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Innovation in Agricultural Developments in Haryana State Using GIS and Remote Sensing Technology

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Abstract

Climate, soil and topography differences in various regions are especially susceptible to agricultural production systems. Both these considerations should be evaluated on a spatio-temporal basis for sustainable agricultural management. For measurement and control, specialised methods such as remote sensing, the global positioning system and the geographical information system may be useful. Remote sensing and GIS are essential methods for solving these problems with a wide variety of applications. These technologies have many agriculture applications, including crop discrimination, crop growth tracking/stress identification, crop inventory, soil moisture estimate, crop evapotranspiration measurement, crop acreage estimate and crop yield prediction for site-specific management/precision agriculture. Processors, administrators and policy planners will benefit significantly from operational decisions on food protection, import/export and economic effects on timely and accurate details on crop property, growth conditions and yield forecasts. Such knowledge may be rendered accessible on a geographic level utilising remote sensing and GIS techniques. Remote sensing and GIS may also be used very successfully in the analysis of land use/lands cover and disruption related to drought, floods and other adverse weather events In the present study an effort was made to review, interpret and evaluate the latest details involving the use of remote monitoring techniques, plant condition assessments and yield estimates.

Haryana is regarded as India's 'bread box.' The state has numerous agro-ecological and planting trends. Corn, wheat, sugar cane, cotton, olive seeds, perl millet, gramme, and barley are the state's major agricultural crops. In India, more than 60 percent of Basmati Rice is exported from Haryana. Over the years, Haryana has adopted progressive policies to enhance agricultural productivity by increased spending, encouraging research and development systems, the public distribution system, development of irrigation, land procurement policies, credit and electricity subsidies, infrastructures such as road, market, generation and supply.

Keywords: Crop growth monitoring, Crop yield prediction, Geographical information system, Remote sensing

INTRODUCTION

The science and art of collecting information (spectral, spatial, or temporal) on physical objects or areas without entering physical contact can be described as remote sensing. Remote sensing uses an electromagnetic spectrum to visualize the ground, sea, and atmosphere using EMR at various wavelengths (visible, red, near-infrared, thermal infrared, microwave). On these wavelengths, the singular spectral signatures for each object on the Earth's surface can be identified and read in order to produce quantitative hydrological data. There are several satellites used to collect knowledge regarding hydrological and biophysical parameters in the Earth's orbit. Pixels vary from only a few meters to kilometres, and time settings vary from 3 to several months. For instance, since 1997, term estimates a rainfall rate of 3 hours at 25 km pixel resolution. The Earth Observation System Advanced Microwave Scanning (AMSR-E) tracks atmospheric, Earth, and ocean parameters. AMSR-E is usable for measured daily soil humidity with a resolution of 25 km pixels. The use of 1 km of the

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AMSR-E and MODIS satellites can be used for Regular evapo-transpiration. The MODIS, the SPOT vegetation, etc. can also be calculated at NDVI, LI, Land use, albedo, biomass at 1 km resolution. The GRACE satellite, which makes monthly storage changes at 400 km of grids, will estimate the groundwater levels. There are two distinct types of remote sensing systems.

