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Issues and Strategies of Natural Resource Management and Land Use Planning in Semi-arid Regions of India

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Abstract: In Indian context, land use planning is usually centred on agricultural land use and livestock management with peripheral window for common property resources and non timber forest produce. National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) has delineated the country into different agro-ecological regions (AER) based on four parameters soil, physiography, length of growing period (LGP) and bioclimate. This article dwells on the land use planning issues and strategies of semi-arid region that covers 101 Mha area of the country. It is home to more than 341 million human population spread in 175 administrative districts. The region has very little area under forest (10%). There are many intra-regional variations that entail different strategies for agricultural development or land use planning. In AER 4, 164 million people reside, which is almost 50% of the total population in semi-arid region. Because the per capita land availability is lowest in this part of India, it is pertinent that the land resources cannot be expected to provide sustenance unless land use changes substantially from agriculture to more rewarding, employment generating activity. In AERs 7 and 8 the net sown area is relatively low, therefore there appears to be land availabe that could be utilized for developments such as pasture lands, agro-forestry development etc. Current utilization status of four main resources namely land, water, forest and livestock is discussed to identify potential for development in each sector. We argue that land resource inventory needs to be developed for this purpose. Modern tools that could be employed for inventorization of soil resources are also discussed.

Key words: Land use planning, semi-arid region, land resource inventorization, agro-ecological region, soil survey.

Agriculture in India accounts for 14% of the GDP, 12% of country's exports, and generates employment to the 50% of the work force of the country. Its dependence on natural resources like soil and water is profound. Increasing concern of land degradation, dwindling water resources, increasing risk of environmental degradation and declining productivity calls for the research on land use planning in the developing countries including India. The natural resource management (NRM) programmes based on scientific land use planning offer a system-based approach of management for efficient utilization and conservation of natural resources for achieving food, nutritional, livelihood security and environmental sustainability.

Land use planning (LUP) finds its origin in the increasing scarcity of land, the competition for scarce land by a growing number of users, and to avoid the risk that might lead to conflicts. It is equally associated with the growing concern for protection of the environment and a more sustainable use of space. Issues related to land use and its planning are becoming increasingly complex and land resource planners/managers/officials often lack the right information which limits their capacity to suggest judicious land use options and appropriate land management decisions. Scientifically guided optimal utilization of land based on precise and quantified information of land resource inventory on 1:10000 scale using geo-spatial techniques for both agricultural and non-agricultural purposes is of utmost importance. The information on land resources certainly guide to the farmers/planners/executors to select proper land use, right technologies based on the potentiality and constraints of well defined land management unit. Thus the scientific land use plan will enable to meet various competing demands of the land on one hand and enhance the production potential of the land and minimize the land degradation on the other. The process of land use planning would facilitate better land care and management which, in turn, would go a long way in ensuring sustainable agricultural development.

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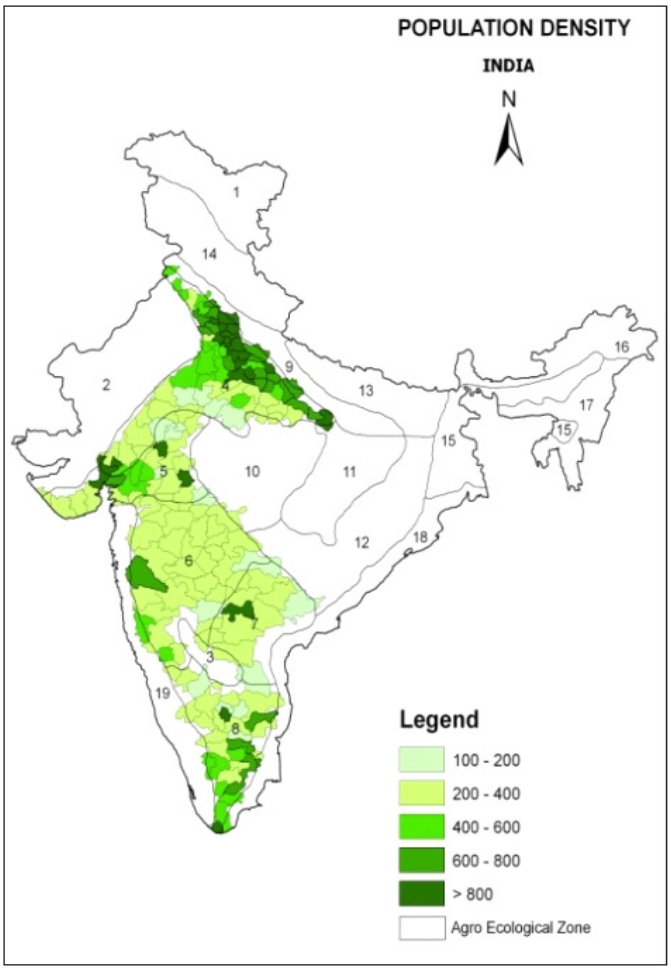

Fig. 1. Population density in semi-arid region of India.

Semi-arid region in India is spread in an area of more than 116 Mha (about 35% of the total geographical area of the country), which is primarily characterized by low and erratic rainfall with high variability, soils with low inherent fertility status, land degradation and poor economic status of farmers. The semi-arid region of the country is thickly populated (Fig. 1) and occupies about 35% land mass and 27% population of the country. Development of irrigated agriculture in the country has enabled self-sufficiency in food requirement. The flip side of this development has been disproportionately low emphasis on developing rainfed agriculture. Though semi-arid parts of Punjab, Haryana and Uttar Pradesh have over the years been food bowl of the country, rest of the semi-arid region continues to grapple with uncertainties of monsoon and subsistence agriculture. Consequently more than 520 million people inhabiting semi-arid region are eking out their livelihood within the constraints of available natural resources. It therefore, becomes essential that the natural resources are used sustainably on the basis of scientific land use planning.

ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) has delineated the country into different agro-ecological regions (AERs) based on four parameters viz. soil, physiography, length of growing period (LGP) and bio-climate. These AERs assist the planners, administrators and policy makers in regional agricultural land use planning of pragmatic value based on scientific rationale. The semi-arid region covers five agro-ecological regions of the country namely, AERs 4, 5, 6, 7 and 8, extending from north-west to the southern part of the country. AER-wise characteristics, area distribution and land use of the semi-arid region are presented in Table 1. Understandably, the issues related to bio-physical features in the region vary

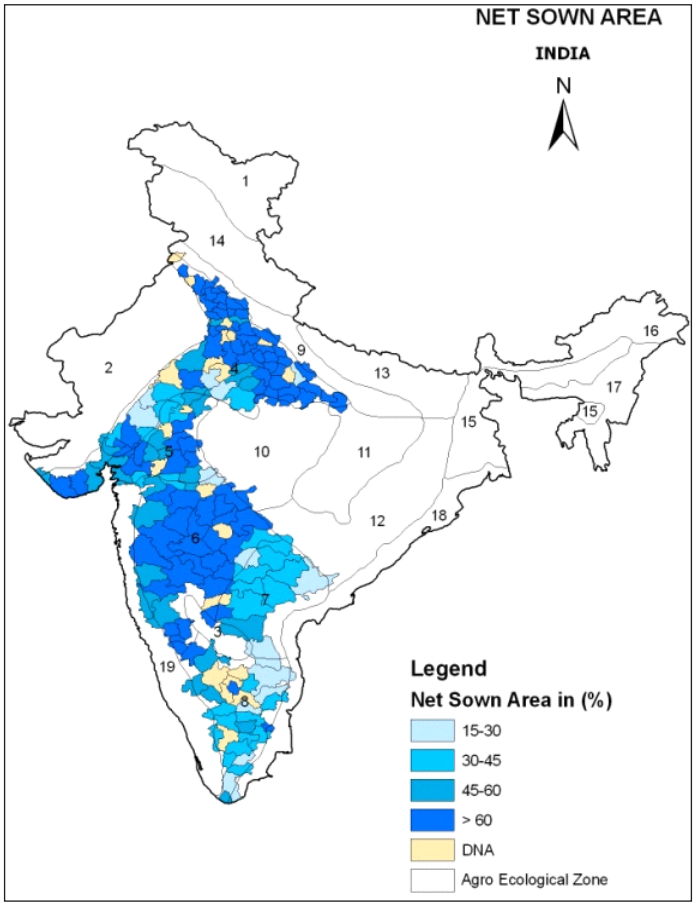

Fig. 2. Net sown area in semi-arid region of India.

widely and the most important among them are discussed accordingly and a strategy of land use planning, accounting soil and climatic resource information, need of the people and market demand is presented as a case study of Sakri and Shirpur tahsils of Dhule district of Maharashtra for the better care of land and people.

Agro-ecological Region (AER) 4

AER 4 constitutes parts of Gujarat, northern plains and central highlands covering an area of 32.3 Mha, representing 9.8% of the total geographical area of the country. Uttar Pradesh (UP) and Punjab contribute the highest and the lowest, respectively, in the total area of AER 4. Per capita land availability is lowest in AER 4 and it is the home of 164 million people, comprising 50% of the population living in the semi-arid region (Fig. 1). Coarse loamy and fine loamy soils constitute the soilscape, frequently interrupted by stable and eroded sand dunes in the northern part and is characterized with more than 69% irrigated area (Fig. 3). Abundant availability of water resources has led to rapid development of irrigation network and the region is known for irrigated rice-wheat cropping system. The net sown area is the highest in Rajasthan and the lowest in Punjab. Productivity is the highest in Punjab and lowest in Rajasthan. Productivity is the combined reflection of groundwater development, area under irrigation and the amount of nutrients applied to different crops (Table 2). UP has agricultural productivity worth Rs. 37556 ha^{-1} (Table 2) as against Rs. 62880 ha^{-1} in Punjab or Rs. 49281 ha^{-1} in Haryana.

The region is classified as hydrologically unsustainable zone for rice-wheat cropping system. Increasing salinity, declining water table (Amarasinghe *et al.*, 2009) (over exploitation of groundwater) and depleting soil fertility are the major concerns (Narang *et al.*, 2001). The groundwater development shows that Punjab ranks first followed by Haryana, Rajasthan and Gujarat in over utilizing groundwater resources. Only Madhya Pradesh (MP) has

