ABSTRACT

Introduction:-

Land evaluation is a prior step towards sustainable management. Land evaluation is formally defined as 'the assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation.

Decreasing per capita land availability is a big challenge to meet the basic requirements of the growing world population. The situation in Asia is alarming. It has been observed that per capita land availability in India is decreasing from 0.48 ha in 1951 to 0.26 ha in 1981 and it decreased to 0.14 ha during 2000 & it may narrow down to 0.09 ha by 2020 A.D. (NBSS & LUP, 2006) These estimates are self-explanatory and indicates to give a due attention on available land resources for its management and therefore it calls for assessment of land resources at village level.

The land system is a combination of land facets together, forming one convenient mapping unit on a reconnaissance scale. Land facet is the central concept for resources inventory and land evaluation. Land facet states to one or more land elements grouped of landscape, which is reasonable uniform and impartially different from adjoining topography. Land system approach of land facet analysis is favorable in land evaluation studies.

In the present study, an attempt has been made to classify the land facets for entire Ghera Sinhagad land system using remote sensing and GIS techniques. Land system approach is widely considered for the present investigation. Plateau Summit Surface (PSS), Plateau Fringe Surface (PFS), Pediment Surface (PDS), Plain Surface (PLS) and Escarpment (ESC) etc. landforms are thus exclusively considered as land facets in the Ghera Sinhagad land
system and its evaluation pertaining to terrain, soil and land use/land cover characteristics applying GIS technique.

In Maharashtra, particularly in hilly tracks of western Maharashtra it is observed that, most of the land facets have been degraded to their maximum due to lack of Best Management Practices (BMPs) and it is also revealed that, if proper steps in view of the land resource management are undertaken these land units can be reclaimed for optimum utilization. Such kind of work in this area has not yet been intended and attempted by any NGO’s, government or any agencies. The major significance of the present study therefore stands to prepare an action plan for land resource management through effective use RS and GIS technology. An inventory of every geomorphic unit is in dependable as basis for regional development of entire area.

**Study area:-**

The study area is a part of Ghera Sinhagad land system, (73° 39' 25" E to 73° 51' E Long. & 18° 18' 45" N to 18° 26' N Lat.) which is situated on the Deccan plateau along the eastern flanks of Sahyadri ranges. Administratively it is a part of Haveli, Velhe, and Bhor tehsils of Pune district of Maharashtra. Total 28 villages are comprises in the Ghera Sinhagad land system area. It is located to about 29 Km of south west of Pune city. The total study area is 131.62 Km² including Sinhagad Fort.

**Objectives of the present study**

1. To systematically explore the application of RS and GIS in the designing of methodology for land evaluation, this in turn is a basis for land resource management.

2. To perform land classification into different geomorphic units/land facets for the entire Ghera Sinhagad land system and thereby to assess potential of terrain & soil with respect to land capability, suitability classification & soil productivity assessment of the land facets for their optimum utilization.
3. To detect the change of land use/land cover in the study area using Remote Sensing and to infer the trend of present land utilization in the study area. Moreover this is necessary as basic input parameters in estimating surface runoff and soil loss, which forms the very basis of land evaluation.

4. To identify the high priority erosion risk zones based on land degradation assessment and to suggest compensatory conservation measures in the study area, to minimize the surface runoff and soil loss.

5. To study & prepare a village level land resource inventory for proper utilization of land resources at root level.

6. To prepare a land facet wise land resource management plan for present agricultural cropping system which will be helpful in enriching the agro-ecosystem within a framework of land system approach.

**Methodology:**

Present study is mainly divided into four major phase's and mostly includes fieldwork, data collection from different sources and fieldwork, data analysis and results, and map preparation. The methodology is so adopted to fulfill the objectives of the present study, which can be conveniently divided into two major components viz. fieldwork components and laboratory components.

Fieldwork component mostly comprises collection of soil samples, infiltration capacity measurements, hydraulic conductivity measurements and field checks using GPS. Extensive soil surveys have been conducted in the study area. Soil samples were collected according to slope variation and variability in land use using soil auger and core tube. Total 272 soil samples were collected in the field. Infiltration rates and hydraulic conductivity of the soil environment has been deduced with infiltrometer and core tube at 201 and 247 sites accordingly. In addition to this profile pits have been observed at respective place.
Base map of the study area has been prepared using SOI topographical maps on 1:50,000 scale. (47F/11, 47F/15). DEM of the study area has been generated by contour digitization in GIS environment. A physical and chemical properties of soil has been determined using different methods of soil analysis in the soil laboratory. Determination of physical properties of soil includes soil texture, bulk density, % porosity & water holding capacity. Chemical properties include estimation of soil pH, NPK, OC, CaCO3, OM, Calcium carbonate etc.

