil conservation measures suggested are tillage and green manuring. The study shows that there is gap of approximately fifty days between rabi and kharif crops which can be utilized by growing green manuring "Dhaincha crop and fodder crop like cowpea or any other pod crops.

Double Crop with clone eucalyptus plantation on field boundary: The ever increasing human and cattle population coupled with increasing numerous requirements have demanded the finest utilization of land resources. Therefore, characteristic of existing land use is essential for sustainable land resource creation. Based on existing land use/ land cover, the recommendation of double cropping activity is suggested for single cropped (either rabi or kharif) areas and agriculture fallows which are spread in flood & Aeolian plains and alluvial plain with sand cover respectively. This activity occupies total area of 127.33 square kilometres which was 3.19 percent of total recommended area.

This class involve Double crop after land levelling or double crop with sprinkler irrigation, Double crop with clone eucalyptus plantation on field boundary, Double crop with drain out sub classes. In these areas, the under ground water quality is good in Aeolian & flood plains but in alluvial plain with sand cover, the ground water quality ranges from good to marginal. However, marginal sub-surface water quality areas also have very good canal network to supplement shortage of ground water. Due to these suitable physical conditions, the double crops activity is suggested. The crops, which give more financial return per unit utilization of water i.e. low water requiring crops are recommended.

Rabi season suitable crops are Wheat, Barley, Mustard. Raya, Gram, Fodder etc. and for kharif season, the crops of Bajra, Guar, Moong, Urad, Cowpea, Maize etc. are included. The soil and water requirement conditions are guiding principle for recommending these crops and hence these crops will not put stress on available water resources. These crops require low inputs and at the same time these are excellent for environment, soil productivity and economically viable with social acceptance in long run.

Double Crop with Suitable Soil and water Conservation Measures: Double crop with soil conservation methods or measures is also advised in area under single crop (either rabi or kharif) in alluvial plains of the study area where quality of ground water arrays from good to marginal along with availability of canal water. This category constitutes an area of 7.86 square kilometers. The soil type of this area is fine loamy Hence, the diversified double cropping pattern with soil conservation measures is economically and ecologically sound alternative land use system than single crop These single cropped areas are under impact of high input intensive green revolution crops either wheat or rice or cotton. The shifting to these monoculture crops has created problem of sustainability of agriculture with agro-ecological consequences. To solve those ecological problems diversified double cropping system with soil conservation measures suggested. The main crops suggested for rabi season are Wheat, Mustard, Raya, Gram, Chickpea, Fodder and for kharif season are desi cotton, Guar, Maize, Pulses and Fodder.

The soils of the area are fine textured with negligible bulk density and further due to pudding of soil for rice crop, the sub-surface hard pan has formed. To counter this problem sand should be added to fields and the paddy crop should be completely avoided. To solve other problem of too much use of agro chemicals, the integrated pest management and integrated nutrient management should be adopted for sustainability of agricultural.

Agro horticulture with crop diversification: Growing of fruit trees with agriculture crops is recommended where only single crop either rabi or kharif is grown. This activity is also desirable practice in the areas where the rainfall is low and unreliable with long dry spell, in the land with logical fertility with proper soil depth and in well drained soil with no shallow water table. These single cropped areas having monoculture cropping pattern in form of either paddy or wheat and these crops basically have adverse agro-ecological impacts. In comparison to this, the agri horticulture is basically diversified, eco-friendly sustainable and help in soil and water maintenance measures. The areas recommended for this activity are spread in central part alluvial plain. These areas have tube well irrigation but the superiority of underground water is marginal. In addition to this, canal water is also available for irrigation to supplement the ground water irrigation. The soils of these areas are fine loamy with very less bulk density. Therefore, these areas are reasonably suitable with soil conservation measures.

Agro horticulture is basically growing of fruit trees with combination of agricultural crops. The increasing of fruit trees in farming lands will be helpful in restoring the efficiency of the land due to the tree element concerned in monitoring soil erosion and refining soil fertility. Economically, the fruit trees give better return in the form of green fodder, fuel wood in lean season and provide employment opportunity round the year. The trees effectively utilize the off-season rainfall and also help in soil and moisture conservation. The agro-horticulture has in built mechanism of soil conservation but due to peculiar situation of fine loamy, very hard soil, which makes it very difficult to plough. Therefore, addition of sand in fields is recommended before ploughing and irrigation. In addition to these, the other measures suggested are green manuring, tillage, mulching and growing of legume crops.

The tree species and crops suitable for agro-horticulture are Ber, Kinnu, Papaya, Guava, Plum, Pomegranate and Amla. As per rainfall pattern and soil moisture condition in view of sound ecology and long term sustainability, the crops like Wheat, Barley, Mustard, Chickpea, Cowpea, Guar, Pulses, Maize and Sugarcane. Total area recommended under the category is 28.82 square kilometres.

