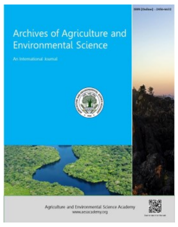
Archives of Agriculture and Environmental Science 2(3): 206-218 (2017)

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: www.aesacademy.org

e-ISSN: 2456-6632



CASE STUDY

Soil and land resource evaluation for rural agricultural land use planning - A case study from hot semiarid ecosystem of Western India

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ARTICLE HISTORY

Received: 25 July 2017
Accepted: 25 August 2017

Keywords

Conservation plans
Lagadwal photo elicitation
Land care
Soil survey

ABSTRACT

The farmers of today are expected to maintain rural agricultural landscapes with production mandates that restrict their mandate to integrate conservation plans with landscape management. In this context, an effort was made to evaluate the degree of land use, management and conservation practices adopted in Lagadwal village of Dhule district through detailed soil survey and photopedological interview walks and discussions with farmers. The landscape photographs were thematically arranged and analyzed to construct and narrate theories of land care by local farmers on erosive high hills covering thirty per cent of area (>620m elevation) and supporting extremely shallow Budkhed and Lagadwal series in southern part of the village. The photo views of erosive mid hill landscapes with gullies and landslip areas (40% of area, 600 to 620m) have soil association of moderately shallow Lagadwal thana series on crests / side slopes to very deep Brahmasila and Gaikot series in lower slopes whereas low hills (35% of area, 580 to 600m) with ridge lines and drainage depressions have moderately deep Lagadwal tola series. The farmer's did not perceive the long term landscape changes occurred due to partially effective conservation plans and pressing financial issues. The photographs revealed the unclear realties of harvesting farm produce on these steeply sloping erosive landscapes emphasizing more on explicit policy toward land management practices and offers opportunity to the farmer's to change their farm production management activities. The photographs were not intended to evaluate land care per se but offers an insight to the farmers how they look of the land at landscape level.

Citation of this article: Bhaskar, B.P., Maske Sunil, Gaikwad, S.S., Chaturvedi, A., Prasad Jagdish, Anantwar, S.G. and Singh, S.K. (2017). Soil and land resource evaluation for rural agricultural land use planning-A case study from hot semiarid ecosystem of Western India. *Archives of Agriculture and Environmental Science,* 2(3): 206-218.

INTRODUCTION

Land is continuously under threat of degradation and erosion due to various reasons. In India, total of 148.9 million ha of land, representing 45% of the total geographical area is subjected to soil erosion and land degradation (Sehgal and Abrol, 1994). On account of various forms of degradation, it has been estimated that the loss of 5.334 million tonnes of top soil occurs annually, which is equivalent to 5.37 to 8.4 million tonnes of plant nutrients (Dharuvanarayana and Rambabu, 1983). The loss of top soil and run-off loss is especially more in an area covered with meagre vegetation / forest cover. Beside this, the human population explosion in the pursuit of meeting the fuel and fodder demand, indiscriminately destroys vegetation cover and such situations get further aggravated in drought prone areas, receiving rainfall less than 750 mm. In Maharashtra State, about 35.2% of area was identified as drought prone covering 89 tehsils of 13 districts. In these areas, an imperative stage has come where suitable soil and water conservation measures are immediately warranted so as to reduce soil erosion and land degradation. With the general acceptance of watershed as principal unit of planning of all developmental activities based on suitable utilization of locally available natural resources, hence the watershed requires the detailed characterization and inventorization of natural resources (Patil *et al.*, 2010; Manchanda *et al.*, 2002). Mapping and assessment of erosion prone areas is pre-requisite for planning soil conservation and watershed management programs (Surya *et al.*, 2008) and several studies reported potentials use of remote sensing for characterization and management of land resources at watershed level (Srinivasa *et al.*, 2008; Elvis *et al.*, 2009; Solankhe *et al.*, 2009). In recent times, the necessity of detailed soil survey and soil mapping at village / watershed level for holistic farm planning taking into account climate landscape-soil characteristics (Soil Health Card) and Socio-economic conditions of the farm holdings linked to Kisan card credit support is therefore obvious, urgent and cannot brook any further delay (Velayutham, 2012). The soil series information was used in evaluating rice based cropping systems in Assam and proved the usefulness of soil series for agrotechnology transfer (Dharam Singh *et al.,* 2014) and in cotton production systems of Yavatmal district (Bhaskar *et al*., 2014).

