Expansion of sericulture in India using geospatial tools and web technology

B. K. Handique, P. T. Das, J. Goswami, C. Goswami, P. S. Singh, C. J. Prabhakar, C. M. Bajpeyi and P. L. N. Raju*

Potential areas for expansion of sericulture in 108 selected districts covering 24 states in the country were mapped using remote sensing, GIS and GPS tools. Special emphasis was given to northeastern (NE) region, where 41 districts out of a total of 108 districts were selected. Potential area identification for sericulture development was based on land evaluation, water resources and climatic requirements for growing silkworm food plants as well as rearing silkworms. Among NE states, Mizoram has maximum highly suitable area (4.7% of total geographical area) followed by Meghalaya (2.8%), that can be brought under mulberry sericulture. Among non-traditional sericulture states, Himachal Pradesh has the highest suitable area (0.9% highly suitable and 6.2% moderately suitable areas) in the selected districts. Among the five traditional sericulture states, Tamil Nadu has the highest area under highly suitable category, which is about 4% of the total geographical area in the selected districts. To provide information on sericulture and spatial information on potential areas for the selected 108 districts, a geoportal titled 'Sericulture Information Linkages and Knowledge System' (SILKS) was conceptualized and developed using open source GIS, and put in the public domain (http://silks.csb.gov.in). Within three years, the portal could make a significant impact in the country particularly in NE states and a number of sericulture expansion activities have been taken up based on the study.

Keywords: Geoportal, geospatial tools, open source GIS, sericulture, web technology.

SERICULTURE is an age-old practice in India, producing all four types of natural silk namely Mulberry, Eri, Tasar and Muga. Sericulture plays an important role in India towards poverty alleviation. Employment generation under sericulture is estimated to be 8.03 million persons during 2014–15. Five states in the country, viz. Andhra Pradesh, Karnataka, Tamil Nadu, Jammu and Kashmir and West Bengal are considered traditional mulberry sericulture states. Sericulture production is still limited to a few pockets in the country and the decline in areas under silkworm food plants is a matter of concern. The current production (about 28,708 MT during 2014–15) is not adequate to meet the demand for silk in the country. Sericulture industry has been struggling to cope with competition from countries like China and Japan, and government intervention in terms of regulating import duty was sought as early as 1938 (ref. 1). There is tremendous scope for improving silk production and quality by expanding sericulture to new potential areas and supporting farmers with up-to-date scientific information through appropriate dissemination system. In this context, geospatial tools comprising remote sensing (RS), geographical information system (GIS), global positioning system (GPS) and web technology have the potential of integrating, analysing and disseminating satellite derived information for further expansion of sericulture in the country.

The Central Silk Board (CSB) under the Ministry of Textiles has been pursuing satellite remote sensing for sericulture development since the launch of the first operational remote sensing satellite, IRS-1A in 1988 (ref. 2). CSB and the Indian Space Research Organisation (ISRO) in collaboration with the concerned state sericulture/textiles departments applied geospatial technology for mulberry acreage estimation, garden condition assessment and for delineating suitable areas for expansion of sericulture in non-traditional states[3,4]. ISRO and CSB carried out a project, called SPAARS (survey of potential and actual area under sericulture with remote sensing), for mapping potential and actual areas under sericulture at 1 : 250,000 scale. Because of the coarse mapping scale the information derived could not meet the requirement

B. K. Handique, P. T. Das, J. Goswami, C. Goswami, P. S. Singh and P. L. N. Raju are in the North Eastern Space Applications Centre, Department of Space, Shillong 793 103, India; C. J. Prabhakar and C. M. Bajpeyi are in the Central Silk Board, Ministry of Textiles, B.T.M. Layout, Madivala, Bengaluru 560 068, India.
*For correspondence. (e-mail: bkhandique@gmail.com)

for district and block/taluka level planning. An ambitious plan was taken up by CSB for implementing in 2008–09 to 2013–14 period, to identify and map additional potential areas for development of silkworm food plants for 108 priority districts from 24 states at 1 : 50,000 scale in three phases; Phase I: 41 districts covering all 8 states in NER including Sikkim. Phase II: 45 districts covering 11 other non-traditional states, viz. Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttarakhand, and Uttar Pradesh. Phase III: 22 districts in the 5 traditional states, viz. Andhra Pradesh, Jammu and Kashmir, Karnataka, Tamil Nadu and West Bengal (Figure 1). It was also envisaged to develop a geoportal for integrating the potential area maps along with other required information for expansion of sericulture at district level.