Double crop with water conservation: The doubled cropped areas in alluvial plain of study area with poor quality of ground water are suitable for implementation of single crop particularly of kharif season with peripheral plantations. These areas are having the constraint of poor quality of ground water along with insufficient canal water and heavy soils. Major crops developed in these areas are rice, wheat and cotton which are unsustainable because these input intensive crops put high pressure on land and water resources. Therefore, single dry land crops with peripheral plantations matching the available soil and water requirement condition has to be selected for sustainable water and land resource creation.

Peripheral plantation consists of one or more shapes along the field borders in all directions and along field bunds and water channels. It has been observed that peripheral plantation in fields preserve soil moisture, improve fertility of soil and guard the crops beside roasting heat and winds. Thus, it makes the climate extra friendly thereby increasing the agricultural production. The farm forestry or horticultural plantation can be planted along field boundaries, bunds and water channels. These areas are confined to south of Hisar district along the block boundary and about 17.13 sq. kms area is covered by this activity.

7.2.2 Management of Wastelands

Afforestation / Silvipasture/ Social and community forestry/MPTS (Multi purpose trees and shrubs): It is a land management system in which land is managed for production of wood as well as for the rearing of domestic animals. Tree species having deep rooted system and grasses with surface feeding habits can be a suitable combination. It is one of the alternatives accessible for refining of resources of the study area. This practice is recommended for degraded pasture degraded grazing lands, which are mainly situated around the villages. This category consists of 60.10 sq. kms which is 1.50 percent of total area under different suggested activities. Due to semi arid climatic conditions of the area, there are only few natural pasturelands around the villages to support the bourgeoning livestock population. These areas have become degraded and denuded because of lack of water and soil conservation processes and overgrazing over the ages. As a result, there is shortage of fodder for livestock and fuel wood. This fodder shortage problem can be solved to great extent by adopting multiplier system of forage production like silvipasture.

The silvipasture system should be developed under aegis of Village Panchayat with rural folks and active cooperation of forest department. This scheme provides an additional yield of grasses during raining period and browse substantial in extensive dry curse. The need of fuel and fodder are growing with ever increasing population of human and livestock. In instruct to create the area environmentally suitable and decrease the pressure on forest there is require to develop silvipasture adjacent area near the villages in degraded pasture lands. A well developed silvipasture system is advantageous from various aspects such as: (1) reduced soil erosion and increased soil moisture (2) improved soil fertility by addition of rummage legume and nitrogen protective trees (3) making additional fuel wood so the precious cow dung can be saved for use in agricultural lands.

The grass species belonging to the area must be grown with few leguminous species to supplement nitrogen to soil nutrients. For fuel and fodder local forest species can also be planted. While selecting tree species following criteria should be kept in mind i.e. drought resistant, nitrogen fixing ability, high palatability, rapid growth ability and ability to grow under wide range of environment. Similarly the grass species that have ability to grow under shadow, tolerance to drought, easy for propagation, high palatability, ability to conserve soil & water and ability to withstand overgrazing should be considered for this purpose. For enlarged fodder invention reseeding of natural grassland and wastelands with suitable plant species are advised. The possible perennial grasses species of above mentioned characteristics are Cenchursciliaris (Anjan), Cenchrussetigerus (Dhaman), Panicumanidole (Blue panic) etc thrive well in different soils of the area. Lasirussindicus grows well in sandy soils and can with stand temperature up to 40°C. Some of the perennial legune spices recommended for the area is Atylosiascarabaeoides (Bankulthi), Rynocosa minima, Stylosanthus species and Macroptilium (Siratro). The tree species and shrubs suggested are Prosopis cineraria (Jand), Acacia nilotica (Babool), Acacia senegal (Kumat), Zizyphusnimmularia (Jharber), Calligonum polygonoides (Phog), Azardichtaindica (Neem), Ailanthus excelsa and Bauhinia (Kachnar) spices.

Levelling and Dune Stabilization: Sand dunes and mainly spread over in south eastern aeolian plain except few patches of dunes. These sand dunes are partially stabilized to unstabilized accumulation of sand and this sand accumulation is predominantly by wind. It also includes barren sandy interdunal plains, which are not under agriculture use due to physical and climatic constraints. The dunes are loose mass of sand and these are prone to low to moderate wind and water erosion and could be categorized as sandy hammock Due to shifting nature of sand dunes, the moving sand engulfs adjoining fertile agricultural lands, irrigation channels etc. and they need levelling and stabilization activities.

The dunes, which have low height, should be levelled but the dune with considerable height needs stabilization which is a long term systematic activity. It involves protection of sand dunes against biotic interferences by fencing or by effective watch and ward staff (2) treatment of dunes by micro wind breaks (3) plantation of grasses shrubs and trees by transplanting or direct showing method (4) continuous and proper management of such dunes for at least for following ten years.

