ABSTRACT

Land is reasonably stable or predictably cyclic part of the earth surface includes relief, soils, near surface rocks, minerals, water storages, flowing water, groundwater, near surface atmospheric elements (i.e. temperature, rainfall, etc.), plants, animals, micro-organisms as well as manmade aspects like land use, settlements, industries, agriculture, etc. Land elements determine its suitability for agriculture, plantation, settlements, industries, dams, watershed management, etc. However, these elements are overused and exploited. Therefore, many lands are facing different problems like soil erosion, water logging, groundwater depletion, heavy run-off, productivity losses, etc. Degraded lands are threatening food and energy securities, water availability and quality, biodiversity, human life, etc. Subsistence economy, poverty, illiteracy, subjugation, etc. are major problems of the farmers in the study region.

Agricultural workers are increased (4.85%) with 6.63% of literacy rate from 2001 to 2011. The area under agriculture has been estimated about 51% of the TGA dominantly distributed in the narrow tracks along River Mula and Pravar. TGA is categorised in NSA (42%), fallow land (9%), area not available for cultivation (8%) and forest (40%). Rice (37% to NSA) is the major crop in Kharif season observed on gentle slopes and Nagali (4.36% to NSA), Varai (3.37% to NSA) and Khurasani (2.65% to NSA) on sloping areas with coarse soils. Steep slopes, coarse soils, less fertility, heavy soil erosion, heavy irregular rainfall, poor human power, inadequate financial support, etc. are identified problems of agriculture in the region. The productivity of all crops in the region is observed less compared to the developed areas. Therefore, this low productivity and unemployability in the region resulted into seasonal out migration in search of employment in summer season. Therefore, present study has been focused on land suitability analysis (LSA) and planning for sustainable development.

LSA is a method of detecting inherent capacities of land and its potential and suitability for different purposes. Multi-criterion evaluation (MCE) technique is widely used for LSA. MCE of land suitability (LS) involves multiple criterion like bio-physical land elements (slope, relief, drainage, soil properties, atmospheric conditions, vegetation, etc.) as well as socio-eco-cultural aspects in decision making.
processes to find solutions of different problems related to land with multiple alternatives. Geographical Information System (GIS) is useful to analyse the multiple geo-spatial data with higher flexibility and precision in LSA. Analytical hierarchy process (AHP) is one of the multi-criterion decision making (MCDM) method originally developed by Prof. Thomas L. Saaty in 1960s for solving complex spatial decision and problems related to LS, land use planning, etc. Therefore, GIS based MCE and MCDM approach using IRS P6 LISS-IV dataset has been used to analyse LS for agriculture and plantation in the region. These techniques used in this study can be outlined into seven steps i.e. 1) decision of criterion, 2) determination of ranks, 3) pairwise comparison, 4) calculation of weights, 5) determination of score, 6) weighted overlay analysis and 7) accuracy assessment. The experts’ opinions and statistical correlation techniques have been used to decide the ranks of influencing criteria and pairwise comparison matrix in ‘Comparison for Super Decision Software’ (CSDS) used to determine the weights. The scores for sub-parameters showing internal variations within the criteria assigned based on fieldwork and reported norms in published literature.

The information regarding selected criterion i.e. slope, land use /land cover (LULC), soil depth, soil texture, soil moisture (SM), organic carbon (OR), maximum water holding capacity (MWHC), pH, electronic conductivity (EC) and primary nutrients has been used for present LSA in hilly zone. Satellite data has been used for preparation of GIS layers of LULC, soil depth and soil moisture. The topomaps (47 E/10, 11, 14, 15) were used to prepare slope map whereas OC, MWHC, pH, EC, Nitrogen (N), Phosphorus (P) and Potassium (K) maps were estimated based on laboratory data of soil analyses. The field work was carried out to collect the information of LULC, cropping pattern, soil depth, soil samples and crop yield.

AHP determines the weight of influence in certain land use using pairwise comparisons of parameters according to relative importance. Experts’ opinions have been used for determination of ranks and criterion for LSA. Correlation technique has been used to understand the association between different variables for selection of criterion to achieve robust results and overcome bias opinion of experts about ranks assigned to influencing criterion. The final output raster maps have prepared using weighted overlay techniques and allotted score were averagely converted into four
classes i.e. 9, 7, 4 and 1. These classes have reclassified into the four suitability levels i.e. highly suitable, moderately suitable, marginally suitable, and not suitable.