Global greenhouse change has challenged natural capital and cultivation on the Earth's surface in several countries. In the past, large changes in severe weather conditions have been observed worldwide. The 2013 Uttrakhand landslides and floods and the 2014 Hudhud cyclone are the latest examples of such occurrences in India, having far-reaching socio-economic consequences over the long term. Global warming has brought on climate change, and severe weather conditions had a huge effect on agriculture. Due to broad climate fluctuations, crops have to face multiple forms of stress, contributing to lower crop production and annual variability. Under these circumstances, quickly evolving remote sensing and geospatial technologies can help track crop development, detect and control various forms of stress, and predict regional yield to maintain natural capital and agricultural productivity. In addition to precision agriculture and water management, Atzberger (2013) showed five key remote sensing application for agriculture, including biomass and yield forecasts, vegetation vigour and drought stress tracking, crop phenology evaluations, crop acreage estimates as well as cropland mapping, mapping disruptions and soil usage transition. India's agriculture is hampered by small-scale farms, insufficient infrastructure and lack of knowledge on agrotechnology. The evolving environment scenarios need precise space-time meteorological and crop data for precise analysis, predictions, effective usage in agriculture and management preparation, irrigation planning, crop stress management, disaster preparedness, and natural resource sustainability. Sustainable agriculture aims to match inherent land resources with crop requirements, paying attention to maximising resource usage for long-term sustainable productivity (Lal and Pierce, 1991). The traditional methods for acquiring weather and crop growth are accurate, but work-consuming and time-consuming knowledge. Recently, however, Remote sensing (RS) and GIS technologies are gaining significance for collecting spatio-temporal meteorological and crop status knowledge to supplement conventional approaches. Remote sensing information may provide a major contribution to tracking by offering timely, synoptic and cost-effective information on the Earth's surface (Justice et al., 2002). It is challenging to use standard approaches to rapidly spatiotemporally determine severe weather events and crop growth status under evolving climatic factors, including identifying crop stress and losses.

In some instances, geospatial technologies, i.e. Remote sensing and GIS can be used to collect and handle massive spatio-temporal data using satellites, interactive maps and simulation models, etc. The fast and repeated data availability, rapid review, and useful knowledge production for decision-makers and policymakers are highly beneficial. Remote sensing technology has the ability to revolutionise agricultural productivity identification and characterization centred on biophysical characteristics of crops or soils (Liaghat and Balasundram, 2010). Remote satellite data may be used for projections of yield (Bernerdes et al., 2012; Doraiswamy et al., 2005), estimates of acreage (Golford et al., 2008), phenological data of crops (Sakamoto et al., 2005), disturbance identification and tension (Guetetal., 2007). Remote sensing is a cheap solution to data collection across broad areas (De beurs and Townsend, 2008). Remote sensing and GIS are very useful for constructing simple spatial and temporal knowledge layers and producing useful interconnected information by overlaying various basic layers. The system will effectively be used in numerous ways, including flood mapping, hydrological simulation, surface energy flow, urban planning, land usage, crop growth tracking and stress identification. Remote sensing is a feasible, realistic method for the management of crops in precision agriculture at the site (Casady and Palm, 2002). With a view to the value of remote sensing and GIS technologies under evolving environmental conditions, the related literature on remote sensing application and GIS was examined and documented in the present manuscript to preserve agriculture and natural resources.

1. Study Area

Haryana is one of India's 28 states situated in northern India. On 1 November 1966, it was linguistically created from the former state of East Punjab. India's scale is ranked 22nd with less than 1.4 percent of the Indian land area (44,212 sqkm or 17,070 sqmi). Chandigarh is its capital, the nation's most populous city in the National Capital Area, Faridabad and the leading NCR financial center Gurugram has a network of Fortune 500 major companies. Haryana consists of 6 administrative divisions, 22 municipalities, 72 subdivisions, 93 income tehsils, 50 sub-tehsils, 140 economic development blocks.

In northern India, Haryana is a landlocked state. It has a latitude from 27°39 to 30°35' N and a longitude from 74°28' to 77°36' E. The state's total geographical area is 4.42 million hactare, or 1.4% of the country's geographical area. Haryana altitude ranges from 700 to 3600 ft (200 to 1200 meters) above sea level. Haryana only has a forest area of 4% (compared with a national area of 21.85%). Karah Peak, the highest point in Haryana in the Sivalik Hills, is a 4,813 ft high mountain peak in the Sivalik Hills range of the larger Himalayans near Morni Hills district of Panchkula.

In this present study, we consider Haryana as our study area, and we are going to discuss the cultivated crops of this state. We will also study the usage and importance of GIS and remote sensing technology in agricultural developments and net enhancements—the productivity of crops in the Haryana state.