To protect sand dunes effectively from erosion, these should be fenced with barbed wire fixed with angle iron post. However, if this is not possible than other locally available jharber brushwood and other available shrubs and grasses could be used for this purpose. By creating obstruction across wind direction in rows 2-5 meter apart can reduce wind velocity considerably on dune surface. This is done by vertically burying brush wood crown down ward. Then, on these temporarily stabilized sand dunes grass could be planted at the time of onset of monsoon. It is observed that high moisture subjects beyond field capacity are available during the year below 1.5 meter depth in dunes. Therefore, it is also possible to directly plant hardy shrubs and tree species using branch cutting and or potted plants. The loose sand dunes generally deficient in nitrogen and hence, planting of nitrogen fixing plants and trees should be given priority. The area under stabilization process should be kept out of reach of human & animals and particularly cropping should not be allowed. The successful dune stabilization process needs maintenance and after care. Grasses can be used in second year but trees could be used for fuel and fodder at least after ten years.

Most of dunal areas are under private owner ship of famers. The farmer can accept dune stabilization process only if it is economically productive. The benefits of dune stabilization are in form of fuel wood fodder, small timber & grasses etc. The tree component would provide fodder during lean season (November onward) when other forage sources go dry. The average cost benefit ratio carried in Bhiwani district which shows that dune stabilization not only economically sound but environmentally desirable.

The perennial grasses and shrubs found to be suitable are Lasirus sindicus (Sewan), Cenchrusciliaris (Anjan) turgidum (Bhurut) etc. and Caligonumpolygonoides (Phog), Ziziphusnur , Cenchrussetigerus (Dhaman). Panicum husjujuba (Jharber) respectively. The tree species recommended for this activity are acianilotica (Babool), Prosopis cineraria (Jand), Acacia senegal (Kumat), Acacia tortilis (Israeli babool), Tecomellaundulata (Rohida) Salvoraoileoides (Jal) etc (HARSAC/TR/01/12).

Forest Plantation/conservation of forest with gap filling: Land with or without scrub largely occurs in alluvial plains with sand cover however few patches are also found in alluvial plain of study areas. These lands normally occupy higher topography and are mostly undulating in nature, prone to degradation devoid of vegetation and suffered absence of soil and water preservation measures. Other factors, which are responsible for degradation of these areas, are immense felling of trees and bushes for fuel and small wooden and unselective grazing &perusing by natives.

These areas require protection and development through forest plantation and these plantations would be out side conventional forest areas. These are the areas which are not or less suitable for agricultural and upon which more benefits can be derived by afforestation. The ownership of these lands is with government or community. The best planting period synchronizes with onset of rainfall in monsoon season. As the study area is facing the complete absence of natural forest, therefore the forest plantation is essential from ecological point of view. Thus, scientific development and regeneration of forest plantation in these areas under social forestry program are immediately required so that original ecological balance may be restored partially if not fully.

The plantation of trees should not only check further land degradation then also provide fuel wood, fodder and small timber from the areas, which were laying waste. It will supply fuel wood to divert cow dung from village hearth to fields. The total recommended for conservation of forest is 2.19 square kilometres due to moisture poor soil moisture & fertility conditions and biotic interferences, trees growth is hindered. As field observations that in spite of elaborate tree plantation program ritually carried out every year but the situations has not improved much and degradation continues. Therefore, to protect these tree plantations from degradation requires timely operations of fencing, effective watch and ward, planting casually replacement and trenching.

The suitability of tree plantation and their species depends upon physical conditions like climate, soil moisture, depth, fertility etc. Besides this, there are two more criteria i. e, economic suitability and social suitability. This will depend upon villager's need and their behaviour will be based on their benefit from this activity.

While selecting tree species the criteria's of drought resistant, nitrogen fixing ability, palatability, rapid growth ability, ability to coppice and ability to produce wood for small timber need should be reserved in brain. The appropriate tree species suggested for the area are Prosopis cineraria (Jand), Prosopisjulifiora (Vilayati babool), Acacia tortilis (Isrealibabool), Acacia Senegal (Kumat), Tecomella undulata (Rohida), Dalbergiasissoo (Shiaham), Azadirachtaindica (Neem) and Zizyphusmauritiana (Beri).

7.2.3 WATER RESOURCES DEVELOPMENT PLAN

The study area is one of most intensively cultivated area where more than 65 percent of agriculture area is irrigated. At present, 60 percent of area is facing a amount of trouble like scarcity of good quality & quantity of ground water and availability of sufficient surface water. Due to inadequate canal water supply, the over misuse of under ground water to meet out requirements of present cropping pattern depleted the water resources rapidly causing serious ecological problems. The area has reached a stage where further growth in agriculture production could be attained only by proper and optimal management of water resources. The land use decisions are basically decisions on water use and in this context, alternate suitable cropping pattern and land use management should take into consideration of traditional wisdom & knowledge with contemporary technologies. On account of erratic spreading of rainfall both in time and space problems of drought and flood can be mitigated only by coordinated approach for optimum utilization with proper require surface and sub surface water resources management and development plan.

