ISSN 2664-4150 (Print) & ISSN 2664-794X (Online)
South Asian Research Journal of Engineering and Technology
Abbreviated Key Title: South Asian Res J Eng Tech

| Volume-3 | Issue-4 | July-Aug -2021 | **DOI: 10.36346/sarjet.2021.v03i04.005**

Original Research Article

Site-Suitability Analysis for Sericulture Development in Sub-Himalayan Region of Haryana, India

Ritesh Kumar[1*], Nitin Chauhan[2], Bijoy K. Handique[3], V. S. Arya[4]

[1]Haryana Space Applications Centre (HARSAC), Citizen Resources Information Department, Govt. of Haryana, CCS HAU Campus, Hisar, Haryana-125004, India
[2]Haryana Space Applications Centre (HARSAC) Node, Gurugram, Citizen Resources Information Department, Govt. of Haryana, GIS LAB, 3rd Floor, New Labor Court Building
Mini Secretariat, Gurugram, Haryana-122001, India
[3]North Eastern Space Applications Centre (NESAC), Department of Space, Government of India, Umiam, Meghalaya-793103, India
[4]Haryana Space Applications Centre (HARSAC), Citizen Resources Information Department, Govt. of Haryana, CCS HAU Campus, Hisar, Haryana-125004, India

***Corresponding Author**
Ritesh Kumar

Article History
Received: 14.07.2021
Accepted: 19.08.2021
Published: 24.08.2021

Abstract: Sericulture is the practice of producing silk through the cultivation of silkworms. India ranks second in silk production after China, producing about 15% of the global silk. Traditionally sericulture is practiced in limited areas of Karnataka, Andhra Pradesh, Assam, West Bengal, Jharkhand, Tamil Nadu and North-eastern states. There is tremendous scope for enhancing the production and quality of silk through increasing area under Mulberry host plant for Silkworms. Adoption of Sericulture as an alternative to agriculture is possible under suitable agro-climatic conditions in non-traditional state like Haryana. Multi-criteria analysis of slope, soil, LULC and climatic limiting factors for Silkworm and its food plants resulted in identification of potential area and suitable season for sericulture practices. The total available wasteland in the study area was targeted for the suitability analysis. The multi-criteria spatial analysis shows that the sub-Himalayan regions falling in three districts of Haryana (viz. Panchkula, Ambala and Yamunanagar), Panchkula district have 3260.93 ha of suitable waste land for Mulberry sericulture practice. Moreover, the sub-Himalayan region falling in Ambala and Yamunanagar district have an area of 1535.81 ha and 1695.95 ha respectively as suitable wasteland for Mulberry sericulture. The remote sensing and GIS technology have proven its capability in finding out the suitable site for mulberry sericulture in the study area. The database thus generated in the project is published online along with other layers at Sericulture Information Linkages Knowledge Systems (SILKS), http://silks.csb.gov.in as well as information on good practices for mulberry sericulture rearing and production for farmers and entrepreneurs.

Keywords: remote sensing, GIS, site suitability, mulberry, sericulture, sub-Himalayan, Multi Criteria Decision Making (MCDM), Sericulture Information Linkages Knowledge Systems (SILKS).

1.0 INTRODUCTION

Sericulture is the practice of rearing silkworms in order to harvest silk from them. Being the second largest producer of silk, Indian silk production industry provides more employment opportunities for the marginal farmers than any other traditional agricultural practices and even fetches more income in comparison to other traditional crops. In addition, this practice includes the growing of plants (*Morus alba*) as a food material for the silkworms which also supports the environment not only by providing oxygen rich air but improves soil health and even prevents its erosion.

This industry includes agriculture based on-farm and off-farm activities which can provide better employment opportunities for unemployed women in rural areas. Because of its enormous employment generation potential, this sector attracted planners and policymakers to distinguish the industry as one of the most appropriate boulevards for socio-economic development of an agricultural economy like Haryana, India.

For the expansion of sericulture in non-traditional areas of India, Central Silk Board (CSB) in collaboration with Indian Space Research Organization (ISRO) advised the applications of Remote Sensing and GIS technologies in 1994 (CSB, 1994). Together, they have put forth a number of standardized techniques for identification of mulberry growing areas, and carried out various studies for assessing the conditions suitable for mulberry plantation in India. Potential areas were identified for sericulture development on National level at a scale of 1:2,50,000 on an experimental basis through a joint project called 'SPAARS' (Survey of Potential and Actual Areas with Remote Sensing). During its XI plan period, CSB identified the cultivable wastelands in order to exploit them for sericulture in 108 districts which spreads over 24 states of India including 41 districts in North Eastern Region. Two approaches for mulberry acreage estimation have been developed, viz., (i) complete enumeration and (ii) stratified random sampling. These two approaches were implemented in many parts of the country and it was discovered that the mulberry area estimates could be derived with 92% accuracy using these techniques (Bijoy, *et al.*, 2016). The launch of RESOURCESAT-1, RESOURCESAT-2A (Dec 07, 2016), CARTOSAT-1, and CARTOSAT-2 (Feb 15, & Jun 23, 2017) with improved spatial and temporal resolution; the remote sensing technology has gained potential to give more promising results. Their resolution ranges from 56 m to less than 1 meter, which allows delineating and mapping potential zones for sericulture on large scale. It has been reported earlier by Dhyani *et al*., 1996 that sericulture based agro-forestry system have great potential for higher returns in northeastern region of India. They tried three sericulture based agro-forestry system viz. (i) sericulture with fruit trees and fodder grasses, (ii) sericulture with field upland crops, and (iii) sericulture with lowland rice. Moreover, they suggested sericulture with field crops (French bean, Groundnut, Mustard/Vegetables) for valley land, with fruit plants (guava, pineapple) and grasses for mid-hill locations, and with rice for low lands are found suitable at the farm and for possible adoption in the north-eastern hill region of India.