Identification of potential areas for mulberry

Evaluation of land, water resources and climatic requirements is the prerequisite for identifying potential areas for sericulture development that includes growing silkworm food plants and rearing silkworms[5,6]. It needs interpretation and integration of physiographic conditions, climatic parameters, vegetation and other aspects of land like soil types, slope, etc. Due to the limited scope of expansion of plantations under silkworm food plants, emphasis was given to identify cultivable wastelands through satellite data using a standard classification approach[7]. Out of 23 wastelands categories at 1 : 50,000 scale as per National Wasteland Classification System[8], 7 were considered for further evaluation of suitability for silkworm food plants. IRS Resoursesat-1 and Resourcesat-2 LISS III satellite data were acquired for the period 2008–09, to delineate cultivable wasteland areas.

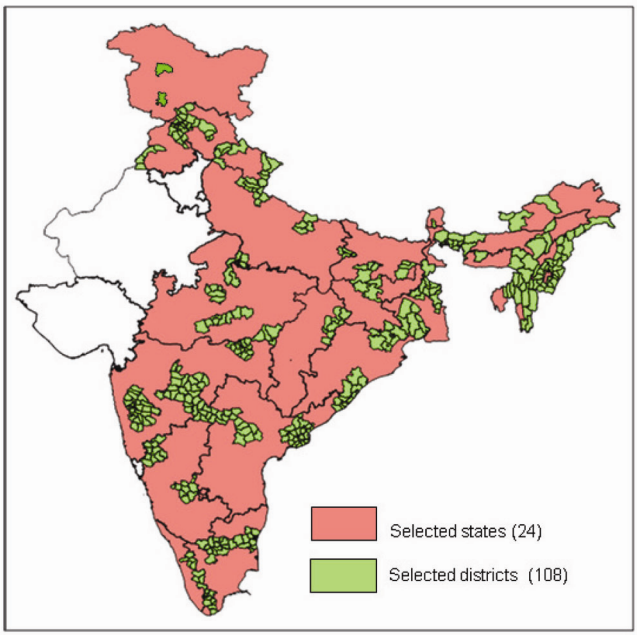

Figure 1. Location map of the study areas.

Evaluation of site suitability based on landscape and soil characteristics

Six most important parameters of soil, viz. texture, drainage, depth, groundwater and pH, along with two topographic parameters, viz. slope and erosion, were considered for site suitability evaluation. Soil characteristics were obtained from soil map prepared under two projects at the national level, viz. National Natural Resources Database at 1 : 50 K (NRDB) of Department of Space and project on soil mapping by the National Bureau Soil Survey and Land Use Planning (NBSSLUP) at 1 : 250 K and Soil and Land Use Survey of India (SLUSI) at 1 : 50 K. Soil map of 1 : 250 K was updated to 1 : 50 K by collecting and analysing soil samples for the required soil parameters in the study areas, mainly cultivable wastelands.

Slope map was derived from SRTM DEM (Shuttle Radar Topographic Mission–Digital Elevation Model). Information on groundwater availability was obtained from groundwater prospect map at 1 : 50 K prepared under the Rajiv Gandhi National Drinking Water Mission. Soil erosion maps of the study areas were generated using Universal Soil Loss Equation (USLE) in GIS environment. Different thematic layers were generated in GIS environment for each of the land characteristics and compared with the requirements of silkworm food plants. All these thematic layers were overlaid in GIS environment and a composite layer prepared by using overlay function of Analysis Tools of ArcGIS software. The attribute values of the composite layer were compared with the requirements of silkworm food plants. They were assigned values of degree of limitation ranging from 0 (suggesting no limitation) to 4 (suggesting very severe limitation) and soil site limitation map prepared following FAO Sericulture Manual standards (1990) (Table 1)[9].