The growth strategy on water management has been organized on the base of hydro geomorphological characteristic, surface water availability, drainage, land use, current surface & ground water exploitation, keeping in view both immediate & long term needs.

7.2.3.1 Ground Water Resources Development Plan

As the existing surface water assets of the area is too insufficient to fulfil the water necessities. It is therefore becoming imperative to locate newer ground water resources on one side and control the fast depleting water table on the other side. Under this scenario, space technology and GIS have began a prevailing tool in ground water prospecting and management. Besides, ground water distribution is evenly distributed and spatio-temporal differences depending on fundamental rocks formations, their organizational fabric, geometry and external countenance.

This integrated map (Figure-20) explains that in universal, there is nonstop association of ground water quality with mainland use units. The study indicates clearly that there is no similarity in quality of terrain. Land water quality depends primarily on the lithology of the area's underlying water bearing formation.

The northern and north-eastern part of study areas particularly along the Ghaggar River, both the prospects and quality of water is good with depth of 5-10 meters. These areas also have dense canal network. Due to presence of canal network and Ghaggar River with geomorphic unit of alluvial plain and aeolian plain, the ground water prospects and recharging potential is excellent. These areas can be exploited for tube well and bore well.

Central part of study area is occupied by alluvial plain, which is composed of fine loamy Aridic Haplustepts soils. This plain establishes the maximum portion of the area, which are under intensive cultivation. The ground water prospects are very good but quality is marginal in this area. Field observation has shown that this area has dense tube well network that irrigates wheat and rice intensive water consuming crops. This plain is also facing the problem of marginal quality of water along with depth due to excessive draft of ground water. The canal water is also available to supplement tube well irrigation. The recharging capacity of this soil is poor. If the over misuse of ground water continues for the longer period, the area is bound to face grave trouble of ground water reduction. To counteract these problems following measures are suggested viz. diversification of cropping pattern along with crops of low water requirements must be encouraged instead of rice & wheat crop rotation. Some parameters also has to be chosen for judicious application of under ground water i.e. mixing of tube well water with canal water and adoption of less water consuming cash crops as an alternative of cereal crops.

In southern part of the area, aeolian plain is major geomorphic unit composed of sand on surface and loamy sand in sub surface. The area is suffering from the problem of poor quality and quantity and very deep water level with depth 10-15 meters. The canal water is not sufficient for irrigation and therefore, a good canal network should be developed with assured water supply. In this area sprinkler and irrigation by drips methods must be invigorated to reduce the water needs. The area is more suitable for agro-forestry with rainfed crops. The dune complexes found in the area are generally having low height and ground water scenario is poor. These areas should be brought under social forestry/ agroforestry with the help of sprinklers. The poor quality ground water can be exploited and used in conjunction with canal water for irrigation and fish culture in aeolian plain of the area. In this area low quality water must be utilized for irrigation the salt tolerant and semi salt tolerant crops.

The study area is water deficit zone and propagation of efficient on farm management practices including methods of irrigation (sprinkler, drip etc.) and imparting regular training to farmers and field functionaries for efficient management of ground water are recommended. Regulation, control and management of ground water exploitation will have to be given special attention for sustainable use of water resources.

7.2.3.2 Surface Water Resources Development Plan

The climate in the area is categorised as sub tropical, semi arid, continental and considered by occurrence of low rainfall. Further more, erratic monsoon causes severe water management problems with period of flooding alternatively with marked season. The area has average annual rainfall varying from 291.7 mm (2013-2017) with coefficient of variation of monsoon more than 45 percent, rainy days less than

25. The yearly water balance is always negative due to crops are always in need of external sources of water such as canal and tube wells. This area is intensively cultivated and agricultural is major consumer of water resources in the district.

Northern, central and north western regions of the study area have the dominance of water intensive crops like wheat, rice and cotton etc. Under these situations, the surface water resources development & management plan is the need of the time. The sustainable development of land resources of the area depends upon efficient managing and growth of water resources and particularly surface water resources because 59 percent of total irrigated area covered by canal irrigation system and rest 41 percent is under tube well irrigation (Department of Irrigation, Haryana 2015). The position of ground water is also not satisfactory quality as well quantity wise with depth Therefore, the surface water resources have to develop and manage on sustainable basis to meet ever growing need of different uses. Thus, the following measures have been suggested for surface resources development plan.