In India, sericulture supports the livelihood of millions because of its employment oriented, low capital intensive and remunerative nature. India produces all four types of natural silk named Mulberry, Tasar, Eri, and Muga and doubled its production of raw silk within last 17 years from 15,857 Metric Tonnes to 30,348 Metric Tonnes (CSB, 2020). However, there is a decrease from 4% to 3% in the production of country's raw mulberry silk from 21,390 MT in 2014-15 to 20,478 MT in 2015-16. The export earnings from the silk goods also showed a decrease of 11.80% in INR during 2015-16, which was Rs. 2495.99 crores compared to Rs. 2829.94 crores in 2014-15 (MoT, 2017). The import of silk goods also shows an accountable increase from 3489 MT to 3795 MT from the year 2014 to 2017 (http://ministryoftextiles.gov.in/sites/default/files/Import-of-Silk_0.pdf). As the data indicates that current production and export of silk is not increasing and is not able to meet the current demand of the country for the past few years. Hence, advancement in technology and more involvement of farmers in the agricultural practices based on the rearing of silkworm and raw silk production is required. This increased sericulture activities can provide better socio-economic benefits to the farmers. However, the sericulture practice is limited only to few states of India and Haryana being a non-traditional state for Sericulture practices can have potential for its implementation in the state. If, Haryana state statistics are considered its figures shows that this state is unable to achieve its target for the annual production of raw silk since 2014 (MoT, 2017). So, in order to achieve the desired production and to find the enhanced scope for improving the production and quality of silk the Central Silk Board (CSB) and Indian Space Research Organization (ISRO) in collaboration with Haryana Space Applications Centre (HARSAC) applied the technology of Remote Sensing (RS) and Geographical Information System (GIS) for approximation of mulberry acreage, garden condition assessment and for identification of suitable areas for introducing sericulture in Haryana.

In spite of the engrossment of many organizations in the production of silk in different states of India, the state-wise information at the district level on the potential area suitable for silkworm food plants is not available. In Haryana, there is a crucial need for the divergence in agricultural practices in order to prevent the further degradation of soil resources and to increase the income from the non-traditional agricultural practices like sericulture, which provides more ecological/economic steadiness than the traditional crop ecosystem. As the potential for the sericulture development is dependent on soil and climatic suitability for its food plant growth which itself implies a prerequisite scientific assessment of a site before the implementation of any plan related to sericulture practices. The present study aims to identify suitable sites for growing Mulberry plantations and development of Mulberry sericulture on the wastelands in the sub-Himalayan region of Haryana. Moreover, it is intended that after the success in development of sericulture practices on wastelands, it will be implemented on other suitable agriculture lands.

2.0 STUDY AREA

The present study was attempted for Sub-Himalayan regions of Haryana distributed in Panchkula, Ambala and Yamunanagar districts for the identification of potential areas for sericulture development. The study area comprises of three sub-Himalayan districts of Haryana state, with the intention to assess the potential areas for Sericulture activities. The three sub-Himalayan districts of Panchkula, Ambala and Yamunanagar is located in Northern part of Haryana State and falls between 29°55'N and 30°55'N latitudes and 76°33'E and 77°35'E longitudes (Fig. 1). The districts are divided into blocks from administrative point of view. Panchkula having a geographical area of 8, 98 sq km is divided into four blocks viz. Pinjore, Barwala, Morni and Raipur Rani. Ambala with a geographical area of 1,574 sq. km. is divided into six blocks viz. Ambala-I (City), Ambala-II (Cantt), Barara, Naraingarh, Saha and Shahzadpur. The district of Yamunanagar is situated at the bank of river Yamuna, is having a geographical area of 1,768 sq. km and is divided into seven blocks viz. Bilaspur, Chhachhrauli, Mustafabad, Jagadhari, Sadhaura, Khijrabad and Radaur. The climate of the study area is classified as subtropical monsoon with mild & dry winter, hot and sub-humid summer. The hot weather season starts from mid-March to last week of the June followed by the southwest monsoon, which lasts up to September. The transition period from September to November forms the post-monsoon season. The winter season starts late in November and remains up to the first week of March. The study area is located between the outer Himalayas and the Ghaggar Yamuna Upland Plain that enriches it with a topographic variety. Siwalik and Morni Hill Tract, Pinjore Doon and Ghaggar Flood Plain are major physiographic divisions of Panchkula. Ambala district is mostly occupied by Indo-Gangetic alluvium and physiographically, the district is divided into Naraingarh Plain, Ambala Plain and the Ghaggar Flood plain. Physiographically, the district of Yamunanagar is sub-divided into Yamunanagar Siwalik, Sadaura Plain, Yamunanagar Plain, Yamunanagar Khadar and Bet Yamunanagar. The study area is drained by mostly non-perennial rivers, its tributaries, streams, nalas, etc. originating in Siwalik range.