Table 1. AER-wise characteristics of semi-arid region of the country

AER and their characteristics	Physiographic region	Land use	Distribution
AER 4 Medium to high AWC and 90-120 days LGP	North Punjab Plain, Ganga-Yamuna Doab, Rajasthan Upland, North Gujarat Plain; Ganga Yamuna Doab, Rohilkhand and Avadah Plain, Madhya Bharat Plateau and Bundelkhand Uplands	Irrigated agriculture on 69% area with crops like rice, millets, maize, pulses, berseem, wheat, mustard and sugarcane; Rainfed agriculture on 25% areas cultivated for sorghum, piegeonpea, soybean pulses (gram), lentil and wheat with one or two protective irrigations	GUJARAT: Sabrakantha, Mahesana, Gandhinagar and Kheda districts HARYANA: Kurukshetra, Kaithal, Jind, Karnal, Sonepat, Rohtak, Jhajjer, Rewari, Gurgaon, Faridabad, Palwal, Satyamev Puram (Mewat) and Panipat districts MADHYA PRADESH: Shivpuri, Sheopur Kala, Morena, Gwalior, Bhind and Datia districts PUNJAB: Taran-Taran, Barnala, Sangrur, Patiala and Moga districts RAJASTHAN: Dungarpur, Udaipur, Karauli, Bharatpur, Dausa, Alwar, Jaipur, Sawai Madhopur, Tonk, Ajmer, Bhilwara, Ajmer, Rajsamand and Dhaulpur districts UTTAR PRADESH: Unnao, Fatehpur, Banda, Mahoba, Hamirpur, Jhansi, Jalaun, Auraiya, Etawah, Agra, Kaushambi, Allahabad, Kanpur Nagar, Kanpur Rural and Kannauj districts
AER 5 Low to medium AWC and 120-150 days LGP	Central Kathiawar Peninsula, Madhya Bharat Plateau, Western Malwa Plateau, Eastern Gujarat Plain, Vindhyan and Satpura range Narmada Valley and Coastal Kathiawar Peninsula	Dryland farming with sorghum, pearl millet, pigeonpea, groundnut, soybean, maize in kharif and wheat (irrigated condition) pulses, sorghum, safflower, sunflower and gram in rabi	GUJARAT: Dahod, Panch Mahals, Vadodara, Anand, Bharuch, Ahmedabad, Bhavnagar, Amreli, Junagarh and Porbandar MADHYA PRADESH: Jhabua, Barwani, Dhar, Khargaon (West Nimar), Khandwa (East Nimar), Alirajpur, Neemach, Mandsaur, Ratlam, Ujjain and Indore districts RAJASTHAN: Banswara, Kota, Chillawgarh, Bundi, Pratapgarh and Chittaurgarh districts
AER 6 Medium to high AWC and 120-150 days LGP	South Western Maharashtra, North Karnataka Plateau, Central and Western Maharashtra Plateau, North Western Telangana Plateau, Eastern Maharashtra Plateau, North Sahyadris and Western Karnataka Plateau	Rainfed agriculture predominantly with sorghum, pigeonpea, pearl millet, cotton (Irrigation) and groundnut	GUJARAT: Narmada district KARNATAKA: Bidar, Gulbarga, Belgaum, Gadag and Dharwad districts MADHYA PRADESH: Burhanpur district MAHARASHTRA: Dhule, Nandurbar, Hingoli, Nanded, Aurangabad, Ahemdnagar, Yavatmal, Amravati, Akola, Washim, Buldhana, Jalna, Beed, Parbhani, Latur, Osmanabad, Solapur, Sangli, Kolhapur, Satara, Pune and Nashik districts
AER 7 Medium to high AWC and 120-150 days LGP	South Telangana Plateau (Rayalseema), Eastern Ghat, North Telangana Plateau and Eastern Ghat (South)	Rainfed agriculture with sorghum, cotton, pigeonpea, rice, groundnut and castor, rice (Irrigation)	ANDHRA PRADESH: Adilabad, Mahboobnagar, Rangareddy, Khammam, Warangal, Nalgonda, Cuddapah, Nizamabad and Karimnagar districts. KARNATAKA: Yadgir and Raichur districts
AER 8 Low to medium AWC and 120-150 days LGP	Tamil Nadu Uplands, Leeward Flanks of South Sahyadris, Central Karnataka Plateau, Tamil Nadu Uplands and Plains	Rainfed agriculture with millets, pulses, and groundnut in kharif; sorghum and safflower in rabi; rice, sugarcane and cotton (Irrigated)	ANDHRA PRADESH: Chittoor district KARNATAKA: Chitradurga, Davanagere, Tumkur, Chikkaballapura, Tumkur, Kolar, Bangalore Rural, Bangalore, Haveri, Hassan, Ramanagaram, Chamarajnagar and Mandya districts TAMIL NADU: Thiruvanamalai, Vellore, Krishnagiri, Dharmapuri, Salem, Perambadur, Tiruchirapalli, Namakkal, Karur, Erode, Coimbatore, Tiruppur, Dindigul, Theni, Madurai, Virudhnagar, Kanniyakumari and Tirunelveli districts

Source: Gajbhiye and Mandal (2008). AWC-Available Water Capacity; LGP-length of growing period.

Table 2. Characteristics of different agro-ecological regions in the semi-arid region of India

State	Rainfall (mm)	Human population	Decadal growth of pop. (%)	TGA	Net sown area	Forest area	Irrigated area	Ground water development	NPK (kg ha^{-1})	Productivity (Rs. ha^{-1})
				Lac hectare		(%)				
AER 4										
Gujarat	603	8141485	13	20.5	12.7	6	53	113	142	27752
Haryana	488	15913005	24	22.1	17.6	3	82	138	358	49282
MP	976	8899387	22	33.5	15.6	21	54	47	85	20116
Punjab	809	6255343	14	10.4	9.4	1	99	208	399	62880
Rajasthan	616	33142917	21	88.2	41.4	7	45	132	63	16686
UP	750	91173705	20	94.4	69.8	3	77	78	186	37556
AER 5										
Gujarat	606	27241619	16	63.6	37.9	8	35	66	115	28631
MP	846	17384160	22	63.8	34.1	13	34	80	103	19984
Rajasthan	659	8819425	20	26.9	11.8	7	47	108	108	19119
AER 6										
Gujarat	775	590379	15	2.6	1.1	37	23	39	52	37723
Karnataka	777	11955577	14	44.0	30.4	5	20	75	67	12687
MP	978	756993	19	3.4	1.04	59	31	59	22	40855
Maharashtra	760	72006934	17	225.0	144.2	8	16	56	88	17490
AER 7										
AP	878	42217882	12	147.9	51.5	17	34	55	200	28267
Karnataka	616	3097758	19	6.8	5.8	0	25	30	161	11073
AER 8										
AP	935	4170468	11	15.1	3.8	16	34	75	108	32794
Karnataka	486	29628064	10	62.8	32.3	10	21	102	78	21469
Tamil Nadu	818	40868706	15	80.8	30.1	18	39	89	149	38188

reasonable amount of groundwater resources that could be utilized for different purposes. Groundwater surveys have shown that about 41-84% of the well water in different states is brackish. Based on criteria suggested by ICAR-Central Soil Salinity Research Institute (Gupta *et al*., 1994), groundwater with higher residual sodium carbonates (RSC) covers about 25% of the total area of Punjab (Bajwa *et al*., 1975). Brackish water covers 21% of the total area of Haryana. Alkali waters are common in Agra, Mathura, Aligarh, Mainpuri, Etah, Unnao, Fatehpur, Ballia and several other districts of UP and to the east of Aravalli range in Rajasthan including parts of Jaipur, Kota, Udaipur, Tonk, Nagaur, Sikar and Jhunjhunu districts. The other associated problem with the groundwater is the presence of toxic levels of boron, fluoride, nitrate, selenium, and silica (Minhas and Bajwa, 2001).