The potentials and constraints of basaltic landscape evaluations for agriculture and or rural livelihood in parts of Maharashtra is well recognized (Bhaskar *et al.,* 2011). In the last fifty years, the rural policies and agri-environmental programs (AES) have brought agro- transformations in terms of landscape management and production of major commodities in hot semiarid eco-region of drought prone areas having length of growing period of 120 to 150 days (K4Dd4, Velayutham *et al.,* 1999; Hunziker and Kienast, 1999). This particular district accounts for the highest percentage of scheduled tribes in the state. Out of the total district population of 20,50,294, scheduled tribe population is 831,064 or 40.53 percent (Walters, 2013). The cultivated area is 4.64 lakh hectares of total area (806300ha) with 65% of area under food crops and 56 per cent of land holding less than 2 ha. The agricultural landscape pictures in rural sectors of this part of Maharashtra offers an opportunity to look into the reflective realties of drought and difficulties faced by farmers with a popular idea of how hard it is to farm. The policies impose the basic obligations on farmers to keep the open and well managed but agri-developmental programmes are poorly implemented with multiple aims in the farming. The present study focuses on the visual perception of cultivated lands in Lagadwal village of Dhule district, Maharashtra with the objectives of interpreting and managing production value of rural landscapes for conservation at farm level.

Soil survey describes soil characteristics in a given area, classify soils according to a standard system of classification, plot the boundaries of soils on a map and makes predictions about the behaviour of soils (Soil Survey Division Staff, 1993). The physiographic surveys produce descriptions of soils in a discrete spatial model without informing variation within the mapping unit (Bregt, 1992). The soil survey can be interpreted in terms of potential productivity and land evaluation for assessment. The storie index assesses the productivity of soils considering four factors such as Factor A (the degree of soil profile development), Factor B (surface texture), Factor C (slope) and Factor X (other soil and landscape conditions viz., drainage, erosion, fertility, alkalinity, acidity and micro relief). A score ranging from 0 to 100 % is determined for each factor and scores are then multiplied together to generate rating index (Storie, 1978). Later these indices were revised that generates ratings digitally (O'Geen and Southard, 2005). The storie indices were proved to be useful in evaluating soil series suitability for maize, soybean, cowpea and groundnut in three soil series of Northern region of Ghana (Ziblim *et al*., 2012). Productivity ratings (based on physical and chemical properties of soils, Huddleston, 1982) are reflection of real value for agriculture or forestry (Miller, 1984) but later recognizing the importance of management in obtaining economic yields, CER values (crop equivalent rating) were used as index of evaluating soils in Minnesota (Rust *et al.,* 1984). These mapping units are evaluated as per the land evaluation classification for different kinds of land use systems (FAO, 1983; van Diepen *et al.,* 1991 and Murphy, 1993). Combination of the FAO Framework for Land Evaluation with computer technology and expert knowledge on specific soils and crops has been demonstrated by several authors (Wood and Dent, 1983, Jones and Thomasson, 1987, Hong Cheng, 1989 and Robert, 1989). However, transferability of the analyses is limited because the expert knowledge applies only to the conditions for which the systems have been developed and calibrated. The UNCED conference (1992) - Agenda 21 identified the importance of widely accepted indicators by which to monitor the status of the environment. Recently, the World Bank initiated the development of Land Quality Indicators (LQIs) to enable monitoring of changes in land resources and the sustainability of managed ecosystems (Pieri *et al.*, 1995). Earlier, Dumanski (1993) set down generic indicators that could be developed as 'international standards for evaluation and monitoring of SLM': crop yield (trend and variability), nutrient balance, maintenance of soil cover, soil quality / quantity, water quality / quantity, net farm profitability, use of conservation practices. Such indicators may be used as objectives and parameters in the construction of an 'SLM Model' (De Bie *et al.,* 1995). The decline in reserves of quality arable land result from the significant loss of agricultural land through degrading land management practices (Scherr and Yadav, 1996), from competition for these reserves for use in forestry, watershed management, maintenance of biodiversity and from the diversion of arable land for urban