Grid wise data analysis has been carried out for preparation of maps applying GIS techniques. Entire Ghera Sinhagad land system area has been divided into 12863 cells and each cell covering about 0.0102 Km² (10200 M²) area. Geomorphic attributes such as slope, absolute relief, relative relief, dissection index maps, runoff and soil loss maps, land capability, suitability, soil productivity etc. maps has been maintaining the same spacing of grid. Terrain analysis, morphometric analysis, soil resources assessment, land degradation assessment, land evaluation, land use land cover etc. studied to infer the influence of the same on overall development of the area.

In order to determine LULC and its trends of utilization in the study area, satellite data of high resolution has been used, which has been procured from Google pro software. Digital image processing of FCC image of April 2003 and Visual interpretation of SPOT images (2007) obtained from Google earth pro programme has been compared and change detection statistics has been obtained. Change detection in LULC has been performed to infer the general trend of land utilization in the study area.

Land degradation assessment has been attempted by estimation of surface runoff and soil loss. NRCS (SCS) curve number method of runoff estimation has been performed for estimation of surface runoff of the study area. Soil loss estimation of the area has been done by applying the USLE model of soil loss estimation.
Based on soil data, physiographic parameters, LULC utilization and land degradation assessment, land facet wise land evaluation of the study area has been executed. FAO’s method of land evaluation has been applied for classification of land capability and suitability. Soil productivity rating of the area obtained using Storie index method.

In order to outline the consequence of land facets in land resource management and its conservation, an attempt has been also made to prepare a land resource management plan and prioritization of sub basins for conservation planning. Attempt has also been made to apply the NABARD’s guidelines for catchments area treatment plan in the study area. Query analysis has been performed for site suitability of land facets for erecting different conservation structure in Ghera Sinhagad land system. This has been done in ArcGIS package and Global mapper software’s of GIS platform. Attempt has also been made to undertake local people and farmers views in implementation of LRMP in the study area, thus discussion with farmers, local peoples and the leaders also kept in mind while summarizing the work and preparing land resource management plan.

**Text arrangements:-**

The entire investigation is outlined in eight chapters. Chapter first gives the introduction about research topic, geographical set up of the study area. It also explores review of literature. Second chapter elaborates description of land facets in the study area. Methodology and database is also outlined in this chapter. The Third chapter describes and quantifies the terrain characteristics of Ghera Sinhagad land system; it illustrates relief, slope and basin morphometric analysis of the study area. Chapter fourth deals with soil characteristics, soil survey and soil analysis, physical and chemical characteristics analysis, results, soil mapping and result interpretation in terms of land evaluation report of the study area. Chapter fifth describes applicability of NRSC (SCS) runoff estimation model and USLE model in a study area to infer the land degradation
for evaluation of land resources. Chapter six quantifies and describes land use, land cover pattern and change detection analysis and generation of statistical data. Chapter seven emphasizes land evaluation for land resource management i.e. land capability classification, land suitability classification, soil productivity analysis mapping and data interpretation. Chapter eight summarizes discussion, conclusion of the research work and provides suggestions of the study.

**Conclusions:**

GIS and Remote sensing techniques are very effective tools in evaluation and management of land resources, which contributes reasonable accuracy and good results at land facet level assessment, of the study area. Hypsometric integral value (84%) of the GSLS (i.e. youthful stage) indicated that, there is need of construction of both vegetative and mechanical soil and water conservation structures to arrest sediment load and conserve water through integrated watershed management. Examination of all aspects of terrain and drainage characteristics of GSLS area shows, there is considerable influence of terrain on land utilization, runoff and soil erosion. Consequently, study area needs a proper land resource conservation and management plan.

Pediment surface is a potential land surface in terms of its utilization. Plateau summit surfaces however are ideal for the recharging the ground water levels. Physical, chemical and hydrological variations in soils in the area are influenced by physiographic and climatic conditions. Major environmental problem in the study area is considerable soil loss and severe runoff. The mean annual soil loss estimated in the study area is 4.41 kg/m² and mean annual runoff is estimated to about 136532.10 M³. In the soil loss parameters of USLE method, slope length factor of the area is highly influenced. Hill fringe surface of GSLS contributes highest amount of soil loss as well as runoff in the study area.
LULC and its change detection show that, the percentage of waste land is increased during last five years. Proportion of cultivable wasteland is very high and there is an increasing trend of same land cover. LULC change detection analysis also shows the change in trend of land utilization is increased in built up land and waste land and decreased trend in agriculture land and forest land. It can be revealed from LULC change detection analysis that, the area needs to be treated with proper land resource management strategies.

Land capability classes, suitability classes almost match with the productivity classes, indicating that, there is a high influence of physical determinants on the soil environment. Land suitability analysis illustrates the potential of land recourses in the study area. LSC (S1) can be extremely used for growing of cash crops and vegetables. Marginally suitable (S2) land is potential site for improvement of land quality using different techniques as well as potential zone for cash crops & food grains in both the season i.e. Rabbi and Kharip, provided dependent water supply. LSC (S3) may be attributed to growing of medicinal plants and agroforestry in the villages of the area that will certainly helpful in enrichment of socio economic status of the villagers through sustainable land resource management. Currently not suitable land (N1) facing problems of soil erosion and high surface runoff and therefore it calls for afforestation programmes which will improved land quality of the area.