Excessive tillage and wet tillage (puddling), use of rotavators, and freewheeling of the tractors and harvesters (combines) have in general, resulted in gradual compaction of soils, leading to a reduction in long term soil productivity, especially under rice-wheat cropping system (Singh *et al*., 2009). There is an increasing acceptance that excessive tillage and puddling is causing compaction in soils where rice-wheat cropping system is continuously practiced (Sharma and De Datta, 1985; Pandey *et al*., 2000). Singh *et al.* (2009) have reported increased bulk density in Punjab soils accompanied by the formation of hard pan at 15.0 to 22.5 cm depth due to migration

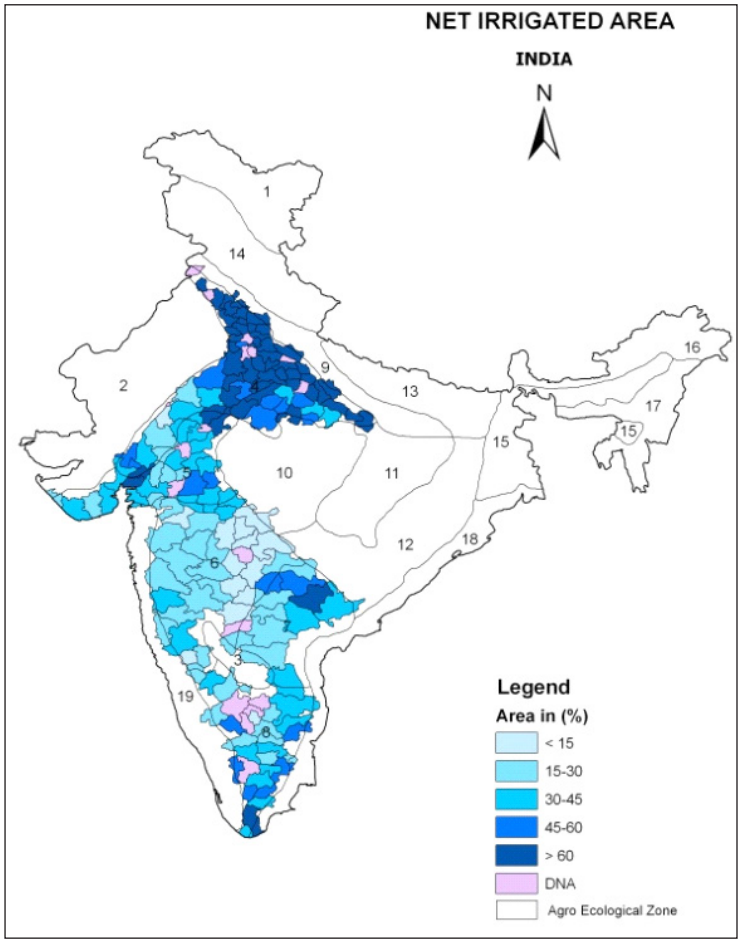

Fig. 3. Net irrigated area in semi-arid region of India.

of silt and clay from upper layers. Decrease in saturated hydraulic conductivity is also noted. Further, projected changes in biophysical environment as a direct consequence of climate change are expected to exacerbate the natural resource management (NRM) issues.

Agro-ecological Region (AER) 5

This region covers the Central highlands (Malwa), Gujarat plains, Kathiawar peninsula, western parts of MP, south-eastern parts of Rajasthan and Gujarat. It covers an area of 17.6 Mha, representing 5.4% of the total geographical area of the semi-arid region of the country. The dominant soils of the Malwa plateau are clayey, slightly alkaline, and calcareous with swell-shrink character. Population and total geographical area is highest in Gujarat, whereas net irrigated area is the highest in Rajasthan. Population density (Fig. 1 and Table 2) is the lowest in Gujarat. Per capita net sown area (Fig. 2) increases from Gujarat to MP and Rajasthan depending upon irrigation potentials. Nutrient application is the highest in Gujarat and lowest in Rajasthan (Table 2). Agricultural productivity of Rs. 28631 ha^{-1} is higher in Gujarat than MP and Rajasthan. The higher land availability in Rajasthan combined with the highest irrigation development is not reflected in terms of agricultural productivity. It implies that irrigation development in this region needs to be coupled with other management practices such as application of soil nutrients and varietal improvement. In MP the forest cover is higher than the other states of the region (Fig. 4).Watershed management programs in this AER have indicated that the agricultural crop yields could improve substantially and livestock management could significantly add to the income.

The major soil constraints are salinity and alkalinity limiting optimum root development and oxygen availability under irrigated agriculture. Severe salinity and seasonal

