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Review Article

Agro-Eco Sub-Region Based Crop Planning in the Black Soil Regions and Indo-Gangetic Plains – Application of Soil Information System

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Agro-Ecological Sub-Regions (AESRs) of the country were conceptualized using limited soil data and accordingly a map was generated way back in 1994. The present paper revisits the AESR concept to revise this map with the help of geo-referenced soil information system (GeoSIS) recently developed at the sub-country levels of the Black Soil Region (BSR) and the Indo-Gangetic Plains (IGP). GeoSIS has been proved to be an excellent tool in successful application of Agro-Ecological Sub Regions (AESRs) at the regional and national levels. This novel approach could narrow the knowledge gap in revising the soil and agro-management technologies, used in dry land agriculture for productivity enhancement with special reference to the BSR dominated by cotton and soybean cropping systems. For the IGP, similar approach was used for the rice-wheat cropping systems. Revised AESR map identifies the areas under different level of productivity of these four important crops of two major food-growing regions of the country. The identified areas in the form of thematic maps shall help the planners and land resource managers to prioritize areas for resource management.

Keywords: Agro-Ecological Sub-Regions; GeoSIS; IGP; BSR; Cropping Systems

Introduction

Land use planning is a systematic and iterative process carried out to create an enabling environment for sustainable development of land resources. It assesses the physical, socio-economic, institutional and legal potentials and the constraints with respect to an optimal and sustainable use of land resources, In addition, it also empowers people to make informed decisions about how to allocate those resources for reaping maximum benefit. Originating from an internationally accepted framework for land evaluation, the agro-ecological zones/sub-regions methodology enables rational land management options to be formulated on the basis of an inventory of land resources and in evaluation of biophysical limitations and potentials. The concept of agro-ecological zone (AEZ) for improving the rainwater use efficiency, conservation of natural resource and practice of sustainable agriculture under rain-fed situation is essential. In this endeavour, highest priority is given to assess land resources and its components; mainly soil, water and climate to create an integrated system to apply the best of scientific technology and knowledge for agricultural development. The major task to develop AEZ was to create a near homogenous soil climatic region that is compatible for (i) potential genetic expression in terms of growth of a particular group of crops and cultivars and their sustenance, and (ii) the AEZ-based

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*Author for Correspondence: E-mail: tapas11156@yahoo.com dissemination of agro-technology to reduce the recurring costs.

FAO (1978) defined AEZ as a near homogeneous area similar with respect to (a) broad soil groups, (b) overhead climate and (c) length of moisture availability period in relation to crop production. The efforts of FAO were to concentrate on creation of broad crop feasibility zone based on FAO/UNESCO Global Soil and Terrain Map on 1:5 m scale by superimposition of climate and moisture availability period. The major drawback of AEZ of FAO so created is its limited utility for crop planning at regional sub-levels for Asia, Africa, Europe and Latin America.

In India, Krishnan and Singh (1968) delineated soil climatic zone by superimposing moisture index (P-PE/PE x 100) and mean air temperature isopleths on broad soil types. Later, Murthy and Pandey (1978) divided the country into eight agro-ecological sub regions (AERs) based on broad physiography, rainfall and potential water surplus/deficit, major soils and agricultural regions, which, however, is an overly simplified approach. Oversimplification led to different limitations in this method, due to grouping together the area with different physiography, temperature and soils in a zone. For instance, Rajasthan desert, the Indo-Gangetic Plains and the Eastern Himalayas were grouped in one AER. Similarly, Jammu and Kashmir and the north -west Uttar Pradesh were also grouped into the same region. Subramanian (1983) later delineated 20 AEZ with 36 combinations of moisture adequacy (AE/PE) Index (IMA) and dominant soil groups of FAO/UNESCO soil map. Subramanian’s method also suffered from limitations since physiography and bio-climate were not considered. Consequently, both cold-arid and warm-humid regions of Jammu and Kashmir were grouped in one zone. Besides, the north-west and north-east Himalayas with contrasting agro-climatic conditions were also grouped in one zone. This method, therefore, was not enough to bring out a uniform AEZ for a practical crop planning.

The Planning Commission, Govt. of India, divided the country into 15 broad agro-climatic zones (ACZs) based on physiography and climate with a view to develop agro-climatic zone-based planning for the mobilization of resources and their optimum utilization within the framework of resource constraints and potential of each region (Anonymous, 1989). Following this, state agricultural universities (SAUs) were advised to divide each zone/state into sub-zones under National Agricultural Research Project (NARP). Thus, a total of 127 NARP sub-zone map was developed on the basis of rainfall, existing cropping pattern and the administrative units. The ACZ and AC (Agro Climate) sub-zones did not consider the length of growing period (LGP) and natural boundaries of soil-scape, water and climate. Moreover, use of state as “unit” for sub-divisions resulted in creation of many sub-zones, showing similar agro-climatic characteristics, as was the case with NARP map. During 90’s the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) proposed the concept of LGP as an index of crop production and fraction of soil-scape (FAO, 1978) of FAO to address these inadequacies. This approach uses bio-climatic concept based on soil-water balance, which is a direct function of quantum of moisture availability and nature of senso-thermal radiation in a landform.

Methodology to Develop Agro-Ecological Sub Regions (AESRs)

Five basic elements which form the AESR framework are described below: i) land utilization types (LUTs) : specific agricultural production systems with defined input and management relationships and crop-specific environmental requirements and adaptability characteristics, ii) land resource database : geo-referenced climate, soil and terrain data, combined into a database, iii) crop yields and LUT requirements matching: procedures for calculating potential yields and for matching environmental requirements of the crop/LUT with the respective environmental characteristics contained in the land resource database, by land unit and grid-cell, iv) assessments of crop suitability and production potential of land (models), and v) applications for agricultural developmental planning.

NBSS&LUP used rainfall, temperature, vegetation and potential evapo-transpiration (PET) as the parameters of bio-climate, with soils and physiography dove-tailed along-with length of growing period (LGP) to arrive at 20 AERs. The LGP was estimated using rainfall, PET and water storage in soils following the method of Sehgal *et al*. (1992) (Fig. 1). Later, narrower LGP interval (~30 days) for diverse crop suitability was brought in for further sub-divisions of bio-climate, which included soil parameters viz. depth and available water content (AWC). This resulted in 60 AESR map as detailed by Velayutham *et al*. (1999). National Agricultural Innovative Project (NAIP) sponsored a research

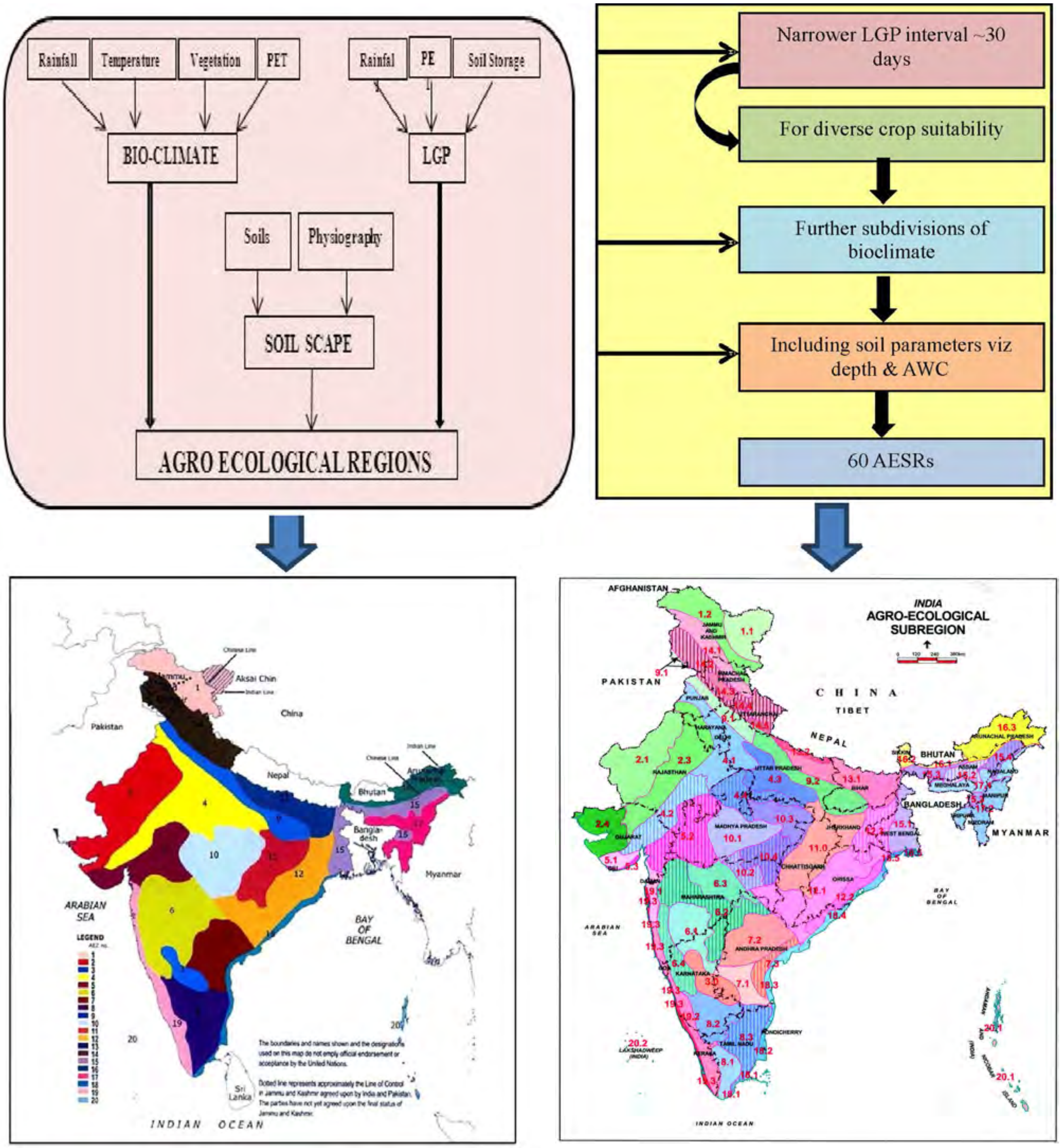


Fig. 1: Chronology of developing Agro-ecological regions (AERs) and sub-regions (AESRs) by NBSS&LUP, Nagpur (Source: Mandal *et al*., 2014)