- Adoption of on farm water management technology & package practices is necessary to reduce the field application losses that are due to poor land levelling' grading and improper methods of irrigation. Three most important factors to ensure efficient farm irrigation system are (1) when to irrigate (2) how much water to apply during each application and (3) method of irrigation. Some of the on farm management practices are sprinkler and drip irrigation methods and precision land levelling with regular training of farmer and field functionaries. The detailed information, guidelines and specifications have been evolved by water management experts of CCS, HAU, Hisar for different crops, soil types, water supply, water quality & depth. These are also included in university's suggested package and practices. These practices will not only minimize water losses but also area under irrigation will increase considerably (Rabi & Kharif Faslon Ki Samagra Sifarsen, 2015).
- To popularize the alternate cropping pattern based on low water requirement like gram, desi cotton, millets etc. instead of existing water intensive crops such like rice, wheat and cotton. This alternate cropping pattern will help in

sustainable use surface water resources and also will reduce agro-ecological problem of present cropping system.

- Throughout monsoon period from mid July to mid September canal water and rainfall generally received in excess of irrigation water requirements in canal command area. Under this availability- demand scenario, reduction of canal water supply by at least 25 percent during this season has been suggested. This canal water saved can be diverted to water scarce southern areas.
- The construction of balancing/ storage in reservoirs along the canal and depression are suggested to divert excess canal water supplied during monsoon season. Subsequently, this surplus water can be used during drought or for pre-sowing irrigation to oilseed /pulses crops.
- Effective and efficient lining of all canal & water courses with good quality construction material and their continuous maintenance & renovation for checking water losses and to bring additional area under command irrigation. However, even after lining of irrigation system, the efficiency of irrigation has not improved up to desired level and seepage losses still exists. This is due to inadequate periodic repair and maintenance. The lining efficiency can be enhanced by use of some petrochemical in brick joints.
- The farmers must be encouraged to use marginal/ poor quality ground water in combination with canal water either alternatively or after mixing for irrigating salt tolerant crops (barley, wheat, cotton and mustard) and semi tolerant crops (guar, maize, bajra). The agro-climatic situations in the area are positive for use of poor ground water quality in sandy and sandy loam soils or after mixing with canal water in all types of soils.
- Forming water users associations/ societies for efficient and effective management of available surface water resources.
- To control the floods of Ghaggar River, the measures recommended, proper management of embankments and bunds along with construction of diversion drains. These measures augment capacity of river, so that no over flow of water takes place.
- In the southern part of the area, the farm ponds should be constructed to provide water storage for irrigation in limited areas particularly in agro

horticulture plantation areas. These can be made by either digging a pit in the flat area or construction of embankments across a watercourse. The location of these depends on the need of the individual farmer but is best suited in the areas recommended for agro horticulture or horticulture purpose.

- The village ponds should be desilted after every five years to maintain their effective depth and water storage capacity. These ponds should be developed as fish ponds under aegis of Village Panchayats. Village Panchayats and individuals adopting fishing culture because it is a good source of income. Department of Fisheries, Govt. of Haryana is supporting it by opening fish seed farm and supplying fish seed at concessional rates.
- Bunding of fields improves conservation of runoff water in rainy season. Off season tillage and ridge furrowing as a part of inter culture during crop season are effective soil conservation measures.

7.3 GENERAL RECOMMENDATIONS

Land and water resources are limited and so their protection, creation and stewardship play formative role in satisfying use of these resources. For this, the land and water resources action plan have been suggested and to enhance effectiveness of these recommendation of action plan, some general recommendations are also given below.

- The need to involve farmers and other stake holders, particularly concerned NGO's in formulation and implementation of integrated natural resources development plan has been well established for success of this planning.
- For successful implementation of integrated natural resources development plan, the concerned Govt. officials should be thoroughly trained & capable with availability of funds otherwise they may not be highly motivated to implement any development plan.
- It is also desirable to make distinction between development plans formulated for soil & water preservation on one hand and land use planning on the another hand in term of farmers involvement, problem analysis and consideration of socio-economic conditions and policy environment including subsidy (Harmsen, 2002).

- A national level community centered Land and Water Care Movement should be launched with effective cooperation and partnership among all stake holders with social & gender equity in sharing benefits. The community centered and grass root level local bodies like Panchayats should be given responsibility under schedule 11 of Constitution Amendment 73(D) for Land and Water Care Movement. These local bodies should have adequate back up of appropriate policy direction with legal, technical and financial support.
- The Land and Water Care Movement is essential component of an evergreen revolution. The excessive and imbalanced exploitation of soil and water resources with agrochemicals under green revolution has resulted into adverse ecological consequences. Thus uninterrupted improvements in production are needed but it is must be capable of being preserved in infinity. Therefore, an ever green revolution fixed in ethics of economics, ecology, social & gender equity, conservation of energy, generation of employment and social auditing is essential for our cropping pattern as well as farming system. Land and water care establishes the foundation for structure an evergreen revolution movement (Recommendation of International Conference on Land Resources Management, 2015).
- The involvement of NGO's and voluntary agencies is necessary in promoting s at grass root level. The experience and work the land and water care program of NGO like Tarun Bharat Sangh should be taken into considerations.
- We must understand women's crucial role in the management of land and water resources because women themselves constitute the best human resources. Environmental degradation increases the burden on women, as they have to cover longer distances to collect fuel, fodder and water that are basis of sustenance. The increased natural resources degradation has halted the education of large number of poor girl child. The women have also played pioneer roles in natural resources preservation movements.
- Both of problems and solutions are identified but action is wanting for sustainable and conservative management and development of water and land resources at local, national and global level. However, contemporary sciences having remarkable advances in information & broadcasting. space, nuclear,