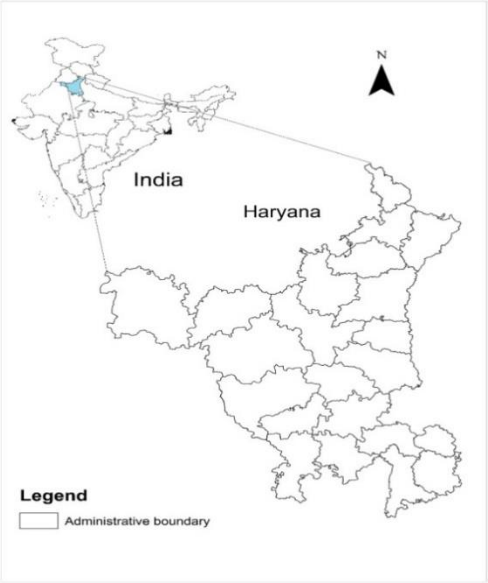

Figure 1. **District Map of Haryana**
(Source: Townsend 2008, p.133)

Materials & Methods

The introduction has contributed to very steady-state agricultural development in conjunction with the responsive farming community of such progressive state-of-the-art policies. In the GSVA province, the share of agriculture (primary sector) is about 19.5%. In 2016-2017, the sector witnessed the phenomenal growth of 7% compared to 3.2% in 2015-16. Haryana is emerging as one of the leading horticultural nations. The state is also pursuing accelerated development in other related agriculture operations, such as fishing, animal husbandry, forestry and irrigation. In order to leverage emerging prospects in the state agriculture market, the state is further fostering diversification within agriculture, developing research and development processes and updating facilities in compliance with international standards. The state is advancing long in the agroforestry area. The Department of Forests annually distributes 2.5 crore crops to farmers and other tree growers free of charge for agroforestry promotion. The Government of Haryana has implemented the Agricultural Production and Food Processing Policy 2018 in order to give impetus to the state's food processing industry. The strategy seeks to build more jobs in the whole food supply chain and also to foster agriculture and rural development. The Haryana Vision ensures that children do not suffer from malnutrition. All Haryana people, particularly women of reproductive age, children and extra-vulnerable communities, eat sufficient, healthy and nutritious food by rendering farming economically feasible, progressive, and climate-resilient. The Government of Haryana has vowed to increase the erosion of soils while strengthening its attempts to limit the usage of pesticides and fertilisers. The state government has provided Soil Health Cards to farmers to control the quantity and form of fertiliser available on their property. The state succeeds in convincing farmers to implement state-of-the-art farming technologies to increase farming sector production to boost their productivity. Haryana is working towards climate growth and adaptation initiatives. The state is improving climate-resilient farming activities in agriculture with 100 climate-smart villages. In drainage, the state instals injection wells in the state as a recharge method.

1.1 Monitoring of vegetation status

Remote sensing of soil and soil may be an enticing complement to conventional field scouting approaches because of the potential to easily and repeatedly cover broad areas and provide spatial and temporal knowledge required for sustainable soil and agricultural management. Remote sensing capacity in agriculture is very strong due to its ability to infer the non-destructive mean for soil and plants. Numerous Vegetation Spectral Indexes (VIs) were established to discern vegetation canopies. One of ecologists and biogeographers' most critical analytical tasks is to grasp spatiotemporal variations of vegetation. The relationship between Advanced Very High-Resolution Radiometer (AVHRR) / Moderate Imaging Spectroradiometer (MODIS) NDVI and rainfall were modelled to monitor plant dynamics utilising regression analysis. Results showed a high correlation between rainfall and NDVI which proved that tracking the vegetation pattern with RS and GIS would mean climate change accurately. The stock of carbon in the two groups was estimated in conjunction with the SPOT satellite's multi-temporary data in 1991, 2004 and 2009 for the research region for 2020.