effort to revise these AESRs using the scheme outlined in Fig. 2, in two important food growing zones of the country namely; the Indo-Gangetic Plains (IGP) and the Black Soil Region (BSR). Earlier, a generalized LGP value (based on overhead climatic data) of dominant soils of the region was considered, while developing an AESR map in 1994 with 60 delineations. Recent research of Pal *et al.* (2006) indicates that the shrink-swell soils do not remain saturated with moisture at field capacity due to poor hydraulic properties caused by sub-soil sodicity characterized by high pH, exchangeable sodium percent and poor to very poor drainage as evidenced by low saturated hydraulic conductivity. To estimate LGP, 100 mm m^{-1} water has been used as standard for the deep soils assuming this amount to be the measure of available water after cessation of rains. Later Kadu *et al.* (2003) reported this measure to be an over estimation. This demanded estimation of the LGP to be modified (Mandal *et al.*, 2014). With the passage of nearly two decades and the advent of modern techniques of database management and improved knowledge based on natural resources the existing AESR map was revised using recently built soil and terrain digital database (SOTER) (Chandran *et al.*, 2014). The estimated available water content, saturated hydraulic conductivity, and use of pedo-transfer functions in assessing the drainage conditions and soil quality helped in computing precise LGP. This newly built data-set enabled the researchers to revise the earlier AESRs (developed in 1994) in BSR and IGP areas. For a better AESR-based agricultural land use planning the revised map would be useful. Fig. 3 details each step for the refinement of AESRs.

Application of Agro-Ecological Sub Regions (AESRs)

At Regional Level

The basic purpose of developing AESR is to delineate a homogenous land unit, which will behave similarly under a given set of management practice imposed on a particular land use. For crop planning, this concept is further narrowed to the behaviour of a polygon of AESR, for instance, for cotton or rice or wheat production. AESR concept in rain-fed system is largely based on available moisture content in soil to sustain plants between rainfall events and after termination of the rains in 78 mha (53% of the net cultivated area). Rain-fed agriculture contributes 85% of the coarse cereals, 83% of the pulse and 70% of the oilseed production apart from 66% cotton fibre output as reported by Bhattacharyya *et al.* (2014a). The majority of the rain-fed areas fall under the BSR and associated areas representing sub-tropical climate with semi-arid to sub-humid bio-climatic systems. Uncertain and erratic distribution of rainfall leads to severe moisture stress in post rainy season causing soil degradation and low crop productivity and frequent crop failures.

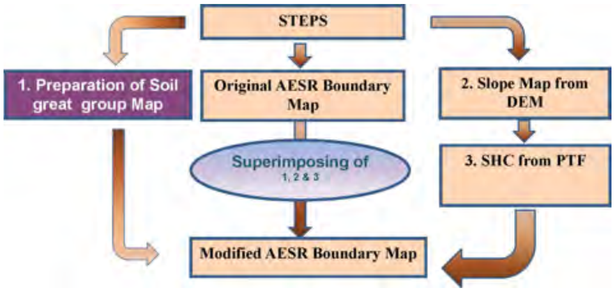


Fig. 2: Schematic presentation to show the modification of agro-ecological sub-regions (AESRs) boundaries (Source: Mandal *et al.*, 2014)

Recent research findings on the use of the soil information system have helped us to identify critical soil constraints, like poor drainage (saturated hydraulic conductivity, sHC) and concomitant development of pedogenic $CaCO_3$ and exchangeable sodium percentage (ESP) in the sub-soil sodicity under SAT environments as described by Ray *et al.* (2014), Tiwary *et al.* (2014) and Basu and Iyer (2004) in various soil physiographic conditions. Therefore, it was imperative to map the sHC and AWC (based on antecedent soil moisture content after the cessation of monsoon rains) for different ecosystems, which was useful to revise the LGP as an index of crop production. The revised LGP within an AESR would help recommending more appropriate crop cultivars and also aid in breeding appropriate and ideal plant types for similar AESRs. The refined BSR map reported by Mandal *et al.* (2014), includes 17 states and 42 AESRs and covers an area of 76.4 mha. Basu and Iyer (2004) dovetailed existing cotton cultivars

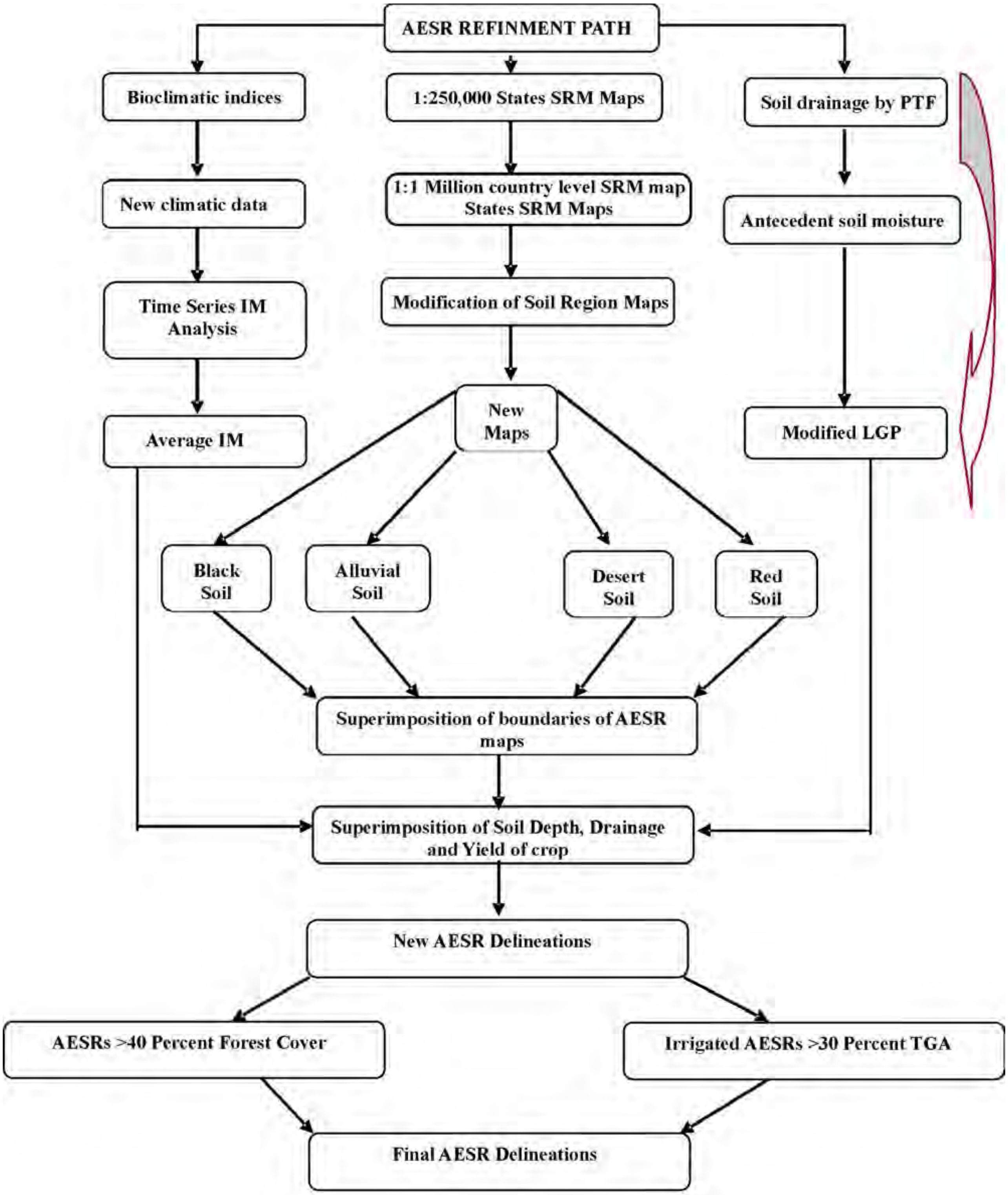


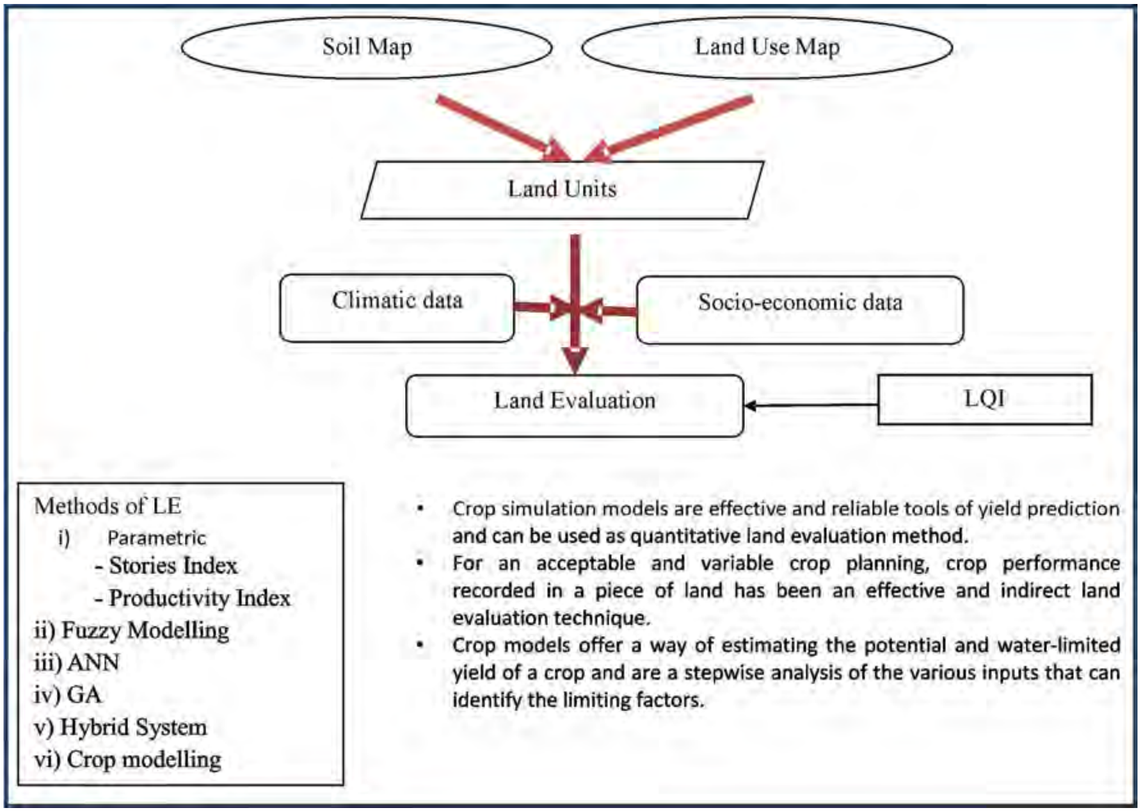
Fig. 3: Flowchart to generate agro-ecological sub-regions (AESR) map

to the original AERS. The refinement of AESRs in BSR further narrows the knowledge gap to help in refining the soil and agro-management technologies which are being used in dry land agriculture for productivity enhancement. More *et al.* (2004) suggested different cotton species and genotypes for different agro-ecological situations of Maharashtra and recommended *G. arboreum* cotton for abiotic stress-prone regions.