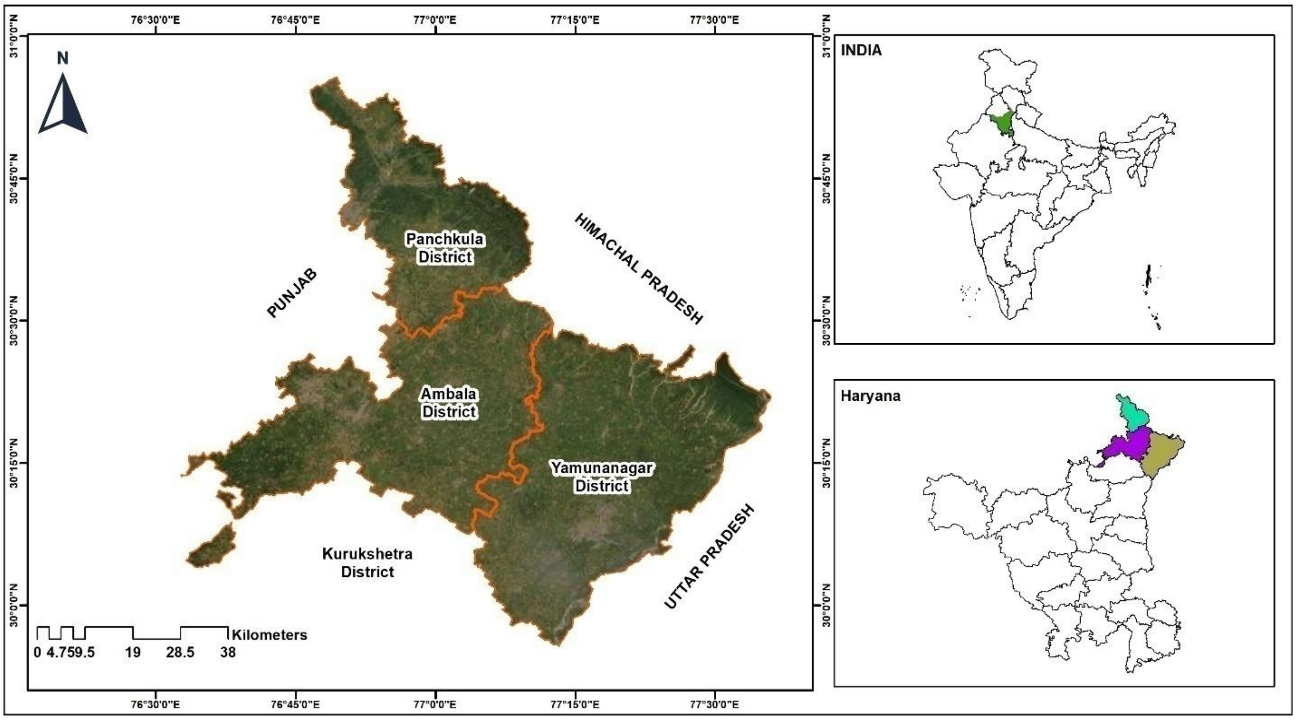

Fig-1: Location map of study area

3.0 MATERIALS & METHODS

Remote sensing using satellites in space is one of the ways to study large area with minimal demand for money and time. The purpose may vary from assessment of environmental parameters to study suitability of a site for the development of sericulture. Moreover, the approach for identification of potential sites for the development of sericulture involves evaluation of land (soil) and water resources requirements for growing silkworm food plants as well as the rearing of silkworms. During phase –I of a national level project "Applications of Remote sensing & GIS in Sericulture Development", it was identified that the three districts of Haryana viz. Panchkula, Ambala and Yamunanagar are suitable for Mulberry silk production (NESAC, 2016). However, due to utilization of coarser resolution dataset in the phase-I project, it cannot be ascertained which area is to be targeted first within these districts to develop sericulture. Mulberry (*Morus spp.*) is the only food plant for silkworm Bombyx Mori. The other three types of silk i.e. Eri, Tassar and Muga are supported on other plant species. Eri silk is produced by *Philosamia ricini*. Eri silkworm mainly feeds on castor (*Ricinus communis*) but can also be grown on other food alternatives like *Heteropanax fragrans*, *Manihot utilissima*, *Earica papaya*, *Ailanthus sp*., *Plumeria acutifolia*. *Anthrea mylitta*, *A. Perniyi*, and *A. royeli* are three main silkworm species, used for the extraction of tasar silk in India. This silkworm is reared on the trees of *Terminalia tomentosa* and *Terminalia arjuna*. The silk produced by *Anthraea assamensis* is called Muga and this silkworm prefers feeding on Som (*Machilus bombycina*) and Soalu (*Litsaea polyantha*).

The sericulture site suitability study involves assessment of land qualities for the requirements of silkworm food plants (FAO, 1976: Sys, 1985, Sys *et al.*, 1993) and silkworm rearing. This study also needs interpretation and integration of climatic parameters, physiographic conditions, soil parameters and land use/ land cover etc. using GIS

(Handique *et al*., 2016). Land use land cover map at 1:10,000 scale for the period 2017-18 was generated by classifying the Resourcesat-2 LISS-IV imagery for identification of wastelands.

3.1 Identification of potential areas for growing Mulberry plant

3.1.1 Evaluation of site suitability based on landscape and soil characteristics

Soil site suitability was derived using dataset for soil characteristics like soil depth, pH, texture, stoniness, soil drainage, etc. These soil characteristics were obtained from soil map prepared at 1:50,000 scale under the project titled "Natural Resources Census (NRC)- Soil Resource Mapping (SRM)". Information on ground water availability was obtained from ground water prospect map (Tewari *et al*., 2013) prepared under the project titled "Rajiv Gandhi National Drinking Water Mission (RGNDWM)". Slope map was derived using 10 meter Carto-DEM. The slope map was reclassified into slope classes based on plant requirements. Different thematic layers like soil texture map, soil depth map, soil drainage map, soil pH map, etc. were generated in GIS environment for each of the soil characteristics (Table 1) and compared with the requirements of silkworm food plants (Table 2). Degree of limitation ranging from 1 (suggesting no or slight limitation) to 4 (suggesting very severe limitation) was assigned and final maps were prepared (FAO, 1976a).

Table-1: Soil site parameters considered for land evaluation

Soil site characteristics	Related land quality
Climate (c) during crop growing period ▪ Total Rainfall (mm) ▪ Mean maximum temperature (°C) ▪ Mean minimum temperature (°C) ▪ Mean relative humidity (%) ▪ Length of growing period (days)	-Available moisture
Topography and landscape (t) ▪ Slope ▪ Erosion	-Landscape position -Resistance to erosion
Wetness (w) conditions ▪ Drainage ▪ Groundwater availability	-Available moisture/ soil aeration -Landscape position -Deficiency and toxicity of nutrients
Physical condition (s) of soil ▪ Texture ▪ Depth	-Water availability/ soil aeration/ soil structure -Available space for root development
Soil fertility (f) ▪ pH	-Availability of plant nutrients

Table-2: Criteria for evaluation of soil site suitability for Mulberry Plant

Soil-site characteristics		**Degree of limitation and Suitability class**			
Limitation	Unit	0-1 None to slight	2 Moderate	3 Severe	4 Very severe
Suitability		S1 (Highly suitable)	S2 (Moderately suitable)	S3 (Marginally suitable)	N (Not suitable)
Topography and Landscape					
Slope	(%)	0-5	5-15	15-33	>33
Erosion		e_1	e_2	e_3	e_4
Soil characteristics					
Drainage	Class	Well	Moderately well	Imperfect	Poor/ Excessive
Ground Water	Availability	Good	Fair	Fair to moderate	Poor
ĒC	Quality (EC mmhos/ cm)	Very good <2000	Fair to good 2000-3000	Moderate 3000-4000	Poor >4000
Texture	Class	Clay loam-gravelly clay	Fine loamy	Coarse-loamy	Sandy fragmental
Depth	Cm	>100	75-100	50-75	<50
pH		6.5-7.5	5.5-6.5 7.5-8.5	4.5-5.5 8.5-9.5	<4.5 >9.5

3.1.2 Evaluation of site suitability based on climatic parameters for silkworm food plants

Climate is one of the important parameters in determining the growth vigor of plant species, as the extreme climatic conditions are limiting factor for plant growth. The suitability of climate for a given crop can be determined for (i) minimal length of growing period, (ii) temperature, (iii) water supply (rainfall). To assess the climatic condition of study area the long-term gridded weather data, procured from IMD was analyzed for rainfall, maximum and minimum temperature, derivation of Potential Evapotranspiration (PET) and Length of Growing Period (LGP) for the mulberry plants.