1.2 Precision agriculture

Remote sensing technology is a vital part of precision farming and is utilised by more and more scientists, engineers and large-scale agriculture farmers. Precision agriculture seeks to minimise farm costs, increase monitoring and productivity in resource usage by providing details on sensors fitted with farm machinery. The most advanced part of precise agriculture is variable rate technology (VRT). Sensors are mounted on moving farm machinery with a device that provides input suggestions, thus tracking the implementation of inputs based on GPS receiver knowledge (NRC, 1997).

1.3 Nutrient and water stress

Nutrient and water stress control is one of the most relevant areas in which we can use specific farming for remote sensing and GIS. Detection of nutrient stress through remote sensing and GIS may help control unique nutrients on site while minimising cultivation cost and increasing fertiliser usage efficiency. The wise usage of water can be made possible in semi-arid and arid areas by adapting precision technology. E.g. drip irrigation with input from remotely sensed data might be used to minimise drainage and percolation losses by growing water usage quality. Developing capability for remote data collection, data analysis and evaluation of ground, airborne and satellite measurements allowed the use of coupled RS technology and crop management systems to maximise productivity in the use of nutrients and water. The spectral reflectance characteristics of wheat under water stress conditions were standardised. In the water-stressed seed, the spectral reflection in the visible area was more significant than the non-stressed. Vegetation indices such as NDVI, RVI, PVI and GI have been observed to be lower for non-stressed crops, and higher.

1.4 Pest infestation

In the evaluation and monitoring of insect defoliation, the remote sensing method was used to link spectral responses variations to chlorosis, yellowing of leaves and leaf decrease over a defined duration, provided that these differences can be associated, categorised and interpreted. The spectrum of remote sensing technologies included defoliation identification and visualisation, pattern disruption characterization etc. and the supply of data to pest control decision support systems. As a timely management method, the capacity for forest trees' prediction and susceptibility to insect defoliation has been documented. Landsat has employed the multi-temporal identification system for mapping defoliated forests in Canada with comparable findings from other research. The scale and magnitude of gypsy moth infestation in Virginia was calculated by Clerke and Dull (1990) using photographs acquired by Place. The outbreak of contagious defoliation was also analysed using MODIS info. De beurs and Townsend (2008) concluded that MODIS data represents an essential tool for creating vegetation indices on the plot scale for insect defoliation damage. Riedell et al (2004) recorded remote sensing technologies to identify infested and diseased plants as an accurate and cheap tool. They used remote sensing techniques to detect and differentiate specific insect pests Insect and oat disease impact. They proposed canopy features and spectral variations in reflectivity between insect infestation damage and disease infection damage can be assessed by remote sensing in oat crop canopies.

1.5 Weed identification and management

Based on the difference of weeds and crops' spectral reflectance characteristics, remote sensing technology offers the means to locate a weed infestation in a crop stand and other assistance for the creation of weed maps in order to find the position of weeds in an agricultural area, to enable the application of site-specific/need-based herbicide. It has been observed that pure wheat can be differentiated from pure Rumexspinosus populations beyond 30 DAS by the use of radiance and NDVI. From 60 DAS on, various levels of rumex communities could be discriminated against.

1.6 Water resource management

Poor water management is also important to water scarcity and storage sites' unavailability. The planning and management of conventional water resources focus mainly on blue water (water in streams, rivers, aquifers, lakes and reservoirs). It is necessary to take rainfall into account, particularly in arid and semi-arid reservoirs that naturally infiltrate the soil and back into the atmosphere in the form of evaporation. A significant decrease in water use can be reallocated to other users through non-beneficial evaporation management.

Experienced at the global and regional level and thus, carefully handled in the implementation of state-of-the-art technology. Remote sensing is one of the essential methods for water management and tracking. In particular, hyperspectral remote sensing is the most in-depth tool for analysis into water-resource spatial, spectral and temporal variations in order to achieve more precise assessments of the knowledge needed for water-resource applications. The invention of remote sensing microwave allowed soil moisture availability from remote sensing data to be measured.