and industrial use. The negative assessment generally associated with farming, forestry and grazing had been largely developed in the context of modern agriculture. The speed and extension of technological, cultural and economic changes that have occurred in recent decades are threatening not only the environment but also the landscapes and rural societies associated with them (Agnoletti, 2006, 2012 and Antrop, 2006). There is a need to develop sustainable land management (SLM) systems through three stage activities involving land character assessment, participatory activities for community driven landscape scenarios and modeling of landscape scenarios and tradeoffs as integral part of the social-ecological framework, provide opportunities for social learning and capacity building (Bohnet and Smith, 2007). It was also reported that individual perceptions and the relationship between visual concepts and aesthetic values of landscape were to be reliable predictors in case of Belgium (Sevenant and Antrop, 2010). However, in areas that are not conducive to be simplified and intensive crop production, a marginalization process has long been underway that has resulted in the abandonment of rural settlements and activity (Agnoletti, 2012). The soil information delivery and education must use modern information delivery techniques coupled with simple landscape-based presentations of interpreted data (Drohan *et al*., 2010). It was further said that the delivery of soil information must be with conceptual toposequence models with special purpose soil classification linked to identifying keys at local level (Grealish *et al.,* 2015). Although there are number of studies on visual perception of agricultural landscapes, the agricultural landscape preferences based on visual concepts were reported and also explained the factors underlying on visual preferences by the local community in Israel (Rechtman, 2013). In land evaluation studies, the agricultural landscape photographs in conjunction with soil surveys were used to measure the perception of farmer's about the quality of landscapes (Tveit *et al*., 2009; Eija *et al.,* 2014). The relevance and feasibility of landscape planning in addressing and resolving the problems of rural communities in Ukarane was highlighted and advocated to develop landscape plans (Rudenko *et al.,* 2014). Later on, the strong links of rural development with landscape planning was discussed in length by Rega (2014). The objective of present study was therefore to characterize agri-landscape systems and their dynamics by up-scaling landscape analyses at farm level and used agri-landscape systems to identify potential zones where reciprocal relationships between land uses and landscape features were clear. Hence, in this case study an attempt was made to characterize the agri-landscape systems in a part of hot semiarid eco system of Lagadwal village, Dhule district, Maharashtra, India.

MATERIALS AND METHODS

Geographical description: The agricultural landscape in Lagadwal village, Sakri tehsil of Dhule district (21^{0}08'01"N latitude and 74^{0}06'51" E longitude) is dominated by dykes and residual hills of the Sahyadri Spurs with shallow to stony soils (Figure 1). The major part of the area is covered by basaltic flows commonly known as Deccan Traps intruded by dykes of Upper Cretaceous-Lower Eocene age. The Deccan Trap includes several flows of Basalt which are supposed to have extruded from fissure volcanoes that includes the "pahoehoe" and the "aa" types of flows, the former being very common (Deolankar, 1980). The water bearing strata occurring below 30 m depth, beneath the red bole and dense massive basalt exhibit semi confined to confined conditions. On the elevated plateau tops having good areal extent and local water table develops in top most layers, the wells in such areas show rapid decline water levels during in post monsoon and go dry during peak summer. This geological structure in rural landscapes are subjected to severe to very erosion on steep slopes running towards south and culminate sharp pinnacles. The tunnel, gully and landslip erosional features are common with duplex soil association with hard and compact sub soils which will favour the lateral movement of water. The climate is dry with mean annual rainfall of 576mm, of which 88 per cent of annual rainfall receives during the south-west monsoon. The natural vegetation consists of trees viz., Gunj - Abrus *precatorius,* Hivvar - Aegle *marmelos*, Piwala – dhotra - Argemona *mexicana,* Neem - Azadirachta *indica*, Katesawar - Bombax *ceiba,* Rui - Calotropis *gigantea*, Dhak - Butea *monosperma*, Bahawa - Cassia *fistula*, Sisam - Dalbergia *sissoo,* Lokhadi - Ehretia *laevis*, Ghute umbar - Ficus *heterophylla,* Umbar - Ficus *racemosa*, Sabar - Euphorbia *neriifolia* (Patil and Patil, 2007).