Estimation of LGP

Length of Growing Period or moisture availability period for crop growth is the period (in days) when precipitation (P) exceeds 50% of the PET. Shorter LGP (less than 120 days for mulberry) may not be suitable for cultivation of silkworm food plants.

PET is defined as the amount of evaporation that would occur if a sufficient water source were available. Monthly Potential Evapotranspiration (mm) was calculated using IMD gridded data for entire study area using Thornthwaite method (1948) as illustrated below:

$$\mathrm{PET} = 16 \times (\mathrm{C}) \times [10 \times (\mathrm{T})/\mathrm{I})]^{a} \qquad \text{for } \mathrm{T} \leq 26.5°\mathrm{C}$$

$$\mathrm{PET} = \mathrm{C} \times [-0.43253 \times (T)^2 + 32.244 \times \mathrm{T}\text{-}415.85] \qquad \text{for } \mathrm{T} > 26.5°\mathrm{C}$$

Where

PET = Potential Evapotranspiration (mm/month)

T = Mean Monthly Temperature (°C)

I = Annual Heat Index for 12 months in a year (I = ∑i)

i = Monthly heat index [i = $(T/5)^{1.514}$]

a = $6.75\times10^{-7}\times I^3$ - $7.71\times10^{-5}\times I^2$+ $1.792\times10^{-2}\times I$ + 0.49239

C = Correction factor for each month where C = (m/30) × (d/12) table 3 below shows the value of C for geographic location at different latitude.

m = No. of days in a month, d = Monthly mean daily sunshine duration in hour

Table-3: Correction Factor C for different latitude

Month / Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
28.5	0.867	0.916	0.984	1.057	1.118	1.148	1.135	1.083	1.014	0.941	0.881	0.851
29.5	0.861	0.913	0.983	1.059	1.123	1.155	1.141	1.087	1.014	0.939	0.876	0.845
30.5	0.855	0.909	0.983	1.062	1.128	1.161	1.147	1.091	1.015	0.936	0.870	0.839
31.5	0.849	0.906	0.982	1.064	1.133	1.168	1.153	1.094	1.015	0.933	0.865	0.832

Monthly PET and 0.5 PET was calculated using 1° x 1° gridded temperature data procured from IMD. The gridded rainfall data of 0.25° x 0.25° was processed for recent ten years (2006 to 2016) to assess the prevailing condition for moisture availability in the study area. Climatic characteristics for each location was analyzed and based on limiting levels the suitability class was assigned such as highly suitable, moderately suitable, marginally suitable and unsuitable by matching the requirements of silkworm's food plants (Table 4). Thus, a climatic limitation map for food plants (*Morus alba*) was generated.

Table-4: Evaluation of site suitability for Mulberry based on climate

Climatic Characteristics	**Suitability classes**			
	Highly suitable (S1)	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Sericulture food plant: Mulberry				
Mean temperature in growing season (°C)	20-30	30-37	30-37	<15, >37
Totally rainfall (mm)	500-750	750-2000	2000-3400	<500, >3400
LGP (days)	>120			<120

3.2 Evaluation of site suitability for silkworm rearing

Silkworms are delicate and very sensitive to environmental conditions. The most important environmental factors limiting the survival and growth of silkworm are atmospheric temperature and humidity predominant at the time of rearing. Excessive fluctuation in temperature should be avoided at the time of rearing silkworm as it has indirect correlation to the growth of silkworms and silk production. The combined effect of both temperature and humidity largely determines the satisfactory growth of silkworms. The growth of silkworm is better under higher temperature and higher humidity condition followed by lower temperature and lower humidity condition during their life cycle. Humidity also has an influence directly on the physiological functions of the silkworm.

The optimum temperature and relative humidity ranges are 20-28°C and 70-85% for mulberry silkworm. The temperature above 30°C directly affects the health of silkworm. The silkworm becomes too weak and susceptible to disease if temperature is below 20°C. However, this limiting factor varies for hilly regions and the limiting condition was derived by taking Mizoram condition as standard, i.e. the minimum temperature and relative humidity will be 15°C and 55%, respectively.

3.3 Integrated evaluation of soil and climatic suitability for silkworm food plants and sericulture development

The spatial data generated for limitation on climate (i.e. temperature, rainfall and length of growing period), landscape and soil characteristics (i.e. slope, soil drainage, texture, depth and pH) were spatially overlaid in GIS environment to produce a composite site suitability layer. Based on number and the intensity of limitations suitability classes were decided and categorized as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) as given in Table 5 (FAO, 1976a). The complete sequence of steps involved in this method is illustrated in Fig. 2.

Table-5: Criteria for determination of land suitability classes

Land Classes	Criteria
S1: Highly suitable	Land units with no or only 4 slight limitations
S2: Moderately suitable	Land units with more than 4 slight limitations and/or not more than 3 moderate limitations
S3: Marginally suitable	Land units with more than 3 moderate limitations and/ or one or more severe limitation
N: Not suitable	Land units with very severe limitation

3.4 Ground Truth Collection

The primary interpretation based on remote sensing and GIS techniques were checked for the quality, before collecting ground truth. The idea was to improve the quality of output in the light of knowledge of interpreter about sericulture. The ground truth information was collected from different identified suitable areas. Soil samples were also collected during ground truth collection, so that it is analyzed later in the laboratory to further strengthen the analysis process. The ground truth collection also included collection of information on availability of resources and trained farmers for sericulture practices.