1.7 Flood monitoring

Remote satellite sensing facilitates prompt study in wide areas and offers regular regional imagery. No real-time flood prediction was feasible until recently, but this has changed dramatically with the sensors such as Hyperion on the EO-1 satellite. The period for prediction and response to flood incidents has been minimised by automatic spacecraft technology in a few hours. Advances in remote sensing culminated in early alert technologies with future global uses being studied. The detected flooding areas with satellite data and analysed humidity classes in flood plain regions in relation to variations in water, soil and silt deposition for multiple classes of land use and erosive flood impacts. Estimated hydrographs from hydraulic knowledge extracted from remotely sensed data are released and flooded. Methods of optimization have often been used to minimise inconsistencies between models and flood scale measurements in the calculation of river release.

3.8 Climate change scenarios

Because the environment is characterised by a diverse community of fundamental physical, chemical and biological interactions between the atmosphere, hydrosphere and lithosphere, climate change awareness and forecasting A difficult job. The atmospheric patterns on Earth have changed and will still alter. Experts and policymakers are scrambling at solutions to combat climate change challenges in the face of dire predictions of extreme weather events and global warming. The complex effects of climatic disruptions in these areas must also be grasped both in real time and in synaptic terms. Adapting humans to these problems includes coordination with data collection and interpretation approaches that can easily acquire and analyse data. Under these circumstances, remote sensing and GIS have seen broad applications for analyses and climate change modifications. Remote sensing allows detailed large-scale data collections, whereas GIS is the means by which data from other sources are viewed, overlaid and merged. And data processing. The vast array of past and current remote sensing images enables the spatial and temporal nature of environmental features and human actions' effects in recent decades to be studied. Remote sensing is necessary for improving environmental data collection at both local and synoptic levels for climate change research. Scientists are now utilising satellite tools to identify ocean and land sinks and CO2 streams. In environmental monitoring and modelling for the combination of dispersed field-based measurements and remotely sensed results, GIS on the other hand plays a major role. Naturally, environment and meteorological patterns are spatially complex and, thus, GIS is a powerful solution for handling large databases of spatial climates for a broad variety of applications.

3.9 Atmospheric dynamics

In order to satisfy the needs of weather forecasts, early civil satellite instruments were, among other uses, launched. Meteorological satellites are used to measure absorption and reflection of radiation which can be extracted from air temperature, waves, precipitation and cloud cover. Remote sensing may be used for ambient radiation, emissivity and surface temperature assessment. Cross-sections of NO2 absorption using the GOME are relevant as reliable benchmarks for remote NO2 atmospheric sensing and the other minor trace gases. Foster and Rahmstorf (2011) have taken a time series of global land and ocean temperature assessments, utilising three surface temperature reports and two satellite microwave records focused on lower-troposphere temperature records. The five series revealed consistent patterns in global warming. These findings demonstrate that remote sensing and GIS can be used successfully for global/regional climate change monitoring.

3.Result and Discussion

Haryana is one of India's major food grain growers. The state exported USD 1.2 billion in agricultural products in 2017-18. The Haryana State Government has dedicated itself to developing a gradual agriculture climate. In Figure 1 has shown the Export of Major Agricultural Products from Haryana (USD Billion).

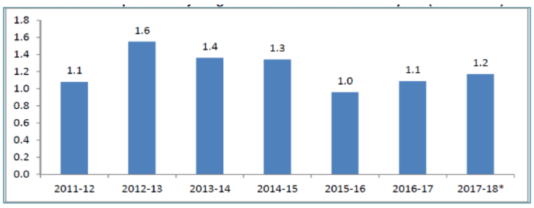

Figure 2. **Export of Major Agricultural Products from Haryana (USD Billion)**

(Sources: PHD Research Bureau, Compiled from various sources)

The average yield of wheat and rice in Haryana is high compared to India. In 2016-2017, Haryana's average wheat yield was 4841 kg/hectare in PE and 3172 kg/hectare in India. The average Haryana rice yield in the same year was 3213 kg/hectare at PE and 2543 kg/hectare in India. Therefore, the state is unquestionably recognised as the "Indian Broad Basket." State-led pro-agriculture and farmer initiatives have generated promising outcomes from time to time. In Figure 2 has shown the Comparison of Average Yield of Wheat and Rice of Haryana (kg/Hectare)