Methodology: The two step methodological approach was adopted in this study involving preliminary landscape analysis at farm scale in terms of land use, farming system and characterization of farms at Lagalwal village of Dhule district, Maharashtra. The first step was based on detailed soil survey on 1:10000 scale cadastral map covering 664 hectares of land in Lagadwal village of sakri tehsil, Dhule district, Maharashtra. The intensive field traverses were made to check field boundries and to aquaint with landscape patterns. Nine representative soils transects with fifty seven soil profiles were studied in different locations and recorded latitude, longitude and elevation of each soil site with the help of hand held GPS and described morphological descriptions of each pedon (Schoeneberger *et al.*, 2002). These soils were classified up to subgroup level in the soil orders of Entisols, Inceptisols, Alfisols and Vertisols as per Soil Survey Staff (2010). The soil map was generated with mapping units defined as phases of each series in GIS environment with ARCINFO. Version 8. The slope land capability classification as per scheme was applied to suggest soil-water conservation measures (Sheng, 1972).

Figure 1. *Location map Lagadwal village in Sakri tehsil, Dhule district.*

The field was supported by an interview with the local farmers to pinpoint the landscape conservation to landscape change and the agricultural typology at farm level. Each geo reference point is linked with photographical file so as to obtain description of landscape and identification of land use change at farm level. In the second step, the landscape photographs during survey were taken and analyzed to form personal construct theory for deriving conservation plans (Dalton and Dunnett, 1990). This involved grouping of photographs under thematic headings and ordering each group into levels of significance. The visual preferences of landscape components were identified and analyzed to do whole farming in accordance with soil capabilities and connecting farms with central corridors. The results of landscape analysis with expert knowledge in developing agricultural planning was integrated with local knowledge to draw main agricultural systems contributing to the landscape in Lagadwal village directly onto the soil map. The base map showing the morphological and topographical characteristics are easy to understand by local farmers and facilitate good interaction between landscape and agricultural systems that possibly contributed to change landscapes at farm level. The schematic methodology is given as under (Figure 2).

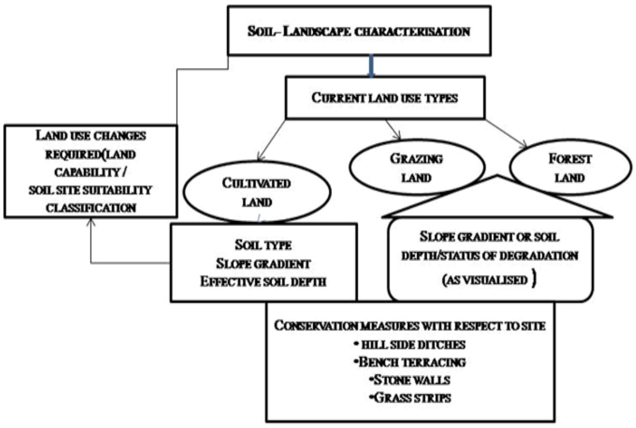

Figure 2. *Flow chart of conservation measures at landscape level based on slope land capability.*

Figure 3. *Field photos of landforms in Lagadwal village; 3a. High hills: (i) severely eroded summit portions with sparse vegetation, (ii) steep side slopes with narrow incised 1st order drainage lines and (iii) undulated, severely eroded back slopes; 3b. Mid hills: (i) broad crests and side slopes (ii) round crests and upper slopes (shoulder) and (iii) undulating back slopes with rises and lows; 3c. Low hills Li) narrow ridges and side slopes, (ii) foot slopes along drainage lines and (iii) drainage depressions.*