About 17% of reviewed land is highly suitable, 29% is moderately suitable, 16% is marginally suitable and 38% is not suitable for agriculture, whereas about 5% of reviewed land is highly suitable, 23% moderately suitable, 14% marginally suitable and 58% not suitable for plantation.

The study area is the part of Eastern slopes of the Mountain, ‘Sahyadri’ and Deccan trap with hard compact basalts. Thin soil (25mm MWHC) covers about 4% of the study area, shallow soil (100mm MWHC) 13%, marginal deep soils (200 mm MWHC) 22%, moderate deep soils (300 mm MWHC) 42% and deep soils (400 mm MWHC) 24%.

The rainfall begins from 22\textsuperscript{nd} week of the year. It varies from 1478mm to 4935mm East to West. Average rainfall is about 3424mm with 1360mm annual water demand for PE. The distribution of PE is 342mm in monsoon, 330mm in Rabbi and 688mm in summer. The study area has assured (variability >25%) rainfall (<3500mm) for agriculture as variability calculated for raingauge stations i.e. Ghatghar (20%), Ratanwadi (21%), Kumshet (22%), Harichandra Garh (19%) and Pachnai (22%). However, raingauge stations Panjare and Bhandardara located in Eastern part of the region show slightly more variability (27%) for 3519mm and 2615mm annual rainfall, respectively. High variability (27%) has been observed for minimum rainfall 3519mm and less variability (20%) for 4935mm maximum rainfall. Rainfall is more than PE from 28\textsuperscript{th} to 32\textsuperscript{th} week and actual evapotranspiration is equal to potential evapotranspiration in rainy season. The soils are saturated from 23\textsuperscript{rd} to 43\textsuperscript{rd} week. Therefore, \textit{Kharif} season seems to be more secure.

Weekly soil moisture adequacy index (SMAI) for ten raingauge stations have been calculated according to the different soil types i.e. MWHC of 25mm (thin soil), 100mm (shallow soil), 200mm (marginal deep soils), 300mm (moderate deep soils) and 400mm (deep soil). Soil water dynamics have been classified into four levels i.e. dry, moderate, wet and humid soils based on calculated weekly SMAI. Humid conditions in soil are observed in \textit{Kharif} season and immediately dry out after rainy
season. These conditions are suitable and secure for agriculture for all soil types in
*Kharif* seasons. The number of humid and wet weeks increases with MWHC of soils.

Calculated values of SMAI have been plotted to prepare soil moisture adequacy calendar (SMAC). Length of available wet and humid SM conditions is about 174 days in deep soils, 166 days in moderate deep soils, 156 days marginally deep soils, 140 days in shallow soils and 110 days in thin soils. Crops and their varieties have been selected based on life cycle of crops, soil moisture availability calendar (SMAC), rainfall assurance calendar, assurance calendar of rainy season, physiographic feasibilities, etc.

Shallow soils dry outs immediately after the rainy season and its water retention capacities also less. Therefore, these soils are suggested for *Nagali, Varai* and *Khurasani*. Life period of Wheat crop is 120 to 130 days and length of available wet condition of soils (deep and moderately deep) is about 110 days after rainy season. Therefore, these soils are suggested for Wheat in *Rabbi* season. However, irrigation required after January. Suitable lands for suggested crops are selected based on geophysical feasibilities and crop calendar. About 46% TGA is suggested for Rice categorised in to three groups of varieties i.e. group - A (17%) for deep soils with gentle to moderate slope, group - B (14%) for stiff slopes and group - C (15%) for steep slopes in *Kharif* season. About 15% of TGA with marginal suitability suggested for *Nagali, Varai and Khurasani* in *Kharif* season. About 17% of reviewed lands are highly suitable and 13% moderately suitable for Wheat in *Rabbi* season. About 42% of TGA is suitable for Mango and Cashew plantation with three suitability classes i.e. highly suitable (5%), moderately suitable (23%) and marginally suitable (14%).

Formulated methodology, findings and analysis in the present study are useful in different fields of research, planning and applications. Therefore, outcomes, methods and techniques used in this study are useful to students, researchers, planners, etc. for analysis of LS for different land use.