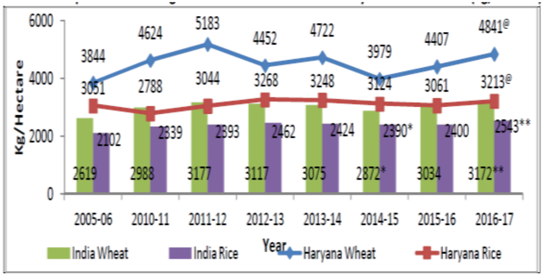

Figure 3. **Comparison of Average Yield of Wheat and Rice of Haryana (kg/Hectare)**

(Source- PHD Research Bureau, Compiled from various sources)

Without a perennial supply of surface water and based on their involvement in numerous Interstate negotiations, Haryana effectively manages surface water supplies. The State has been one of the largest donors to the national food grain basket. The Haryana Department of Irrigation & Water Management (IWRD) is responsible for the service and conservation of the State's water supply and drainage network, including irrigation, drinking water, pond and agricultural and other industry purposes. Haryana has established a wide channel network of 14,085 km in duration comprising of 1,461 channels. Bhakra's grid comprises of 522 channels with a total length of 5,961 km, and 446 channels covering a total length of 4,422 km. And there are 493 canals spanning a total of 3,702 km in the elevator scheme. The State also has a large drainage system with nearly 800 drains extending 5,150 km. Haryana has 1,350 Canal Tails in all. 1,343 Tails were fully fed. The state government vowed to fulfil the 'HarKhetkoPani' vision and in Budget 2018 19 raised its irrigation and water supply by about 20 per cent. The Government has undertaken a variety of irrigation measures in order to preserve and allow efficient use of each water decrease, in compliance with the requirements of the state "Per Drop More Crop Initiative." In order to use the surplus water in the Yamuna river during the mountain time, four projects are under way to improve carrier systems' ability, which target for approximately 4000 cusecs of additional water during the mountain season. These are: I West Jamuna Canal Main Line Lower RD 68,220 (Hamida Head) to RD 1,90,950 (Indri Heath), (ii) WJC Main Branch 0-1,54,000, (iii) reconstruction of RD 0 to 1,45,250 parallel Delhi Branch for capability upgrades and (iv) refitting of the Augmentation Canal to create a modern cement concrete, 6,000-cusec lined pipe.

Table 1. **Percentages of selected crops and orchards suitability classes**

Sl. No.	Suitability classes	Highly suitable	Moderately suitable	Marginally suitable	Marginally suitable	Permanently not suitable
1	Cotton	15.38	20.74	4.53	11.1	38.27
2	Finger millet	22.22	12.65	19.27	–	33.12
3	Groundnut	12.85	18.08	9.25	10.59	37.69
4	Rice	10.39	6.66	26.78	–	45.06
5	Sorghum	25.59	2.32	12.56	–	48.92
6	Soyabean	18.97	8.26	13.02	1.26	48.57

(Source- PHD Research Bureau, Compiled from various sources)

Several soil-site studies for different plant species have beenreported in the literature. These illustrate how soil depth, soiltexture, salinity and drainage conditions are related to soilsitequality. The objective of various soil-site evaluation studieshas been to predict and classify land for plant growth (Sehgal,1996). Many scientists have evaluated observations on growth-inhibiting factors for certain species and tolerance of others to extremely adverse conditions.Haryana's soil and land resource units wereassessed for its suitability for growing of different crops andorchards. The result showed the highly suitable areas for selected crops and orchards (Cotton 15.38%, Finger millet22.22%, Groundnut 12.85%, Rice 10.39%, Sorghum 25.59% andSoyabean 18.97%) in the district. Any crop's performance is mostly dependent on soilparameters (depth, drainage, texture, etc.) as conditioned byclimate and topography. The study of soil-site characterizationfor predicting the crop performance of an area forms landevaluation. According to Van Wambeke and Rossiter (1987),land evaluation is the rating of soil and site for optimumreturns per unit area. The yield influencing factors for importantcrops have to be evaluated. The results obtained may apply for higher production of these crops through properutilization of similar soils occurring elsewhere in the same agroclimatesub-regions under scientific management practices(Khades and Gaikwad, 1995).The studied soils vary in their suitability for different crops,according to the criteria for the determination of the land suitabilityclasses.