Due to intensive cultivation, coupled with high intensity irrigation practices and use of heavy machinery, the soils of IGP are plagued with various types of biotic and abiotic stresses. The IGP is endowed with rich water sources from monsoon rain and snow melt-fed rivers and canals. But due to injudicious use of irrigation water available from ground and canal water, the vast area of IGP is now water-logged and afflicted with soil salinity, which together threaten food security of the IGP area reported by Swaminathan (2002). Although, the combined rice-wheat productivity in favourable climate has reached a peak of 12-19 tha^{-1}, nevertheless the region has been showing stagnation in the yield for quite some time. There is conspicuous yield gap between the western and eastern IGP, the latter being prone to periodic flooding and sub-optional input applications. Aggarwal *et al.* (2000) reported the occurrence of plant diseases and proliferation of herbicide resistant weeds under the rice-wheat cropping system.

The impairment of physical conditions of soils, as discussed earlier, needs to be arrested by adopting improved agro-technology. AESR map has a role to play at this point by flagging exact areas which require attention and prioritization. The map would also help in extrapolation of the recommendation domain on a particular technology validated at one/few locations.

Various steps followed for land evaluation include developing land units to build a model for understanding of evaluating a piece of land (for a particular model) as shown in Fig. 4. For land evaluation, land quality index is a pre-requisite (Fig. 5). Use of soil information system and the principal component analysis described by Ray *et al.* (2014) can provide soil quality indices using minimum data-sets developed by Ray *et al.* (2014) and Chatterjee *et al.* (2014). Various methods for land evaluation were applied within a particular AESR for the soils of the IGP and BSR (Fig. 4).



Methods of LE
- i) Parametric
  - - Stories Index
  - - Productivity Index
- ii) Fuzzy Modelling
- iii) ANN
- iv) GA
- v) Hybrid System
- vi) Crop modelling

- Crop simulation models are effective and reliable tools of yield prediction and can be used as quantitative land evaluation method.
- For an acceptable and variable crop planning, crop performance recorded in a piece of land has been an effective and indirect land evaluation technique.
- Crop models offer a way of estimating the potential and water-limited yield of a crop and are a stepwise analysis of the various inputs that can identify the limiting factors.

Fig. 4: Various steps showing the process of land evaluation (Source: Chatterji *et al.*, 2014)

Soil, land use/land cover and AESR maps in conjunction with information on socio-economic and production systems are used in various steps of land evaluation that help in land allocation to suggest land use plans (Fig. 5). The framework for district level can be downscaled to block level using large scale soil map at 1:10,000. Planners/policy makers need perspective in land use plans for altering the land use allocations through suitable technological and institutional interventions. The NBSS & LUP is entrusted with the responsibility of suggesting land use options and planners/policy makers need the optimum plan along with other alternative plans in the form of decision support system (DSS). Fig. 6 provides a frame work for developing land use plans at district level using Land Management Units (LMU) as primary units for land evaluation. An LMU is a specific area having common land characteristics that can be delineated on a composite map, prepared by super-imposing the soil map, land use/land cover map and AEZ map along with demographic and other socio-economic attributes and the existing production systems. The methodology involves land evaluation techniques that assess the performance of land when put under a specific use and LQI assists this exercise by providing threshold values for environmental indicators and for monitoring the performance of land when put under alternate uses. Socio-economic data on the resource demand and supply is needed for preparing perspective scenarios and Multiple Goal Linear Programming is a tool used for land use optimization.

At national Level

Black soils compete for both cotton and soybean and moisture stress/cracks after cessation of rain result in shrivelled grains of soybean in years experiencing terminal drought. Besides, poor germination and heavy weed infestation result in low groundnut yield in semi-arid Saurashtra, Western Maharashtra and Andhra Pradesh represented by agro-ecoregions (AERs) 2, 6 and 7 as described by Pal *et al.* (2009). In humid regions representing eastern part of the country (AERs 13, 15, 17), the cloddy surface (after harvesting low land paddy) hinders land preparation for the succeeding crop. The AERs 3, 6, 10, 11 and 12 representing the drier parts of the country are characterized by water stress adversely affecting oil seed production. The uplands of Odisha, Jharkhand and Chhattisgarh (AERs 11, 12) have shallow soils deficient in multiple nutrients resulting in low yield of niger, linseed, castor and sunflower. In AERs 8, 10, 13 and 18 on the other hand, low yield of sunflower results due to nutrient deficiency and water-logging.

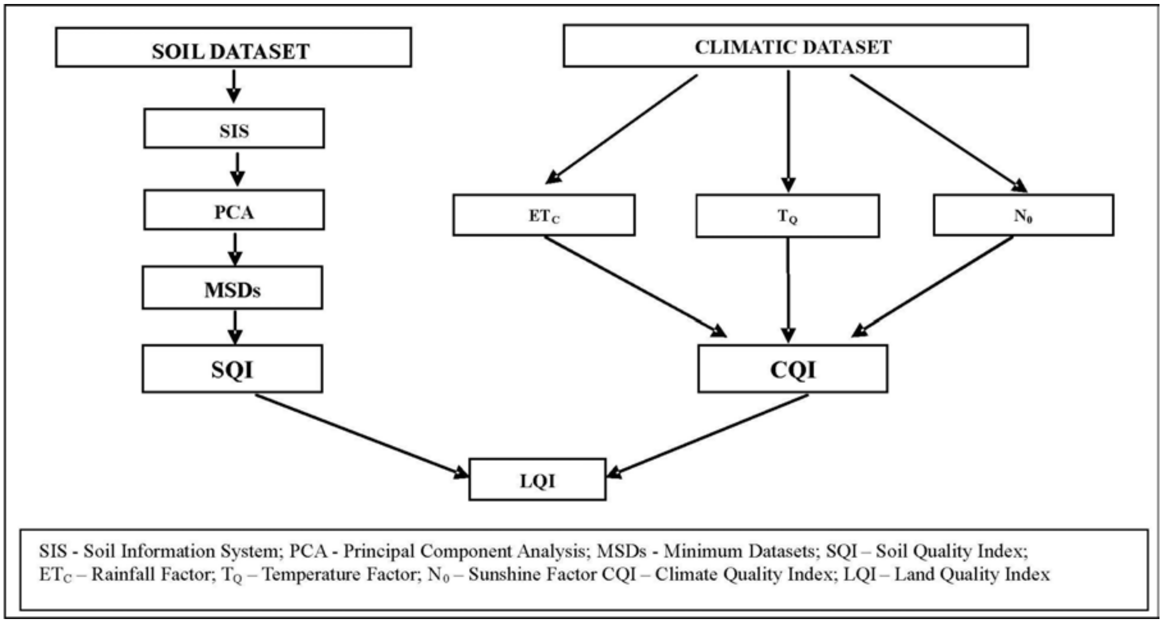


Fig. 5: Schematic representation to derive the land quality index using soil information system (Source: Ray *et al.*, 2014)

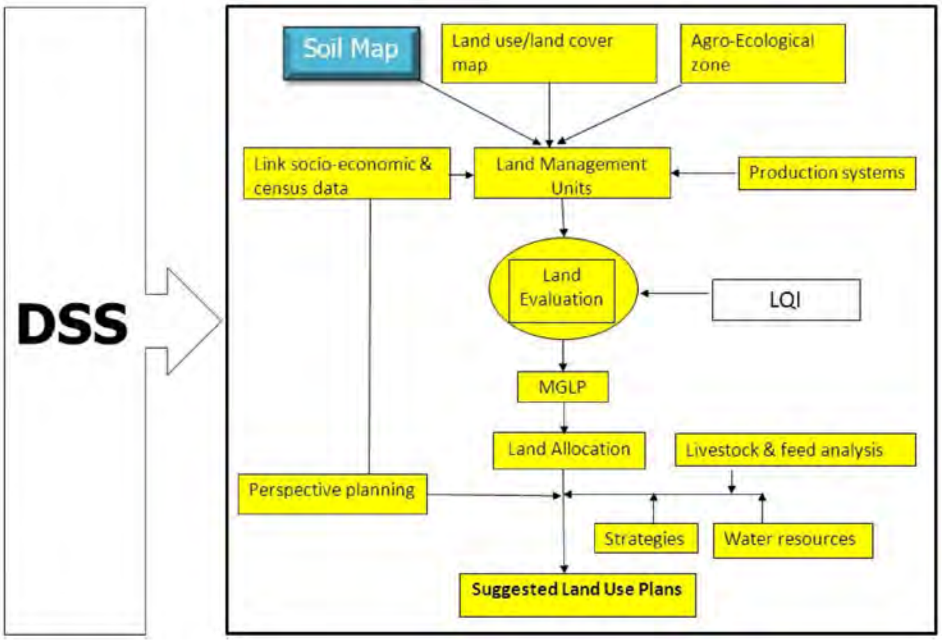


Fig. 6: Framework for developing land use plans at district level-An NBSS&LUP Initiative (DSS: Decision Support System)

Much of these scenarios may be explained better when revised AESR map is used as detailed in the next paragraphs.