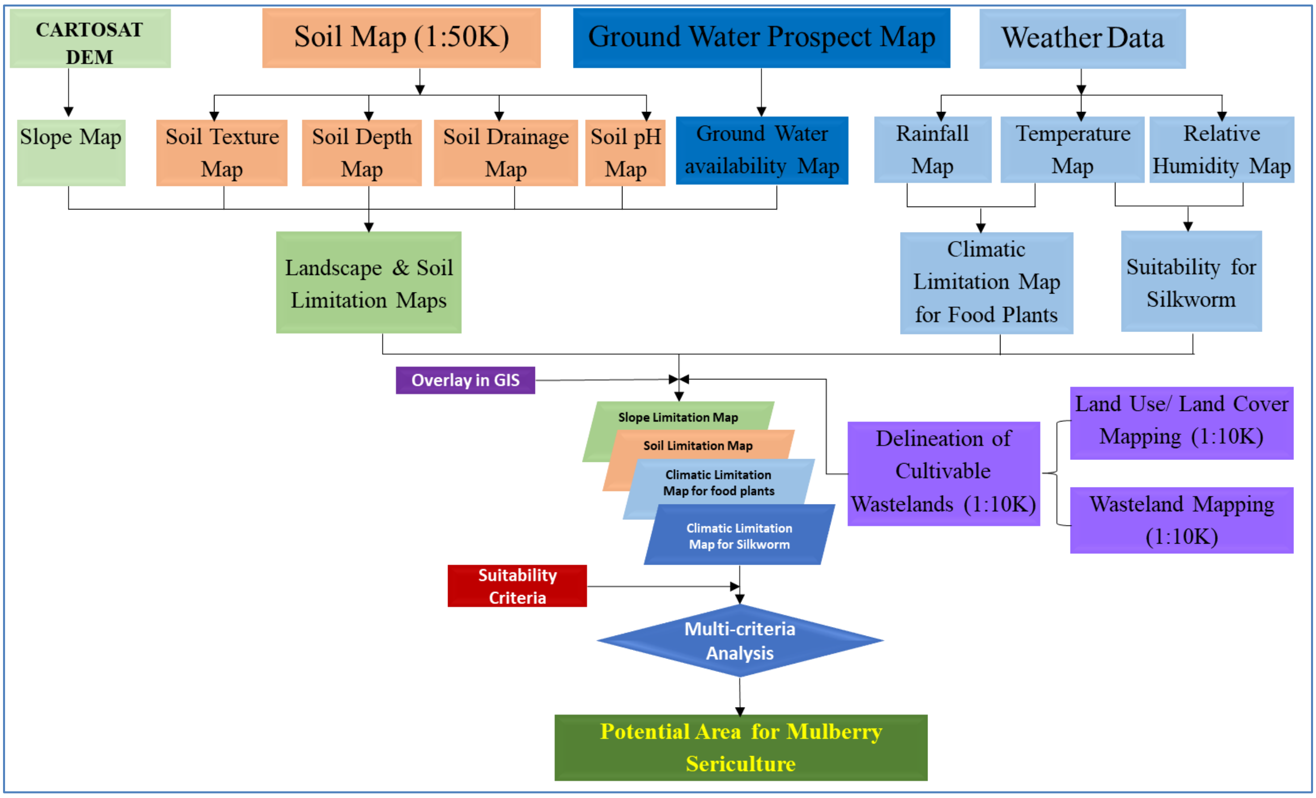

Fig-2: Methodology Flow Chart

4.0 RESULTS & DISCUSSION

4.1 LULC (1:10K, 2017)

In order to find out the wasteland which is not currently used for any purpose and also to delineate other usage of land in the study area, a Land use and Land cover(LULC) map was prepared for the three districts for year 2017 using LISS-IV images.

The LULC analysis of LISS-IV images for the year 2017 shows that the percentage of Agricultural Land is around 72.2% (297420.69 ha) which also includes area of 1 % under Agricultural Plantation. The second largest LULC class is Forest having coverage area of around 57574.89 ha (14.0%) in the study area. The waterbody category comprises of 1124.97 ha which is almost 2.7% of total area. If a closer look is taken it is very imperative that the third largest group is of Builtup category which is having an area of around 8.9% of total geographical area.The target wasteland (scrub land and waterlogged) category covers around 8956.92 ha (2.2%) of total area. This is the land category not being utilized for any useful purpose. This study envisages and promulgates to make utilizable these wastelands after scientific analysis for landscape, soil and climatic (rainfall, temperature & relative humidity) conditions predominant in the region.

4.2 Slope limitation for Mulberry plant

Slope is one of the important factor for retention of soil moisture. An area of heavy rainfall may not have sufficient soil moisture, as almost all water drains out in the form of surface runoff if slope is large. Moreover, soil moisture retention is also dependent on soil texture, depth, humus content, etc. The whole study area was categorised into different slope classes with 0 – 5% slope as Highly suitable, 5 – 15% slope as moderately suitable, 15 – 33% as marginally suitable and slope >33% as not suitable class for growing mulberry, the food plant for silkworm. Slope limitation classes were derived utilizing Cartosat DEM (10m). In all the districts, Ambala and Yamunanagar districts with less of hills, the area having slope greater than 33% is about 22511.5 ha (table 9**)** while the area having slope between 15 to 33% is about 24610.5ha. The most suitable class i.e. 0 – 5% slope is having an area of 271864.3 ha and the moderately suitable slope class is having area around 92700.3ha.

4.3 Soil limitation for Mulberry plant

The soil, its chemical composition and physical characteristic is one of the most important factor for the growth of a plant. The soil in the study area was analysed for its suitablity for growing mulberry plant. The soil of the study area was analysed for ground water availabilty i.e soil moisture availablity, Electrical Conductivity (EC), Texture, Depth and pH. Moreover, spatial analysis based on all these factors of soil shows that 318092.15ha area is moderaltely suitable while 49263.12ha is marginally suitable for silkworm food plant. An area of 42820.82 ha is under not suitable category for mulberry cultivation in the study area which also includes area of waterbodies and builtup.

4.4 Climatic limitation for Mulberry plant

Climatic parameters like rainfall and temperature were analyzed for the study area and it was found that, two seasons are suitable for growing mulberry plants in the region. One season time period is from December to March and another is from June to September having LGP> 120 days giving sufficient time to grow mulberry plant. The complete geographical area of the Pachkula, Ambala and Yamunanagar district are suitable for growing mulberry plant but limited by other factors like LULC, Slope, Soil, etc. The climatic limitation map for growing mulberry plant is shown in the Fig. 3.