renewable energy and biotechnology have offered unlimited opportunities and convert these opportunities into assets in the form of sustainable development and management of natural resources. Experience has shown that for effective execution of these natural resources management plan, the combination of people's cooperation and political will and action professional skill is dire necessity.

- The continuous, periodic monitoring and evaluation of natural resources management plan and their implementation by state and national level organization should be integrated with remote sensing and GIS organizations. These organizations should develop an efficient and synchronized system for monitoring and evaluation of natural resources development plan with national data warehousing system.
- A curriculum on science and art of natural resources management and ecology restoration should be started compulsorily in education institutes. Simultaneously, efforts should be made for training of the farmers in using modern information & broadcasting technologies for interaction with scientist for guidance and solution of their problems. This can be done by establishing users controlled and driven computer and internet connectivity based rural knowledge centre for disseminating information on scientific land use with soil and water management practice.
- The services of college/ university students, ex-servicemen and willing citizen should be taken in forming national level Land Service Scheme of two years on similar pattern of National Cadets Corp (NCC).
- Renewable energy sources like biomass, biogas, solar and wind energy should be promoted. The diversion of primary farmland for non-agriculture uses should be restricted/ prevented (Thakur, 2001). The burning of crop residues and biomass should be discouraged. Efforts should be made for developing biological software for soil health management like vermiculture, bio fertilisers and bio pesticides.

CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1 SUMMARY

Land and water resources are critically important natural resources and whose exploitation beyond their regenerative ability has led to degradation of environmental, enlarging the life sustaining mechanisms elsewhere their recuperative boundaries. The quickly growing of population puts serious demand on natural resources and production systems. Thus increasing emphasis is being laid on scientific supervision of natural resources to safeguard their optimum uses, keeping the view of environmental, conservation and socio-economic needs in mind.

Agriculture practices were leading user of soil and water resources is dangerous to sustainable development. Modern agricultural practices and technologies settled and protracted over three decades have donated unprecedented growth in food production of the nation. But now it is rising concern that these mainstream expertise which have profits as well as charges, might also not be sustainable. Therefore, there is definite need of natural resources sustainable development and management of natural resources of the area to ensure development of rural as well as urban areas in harmony by providing much needed food, livelihood and environmental security.

The present study aimed on provision of land and water resource sustainable development plan of Hisar district. The study recommends the optimal usage of land & water resources through soil and water conservation measures, selection of efficient crops with alternate farming system which are appropriate to local agro-climatic conditions and socio-economic needs as well as fit into national objectives of sustainable development of natural resources.

Present research work has demonstrated that integration of remote sensing and GIS play main role in assessment and management of natural resources. Remote sensing provide time to time, accurate, cost effective and unbiased information on various natural resources which are prerequisite for optimal utilization and effective management for sustainable development of the study area.

IRS (LISS-III) satellite images were used as primary data source with Survey of India, 1:50000 scale topographical sheets as secondary data source for land use/land cover mapping, soils, water supplies and physiography. Ancillary data taken from district administration, Census 2016, literature related to remote sensing & GIS with other related fields and exhaustive field observations through visual analysis of remote sensing data, various theme maps were prepared and further based on field ground truth observations of the area, these maps were finalized. These maps are digitize and demarcated in the GIS atmosphere and after due correction and attributes attachment, final digital maps of different themes were prepared. The land and water resources development plan have been prepared using integration techniques various thematic maps in GIS environment.

The overall ground water prospects of the district vary from poor to excellent. The units of alluvial origin have very good to excellent underground water scenarios but on the other hand, ground water prospects in aeolian plain and sand dunal areas are moderate and poor respectively. Alluvial plain with sand have good ground water potential. The ground water quality found in area is good to saline. These include fresh water (38.11 %), sub marginal (40.00) marginal (18.44%) and saline (3.45%). It was observed that adjacent to water body like canal, ponds and river, the sub surface water quality is good.

The depth of water table in the study area is 1.5 to >15 M below ground level (BGL) in various parts. 96 percent of total area falls under the depth zone of 1.5 to >15 meters below ground level during pre monsoon. Highest depth of water table observed in surrounding Balsamand village.

Surface water resources of the area are available in form of ephemeral river Ghaggar, Bhakhra Canal Network and village ponds. Ghaggar River is main seasonal stream flowing along northern boundary of the study area. In normal condition water flow is very less in this river but during monsoon it becomes very active and many time adjoining areas are flooded by water over flowing the embankments.