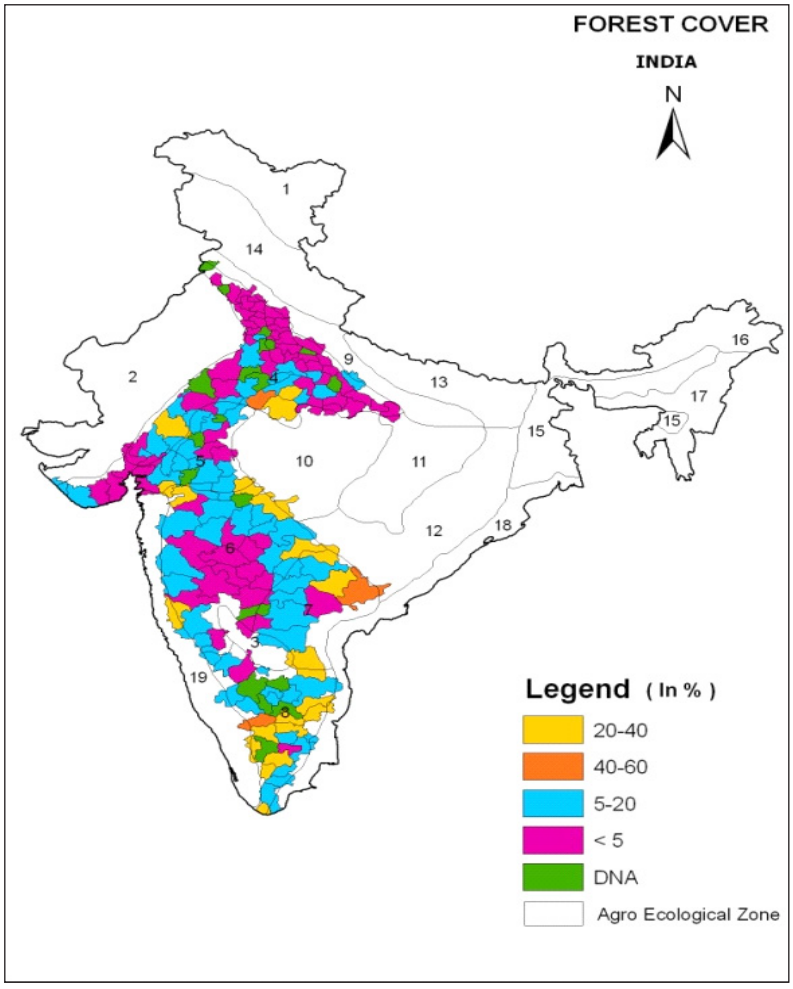

Fig. 4. Forest cover in semi-arid region of India.

inundation of sea water in the Kathiawar coast result in crop failure. The region also experiences sporadic dry spells in the monsoon season.

Agro-ecological Region (AER) 6

The agro-ecoregion with hot, semi-arid climate covers the Deccan plateau, comprising the central and western parts of Maharashtra, northern parts of Karnataka and western parts of Andhra Pradesh. It spreads over 31.0 Mha, representing 9.5% of the total area of the country. Maharashtra contributes the highest in total area of AER 6 covering 22 districts of the state (Table 1). There are wide variations in soil types, which occur on moderately sloping to nearly level lands. Soil texture varies from gravelly sandy loam on the upland to clayey in the low land. The clayey soils are calcareous and moderately alkaline showing marked swell-shrink phenomenon. Calcareousness and sodicity are the major soil constraints. Prolonged dry spells during the monsoon season adversely affect the crop growth and yield.

The net sown area in Maharashtra under AER 6 exceeds 60% (Fig. 2; Table 2). However, only 16% area is irrigated and the groundwater development is noted only on 56% of the area. Traditionally the area is known for rainfed agriculture. Sorghum, pigeon pea and pearl millet are the major kharif season crops. The drought-prone districts of the region, interestingly, have bimodal rainfall distribution pattern. Therefore, crops are grown during September/October on stored residual soil moisture. The main post-rainy season crops are sorghum, safflower and sunflower. Cotton and groundnut are grown under irrigated conditions.

The agricultural productivity in AER 6 is lowest Rs. 12687 ha^{-1} in Karnataka and the highest Rs. 40855 ha^{-1} in MP state. However,

the state of Karnataka is the second largest contributor of the area in AER 6.

Agro-ecological Region (AER) 7

This agro-ecoregion is characterized with hot, semi-arid climate covering the parts of the Deccan plateau (Telangana) and major parts of Eastern Ghats of AP. It occupies an area of 16.5 Mha, representing 5.2% of the total area of the country. It spreads over the states of AP and Karnataka with net sown area of 34% and 85% of the AER, respectively (Fig. 2 and Table 2). The soils in the region are gravelly sandy loam on the uplands and clayey in the low lands. The black soils are clayey, calcareous and strongly alkaline showing remarkably swell and shrink phenomena on wetting and drying. The major soil constraints are subsoil salinity and sodicity. These soils have high production potential, but are difficult to manage. Reddish brown to brown gravelly sandy loam soils of the region are non-calcareous and neutral in reaction. The region is described as drought prone and frequently subject to dry spells during the monsoon season.

Rainfed agriculture is the traditional practice in the region. The major kharif crops grown in the area are sorghum, cotton, pigeon pea, rice, groundnut and castor. The crops grown on stored/residual soil moisture during post-rainy season are sorghum, sunflower, safflower and oilseeds. Rice is cultivated as irrigated crop in rabi season at places.

The agricultural productivity of Rs. 11073 ha^{-1} in Karnataka is almost 60% less than that of AP. Productivity is also the lowest in the entire semi-arid region of the country (Table 2). The reason could be attributed to the type of crop grown and also to the improper development of water resources resulting in lower groundwater development and lower area under irrigation. The net sown area in AP is 35% of the AER, therefore there appears to be surplus land that could be utilized for development of pasture lands and agroforestry.

Fig. 5. Selected blocks under LRI project.