Performance of Crop in Different AESRs and the Revision Thereafter

The following examples illustrate how in different AESRs crop performance is influenced by soil parameters and how different properties affect AESR delineation.

AESRs 6.3 (Eastern Maharashtra Plateau, Hot, Moist Semi-arid and Arid) and AESR 10.2 (Satpura and Eastern Maharashtra Plateau, Hot, Dry-sub Humid)

These AESRs (6.3) are represented by Nagpur, Amravati and Akola districts of Maharashtra. Based on 30 years climatic data, the humid period (when precipitation exceeds potential evapo-transpiration) was worked out as 103 days. This helped to estimate the length of growing periods (LGP) as 183 days following the method of FAO (1976). Amravati and Akola districts have shorter humid period and LGP than Nagpur. Between Amravati and Akola districts, difference in humid periods is of 6 days and the difference in LGP is only 10 days. Earlier report indicate seed cotton yield as 1.0-1.8, 0.6-1.7 and 0.6-1.0 t ha^{-1} in the representative soils of Nagpur, Amravati and Akola respectively (Pal *et al.* 2009). This difference in yield and soil properties were researched in detail which shows sHC to influence the yield suggesting a revisit of AESRs in terms of reassessing LGP. The AESR 6.3 has thus been sub-classified by Mandal *et al.* (2014) as 6.3a (LGP: 180-210 days, moderately well drained black soils) and 6.3b (LGP: 180-210 days, imperfectly drained black soils). For AESR 10.2, LGP was reassessed to 180-210 days and old polygon boundary was modified in the AESR map. Short duration cotton variety like PKV 081 with broad bed and furrows performed better than medium to long duration NH615 or Suraj varieties in Akola but the latter two out yield PKV081 at Nagpur, where the LPG was longer. This shows how index soil properties obtained through the basic and fundamental research can answer the inadequacy of pre-revised AESR maps in translating into crop performance differences. It also indicates that the revised AESR map can overcome this inadequacy and can also suggest exact crop varietal choice,as far as soil capacity to support crops is concerned.

AESR 9.1 (Punjab and Rohilkhand Plains, Hot, Dry Moist Subhumid Transition) and 9.2 (Rohilkhand, Avadh and South Bihar Plains, Hot, Dry Subhumid)

Punjab and Haryana (AESRs 9.1 and 9.2) produce nearly 4.5 t ha^{-1} of wheat whereas Bhojpur district of Bihar representing AESR 9.2 produces only 1.6 t ha^{-1}. However, soils of Punjab and Haryana, in general, do not experience waterlogging. This suggests modification of LGP estimation considering real time moisture holding capacity of soils.

In Vertisols (Jhalipura, Kota) of Rajasthan representing semi-arid (dry) bioclimatic system wheat yields (~4.5 t ha^{-1}) are comparable with those of Punjab and Haryana. This fact assumes importance since Vertisols are clayey and usually are not freely drained as the soils of the Indo-Gangetic Plains. Research endeavour by Pal *et al.* (2006) indicates the presence of Ca-rich zeolites in Kota soils. These zeolites improve the sHC to the level of >10 mm hr^{-1} to make these soils well drained permitting to support a good crop. It suggests that crop performance in rain-fed Vertisols is governed mostly by entry of rainwater in soils, amount of rain stored at depth in the soil profile and the extent to which this soil water is released during crop growth. Both the retention and release of soil water are governed by the nature and content of clay minerals, as well as by the nature of the exchangeable cations as reported (Pal *et al.* 2009).

Usefulness of GeoSIS in Planning the AESR-based Crop Performance

Black Soil Region (Cotton)

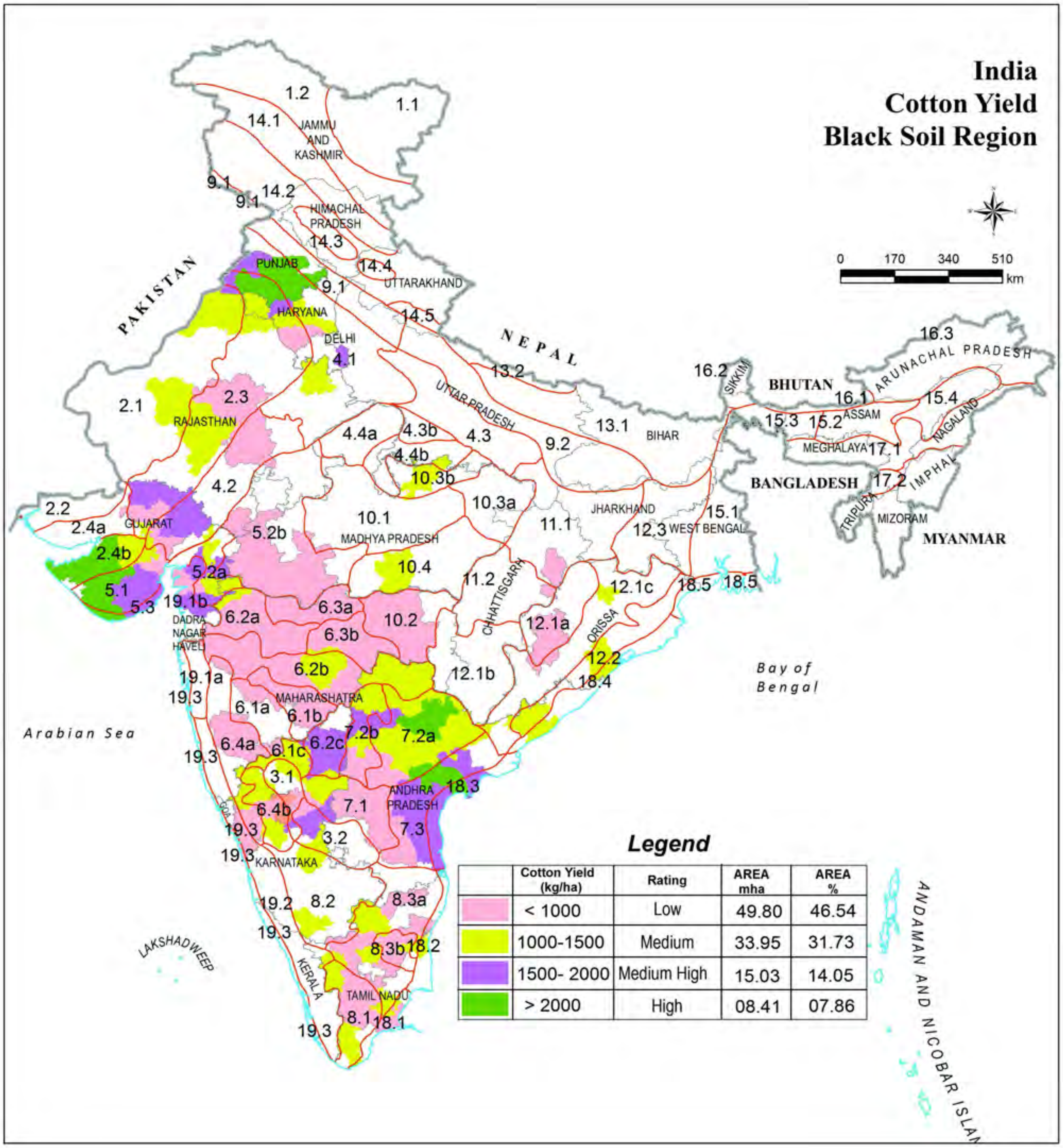
Based on productivity, the cotton growing areas in different AESRs of the BSR are mapped as a part of crop planning. Using all India district level crop yield data of DES (2012), the entire BSR is divided into four different regions such as low, medium, medium-high and high indicating <1000, 1000-1500, 1500-2000 and >2000 kg seed cotton ha^{-1} (Fig. 7). It is interesting to note that merely 23% area under cotton produce >1.5 t ha^{-1} which is the national average. The distribution of cotton yield in different AESRs shows that there is a scope to elevate low to medium cotton yield areas to medium high or high yield categories in 77% area through appropriate site specific management interventions including cultivar selection (Table 1). Alternatively, area under cotton from the low productivity areas can be diverted to more productive crops to ensure food security. Keeping crop variety and other management factors similar, the recently built geo-referenced soil information system (GeoSIS) (Bhattacharyya *et al*., 2014a) was used to find out exact soil-related constraints (mainly physical properties, such as sHC), which can be ameliorated to improve the soil quality to plan cotton production in low and medium cotton yield areas for posterity.

Black Soil Region (Soybean)

Fig. 8 shows soybean growing areas in the black soil region. District level soybean yield data were used to divide the BSR into four regions such as low, medium, medium high and high representing areas yielding < 500, 500-1000, 1000-1500 and >1500 kg ha^{-1} soybean. It may be noted that only 8% area is falling under low category, and ~ 56% areas fall under medium high to high yield category (Fig. 8). The GeoSIS provides soil parameters in terms of their physical, chemical and biological properties to develop a theme map on soybean and its distribution cutting across different AESRs. Exact AESR and the locations of the districts are shown in Table 2 to identify areas under low and medium soybean yield.

Indo-Gangetic Plains (rice)

Fig. 9 shows the rice growing areas in the Indo-Gangetic plains. The district level rice yield data was used to divide the rice growing areas in the Indo-Gangetic Plains into four number of regions such as low, medium, medium high and high representing areas with rice yield of <1000, 1000-2500, 2500-4000 and >4000 kg ha^{-1} rice. Nearly 33 % area fall under medium high to high category of rice yield and medium level of yield is observed in 63 % of the total areas. The use of the GeoSIS and the level of rice yield (Fig. 9) help developing a theme map to indicate the location of AESRs and the districts representing different categories of yield of rice (Table 3). The



	Cotton Yield (kg/ha)	Rating	AREA mha	AREA %
🟥	< 1000	Low	49.80	46.54
🟨	1000-1500	Medium	33.95	31.73
🟪	1500- 2000	Medium High	15.03	14.05
🟩	> 2000	High	08.41	07.86

Fig. 7: AESR-based crop planning in Black Soil Region: Cotton

GeoSIS provides the base maps which have been generated using the physical, chemical and biological parameters affecting crop performance. The revised AESR map thus serve as a base to generate rice yield map using yield data of this crop obtained from various stations.