Evaluation of site suitability based on climatic parameters

Suitability of climate for food plants was analysed considering three parameters, viz. (i) temperature (ii) rainfall (water supply) and (iii) minimal length of growing period. The weather data, collected from the class-I observatories of IMD and Automatic Weather Stations (AWS) established by ISRO were utilized for deriving the required parameters.

The point observations on temperature and rainfall were needed to be translated into spatial domain and this was done by analysing long-term monthly and annual average of mean temperatures of all stations with

Table 1. Criteria of limitation rating for evaluation of soil site suitability for mulberry

Soil-site characteristics		Degree of limitation and suitability class			
	Unit	0–1 None to slight S1 (highly suitable)	2 Moderate S2 (moderately suitable)	3 Severe S3 (marginally suitable)	4 Very severe N (not suitable)
Topography and landscape					
Slope	%	0–3 (level to very gentle)	3–5 (gentle)	5–10 (moderate)	>10 (steep)
Erosion		e_1	e_2	e_3	e_4
Soil characteristics					
Drainage	Class	Well	Well	Well	Excessive
Groundwater	Availability	Good	Fair	Fair to moderate	Poor
	Quality (EC microohms/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	Deep	Moderate shallow– moderate deep	Shallow	Very shallow
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

Table 2. Evaluation of climatic site suitability for mulberry

Climatic characteristics	Suitability classes			
	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Mean temperature in growing season (°C)	20–30	30–37	30–37	<15, >37
Total rainfall (mm)	500–750	750–2000	2000–3400	<500, >3400
LGP (days)	>200	–	–	–

corresponding elevation data[10]. The empirical relation thus developed was used in GIS environment for depicting spatial variation of annual mean temperature for the growing season of silkworm food plants. To interpolate rainfall data from point locations to represent the spatial coverage, Kriging method was adopted as it is assumed to yield more accurate predictions than linear regression[11].

Length of growing period (LGP) or moisture availability period for crop growth, is the period (in days) when precipitation exceeds 50% of PET (potential evapotranspiration). Shorter LGP (example, less than 120 days for mulberry and 90–120 days for castor) are not suitable for cultivation of silkworm food plants. Monthly potential evapotranspiration (mm) was computed by Thornthwaite method (1948)[12]. The calculated LGP is presented in spatial domain with interpolation using Kriging method.

Three categories of mulberry climate suitability were made based on ranges of climatic characteristics. Highly suitable category was assigned to areas having mean temperature of 20–30°C, total rainfall of 500–750 mm with LGP more than 200 days. Moderately suitable areas were categorized for areas with mean temperature of 30–37°C with total rainfall of 750–2000 mm. Areas with mean temperature of 30–37°C with total rainfall of 2000–3400 mm were categorized as marginally suitable. On the contrary, areas having mean temperature of less than 15°C or more than 37°C with total rainfall more than 3400 mm or less than 500 mm were categorized as not suitable (Table 2). The climatic limitation map was superimposed on the soil constraints map to derive site suitability map.

For rearing silkworm, among the various environmental factors, the most important are atmospheric temperature and humidity prevailing during rearing. The combined effect of temperature and humidity largely determines the satisfactory growth of silkworms. The optimum temperature and humidity for normal growth in mulberry silkworm is between 23–28°C and 70–85% respectively. Spatial layers on the temperature suitability for silkworm were generated as was done in case of silkworm food plants.