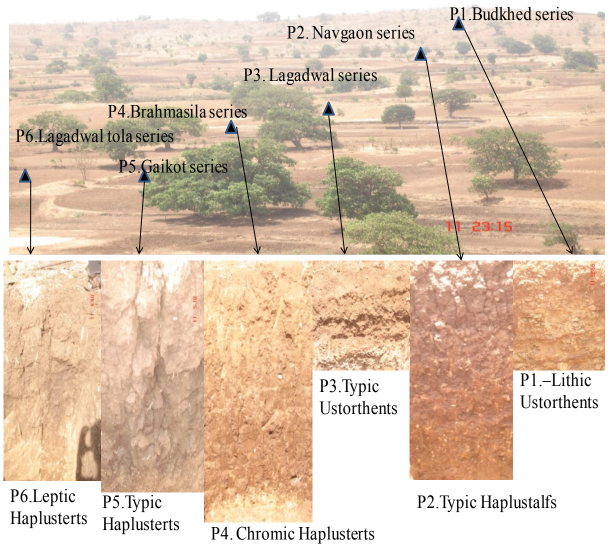

Figure 4. *Soil-landscape systems in Lagadwal village.*

RESULTS AND DISCUSSION

Soil landscape systems: A soil landscape is a mapping unit that has recognizable and specifiable topographic and soil properties which can be meaningfully represented on a map and described by concise statements (Tulau, 1994). Soil landscapes are not uniform in terrain and soil characteristics, but have a definable pattern of variation. For instance, the Lagadwal landscape ranges from gently sloping ridge crests to very steep side slopes and narrow drainage lines (Figure 3a). There is considerable variation in slope gradient, soil depth, drainage characteristics and hence the properties which determine capability. The village covers 664 hectares of land (ha) having high hills in southern part (>620m above mean sea level) with distinct steep slopes of 40 to 60 per cent and covers more than 306.3 ha. The steeper side slopes cover ten per cent of total area with narrow incised drainage lines (forty six per cent of area) supporting extremely shallow Budkhed (P1) and Lagadwal series (P2). The mid hills (600 to 620m) covers thirteen per cent of area with four land forms viz., broad crests, rounded crests and side slopes, gently undulating uplands and lower slopes. These land forms have moderately shallow Lagawal Thana series (P3) on crests and side slopes Gaikot (P4) to and Lagadwal tola (P5) in lower slopes. The low hills (580 to 600m) have ridge lines and drainage depressions covering thirty five per cent of area with soil associations of moderately deep Navgaon (P6) and Brahmasila series (P7). These landscapes show varying degrees of sheet erosion on undulating plains, gullies near drainage lines and rocky exposures, stone cover on hill tops and ridges, crests and side slopes (Figure 4). These agricultural landscapes suggest themselves as measures to estimate the impacts of current land use activities on steep lands with posing questions such as (i) is production sufficient to subsistence or profit, (ii) does the ground cover capable of maintaining good soil conditions and (iii) is the soil erosion a cause of declining crop productivity under semi-arid climate.

Soil typology and classification: Soil typology is usually defined as a portion of soil cover with diagnostic characteristics resulting from similar process of soil genesis and location of soil typology is known through soil mapping unit delineation. The soil typology with taxonomy in high, mid and low hills with land use, soil depth and crop calendar is presented Figure 5. Basaltic terrain is common in this part of Maharashtra and has been in the focus of tribal dominated and developmental programmes linked with dry land agricultural crops in the past 20 years. The high basalt rises (>620m above sea level) are more or less undulating on top with strongly sloping and severely eroded for the development of moderately deep Typic Haplustepts to moderately shallow Typic Ustorthents under the cultivation of bajra and black gram with thin forest cover. The distinctive composition of the top basalt flow may be a contributing factor to the development of the clay soils for the growth of agro - forestry. The mid hills (600 to 620m) have four land forms viz., broad crests , rounded crests and side slopes, gently undulating uplands and lower slopes . These land forms have moderately shallow Typic Ustorthents under bajra, groundnut, red gram cultivation on crests and Lithic Ustorthents with forest cover on side slopes to very deep Typic or Chromic Haplusterts (Brahmasila and Gaikot series) in lower slopes used for jowar, maize and sugarcane. The moderately deep Typic Haplustalfs on 3 to 6% slopes are used for cultivation of soybean and red gram. The low hills (580 to 600m) have ridge lines and drainage depressions covering thirty five per cent of area and have moderately deep Typic Haplustepts and Typic Haplustalfs. These soils are used for cultivation of soybean, onion and sugar cane, whereasvery deep Typic or Leptic Haplusterts are put under wheat, maize and soybean. These landscapes shows varying degrees of sheet erosion on undulating plains, gullies near drainage lines and rocky exposures, stone cover on hill tops and ridges, crests and side slopes. The typical soil associations on basalt usually called a "red-black" soil catena (Kantor and Schwertmann, 1974), with "red soils" on the higher positions of the landscape, and black Vertisols in the lower positions. This kind of occurrence of red-black soil associations was reported due to presence of smectites and zeolites made the formation of black soils possible in micro depressions and interstratified smectite - kaolin (Sm/K) is dominant in red soils of upland positions (Bhattacharyya *et al.,* 1993). This kind of soil-landscapes are put under dry land agriculture during kharif season starting from June to September and for rabi crops (wheat, maize and groundnut) from November to February wherever irrigation facilities are available.