Indo-Gangetic Plains (Wheat)

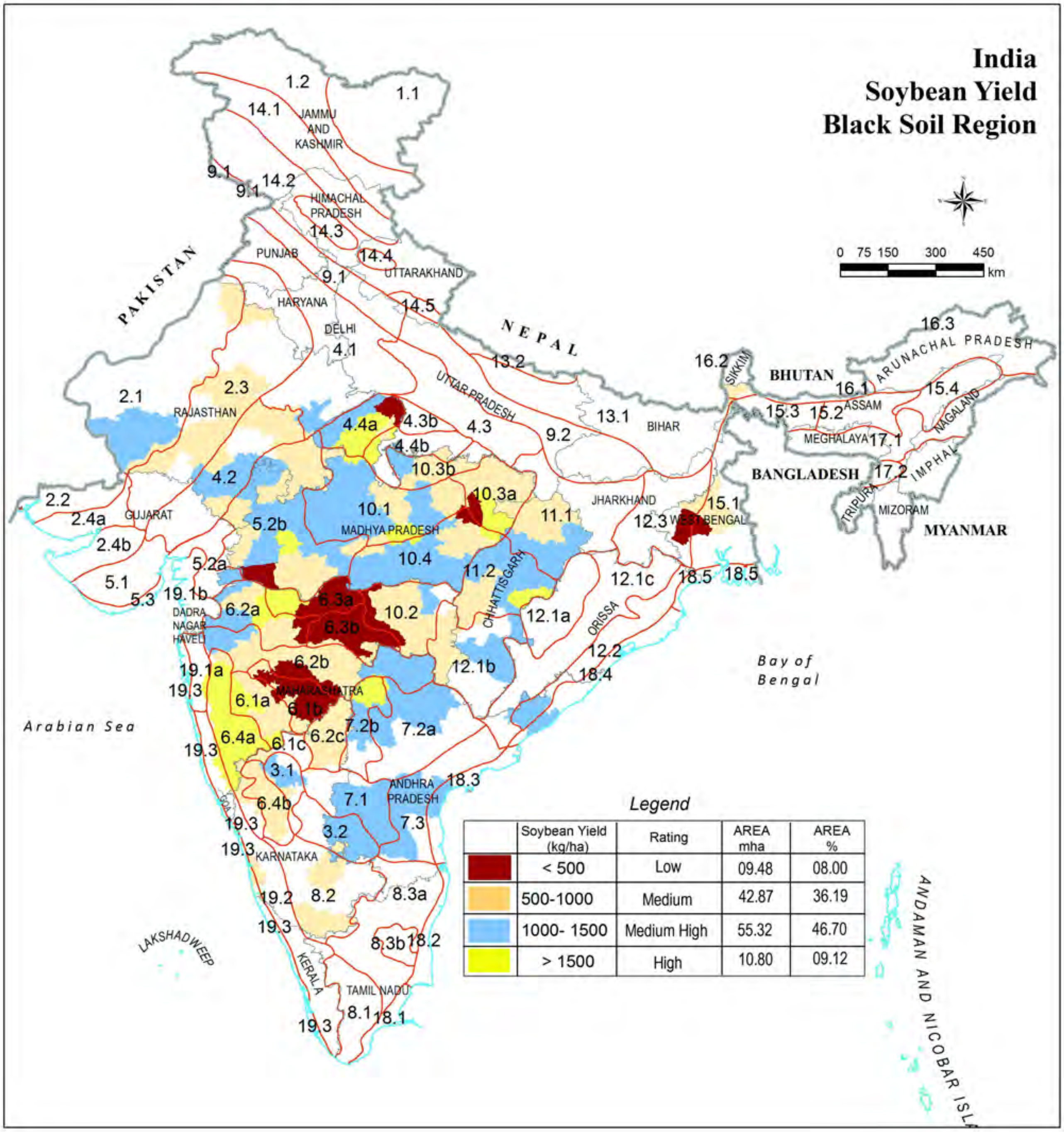
Fig. 10 shows the wheat growing areas in the Indo-Gangetic plains. The district level wheat yield data was used to divide the wheat growing areas in the IGP into four regions such as low, medium, medium high and high representing areas with wheat yield of

Table 1: Cotton yield and acreage in different agro-ecological sub-regions in the black soil region

AESR	Total area of AESR (mha) (a)	Area covered by cotton		Districts
		mha (b)	% (a/b)* 100	
		Low < 1000 kg ha^{-1}		
2.3	15.50	3.37	21.74	Nagpur, Bhiwani, Patan
2.4a	2.30	0.05	2.38	Patan
3.1	1.56	0.37	23.87	Koppal, Gadag
3.2	3.08	0.27	8.65	Koppal
4.1	13.63	0.18	1.29	Rohtak
4.2	7.91	2.23	28.26	Ajmer, Bhilwara
5.1	3.44	0.42	12.25	Ahmadabad
5.2a	2.24	0.13	5.75	Jhabua, Bharuch
5.2b	12.71	6.00	47.23	Banswara, Ratlam, Dhar, Jhabua, Barwani, Khargo, Khandwa, Dewas, Bhilwara
6.1a	2.77	0.99	35.85	Ahmadnagar, Satara, Sangli
6.1b	2.38	2.02	84.66	Latur, Ahmadnagar, Bid Osmanabad
6.2a	3.75	3.38	90.14	Dhule, Nashik, Aurangabad, Jalna, Buldhana, Jalgaon
6.2b	7.34	4.07	55.40	Dhule, Nashik, Aurangabad, Jalna, Buldhana, Jalgaon, Ahmadnagar, Bid, Nanded
6.3a	2.34	2.33	99.17	Akola, Jalgaon, Buldhana, Amravati
6.3b	2.73	2.57	94.03	Washim, Akola, Yavatmal, Buldhana
6.4a	4.67	2.44	52.13	Satra, Sangli, Ahmadnagar, Uttarkahhad
6.4b	2.08	0.61	29.32	Dharwad, Gadag
7.1	3.95	2.63	66.50	Kurnool Kadapa, Koppal
7.2a	7.19	0.86	11.93	Mahbubnagar
7.2b	2.77	0.88	31.82	Mahbubnagar, Nizamabad
7.3	5.58	1.12	20.08	Kurnool, Kadapa
8.1	3.37	1.75	51.94	Teni, Dindigul, Erode, Madurai, Virudunagar
8.2	6.80	0.18	2.61	Erode
8.3a	7.38	2.29	31.10	Vellore, Viluppuram, Erode, Salem, Tiruchirappalli
8.3b	1.15	0.82	70.99	Tiruchirappalli, Salem, Perambalu
10.1	9.24	0.13	1.44	Dewas
10.2	4.41	3.57	80.91	Wardha, Nagpur, Chandrapur, Yavatmal, Amravati
10.4	6.56	0.08	1.18	Nagpur, Betul
11.1	9.07	0.58	6.42	Raigarh
11.2	5.12	0.14	2.76	Raigarh
12.1a	3.91	1.30	33.22	Balangir, Bhawanipatna, Bargarh
12.1c	8.71	0.25	2.87	Bhawanipatna
18.1	0.91	0.39	42.35	Ramanathpuram
18.2	1.31	0.09	6.87	Viluppuram, Pondicherry
19.1a	1.38	0.02	1.81	Nashik
19.1b	2.02	0.44	21.59	Bharuch
19.2	7.63	0.54	7.13	Uttarkahhad
19.3	1.87	0.12	6.42	Uttarkahhad
		Medium 1000-1500 kg ha^{-1}		
2.1	14.74	3.61	24.45	Ganganagar, Hanumangarh Jodhpur
2.3	15.50	3.78	24.38	Pali, Patan Sirsa, Hanumangarh, Jodhpur, Pali, Alwar
2.4b	2.58	0.62	24.02	Surendrangarh
3.1	1.56	0.39	24.85	Bijapur, Belgaum
3.2	3.08	0.31	10.14	Chitradurga
4.1	13.63	1.54	11.30	Alwar, Jind, Sonipat
4.2	7.91	0.20	2.51	Surendrangarh, Kheda