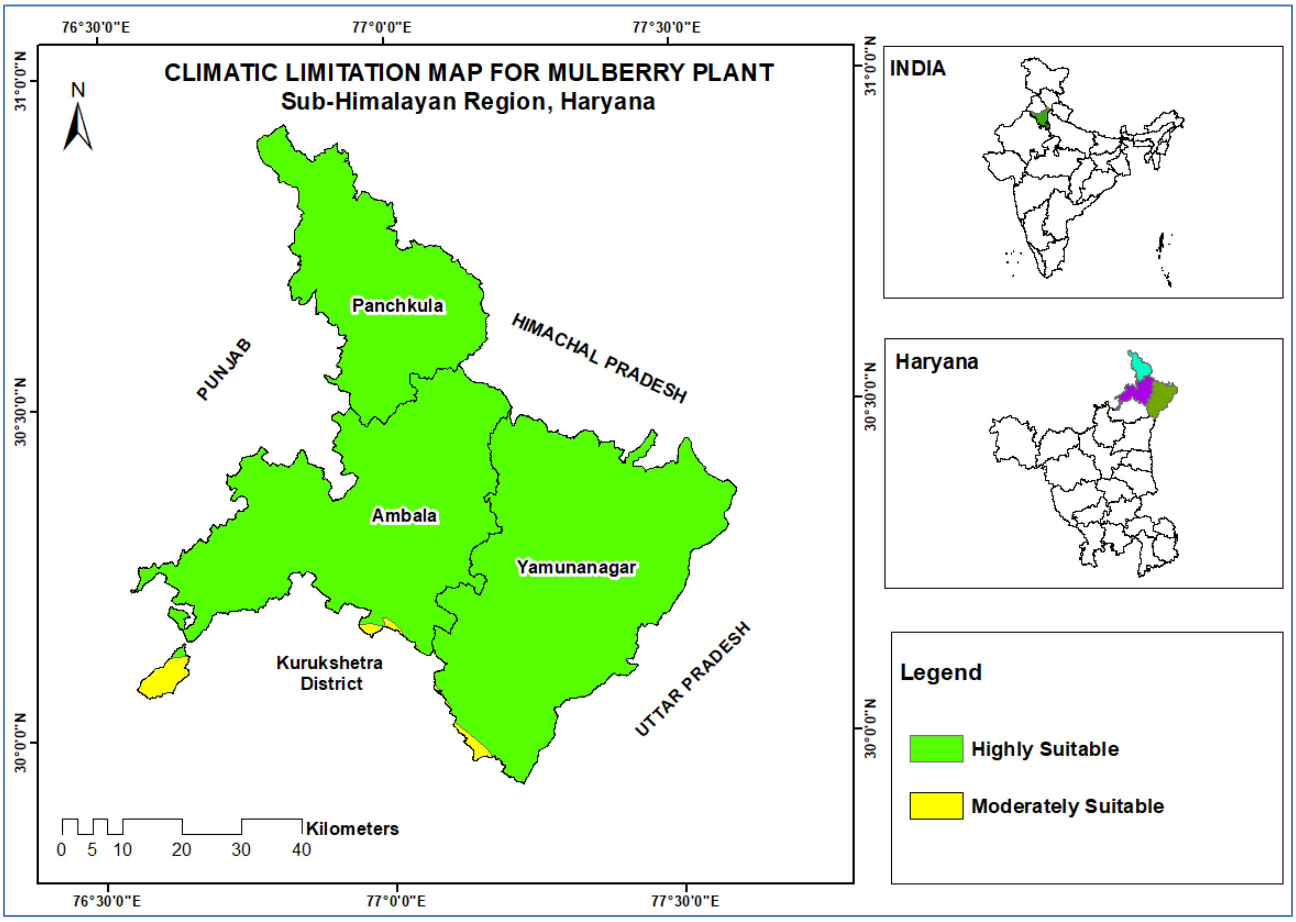

Fig-3: Climatic Limitation Map for Mulberry Plant

4.5 Climatic limitation for silkworm

Climatic parameters like rainfall, temperature and relative humidity were analyzed for around 10 years (2007 – 2017) of the entire study area and it was found that only one out of two seasons is conducive for growing Mulberry Silkworm. The study area was found suitable for growing Silkworm in the season having its span from June to September. However, the other time duration (December to March) was found suitable for growing Muklberry plant but is not suitable for growing silkworm due to cold condition during the period. The climatic limtation study shows that the southern plain region lying in Ambala and Yamuanagara districts are not suitable for silkworm rearing. The climatic limitation map showing suitable areas for cultivating mulberry silkworm is shown in Fig. 4.