The map of land use and land cover was created by visual analysis of October 2017 and March 2018 satellite images. The land use of the study area has been narrowly divided into constructed land, agriculture, wastelands, and bodies of water. The landuse statistics reveals that major land use in this area is agriculture, which covers 3877.12 sq. km including double harvest, only rabi, only kharif and existing fallow-class. While double cropped area under agriculture land use constitute 80.89 percent of total area. The study indicated a moderate intensity of cropping of 191.92 percent. The wasteland categories viz. degraded pastures, scrublands and sands comprises of only 3.65 percent of the area. Built-up land use categories occupy 8 percent of total area and rest is covered by water bodies.

The central western alluvial plain of the study area is plasticized by cropping pattern of rice-wheat and northern alluvial plain have high intensity of rice wheat and cotton wheat crops. The central plains have suitable conditions of heavy soil and availability of ground and surface water resources. But soils of the northern plain is loamy sand and less suitable for rice cultivation. The south western plain has more dominance of fallows and single cropped area.

It is concluded that area under input intensive crops of green revolution has increased at the cost of traditional crops and desi cotton, gram, pulses and millets cropped area have declined significantly.

Due to these input intensive agriculture, the area is suffering from decreasing water table, excessive use of fertilizers and pesticides primary to serious ecological difficulties. The study has exposed that there is serious need for diversification of cropping pattern. The area is also facing another problem of complete absence of natural forest, therefore; there is urgent need of forest plantation on wastelands community land, government land and along with transport network and irrigation channels to restore ecological balance of the area.

On the basis of physiographic or land-soil relationship, the soil mapping was carried out up to series level along with associated soils in that particular unit. Physiographically, the study area were divided into mainly aeolian plain and alluvial plain. Further; these units are sub-divided into dunes, partially stabilized, very gently undulating plain, upland, low land and recent flood plain. Total eleven soil series were established in the district and soils are classified taxonomically as per USDA guidelines. The soil types mainly consist of Fine Loamy, Fluventic Haplustepts, Coarse Loamy, Typic Ustipsamments, Fine Loamy, Typic Haplustepts, Coarse Loamy, Nitric Haplustepts, Coarse Loamy, Typic Haplustepts, Coarse Loamy, Typic Ustifluvents, Sandy, Typic Ustipsamments, Fine, Aeric Halaquents and Fine Loamy, Fluventic Haplustepts. The soils of the district have been evaluated for their suitability and sustainability for main agriculture crops and agricultural plantation of land evaluation and soil sustainability status of different crops are also discussed.

The chief objective of present study is to generate land and water resources sustainable management plan for the study area which is optimally suitable to the topography, climate and creative potential of local resources then the production level will be maintained without decay over time. Current technology, resource capacity, terrain and environment criteria have been taken into account in the resource plan recommendations.

The land resource development plan have been prepared by integrating different thematic maps such as landuse / land cover, physiography, soils, available water holding capacity, ground water quality, underground water table depth, rainfall, irrigation facilities and socio-economic conditions. These thematic maps were evaluated individually and jointly in terms of resource capacity and constraints. For recommending land resource action plan various decision rules have been formulated. Based on decided rules and integration of all thematic maps, land resources action plan has been explained. For management of agricultural land, the suggested recommendations are agro-horticulture, agro forestry, agro forestry with dry land crops management, double crop, crop diversification with suitable soil conservation measures and agri horticulture with suitable soil conservation measures etc. The management of wastelands includes forest plantation for scrubland, silvipasture for degraded pastures and levelling & dune stabilization for sand dunal areas.

Integrating ground water resources map was prepared using interpolation techniques of collected data from Central Ground Water Board in GIS environment. Water table depth maps for pre and post monsoon with water quality and draping of depth to water table map in GIS environment. It shows that 31 percent of area is which lies in north central part of the district has good quality along with good to excellent prospects of ground water. This area has good canal network also. This area is suitable for tube well irrigation. The central part consisting of alluvial plain has very well underground water prediction with marginal quality of water and this sub-surface water depleting due excessive draft of water to irrigate water intensive rice wheat cropping pattern. The measures like diversification of crops with less water consuming water crops and mixing of ground water with canal water are suggested. The south western aeolian plain is suffering from problem of poor quality as well prospects with insufficient canal water supply. Therefore, agro forestry, dry land crops management etc. recommended for this area.

The appropriate water resource management activities for the management of surface water supplies in command areas such as sprinklers irrigation, drip irrigation, conjunctive utilize of underground and surface water, mixing of saline water with canal water, growing salt and semi salt tolerant crops, rain water harvesting, lining of canal and water courses have been suggested.