Evaluation of soil and climatic suitability for silkworm food plants and silkworm rearing

The limitation maps generated for climate, landscape and soil characteristics were spatially overlaid in GIS environment and a resultant polygon layer produced by using overlay function of ArcToolbox. Each polygon has nine values of degree of limitation. Based on the number and

Table 3. 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 no 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

Table 4. Suitable areas for mulberry host plants in north eastern states

States	No of selected districts	Geographical area ('000 ha)	Highly suitable (ha)	Moderately suitable (ha)	Marginally suitable (ha)	Total ('000 ha)	% of TGA
Arunachal Pradesh	7	3,698	13	1,908	15,321	1,724	0.5
Assam	9	3,271	1,169	76,893	232,377	31,044	9.5
Manipur	9	2,233	–	–	67,675	6,768	3.0
Meghalaya	2	505	13,928	32,381	33,425	7,973	15.8
Mizoram	6	1,828	85,598	73,495	17567	17,666	9.7
Nagaland	5	1,091	–	–	239,306	23,931	21.9
Sikkim	1	75	–	827	5,095	592	7.9
Tripura	2	442	219	17,388	14,745	3,235	7.3

intensity of limitations (as per FAO framework, 1976)[13], suitability is decided and graded as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) (see Table 3).

Results and discussion

Additional area suitable for mulberry food plants in north eastern states

Out of total 108 districts, 41 districts were selected from 8 NE states including Sikkim, covering a total geographical area of 935,195 sq. km (Table 4). Among the NE states, Mizoram has maximum highly suitable area (4.7% of total geographical area) followed by Meghalaya (2.8%), that can be brought under mulberry sericulture.

In terms of total area coverage, Nagaland has maximum area (combining highly suitable, moderately suitable and marginally suitable) among NE states, which is about 22% of TGA. Meghalaya occupies second position with 15.8% followed by Mizoram (9.7%). Due to limitation of physiographic conditions and climate, Arunachal Pradesh has very limited areas (0.5% of TGA) that can be brought under sericulture.

Additional area suitable for mulberry host plants in other selected states

Among non-traditional sericulture states, Bihar has been found to have the highest percentage of areas suitable for mulberry sericulture, which is about 11% of total geographical areas in the three selected districts, followed by Madhya Pradesh (10.2%) and Himachal Pradesh (9.7%). Himachal Pradesh has also been found to have the highest 'highly suitable' areas (0.9%).

Among traditional sericulture states, Karnataka has 11.6% of total geographical area in the selected districts for mulberry sericulture. On the other hand, Tamil Nadu has the highest area under high suitable category, which is about 4% of total geographical area in the selected districts. Punjab has been found to be least suitable for mulberry sericulture with only 521 Ha of areas delineated as marginally suitable in the selected two districts. The other two states found less suitable for mulberry sericulture are Uttarakhand (0.05%) and Chhattisgarh (0.6%), but Uttarakhand has about 595 ha of area under highly suitable categories in the five selected districts. For non-mulberry sericulture, Bihar and West Bengal have significant proportion of suitable areas for eri, and West Bengal and Uttarakhand have significant suitable areas for muga. For tropical tasar, Orissa has the highest percentage of suitable area (25% of TGA) in the selected four districts, followed by Jharkhand (21.2% of TGA) (Table 5).

Development of SILKS geoportal

The large database generated with maps and statistics of potential areas for sericulture development in the 108 selected districts could be integrated to form a spatial decision support system. Thus, a geoportal named SILKS (Sericulture Information Linkages and Knowledge System) was conceptualized and developed. The portal was developed using open source software packages as a

Table 5. Suitable areas for mulberry host plants in other than NE states

States	No. of selected districts	Total geographical areas ('000 ha)	Highly suitable (ha)	Moderately suitable (ha)	Marginally suitable (ha)	Total suitable areas ('000 ha)	% of TGA
Andhra Pradesh	4	3,752	2,366	10,339	6,641	1,935	0.5
Bihar	3	893	–	59,916	41,458	10,137	11.4
Chhattisgarh	2	2,206	–	3,162	9,994	1316	0.6
Himachal Pradesh	4	1,561	13,755	96,073	42,254	15,208	9.7
Jammu and Kashmir	2	211	2,551	6,154	11,299	2,000	9.5
Jharkhand	3	874	–	7,651	11,531	1,918	2.2
Karnataka	4	3,388	–	11,877	379,932	39,181	11.6
Kerala	2	941	9,914	21,970	14,803	4,669	5.0
Madhya Pradesh	6	3,513	1,136	77,208	279,563	35,791	10.2
Maharashtra	7	7,252	–	6,441	76,401	8,284	1.1
Orissa	4	2,599	238	7,976	88,217	9,643	3.7
Punjab	2	457	–	–	521	52	0.1
Tamil Nadu	4	2,413	95,325	59,449	10,446	16,522	6.9
Uttar Pradesh	6	2,389	584	8,135	16,382	2,510	1.1
Uttarakhand	5	2,499	595	300	263	119	0.1
West Bengal	9	5,044	38,038	54,272	24,571	11,688	2.3