4.4b	1.08	0.20	18.33	Chhatarpur
5.1	3.44	0.25	7.40	Surendranagarh
5.2a	2.24	0.87	38.71	Nadurbar, Narmada, Godhra
5.2b	12.71	0.03	0.27	Nadurbar
6.1a	2.77	0.03	0.99	Bijapur
6.1c	0.97	0.90	92.45	Bijapur, Kolhapur
6.2a	3.75	0.30	7.89	Nadurbar
6.2b	7.34	3.22	43.84	Parbhani, Hingoli, Adilabad Karimnagar
6.2c	2.22	0.15	6.67	Bijapur, Raichur
6.3b	2.73	0.16	5.97	Parbhani, Hingoli
6.4a	4.67	0.42	8.90	Belgaum
6.4b	2.08	1.20	57.94	Belgaum, Haveri
7.1	3.95	0.78	19.80	Raichur
7.2a	7.19	4.13	57.46	Karimnagar, Khammam Nalgond, Hyderabad
7.2b	2.77	1.18	42.59	Nizamabad, Hyderabad
7.3	5.58	0.16	2.89	Khammam
8.1	3.37	1.21	35.82	Coimbatore, Sivaganga Tirunelveli
8.2	6.80	1.33	19.60	Chitrdurga, Mysore Dharmapuri
8.3a	7.38	1.62	21.96	Dharmapuri, Namakkal Coimbatore, Sivaganga
8.3b	1.15	0.14	12.39	Cuddalore, Dharmapuri
10.1	9.24	0.02	0.21	Chhatarpur
10.3b	2.41	0.74	30.82	Chhatarpur
10.4	6.56	1.26	19.18	Chhindwara
12.1c	8.71	0.56	6.47	Deogarh, Chhatrapur
12.2	4.19	1.26	30.05	Chhatrapur, Vishakhapatnam
18.1	0.91	0.14	15.08	Thiruvananthapuram
18.2	1.31	0.19	14.41	Cuddalore
18.4	2.90	0.72	24.81	Vishakhapatnam
19.1b	2.02	0.01	0.47	Godhra
19.2	7.63	0.21	2.75	Coimbatore
Medium High 1500-2000 kg ha^{-1}				
2.1	3.61	0.12	3.36	Firozpur
2.3	3.78	1.65	43.60	Firozpur, Banaskantha Fatehbad
2.4a	0.01	0.01	100.00	Banaskantha
3.1	0.39	0.06	16.08	Bellary
3.2	0.31	0.54	174.22	Bellary
4.1	1.54	0.76	49.61	Firozpur, Faridkot, Fatehbad
4.2	0.20	1.44	723.79	Ghandinagar, Mahesana Sabarkantha
5.1	0.25	1.38	542.29	Amreli, Bhavnagar
5.2a	0.87	0.53	61.24	Vadodara, Surat
5.2b	0.03	0.20	591.32	Vadodara
5.3	0.61	0.32	52.95	Bhavnagar, Amreli
6.1a	2.77	0.00	0.16	Gulbarga
6.1b	2.38	0.01	0.58	Gulbarga
6.1c	0.97	0.05	5.57	Gulbarga
6.2a	3.75	0.04	1.12	Surat
6.2c	2.22	1.50	67.25	Gulbarga, Medak
6.4b	2.08	0.03	1.65	Bellary
7.1	3.95	0.27	6.76	Gulbarga, Bellary
7.2a	7.19	0.56	7.84	Medak, Krishna
7.2b	2.77	0.70	25.39	Medak, Gulbarga
7.3	5.58	2.65	47.42	Ongole, Nellore, Krishna
18.2	1.31	0.03	2.16	Nellore
18.3	1.97	1.32	66.84	Ongole, Nellore, Krishna
High > 2000 kg ha^{-1}				
2.1	3.61	0.002	0.05	Muktsar
2.3	3.78	0.88	23.30	Muktsar, Bathinda, Mansa
2.4b	2.58	1.79	69.20	Jamnagar, Rajkot
4.1	13.63	1.28	9.40	Moga, Ludhiana, Sangrur Faridkot, Patiala
5.1	3.44	1.26	36.55	Junagadh, Rajkot
5.3	0.61	0.27	44.88	Junagadh
7.2a	7.19	1.61	22.45	Waragal, Nalgonda
7.3	5.58	0.69	12.33	Guntur
9.1	4.59	0.41	8.86	Ludhiana, Patiala
18.3	1.97	0.22	11.06	Guntur

* AESR: Agro eco sub-regions



	Soybean Yield (kg/ha)	Rating	AREA mha	AREA %
🟥	< 500	Low	09.48	08.00
🟧	500-1000	Medium	42.87	36.19
🟦	1000- 1500	Medium High	55.32	46.70
🟨	> 1500	High	10.80	09.12

Fig. 8: AESR-based planning in Black Soil Region: Soyabean

< 1000, 1000-2500, 2500-4000 and > 4000 kg ha^{-1}. More than 64 % of the total wheat growing area is covered under medium high to high range of wheat yield. By using GeoSIS and the level of wheat yield the theme map developed indicate exact areas showing different categories of yield (Fig. 10). In Table 4, the areas (districts) representing all the AESRs are shown to indicate different yield levels of wheat.

Concluding Remarks

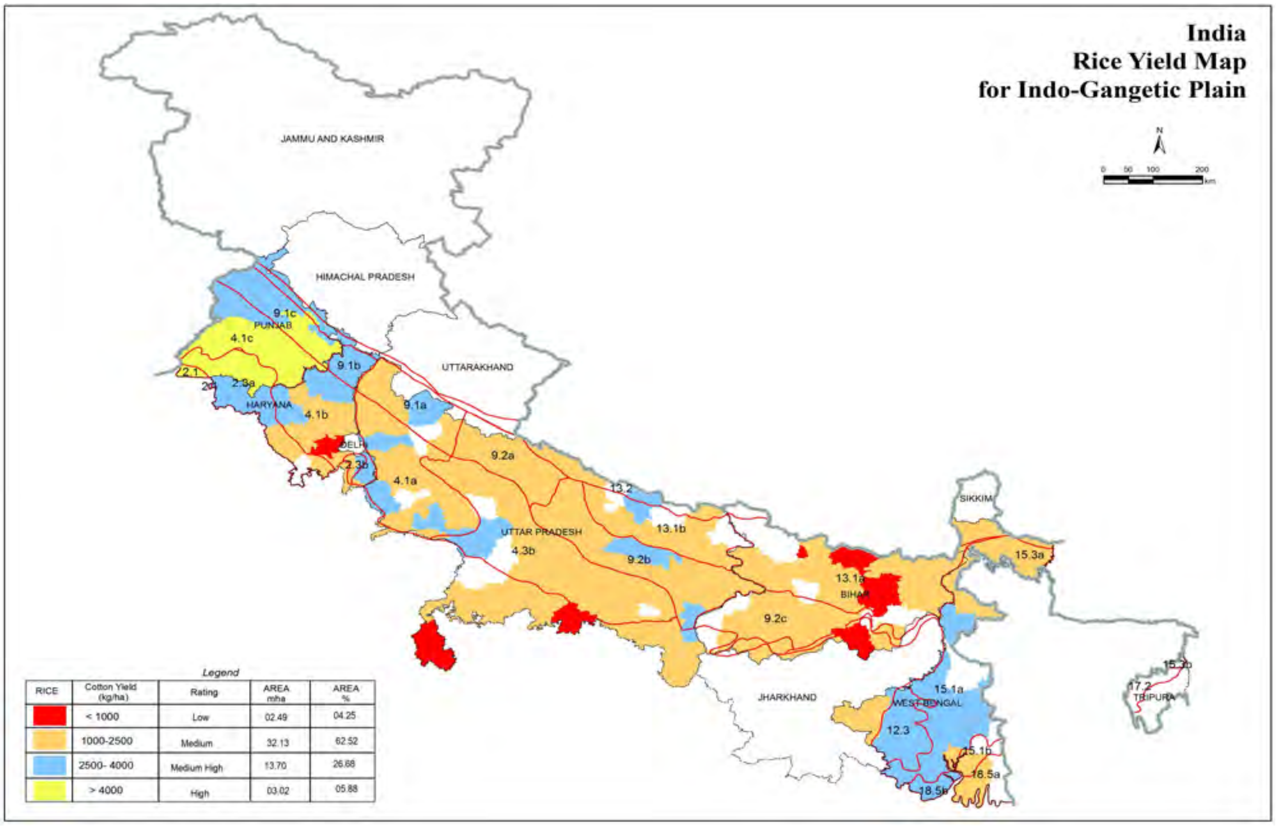
The utility of AESR based soil information systems has earlier been reported to estimate soil carbon and

Table 2: Soybean yield and acreage in different agro-ecological sub-regions in the black soil region

AESR*	Total area of AESR (mha) (a)	Area covered under soybean mha (b)	% (a/b)* 100	Districts
Low < 500 kg ha^{-1}				
5.2b	4.73	0.60	12.71	Barwani
6.1a	5.15	0.14	2.77	Bid, Osmanbad
6.1b	72.45	1.73	2.38	Bid, Osmanbad, Latur
6.2a	9.72	0.36	3.75	Buldhana
6.2b	10.82	0.79	7.34	Bid, Latur, Yavatmal
6.2c	1.20	0.03	2.22	Osmanbad, Latur
6.3b	84.90	2.32	2.73	Amravati, Akola, Buldhana, Washim, Yavatmal
10.1	0.15	0.01	9.24	Umaria
10.2	15.60	0.69	4.41	Amravati, Yavatmal
10.3a	7.51	0.29	3.83	Umaria
10.4	3.48	0.23	6.56	Umaria
12.3	8.26	0.50	6.03	Bankura
15.1	5.13	0.28	5.51	Bankura
Medium 500-1000 kg ha^{-1}				
2.3	15.50	0.28	1.81	Ajmer
3.1	1.56	0.24	15.55	Belgaum, Gadag
3.2	3.08	0.15	4.74	Tumkur
4.1	13.63	0.13	0.92	Kota, Tonk, Bundi
4.2	7.91	2.14	27.12	Ajmer, Tonk, Bundi, Dungarpur
4.3	6.03	0.01	0.15	Rewa
4.3b	1.08	0.02	1.44	Bind
4.4a	2.96	0.63	21.21	Bind, Datia, Baran
4.4b	2.83	0.32	11.24	Bind, Datia, Chhatrpur, Panna
5.2a	2.24	0.02	0.88	Jhabua, Banswara
5.2b	12.71	6.16	48.47	Jhabua, Banswara, Khargon, Khandwa, Hoshngabad, Mandsaur, Jhalawar, Kota, Bundi, Baran, Dhule
6.1a	2.77	1.68	60.61	Solapur, Ahmadnagar
6.1b	2.38	0.66	27.55	Solapur, Ahmadnagar, Bidar
6.1c	0.97	0.25	26.09	Belgaum, Gulbarga
6.2a	3.75	1.84	49.00	Dhule, Aurangabad, Jalna
6.2b	7.34	3.59	48.88	Ahmadnagr, Aurangabad, Jalna, Parbhani, Hingoli, Nanded
6.2c	2.22	2.02	91.03	Bidar, Gulbarga
6.3a	2.34	0.05	1.95	Khargon, Khandwa
6.3b	2.73	0.39	14.31	Hingoli, Nanded, Parbhani, Chandrpur
6.4a	4.67	0.74	15.95	Ahmadnagr, Belgaum, Dharwad, Haveri
6.4b	2.08	1.81	87.26	Belgaum, Dharwad, Haveri
7.1	3.95	0.03	0.77	Gulbarga
7.2a	7.19	0.00	0.05	Gadchiroli
7.2b	2.77	0.16	5.89	Gulbarga, Nanded
8.2	6.80	1.59	23.33	Mysore, Tumkur
10.1	9.24	2.53	27.35	Baran, Sagar, Hoshangabad, Panna, Katni
10.2	4.41	2.90	65.77	Wardha, Nagpur, Chandrapur
10.3a	3.83	2.26	59.09	Satna, Rewa, Sidhi
10.3b	2.41	1.41	58.57	Chhatrapur, Panna, Satna, Rewa
10.4	6.56	1.71	26.05	Hoshangabad, Mandla, Dindori, Nagpur
11.1	9.07	1.84	20.31	Ambikapur
11.2	5.12	1.55	30.31	Rajnadgaon, Durg
12.1b	6.70	1.70	25.42	Gadchiroli, Durg
12.3	6.03	0.29	4.84	Barddhaman, Birbhum
13.1	11.23	0.05	0.42	Darjiling
15.1	5.51	0.99	18.01	Barddhaman, Birbhum
15.3	1.81	0.01	0.68	Darjiling
16.2	1.19	0.30	24.83	Darjiling