In the present study an attempt has also been made to develop and prepare a land evaluation index (LEI) to delineate zones of land according to its suitability for different uses applying factor weighing and rating method. Ranking of variables given according to their importance which includes % slope, absolute relief, relative relief, dissection index, soil erosion, runoff, land capability, land suitability, soil productivity categories of GSLS. Finally average grades divided into five equal categories of LEI and land facet wise extent of all categories has been estimated. Extremely suitable land comprises maximum area of plain surfaces 10.96 Km² (8.33%) of the total study
area. Highly suitable land noticed in pediment surface area (16.14 Km² i.e. 12.26%) and covers about to 33.81 Km² (25.68 %) of the total study area. Medium highly suitable land comprises to about 27.14 Km² (20.62%) of the total area and covers maximum area of plateau fringe surfaces (12.55 Km² i.e. 9.54%). Medium and low suitable land mainly covers area of PFS and PSS and comprises about 25.59 Km² (19.44%) and 26.31 Km² (19.99%) area respectively.

Proper implementation of LRMP will not complete without active involvement of local communities, peoples and farmers. Therefore, there is need to outline the participatory land resource management plan for GSLS.

Suggestions:-

Land evaluation and its management is multidisciplinary activity, therefore farmers, local peoples, experts and government should be encouraged for truthfull implementation of LRMP suggested by author for conservation of land facets in GSLS.

Based on soil loss and runoff studies, sub basin wise priority levels and land resource management plan for conservation planning of land facets of GSLS have been suggested. Priority level I (Very Severe) category contain one fifth order basin namely GSLS 1. The second priority level (Severe) mainly comprises one first order (GSLS 12) and one fourth order basin (GSLS 15) covering about 0.10 Km² & 6.31 Km² (04.88%) of the total area. Priority level III (High) contains about 11 sub basins contains this category and covering about 4.82 % of the total area. In this category in all 11 sub basins have been noticed, which comprises eight first order basins namely GSLS 13, 16,17,18,19, 21,22 and 23, Two second order basins GSLS 6 & GSLS 21, and one third basin GSLS 11 covers this entire category of priority for conservation measures. The priority level IV (Medium) covers maximum area, about more than 60%% of the total area and mainly covers four first order channels (GSLS 4, 5, 9 & 10), One 2nd order basin (GSLS 6), One 3rd order basin (GSLS 8) and two fifth order
basins (GSLS 2 & 3). Last priority level is V (Low) covers only one first order basin (GSLS 14) and accounts about 0.05% of the total area.

In the LRM plan of the study area, attempt has been made to apply the NABARD’s guidelines for land facet wise catchments area treatment plan which provides guidance to the persons, institutes or NGO’s who are involved in the process of planning and management of land resources of the land systems in western Ghat of Maharashtra state. On the basis of plan, a treatment map is generated for the implementation of NRM plan in the study area. Land facet wise extent of site suitability for CCT in the study area reveals that, about 16.10 Km² (47.80%) area suited for CCT treatment in Plateau summit surfaces of the study area. Plateau fringe surface shows, about 14.33 Km² (42.55%) surface of total area is suitable for CCT structure. In pediment surface land facets, 3.05 Km² (9.06%) of the study area is favorable for site suitability for CCT.

An attempt has been made to find, land facet wise site suitability for farm bunds and contour bunds in the study area thus about 33.54 Km² (25.48%) land is found to be treated with contour bunds and 14.43 Km² (10.96%) of the total study area should be treated with construction of farm bunds. Plain surface area or agriculture bunds may be used for farm bund constructions which admeasures to about 8.03 Km² (6.10%) area of total study area.

Second order stream junctions have been considered for EGP, which reduced high peak will flow of water in rainy season and river bank erosion. BGP construction require more than 100mm diameter of boulders. Here, farmers view shall also be taken into consideration. Generally third order channel junction has suitable for this type of construction. Farmer’s agreement should be considered for this intervention.

LULC analysis exposes that, 68.36 Km² % (51.91%) of the total area is wasteland and can be regenerated by adopting catchment treatment plan suggested formerly. Vast stretches of waste lands thus can be transformed applying these techniques like, continuous
contour trenches, contour bunds, terracing and applying agroforestry as well as social forestry principles. Total vegetation cover estimate for the entire GSLS is about 10.83 Km² (8.23%) of the total study area in the year of 2007. Therefore there should be a massive programme of afforestation in the area be initiated. Tree plantation, social forestry, agroforestry, nursery raising, horticulture, medicinal plant, rural fuel wood plant should be included in afforestation programme. Wasteland category can be used for this plantation, which will be helpful in regeneration of wasteland and decreasing in soil loss runoff in the study area.

Ghera Sinhagad land system area has natural attractions such as escarpment, historical place as a fort, water falls, dam sites, and water parks. There is remarkable consideration of ecotourism potential which will be helpful in socio-economic development of the area.

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