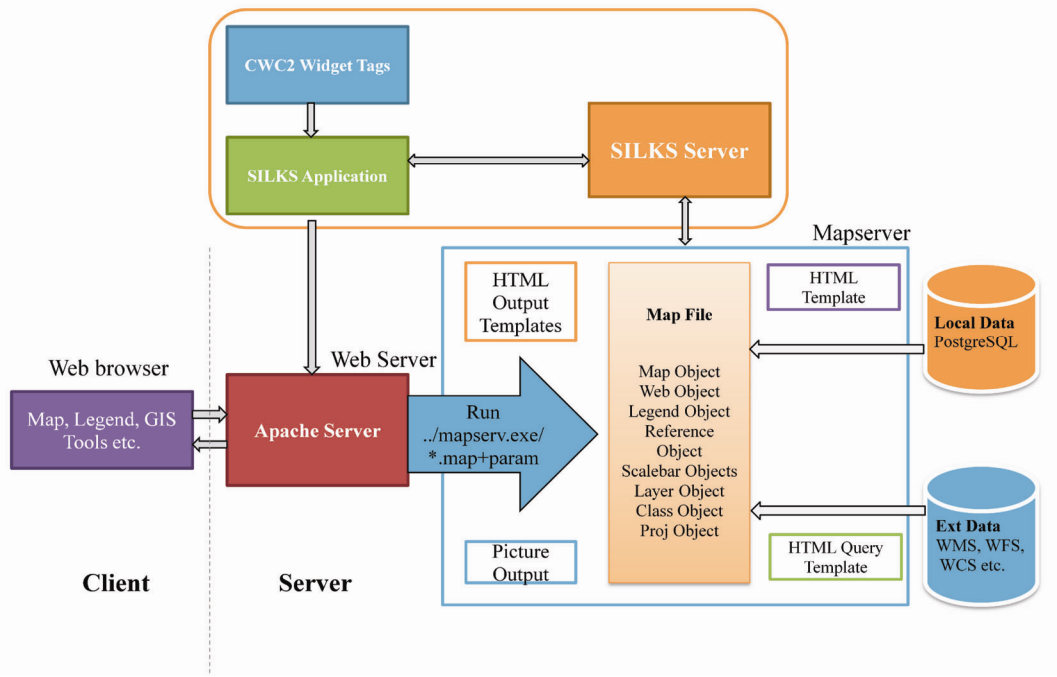

Figure 2. SILKS application architecture.

single window decision support system, to provide all sericulture related information for the selected 108 districts.

The SILKS application has Mapserver for serving and rendering GIS data, PostgreSQL as main database server, PostGIS for processing and querying on geographic data and Geoserver for publishing geospatial data as OGC compliant services. The Mapserver mapscripts are culled using PHP to build the SILKS user application framework. The SILKS enables proper management of geospatial database and allows for public dissemination and sharing of data via Internet. The non-spatial modules were created using web tools such as HTML, CSS, JavaScripts, etc. The basic architecture of SILKS is shown in Figure 2. First, the user makes a request having Mapserver parameters. The Apache HTTP web server upon receiving the parameters invokes the Mapserver engine. The Mapfile inside the Mapserver defines the basic and the query template and tells how the maps will appear in the browsers. The Mapserver can connect to both local PostgreSQL data as well as external OGC data services from remote servers. The incoming data can be reprojected on-the fly as per the projection defined in the