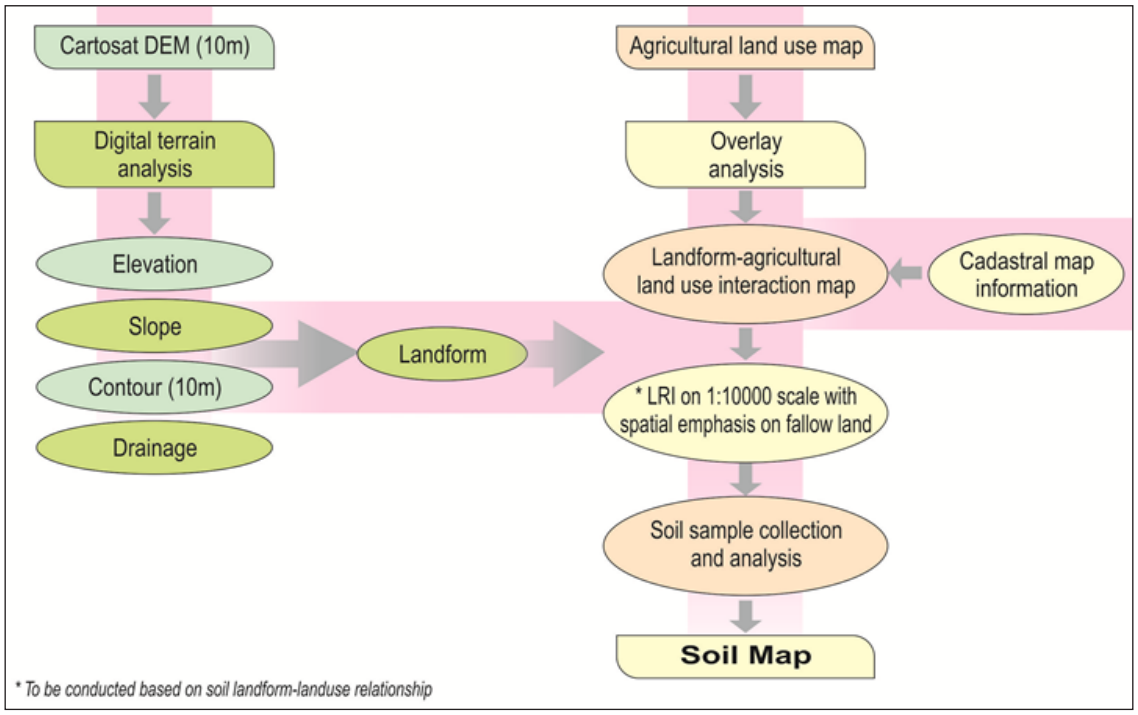

Fig. 6. Methodological framework for LRI on 1:10000 scale.

Agro-ecological Region (AER) 8

The agro-ecoregion 8 with hot, semi-arid climate covers Eastern Ghats, southern parts of Deccan plateau, Tamil Nadu uplands, and western parts of Karnataka. It has an area of 19.1 Mha, representing 5.8% of the total geographical area of the country. The soils of the area are brown to reddish brown occurring on moderately to very gently sloping lands. These are mostly non-calcareous and slightly acidic. The soils are sandy loam to loam in texture with low to medium potential available water capacity (PAWC) and subject to severe droughtiness during crop growth period.

Rainfed agriculture is the traditional practice of the region. Millets, pulses, and groundnut are cultivated in kharif season, whereas sorghum and safflower are grown in rabi season. Rice is cultivated under irrigation. At places, sugarcane and cotton are also grown with irrigation. The irrigated area is about 30% suggesting there is scope of further improvement in the irrigation potential. The agricultural productivity of this region is comparatively higher than that of AERs 5 and 6. The districts of Karnataka have the lowest agricultural productivity of Rs. 21469 ha^{-1} in this part of semi-arid region.

Furthermore, the land resources appear to have been utilized to the limited extent. The reasons for this may be the bio-physical constraints. However, the pertinent point from land use perspective is that the lands could be utilized for useful non-agricultural purposes such as environment services, energy plantations and pasture development.

Issues Related to Land Use Planning

Land degradation, desertification, low irrigation potentials, recurrent dry spells and resource poor farmers are the major constraints for agriculture in the semi-arid region. Small holdings and low per capita availability of land are the other constraints of the region. The predicted climate change is another dimension and may affect the present state of art of agriculture. In AERs 4, 5 and 6, the net sown area ranged from 50 to 61% implying that there is little or no scope for bringing additional area under cultivation (Fig. 2). Agro-ecological regions 7 and 8 have relatively less net sown area primarily due to the natural constraints like poor quality soils and climatic aberrations.

At present, net sown area of the semi-arid region is about 50% of the total area, a very high proportion by any standard. Of the

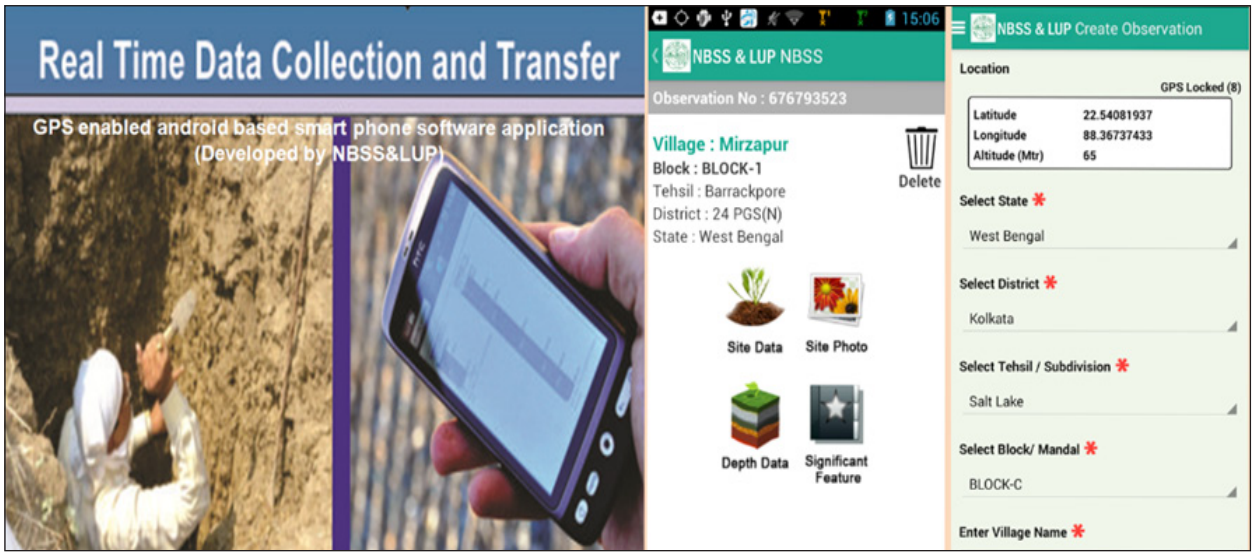

Fig. 7. Android based portable digital assistant for soil survey.

remaining area, 10% is classified as forest for use, leaving thereby 40% for all other land uses including residential, industrial, infrastructure, public utility and other land uses. Intra-regional variations indicate that MP is better placed as compared to other states in AER 4 (Table 2). However, it is also poorly placed in terms of productivity. In UP it becomes worse as almost every possible parcel of land is already under cultivation (0.07 ha per person).