19.2	7.63	0.30	3.88	Udupi, Belgaum
19.3	1.87	0.11	5.84	Udupi
Medium High 1000-1500 kg ha^{-1}				
2.1	14.74	4.33	29.39	Hanumangarh, Barmer
2.3	15.5	5.04	32.49	Hanumangarh, Pali, Samand, Jalor
3.1	1.56	0.62	39.54	Bagalkot
3.2	3.08	1.65	53.43	Anantpur
4.1	13.63	0.64	4.69	Sawai
4.2	7.91	2.15	27.21	Samand, Uadaipur, Chittaurgarh
4.4a	2.96	1.08	36.50	Morena, Sheopur
4.4b	2.83	0.10	3.41	Tikamgarh, Damoh
5.2a	2.24	0.28	12.37	Nandurbar
5.2b	12.71	5.00	39.37	Nimachi, Ratlam, Dhar, Ujjain, Shajapur, Harda, Dewas
6.1c	0.97	0.01	0.69	Bagalkot
6.2a	3.75	1.02	27.32	Nashik
6.2b	7.34	2.87	39.17	Adilabad
6.2c	2.22	0.03	1.48	Hyderabad
6.3a	2.34	0.02	0.83	Baitul, Chhindwada, Seoni, Balaghat
6.3b	2.73	0.02	0.79	Adilabad
6.4a	4.67	0.03	0.61	Nashik
6.4b	2.08	0.02	1.03	Bagalkot
7.1	3.95	2.53	64.04	Kurnool, Cuddapah, Anantpur
7.2a	7.19	3.09	42.99	Karimnagar, Warangal, Sangereddi
7.2b	2.77	0.97	35.17	Warangal, Sangareddi, Hydrabad
7.3	5.58	2.50	44.85	Ongle, Cuddapah
8.2	6.8	0.61	8.95	Chamrajnagar, Anantpur
8.3a	7.38	0.05	0.72	Chamrajnagar, Anantpur
10.1	9.24	6.02	65.13	Guna, Vidisha, Rajgarh, Bhopal, Sahajanpur, Sehore, Raisen, Dewas, Damoh, Jabalpur
10.2	4.41	0.43	9.82	Bhandara
10.3a	3.83	0.38	9.80	Bainkuthpur, Bilaspur
10.3b	2.41	0.56	23.29	Tikamgarh, Damoh
10.4	6.56	4.33	66.03	Baitul, Chhindwada, Seony, Balaghat
11.1	9.07	2.38	26.29	Baikunthpur, Korba, Raigarh, Jashpurnagar
11.2	5.12	2.88	56.21	Kawaradha, Bilaspur, Jangir, Raipur
12.1b	6.7	1.84	27.39	Jagdalpur, Raipur
12.1c	8.71	0.17	1.95	Vishakhapantam
12.2	4.19	0.70	16.60	Vishakhapantam
18.3	1.97	0.46	23.22	Ongle
18.4	2.9	0.40	13.70	Vishakhapantam
19.1a	1.38	0.02	1.81	Nashik
High > 1500 kg ha^{-1}				
4.4a	2.96	1.20	40.50	Shivpuri, Gwalior
4.4b	2.83	0.37	13.02	Shivpuri, Gwalior
5.2b	12.71	0.44	3.49	Indore, Jalgaon
6.1a	2.77	0.92	33.31	Pune, Satara, Sangli
6.2a	3.75	0.45	12.01	Jalgaon
6.3a	2.34	0.77	32.99	Jalgaon
6.4a	4.67	3.28	70.20	Sangli, Kolhapur
6.4b	2.08	0.00	0.06	Kolahapur
7.2a	7.19	0.06	0.88	Nizaamabad
7.2b	2.77	0.76	27.44	Nizaamabad
10.1	10.45	0.63	6.06	Shivpuri
10.3a	3.83	0.85	22.10	Shahdol
10.4	6.56	0.26	4.01	Shahdol, Narsimhpur
11.1	9.07	0.00	0.01	Shahdol
11.2	5.12	0.49	9.49	Mahasamund
12.1a	3.91	0.03	0.68	Mahasamund
12.1b	6.70	1.91	28.45	Dantewara
19.1a	8.71	0.01	0.11	Pune
19.2	1.38	0.11	8.12	Kolapur

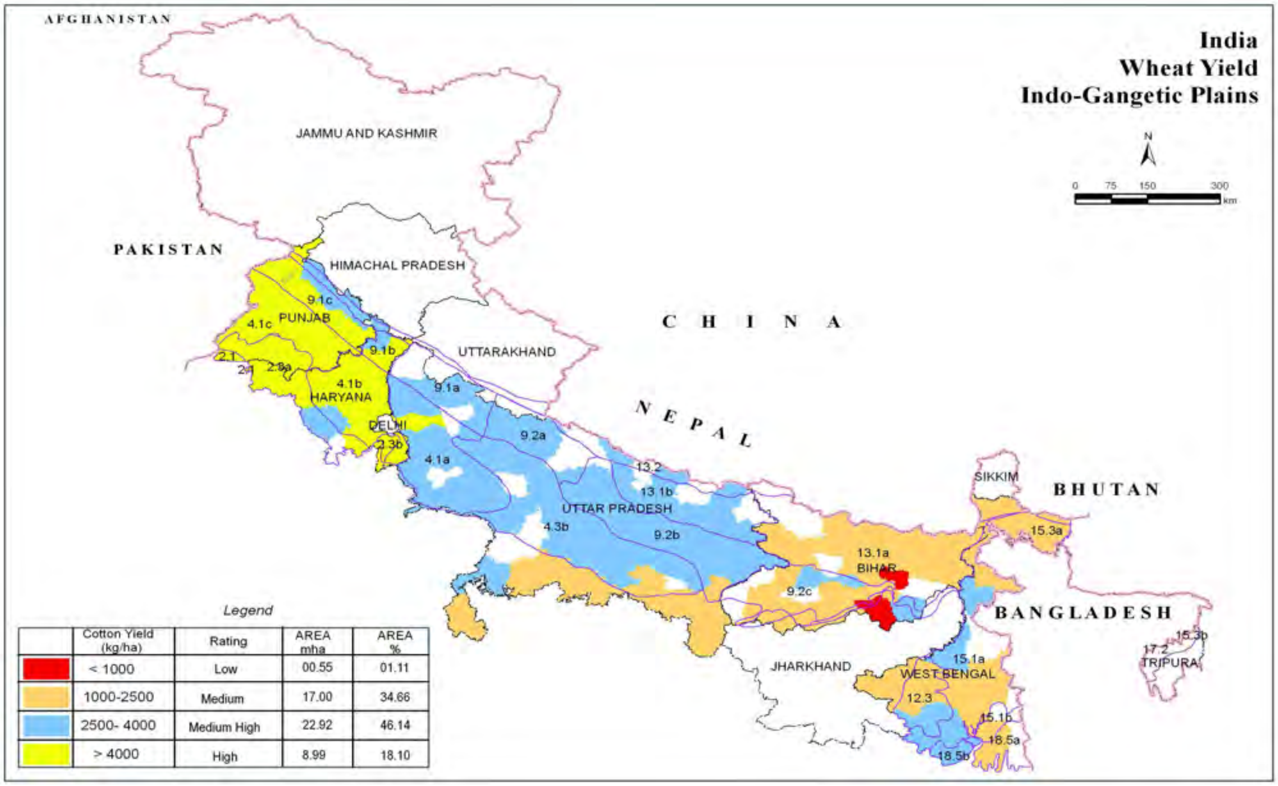
* AESR: Agro eco sub-regions



Legend

RICE	Cotton Yield (kg/ha)	Rating	AREA mha	AREA %
🟥	< 1000	Low	02.49	04.25
🟧	1000-2500	Medium	32.13	62.52
🟦	2500- 4000	Medium High	13.70	26.68
🟨	> 4000	High	03.02	05.88

Fig. 9: AESR-based crop planning in Indo-Gangetic Plains: Rice



Legend

	Cotton Yield (kg/ha)	Rating	AREA mha	AREA %
🟥	< 1000	Low	00.55	01.11
🟧	1000-2500	Medium	17.00	34.66
🟦	2500- 4000	Medium High	22.92	46.14
🟨	> 4000	High	8.99	18.10

Fig. 10: AESR-based crop planning in Indo-Gangetic Plains: Wheat

Table 3: Rice yield and acreage in different agro-ecological sub-regions in the Indo-Gangetic Plains