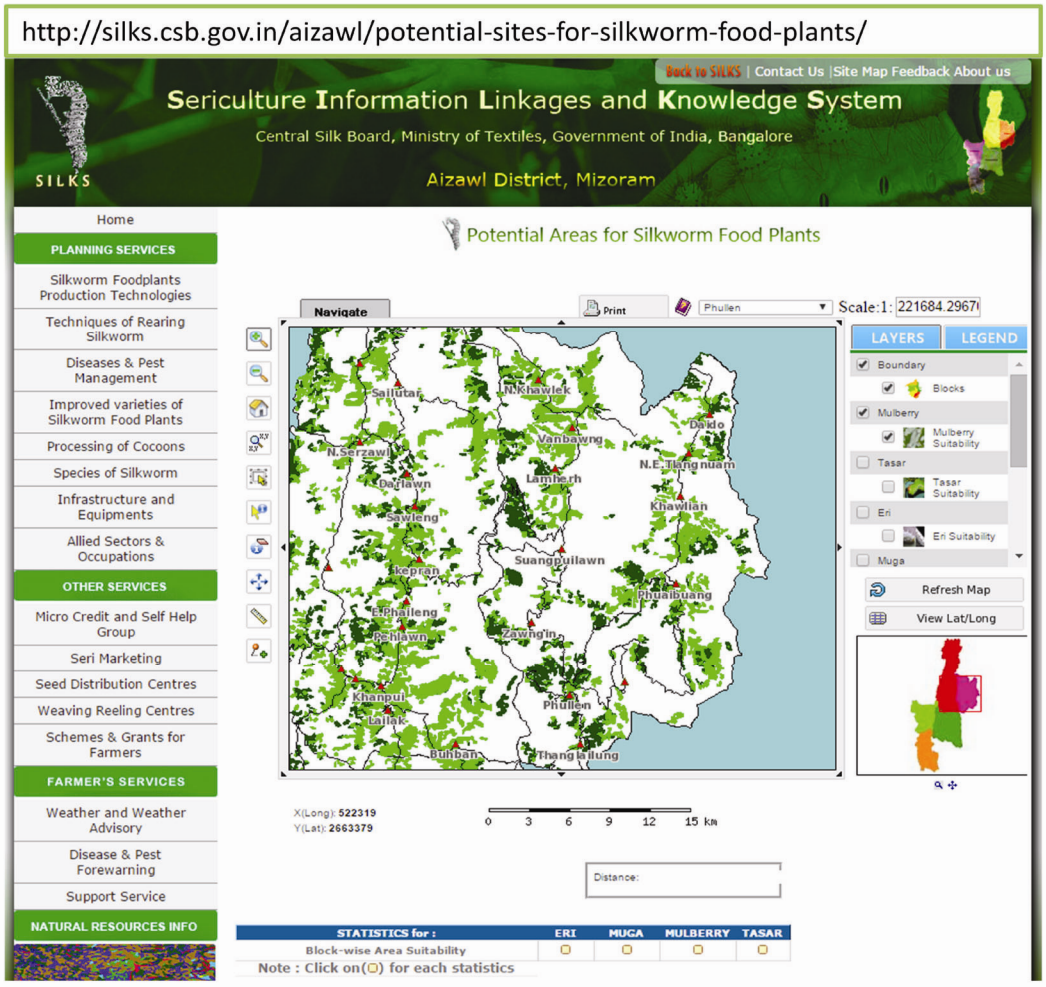

Figure 3. A page of SILKS geoportal (part of Aizawl district, Mizoram).

'projection object'. The Mapserver then processes the data as per the parameters and returns images in the desired map output format defined in the Mapfile.