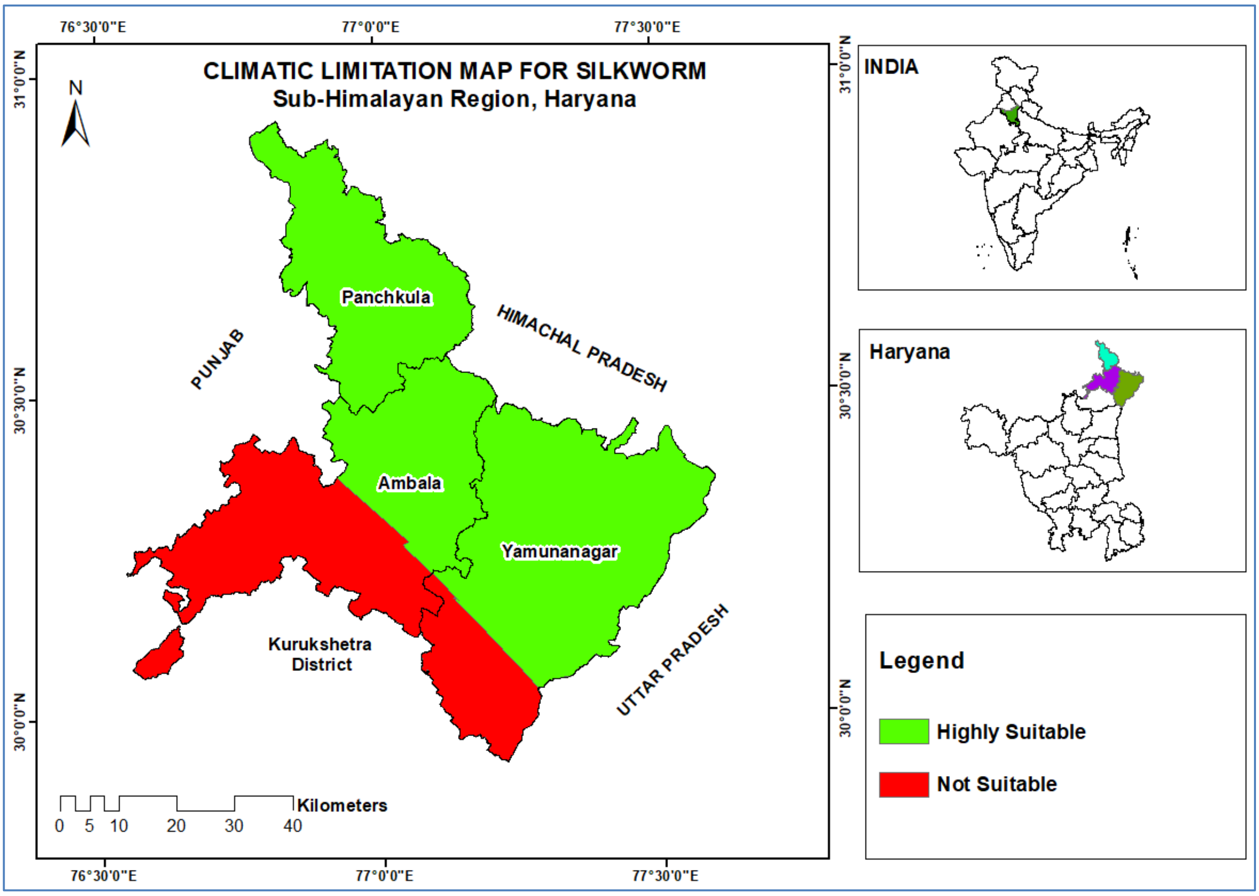

Fig-4: Climatic Limitation Map for Silkworm

4.6 Potential area for Mulberry sericulture

The slope limitation data, the soil limitation data, the climatic limitation data for food plants and the climatic limitation data for mulberry silkworm were overlayed for multicriteria analysis on wasteland layer obtained from the LULC database. Total suitable wasteland available for sericulture development in the study area out of 8956.92 ha wasteland is around 6492.69 ha of which the maximum area of 3260.93 ha is in Panchkula district.The suitable wasteland in Ambala district is around 1535.81ha and of this, 21.66% wasteland i.e. 332.68 ha is under Highly Suitable category, 29.73% wasteland i.e around 456.59 ha is under moderately suitable and, 48.61% land i.e. 746.54 ha is under marginally suitable category. The outcome of multi-criteria analysis shows that the Naraingarh block (Ambala) is having maximum suitable wasteland area of 679.60ha and Saha block (Ambala) is having minimum suitable wasteland area of 103.91 ha for mulberry sericulture. Barara block (Ambala) is having 116.11 ha and Shahzadpur block (Ambala) is having 636.18 ha of wasteland suitable for mulberry sericulture. Total suitable wasteland available for sericulture development in Panchkula district is around 3260.93 ha and of this, 9.64% wasteland i.e. 314.44 ha is under Highly Suitable category, 52.56% wasteland i.e around 1714.07 ha is under moderately suitable category and, 37.79% land i.e. 1232.42 ha is under marginally suitable wasteland. The outcome of multi-criteria analysis shows that the Barwala block (Panchkula) is having maximum suitable wasteland area of 1539.58 ha and Morni block (Panchkula) is having minimum suitable wasteland area of 42.49 ha for mulberry sericulture. Raipur Rani block (Panchkula) is having 1073.66 ha and Pinjore block (Panchkula) is having 605.20 ha of wasteland suitable for mulberry sericulture. Total suitable wasteland available for sericulture development in Yamunanagar district is around 1695.95 ha and of this, 31.81% wasteland i.e. 539.40 ha is under Highly Suitable category, 13.60% wasteland i.e around 770.64 ha is under moderately suitable category and, 22.75% land i.e. 385.91 ha is under marginally suitable wasteland. The outcome of multi-criteria analysis shows that the Khizrabad block (Yamunanagar) is having maximum suitable wasteland area of 937.03 ha and Mustafabad is having minimum suitable wasteland area of 17.81 ha for mulberry sericulture. Bilaspur block (Yamunanagar) is having 420.31 ha, Chhachhrauli block is having 181.65 ha, Jagadhri is having 106.26 ha and Sadaura is having 32.89 ha of wasteland suitable for mulberry sericulture. Radaur block in Yamunanagar district is not suitable for mulberry sericulture development due to climatic limtitations.

The spatial distribution of potential area (wastelands) for Mulberry sericulture development falling under different suitability class in the sub-Himalayan regions of Haryana is shown in the Fig. 5.