- **Cotton**

The yield influencing factors on cotton are rainfall, soil depthand free $CaCO_3$. The study area was moderately and marginallysuitable for cotton. Because of the severe limitations of erosion and organic matter content, uplands' areas were marginally suitable for cotton. Similarly, midlandswere also marginally suitable, whereas lowlands weremarginally suitable for cotton because of moderate drainage limitations (Sehgal, 1991).

- **Finger millet**

Finger millet comes up well on soil depth of100 cm, clay content from 48% to 56%, CEC from 43 to53 cmol (p+) per kg and organic carbon from 0.63% to0.74% (Bhaskar et al., 1996). The areas represented by uplandpedons were moderately suitable, because of moderate limitationsof soil. The upland pedons were marginally suitable. Themidlands were moderately suitable, because of moderate limitationsof soil and climate.

- **Sorghum and groundnut**

The factors influencing sorghum yield are rainfall, temperature,slope, BS, $CaCO_3$, CEC and texture. The area representedby uplands were marginally suitable because of the severe limitations of slope, erosion, organic carbon, and the midlandswere moderately suitable, whereas the lowlands weremarginally suitable due to moderate drainage.The uplands were relatively suitable for these crops owingto their severe limitations of slope; erosion and lowlands werenot suitable (but potentially suitable) because of poor drainage,whereas midlands and lowlands were moderately suitableattributed due to moderate limitations of drainage and fertility.

- **Rice**

The hilly areas and sloping upland areas were permanently notsuitable due to very severe drainage and slope limitations.The other uplands and midlands were marginally suitable,due to slope, erosion and drainage whereas lowlands weremoderate to highly suitable due to moderate restrictions ofclimate and fertility factors. 4.4.5. SoyabeanThe uplands and midlands were moderately suitable due to the tomoderate limitations of the slope, drainage and soil limitationsand some upland areas were marginally suitable. In contrast, low landswere not suitable but potentially suitable theirmoderate drainage conditions.All the study area landscapes except lowlands were marginally suitable for the crop due to severe limitations ofslope, drainage, and moderate limitations of climate and soil. In contrast, lowlands were permanently not suitable due to moderatedrainage.

Conclusion

The concerns posed in this study must be discussed urgently by utilising limited and intense campaigns to integrate remote satellite sensing and GIS techniques with hydrologic modelling. Hydrological modelling is an essential instrument for understanding the salt and water transport mechanism from land to groundwater and the explanations for increasing soil water. Combining information gathered from satellite remote sensing with soil data in a GIS format has successfully identified and determined the region and yields of major crops in the rabi season under Haryana. In addition, these methods are cost-effective in diagnosing problems correlated with the efficiency of a wheat-based irrigation method. The inventory of the satellite was finished for around US$0.03/ha. The method of allocating and sharing channel water sources under the warbands theory contributes to the Haryana irrigation scheme's present high water production. However, the long-term sustainability of the agricultural output continues to be under pressure. In certain areas, acidic water tables are growing, and soils are being thickened while water tables decrease in places with fresh freshwater. The irrigation agency desperately needs to discuss water conservation issues at the field, regional and systemwide in detail. By integrating satellite remote sensing and GIS techniques with hydrological modelling, effective approaches can be found to modify existing water management patterns and allocate them to sustain sustainability and the wellbeing of the GIS system.

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