The problem becomes even more severe in a market-driven, unplanned diversification, as well as, urbanization that lead to non-sustainable development. Demand-driven or market-driven land use changes can severely impact natural resources, consequence of which may not be conspicuous immediately, but could cause long term damage. Hence, land use planning becomes imperative.

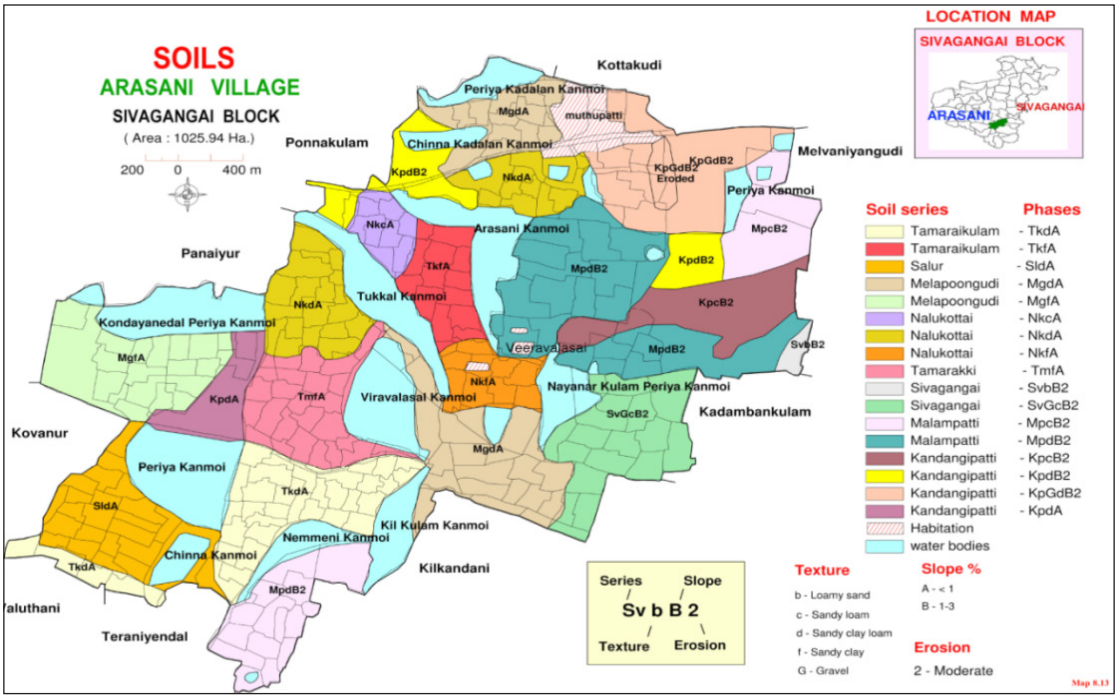

Fig. 8. Farmers/Farm wise soil map.

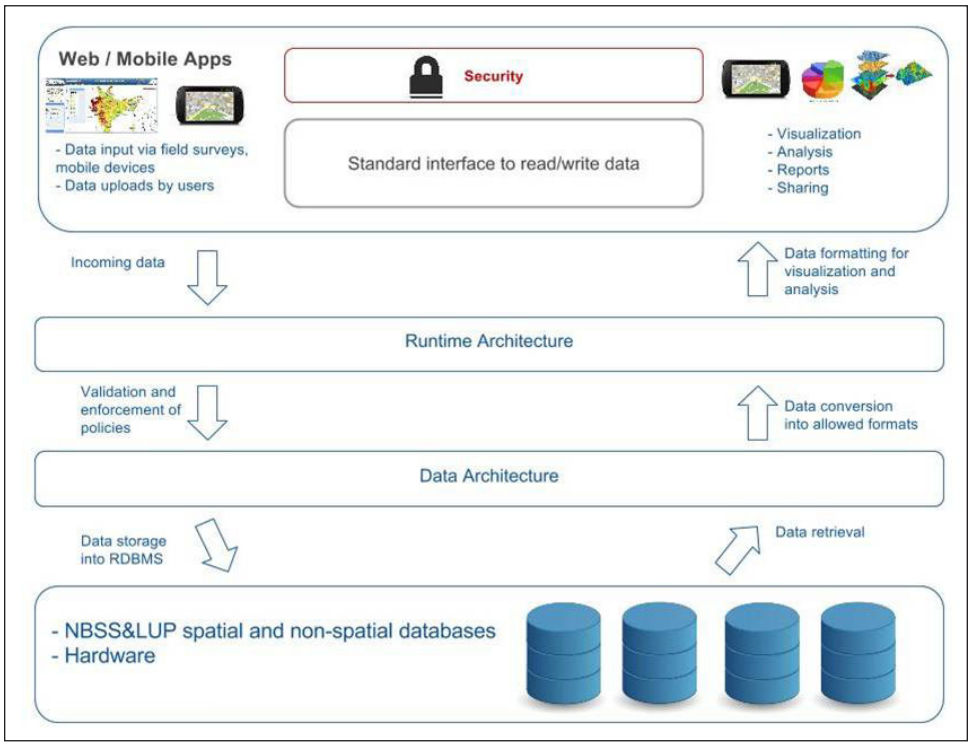

Fig. 9. Conceptual model of Geo-portal under LRI project.

Strategies for Developing Scientific Land Use Planning

Many technologies including rain water harvesting and *in situ* moisture conservation have been initiated for enhancing productivity of rice-fallow, sorghum, pearl millet, soybean, oil seed and pulse based production system. Still rice-fallow system holds the maximum area on the ground. Other important informations like time of sowing with the onset of monsoon, mulching, contingency crop planning are available to offset the delayed onset or early withdrawal of monsoon. However, the application technologies in isolation could not fetch the desired result in arresting land degradation and enhancing crop productivity. Moreover, land use plan depending upon the problem and potentiality of resources was not attempted. The major reasons are lack of site-specific information and situation-specific recommendation. Of course the soil resources of the country have been developed on 1:250000 scale and the maps have been published on 1:500000 and 1:1000000 scale. The information is useful for planning on state and at most on district level. This information has limited scope to develop information on farm scale.