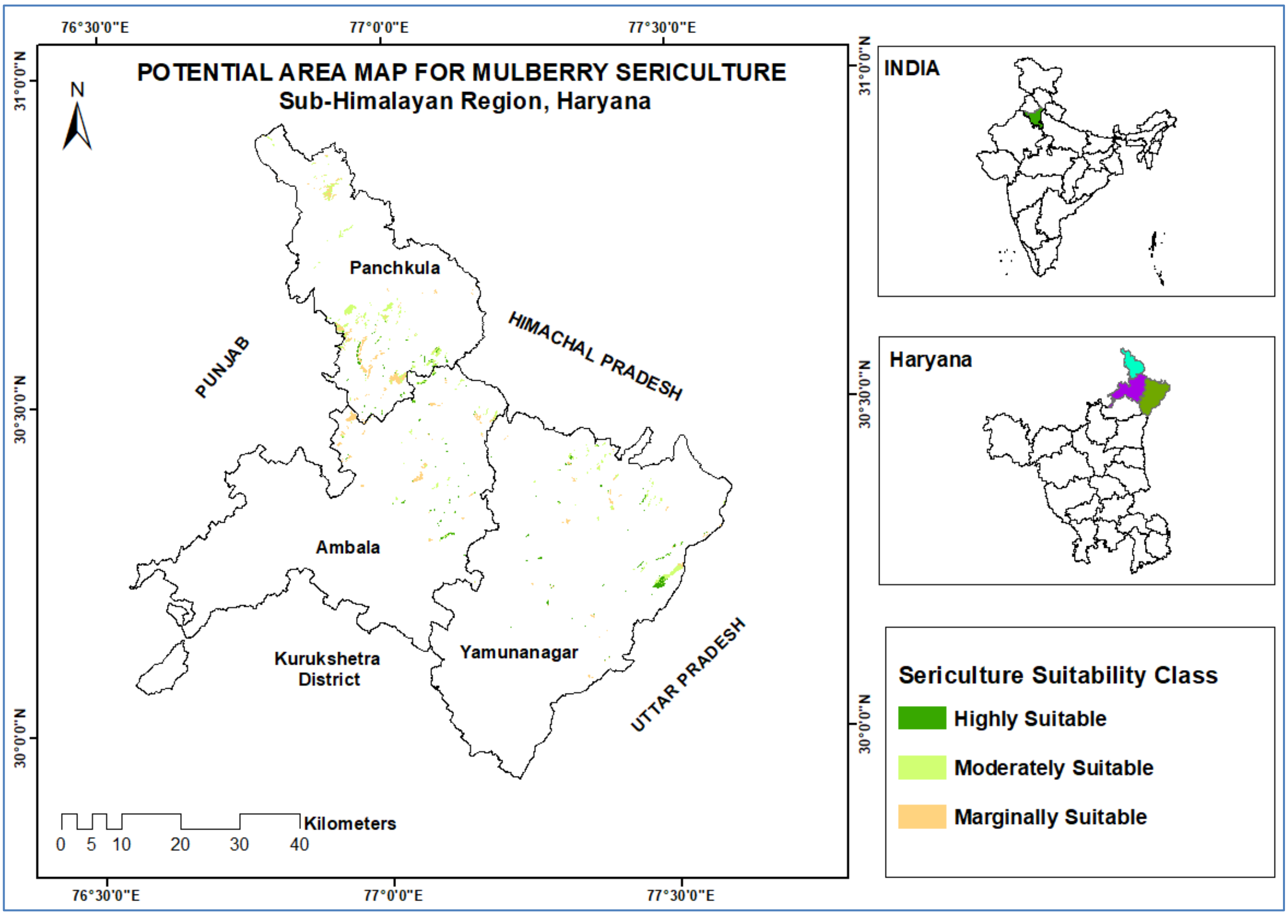

Fig-5: Potential Area Map for Mulberry Sericulture

5.0 CONCLUSION

The remote sensing data and GIS techniques are helpful in delineating suitable area for Mulberry sericulture in the study area. The space based technology was not only useful to quantify the suitable area but also to locate them in the sub-Himalayan regions of Haryana. Although, wasteland is targeted initially for Mulberry sericulture development but, it can be expanded to other suitable sites under other land use land cover category, once success is derived from these identified wastelands. It was discovered from field observations that the mulberry plants do existed at sites found suitable for its growing although not utilized for rearing of silkworms. The database thus generated in the project is published online along with other relevant layers at Sericulture Information Linkages Knowledge Systems (SILKS), http://silks.csb.gov.in as well as information on good practices for mulberry sericulture rearing and production for farmers and entrepreneurs. The spatial and non-spatial information thus generated will help farmers, Seri-culturists and policy makers in better implementing the objectives of promoting sericulture as an alternative to agriculture in non-traditional states like Haryana and in turn help achieving the target of Central Silk Board, Govt. of India, and Bengaluru.

ACKNOWLEDGMENTS

The financial help provided by North Eastern Space Application Centre (NESAC), Government of India, Department of Space, Umiam, Shillong, Meghalaya, India is thankfully acknowledged. The authors also acknowledge the support received from regional centre of Central Silk Board (CSB), Govt. of India, Panchkula and Horticulture Department, Govt. of Haryana, during collection of field information.

6.0 REFERENCES

1. Handique, B.K., das, P.T., Goswami, J., Goswami, C., Singh, P.S., Chutia, D. Rocky, P. and Raju, P.L.N. (2016). Mapping of Potential areas for sericulture development and information determination through SILKS web portal. NNRMS Bulletin, 40: 35-42.
2. CSB. (2020). Functioning of Central Silk Board & Performance of Indian silk Industry, Central Silk Board, Bengaluru, India. 18-20.
3. MoT. (2017). Export Earnings on Silk and Silk Goods. Textile Data. Ministry of Textile, Govt. of India.
4. MoT. (2020) http://ministryoftextiles.gov.in/sites/default/files/Import-of-Silk_0.pdf

5. CSB. (1994). Manual of Satellite remote sensing application for sericulture development, Central Silk Board, Bangalore, India.
6. NESAC. (2016). Applications of remote sensing and GIS in Sericulture Development (Phase-II), Project Report No. NESAC-SR-164-2016. North Eastern Space Applications Centre, Umiam, Meghalaya and Central Silk Board, Bengaluru.
7. District Census Handbook Ambala. (2011). Village and Town Directory, Directorate of Census Operations, Haryana.
8. Chukka, T.B., Kumaraswami, G., Venkanna, R., Vani, T., Baba, G.M., Sastry, D.V.J. and Bhagavan, S.V.B.K. (2013). An Integrated evaluation of soil and climatic suitability for silkworm mulberry food plants in Andhra Pradesh: A Geo-Spatial Approach. *International Journal of Biological Sciences and Engineering, 4*(2); 57-63.
9. Rangaswami, G., Narasimhanna, M.N., Kasiviswanathan, K., Sastry, C.R. (1976). Manual of Sericulture, Food and Agriculture Organization, Agricultural Services Div. FAO, Rome.
10. Tewari, D., & Bhatuia, A. K. (2013). Ground Water Information Booklet Ambala District, Haryana, Central Ground Water Board, Ministry of Water Resources Government of India, North Western Region Chandigarh.
11. Thornthwaite, C.W. (1948). An approach toward a rational classification of climate. *Geog. Re, 88;* 55-94.

CITATION: Ritesh Kumar *et al* (2021). Site-Suitability Analysis for Sericulture Development in Sub-Himalayan Region of Haryana, India. *South Asian Res J Eng Tech, 3*(4): 135-145.