The descriptive statistics of identified seven soil series with elevation wise is presented in table 1. The mean thickness of A horizon is varied from 11.7 ± 3.2 cm for Budkhed series to 15.2 ± 2.8cm for Novgaon series with coefficient of variation (CV) of 18.4 %. The mean thickness of B horizon is 129 ± 34.0cm for Gaikot series with CV of 35 per cent, 133.8 ± 5.4 cm for Brahmasila series

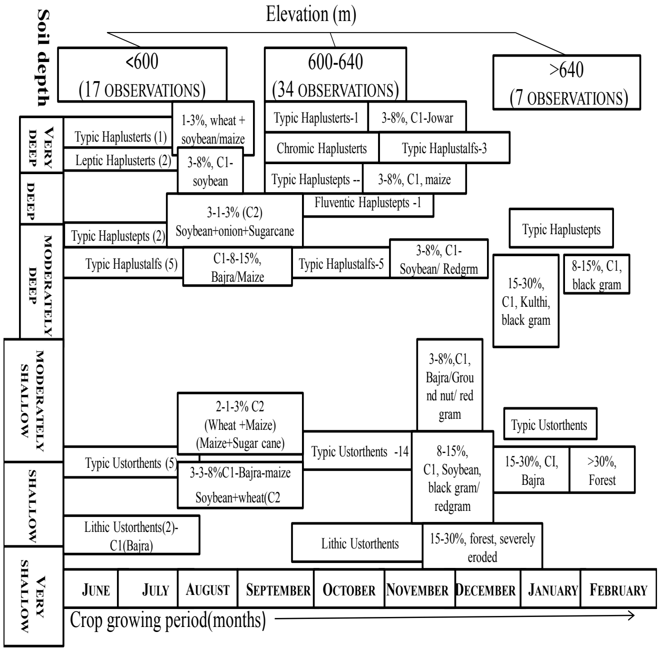

Figure 5. *Soil typology and classification.*

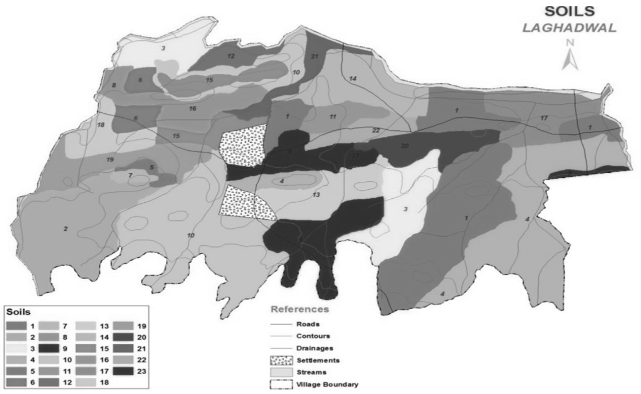

Figure 6. *Soil map of Lagadwal village; Note: soil unit numbers as shown in map is in accordance with numbers if soil units described in table 3.*