Information dissemination through SILKS geoportal

The SILKS geoportal was hosted in the public domain and can be accessed live at http://silks.csb.gov.in (Figure 3). SILKS is an ICT based platform, developed specially for farmers and sericulture extension workers and offers essential information modules on sericulture planning and other relevant advisory services. It provides interactive maps of site suitability for silkworm food plants and other relevant spatial information for taking up planning activities. In addition, it also has other local planning and advisory services modules, specific for the districts and in their local languages. The portal is now made available in 12 languages, viz. English, Hindi, Telugu, Kannada, Assamese, Bengali, Mizo, Manipuri, Khasi, Garo, Ao Naga and Sumi Naga. It has 13 major non-spatial modules and 4 spatial modules, which are grouped into 4 categories, namely, planning services, other services, farmer's services and natural resources information. The available modules under planning services are on silkworm food plants production technologies, techniques of rearing silkworm, diseases and pest management of silkworm food plants, improved varieties of silkworm food plants, species of silkworm, processing of cocoons, infrastructure and equipments and allied sectors and occupations. Other service has modules like micro credit and self-help group, seri marketing, seed distribution centres, weaving reeling centres and schemes and grants for farmers. Farmers' services module consists of weather and weather advisory, disease and pest forewarning and support services. Regular updation of information content in the portal requires continuous support from all stakeholders based on feedback from users particularly the sericulture farmers.

A series of hands on trainings was provided to officials and other stakeholders on the use of SILKS geoportal. Recently SMS based sericulture advisory was started in support of India Meteorological Department, which

would be linked to SILKS portal for maintaining the database and evaluate feedbacks.

A case study made by the Central Silk Board in NE region reveals more than 86% accuracy in terms of mapping of potential areas for sericulture development, and is boosting development of sericulture in the region. Out of the 3.1 lakh ha of highly suitable areas identified, an increase of about 8500 ha of food plants has been reported since 2013. The SILKS portal has recorded more than 28,000 hits reflecting its wide usage through internet. Regular updation of information in the language of the wide range of users will be critical for successful use of the geoportal. Each stakeholder of the sericulture sector has to play an active role in utilizing the services of the portal, which will support expansion of sericulture in the non-traditional areas.

1. Rama Rao, N., Protection for Indian Sericulture. *Curr. Sci*., 1938, **7**(6), 263–266.
2. Navalgund, R. R., Parihar, J. S., Ajai and Nageswara Rao, P. P., Crop inventory using remotely sensed data. *Curr. Sci*., 1991, **61**(3&4), 162–171.
3. Nageswara Rao, P. P., Ranganath, B. K. and Chandrashekhar, M. G., Remote sensing applications in sericulture. *Indian Silk*, 1991, **30**, 7–15.
4. CSB, *Manual of Satellite Remote Sensing Applications for Sericulture Development*, Central Silk Board, Bangalore, 1994.
5. Sys, C., *Land Evaluation: Part I, II& III*. 1985, State University Ghent Publication, Belgium.
6. Sys, C., Ranst, V., Debaveye, J. and Beernaert, F., Land evaluation Part III, crop requirements. *Agric. Pub*. 1993, No. 7, ITC, Ghent.
7. NRSC, *Manual–National Land Use Land Cover Mapping using Multi-temporal Satellite Data*, Land Use Division, National Remote Sensing Agency, Hyderabad, 2006.
8. NRSC, *Wasteland Atlas of India*, National Remote Sensing Agency, Hyderabad, 2011, pp. 4–14.
9. FAO, *Manual of Sericulture*, United Nations, Rome, Italy, 1990.
10. Patel, N. R., Mandal, U. K. and Pande, L. M., Agro-ecological zoning system. A remote sensing and GIS perspective. *J. Agrometeorol*., 2000, **2**(1), 1–13.
11. Goovaerts, P., Performance comparison of geostatistical algorithms for incorporating elevation into the mapping of precipitation. *Geocomputation*, 1999, **99**, 1–17.
12. Thornthwaite, An approach for a rational classification of climate. *Geog. Rev*., 1948, **38**, 55–94.
13. FAO, A framework for land evaluation. *Soil Bulletin*, Food and Agriculture Organization. United Nations, Rome, Italy, 1976, No. 32.

ACKNOWLEDGEMENTS. We thank the Central Silk Board, Ministry of Textiles, Govt of India, who has funded the study through a national level project. Contributions from scientists and engineers from State Remote Sensing Centres and officials from State Directorates of Sericulture are duly acknowledged.

Received 8 March 2016; revised accepted 11 July 2016

doi: 10.18520/cs/v111/i8/1312-1318