8.2 CONCLUSIONS

Based on research work carried out in this thesis, following conclusions have been derived:

- The study establishes the role and usefulness of remote sensing and GIS for monitoring and mapping of natural resources and for formulating integrated action plans on land and water resources growth for their judicious management. Space borne data & GIS has also proved their worthiness in creating timely and reliable, nominal and unbiased information on natural resources.
- Remote sensing and GIS modern technologies of natural resources inventories and management are prerequisite for implementing sustainable development plan and continuous assessment of natural resources at local, regional and national level.
- The study area is facing the problems of natural resource over exploitation, their degradation and problems related to their management. The northern and

central part of study area is under green revolution input intensive crops. This agriculture system has adverse agro-ecological impacts in form of narrow crop rotation degradation of soil structure, deficiency of soil nutrients, soil pollution emanating from use of excessive fertilizers & other agro-chemicals, falling water table and over all environmental degradation. Major problems of southern part of study are is low soil fertility, light texture, low carbonic & organic matter, soil erosion, poor quality of underground water, and non accessibility of canal water for irrigation.

- It is concluded that the current use and management of land & water resources is not sustainable. The study shows that there is urgent need of integrated land & water resources development and crop diversification plans for sustainable agriculture development. This crop diversification plan has considered the climate, existing soils, irrigation facilities, mechanization and socio-economic factors.
- Integrated land resources development plan as recommended for area should be adopted for sustainable use natural resources. This plan is in the field of agricultural land and wastelands management Agricultural land management includes agri horticulture/ horticulture plantation, agroforestry, agro forestry with dry land crops management, double crop with soil and water preservation measures and crop diversification with soil conservation measures. Under wasteland management, the remedial measures i.e. silvipasture, social and community forestry, levelling and dune stabilization on the basis of probable cause of individual problem and potential of each type of wastelands available in study area.
- For making alternate land use and cropping pattern, the innovative considerations like sustainable misuse of ground water, adopting more efficient system of irrigation with water management by soil and water conservation measures are kept in view.
- Land use decisions are also decisions of water use. Unscientific landuse and pattern of crops in the area has led to over utilization of underground and surface water resources. Due to this, at present area is facing problem of good quality & quantity and shortage of canal water. The parameters of landform,

soils, sub-surface water prospects and quality, availability of surface water, present land use, futuristic consideration etc. are taken into account for formulation of water resources management plan.

- Under this sustainable plan, the practices suitable for the area are crop diversification with less water consuming crops, dry land crops with their management (agro-forestry) and location improvements adopting soil and water conservation methods. In addition to these, study area have urgent need of on farm water technology and package practices such as sprinkler irrigation, drip irrigation, mixing of saline with fresh water, lining of irrigation channels and regular training of farmers and field functionaries for efficient water management.
- The sustainable alternative management practices for high input based agricultural system includes a) introducing integrated (biological) control of pests, weeds and diseases b) broadening of crop species, cropping patterns and crop rotations) adopting the agro forestry, Afforestation and livestock component in production system) introducing less intensive soil tillage method) improving the efficiency of irrigation management)introducing integrated nutrient management in the form of chemical fertilizers, animal manures, biological nitrogen fixing and crop residues.
- Low inputs dry land agricultural system is located in southern part of area with less favourable conditions for agriculture production. The alternative management practices include land and water conservation, integrated nutrient, weed, pest and diseases along with introduction of agro-forestry and silvipasture. In this area, driving force for sustainable production of recommended cereals, pulses, legumes, trees and livestock products is in government policies and subsidies.
- The area has suffered complete loss of natural forest and this grim situation forces us to make a clarion call to take serious remedial measures to avoid foreboding of an ecological disaster. To restore ecological balance, a massive self-sustaining, self-propagating autonomous peoples' Afforestation movement with Govt. support should be launched without delay.

- There is dire necessity for launching of people supported Land and Water Care Movement and driven by grass root level local bodies with proper legal, technical and financial resources.
- In the protection and management of natural resources, voluntary organisations and NGOs have a significant role to play. It is also necessary that government department should have workable and effective linkages and collaborations with NGO for successful management of natural resources.
- Gram Panchayat should be main community based organization for all activities related to land, water, forest and natural resources management and development.
- Women being the worst victim of natural degradation must be involved in natural resources conservation and management. It is acknowledged that women feed the world and they are considered the best human resource.
- After implementation of water and land resources management plan, the area will have tremendous potential for dairy, processing and production of fruits, vegetables and poultry. The other spin-off potential activities are for bee keeping with mustard crop and inland fisheries with improvements of water bodies.
- The potential benefits of natural resources development plan in the form of improved output of food grains, oil seeds, pulses, fruits and vegetables. Increased production of feed and, correspondingly, of livestock products. The natural resources development plans will also help to generate employment opportunity and improve economic and nutrition standard of the people. In order to save the land from erosion, boost soil fertility, increase the area under irrigation and reduce the effects of drought, this resource development plan would improve all environmental conditions in the area.

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