Recently Government of India has released first draft of National Land Use Policy in September 2013. It emphasizes the identification of Land Utilization Zones and Land Use Management Areas for offsetting the impact of climatic aberration and degradation and also to ensure food security. To achieve this purpose, a very precise and quantified data on larger scale preferably on 1:10000 scales is required. Such kind of mapping is likely to consume a lot of resources and time, but could greatly facilitate decision makers in deciding the strategies for sustainable agriculture. It is in this context that the collection of farm level data in the semi-arid region assumes importance for its continued contribution to the agricultural production in the country.

The Land Resource Inventory (LRI) initiated by NBSS&LUP plans to fill the vital gap by generating farm level data on soils and other land resources information. LRI involves systematic surveys of soils (cultivable land) on 1:10000 scales and collection of other collateral data needed for scientific land use planning in GIS environment. The project is being executed in a consortia mode by involving state governments, state departments of agriculture,

state agricultural universities, National Remote Sensing Centre, State Remote Sensing Applications Centre and Soil and Land Use survey of India. Sixty blocks, each representing one agro-ecological sub-region of the country, targeting 3.3 Mha land in four years has been chosen (Fig. 5). Many states like governments of Karnataka, West Bengal, Telangna, Goa and Meghalaya came forward and started this kind of survey from their own resources. Many other states are also attempting to initiate this kind of project under soil health mission program. NBSS&LUP provides technical knowhow to these governments. Application of android based smart mobile phone for collecting real time soil and site characteristics is another attraction of the program (Fig. 6). Methodological framework for delineating landform and soil on 1:10000 scale is given in Fig. 7. Phases of soil series are mapped for developing farm and farmer wise data (Fig. 8).

Developing land use options on well defined land management unit will be next step in developing scientific land use planning. Application of information like geo-portal and GIS based decision support system has great role in developing land use options. Geo-portal and decision support system (Fig. 9) has the capability of integrating land resources information and the region-based agro-technologies developed by different institutes and SAUs. Timely dissemination of land use options to the farmers, planners and executors is an important part of developing scientific land use planning. Geo-portal has the capability of mobile and web application that can be best utilized for disseminating land use options among the farmers.

LRI Based Land use Planning in Northern Region of Maharashtra - A Case Study from NAIP (component 3)

Basaltic terrain is the dominant landform of the northern region of Maharashtra. Dhule district in the region covers an area of 8061 km^2 and administered with 6 tahsils. The annual rainfall varies from the highest 1800 mm in Sakri to the lowest 600 mm in Shirpur Tehsil. Rainfall is normally distributed in 27 rainy days in most of the years. Shortage of water and recurrence of drought are the perpetual problems in the district. Fragmented and marginal size land holdings, undulating terrain, resource poor tribals are the other limitations Paddy-fallow and paddy-wheat are the dominant cropping systems.

Soil survey on 1:10000 scale has been conducted and the results indicated that soils of Sakri Tehsil are shallow, gravelly, sandy loam on the surface and loam in the sub-surface. In contrast, soils in Shirpur Tahsil are moderately deep, clay loam on the surface and clayey in the sub-surface. Soil-site evaluation indicated that paddy-onion is one of the best suited combination as an intervention to improve agricultural productivity in Sakri Tahsil, while cotton and pulse-based cropping system are the most suitable options for Shirpur Tahsil.

Crop diversification was identified as an intervention to improve agricultural productivity after the above said processes. Upon assessment, it emerged that a 'Paddy-Vegetable' cropping system could be adopted in the Sakri tahsil, as a big market for vegetables is located at 100 km distance (Surat in Gujrat). The soil suitability studies also indicated that most of the soils were suitable for growing vegetable crops.

Introduction of Onion Crop

As stated above, farmers and experts discussed about growing of short duration vegetable crops like tomato, coriander, onion, etc. Farmers felt that the prevailing prices for onion are higher and additional income from it can substantially contribute to their income. Moreover, onion production in India during 2012-13 was estimated at 7.7 MT which fell short of demand. The country lost 2.55 MT because of poor storage capacity. Domestic consumption of this vegetable was around 5.5 MT, whereas, 1.67 MT was exported. Hence, there was a net deficit of 2 MT onion.

The crop has been readily accepted into the integrated farming system in Sakri cluster having 1000-1200 mm, annual rainfall shallow soils on undulating terrain. In fact, soil suitability for the onion crop in the district shows that it could be grown on approximately 1900 km^2 land. This could raise the income and livelihood of farmers in the village.

Endnote

Stagnant productivity, land degradation, increasing environmental risk, declining per

capita availability of land are some of the constraints in semi-arid regions of India, which alone or in combination are of increasing concern about the natural resources. Such constraints are magnified due to the climatic aberrations like late onset and early withdrawal of monsoon, increasing frequency and magnitude of storms and rising temperature. Natural resource management system based on scientific land use planning offer scope for efficient utilization and conservation of these resources towards achieving food, nutritional, livelihood and environmental security in the country.

Relevance of land use planning is more pronounced in semi-arid region covering 116 Mha (about 35% of TGA) because of low and erratic rainfall with high variability, soils with low inherent fertility status, land degradation and poor economic status of farmers. High rate of population growth and food insecurity for more than 520 million people (27% of total population) residing in the region are dependent for their livelihood within the constraints of available natural resources. It therefore, becomes necessary that the natural resources are used sustainably based on scientific land use planning. Land resource planners/managers/ officials often lack the right information, which limits their capacity to suggest judicious land use options or for that matter take appropriate land management decisions. To achieve this, land resource inventory would first need to be developed and undoubtedly assumes mammoth importance. Such an exercise could greatly facilitate decision makers to decide upon the strategies for judicious natural resource management and land use planning in semi-arid regions of India

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