AESR	Total area of AESR (mha) (a)	Area covered under rice		Districts
		mha (b)	% (a/b)* 100	
		Low < 1000 kg ha^{-1}		
4.1b	2.83	0.21	7.56	Jhajjar
4.3b	6.37	0.02	0.35	Jhajjar
9.2c	2.64	0.03	1.02	Jamui
13.1a	6.12	1.00	16.40	Shivhar, Madhubani, Madhepura, Saharsa, Khagaria
		Medium 1000-2500 kg ha^{-1}		
2.3a	2.49	0.51	20.60	Bhiwani, Rewari
2.3b	0.16	0.10	61.83	Guragaon
4.1a	4.08	2.44	59.72	Baghpat, Meerut, Muzaffarnagar, Muradabad, BulandShahr, Aligarh, Etah, Agra, Muradabad
4.1b	2.83	1.31	46.46	Panipat, Jind, Rotak, Sonipat, Bhiwani, Rewari, Gurgaon
4.3b	6.37	5.23	82.11	Budaun, Hardoi, Unnao, Kanpur, Fatehpur, Kanpur, Bareilly, Rae Bareli, Fatehpur, Pratap Garh, Shajahanpur, Agra, Jaunpur, Kaushambi, Allahabad, Varanasi, Ghazipur, Lucknow
9.1a	2.1	1.06	50.39	Saharanpur, Muzaffarnagar, Meerut, Rampur
9.2a	2.09	1.87	89.70	Saharanpur, Lakhimpur, Pilibhit, Rampur, Bareilly, Sitapur
9.2b	4.17	3.48	83.35	Sitapur, Bara Banki, Lucknow, Sultanpur, Azamgarh, Maunath Bhanjan, Ballia, Ghazipur
9.2c	2.64	2.16	81.67	Ara, Patna, Sasaram, Bhiar Sharif, Luckeesarai, Begusarai, Gaya, Nawada, Jahanabad, Shekpura
12.3	1.38	0.03	2.31	Puruliya
13.1a	6.12	3.69	60.36	Gopalganj, Siwan, Chhapra, Muzaffapur, Banka, Sitamarhi, Darbhanga, Samastipur, Begusaraj, Supaul, Araria, Purnia, Katihar, Kishanganj, Jalpaiguri
13.1b	2.82	1.86	65.83	Gonda, Bahraich, Basti, Sant Kabir Nagar, Gorakhpur, Deoria, Maharajganj
13.2	1.33	0.71	53.57	Maharajganj, Lakhimpur, Pilibhit, Bahraich
15.1a	4.32	0.73	16.91	Raiganj, Balur Ghat, Haora
15.1b	0.44	0.23	52.24	Lalipur, Haora
15.3a	0.89	0.89	99.57	Koch Bihar, Jalpaiguri
18.5a	0.83	0.45	54.52	Lalipur, Haora
		Medium High 2500-4000 kg ha^{-1}		
2.1	0.13	0.01	4.70	Sirsa
2.3a	2.49	0.83	33.34	Sirsa, Fatehbad, Hisar
2.3b	0.16	0.05	31.51	Fatehbad
4.1a	4.08	1.26	30.91	Mathura, Firozabad, Manipur, Gaziabad
4.1b	2.83	1.12	39.69	Fatehbad, Hisar, Karnal, Kurukshetra
4.1c	2.54	0.60	23.45	Amritsar, Jalandhar, Kapurthala
4.3b	6.37	0.61	9.64	Etawah, Auraya, Kannauj
9.1a	2.1	0.46	22.05	Bijnor
9.1b	0.55	0.52	94.68	Ambala, Yamunanagar, Karnal, Kurukshetra, Panchkula
9.1c	1.66	1.01	61.14	Gurdaspur, Hosharpur, Kapurthala, Asmritsar, Jalandhar, Rupnagar
9.2b	4.17	0.70	16.71	Faizabad, Ambedkar Nagar, Chandauli
9.2c	2.64	0.01	0.26	Chandauli
12.3	1.38	1.34	97.44	Bankura, Medinapur, Birbhum, Bardhman
13.1a	6.12	0.01	0.13	Maldah
13.1b	2.82	0.21	7.34	Balarampur
13.2	1.33	0.18	13.83	Balarampur
15.1a	4.32	2.84	65.69	Maldah, Birbhum, Krishnanagar, Chunchura, Medinipur
18.5b	0.36	0.36	99.00	Medinipur
		High > 4000 kg ha^{-1}		
2.1	0.13	0.12	94.67	Firozpur
2.3a	2.49	0.95	38.34	Firozpur, Muktsar, Bathinda, Mansa, Faridkot
4.1c	2.54	1.95	76.60	Firozpur, Muktsar, Bathinda, Mansa, Faridkot, Moga, Sangrur, Patiala, Ludhiana, Fatebagarh Sahib
9.1c	1.66	0.65	39.00	Patiala, Fatehgarh Sahib, Ludhiana, Nawashahr

Table 4: Wheat yield and acreage in different agro-ecological sub regions in the Indo-Gangetic Plains

AESR*	Total area of AESR (mha) (a)	Area covered under wheat		Districts
		mha (b)	% (a/b)* 100	
		Low < 1000 kg ha^{-1}		
9.2c	2.64	0.03	1.02	Jamui
13.1a	6.12	0.19	3.06	Khagaria
		Medium 1000-2500 kg ha^{-1}		
4.3b	6.38	0.57	8.89	Allahabad, Mirzapur, Chitrakut, Banda, Hamirpur
9.2b	0.55	0.22	40.23	Chadauli, Mirzapur
9.2c	2.64	1.58	59.97	Ara, Sasaram, Aurangabad, Gaya, Nawada, Bhiarsharif, Shekhpura, Munger, Begusari
12.3	1.38	0.86	62.60	Bankura, Barddhaman, Puruliya
13.1a	6.12	4.45	72.78	Gopalganj, Siwan, Chhapra, Muzaffarpur, Darbhanga, Samastipur, Madhubani, Supaul, Saharsa Madhepura, Purnia, Kathiar, Kishanganj, Jalpaiguri
13.1b	2.82	0.01	0.24	Gopalganj, Siwan
15.1a	4.32	2.14	49.44	Barddhaman, Kariahnagar, Chunchura, Haora, Bankura
15.1b	0.44	0.23	52.91	Haora, Lalipur
15.3a	0.89	0.89	99.57	Jalpaiguri, Koch Bihar
18.5a	0.83	0.45	54.52	Lalipur
		Medium High 2500-4000 kg ha^{-1}		
2.3a	2.49	0.36	14.40	Bhiwani
4.1a	4.08	3.81	93.50	Baghapat, Meerut, Muzaffarnagar, Muradabad, Gautam Buddha Nagar, BulandShahr, Aligarh, Mathura, Agra Firozabad, Mainpuri, Etawah, Etah, Muradabad
4.1b	2.83	0.25	8.75	Bhiwani, Muzaffarnagar
4.1c	2.54	0.00	0.01	Ambala
4.3b	6.37	5.08	79.78	Budaun, Etah, Etawah, Auraiya, Kunnauj, Hardoi, Kanpur, Unnao, Raebareli, Pratapgarh, Jaunpur Varanasi
9.1a	2.1	1.07	50.90	Muzaffarnagar, Bijnor, Meerut, Moradabad
9.1b	0.55	0.17	30.72	Ambala, Panchkula
9.1c	1.66	0.37	22.35	Hoshiarpur, Nawashahar, Rupnagar, Ambala
9.2a	2.09	1.39	66.49	Rampur, Bareilly, Pilibhit, Shahjahanpur, Sitapur
9.2b	4.17	3.85	92.38	Sitapur, Barabanki, Faizabad, Azamgarh, Lucknow, Sultanpur Azmgarh, Maunath Bhanjan, Ballia, Ghazipur, Jaunpur, Varanasi, Hardoi
9.2c	2.64	0.39	14.92	Patna
12.3	1.38	0.51	37.15	Medinipur, Bhrbhum
13.1a	6.12	0.11	1.78	Banka, Patna
13.1b	2.82	2.06	72.89	Bahraich, Gonda, Balrampur, Bsti, Sant Kabir Nagar, Gorakhpur, Deoria, Maharajganj
13.2	1.33	0.60	44.83	Maharaganj, Bahraich, Pilibhit, Balrampur
15.1a	4.32	1.43	33.16	Medinipur, Bhrbhum, Maldah
18.5b	0.36	0.36	99.00	Medinipur
		High > 4000 kg ha^{-1}		
2.1	0.13	0.12	94.67	Firojpur, Sirsa
2.3a	2.50	1.94	77.62	Rewari, Sirsa, Fatehbad, Mansa, Bhatinda, Muktgar, Hisar, Firozpur
2.3b	0.16	0.15	93.35	Gurgaon, Fatehbad
4.1a	4.08	0.30	7.23	Ghaziabad, Fatehbad
4.1b	2.83	2.42	85.55	Hisar, Sonipat, Fatehbad Jind, Karnal Kurukshetra, Panipat, Sonipat, Rothak, Jhajjar Rewari
4.1c	2.54	2.54	100.04	Amritsar, Firozpur, Moga, Sangrur, Patiala, Faridkot, Muktsar, Ludhiana, Jalandhar, Kapurthala, Bathinda
9.1a	2.10	0.00	0.00	Yamunanagar
9.1b	0.55	0.35	64.31	Yamunanagar, Kurukshetra, Karnal
9.1c	1.66	1.29	77.79	Gurudaspur, Amritsar, Kapurthala, Ludhiana, Fatehgarh Sahib, Patiala, Jalandhar

*AESR: Agro eco sub-regions

available K stock (Bhattacharyya *et al.*, 2007a,b,c; 2013; Telpande *et al.,* 2013), for prioritizing areas for soil carbon sequestration (Bhattacharyya *et al.,* 2008) and for conservation agriculture (Bhattacharyya *et al.,* 2014a). In the present study, recently built soil information system developed by Bhattacharyya *et al.* (2014a) has been utilized for generating theme maps for cotton and soybean crops in BSR, rice and wheat in the IGP by relating various soil factors influencing crop performance. Information on crop yield in different AESRs representing various districts for cotton, soybean, rice and wheat to improve crop yield in these AESRs are explained. It is observed that keeping crop and management factors similar, the major soil parameters such as bulk density (BD), saturated hydraulic conductivity (sHC) and exchangeable sodium percent (ESP) not only govern the crop performance but also determine the soil and land quality (Bhattacharyya *et al.*, 2014a; Ray *et al.*, 2014; Tiwary *et al.*, 2014; Srivastava *et al.*, 2014 and Velmourougane *et al*., 2014). The low and medium yield levels of these crops are caused due to poor soil quality which can be ameliorated so that the areas experiencing low yield can reach medium high to high yield level for all these crops. The Geo-SIS assisted AESR based crop planning thus not only help identifying exact locations (districts) for soil management interactions, but also amply demonstrates how at the national and regional level the revised AESR delineations can act as a technology transfer tool for agricultural land use planning thus paving the way to web-based soil information technology (Bhattacharyya *et al*, 2014b, 2015).

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