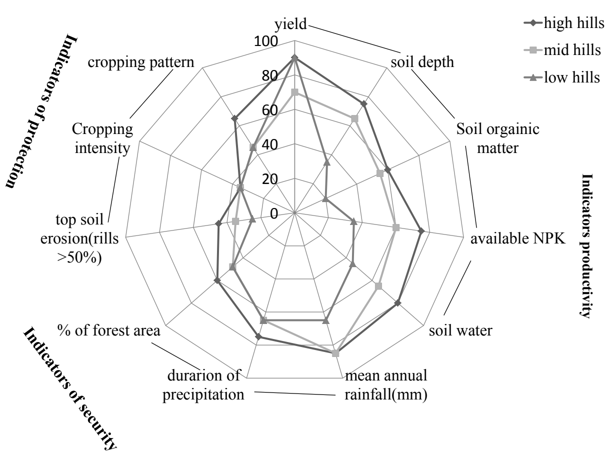

Figure 7. *Amoeba graph for determinants of agri-resources.*

with CV of 4 per cent and 16.8 ± 16.3cm for Lagadwal Thana series with CV of 96.9 per cent. The mean solum thickness is 11.7 ± 3.2 cm for Budkhed series but of 147.6 ± 4.5cm for Brahmasila series. Twenty seven soils occurring in between 600 to 620m have 12.67cm ± 2.98 for A horizon, 29.78cm ± 41.45 for B horizons and 42.44cm ± 42.02 for solum thickness. Fourteen soils occurring on 620m and above have mean thickness of 12.86cm ± 2.59 for A horizon, 30.86cm ± 49.85 for B horizons and 43.71cm ± 50.94 cm for solum. The thickness of B horizon in general have high coefficient of variation in soils occurring above 620m (161%) as compared to soils on 600 to 620m (139%) and in soils between 560 to 600m (111.9%). The A horizon thickness is positively and exponentially related with elevation (R^2 = 0.32*, significant at 5 % level).

Particle size distribution and selected chemical characteristics: The extremely shallow Budkhed series (P_1) has clay loam texture with clay content of 29 to 35 per cent and a particle size class of fine loamy at family level. The surface horizon is neutral with more than 1 per cent of organic carbon, 19 to 23 cmol / kg exchangeable Ca and DTPA extractable zinc of 0.38 mg / kg. The Lagadwal series (P_3) is slightly acid with fine loamy particle size class (clay of 19 to 26 per cent), exchangeable Ca of 21 to 32.3 cmol / kg and DTPA extractable Zn more than 1 mg / kg. The moderately shallow, slightly acid to neutral and fine loamy Navgaon series (P_2) has 18.8 to 27.6 cmol / kg exchangeable Ca, 10.9 to 14.3 cmol / kg Mg and irregular distribution of DTPA extractable Zn of 0.48 to 0.98mg / kg. Brahmasila series (P_4) is very deep, fine textured (clay content more than 30 per cent with irregular depth trends) and have neutral surface layers with moderately alkaline slickensided zones. This soil has ex Ca to ex. Mg ratio more than 1 with its contents varying from 19 to 32 cmol / kg. These soils have DTPA extractable Zn below critical limit (0.8mg / kg, Lindsay and Norvell, 1978). The gaikot series (P_5) is very deep with increasing pH from neutral to slightly alkaline and moderately alkaline slickensided zones, more than 1 per cent of organic carbon throughout depth except in Bss2 layer (72-102cm) and increase of exchangeable magnesium from 36.9 to 48.4 cmol/kg and sudden drop in DTPA extractable Zinc (0.44 mg / kg) in that particular layer. Lagadwal tola series (P_6) is very deep, fine textured (irregular clay with depth, 25 to 35%) and neutral to slightly acid with an exchangeable Ca of 25 to 32 cmol / kg, Mg of 12.8 to20.1cmol/kg and DTPA extractable Zn of 0.38 to 0.52mg/kg). Lagadwal Thana series (P_7) is loamy with 35 to 46 per cent sand, 39 to 50 per cent silt and (increasing trend with depth) 15 to 16 per cent clay. The particle size class is defined as fine loamy with clay content above 18 per cent .This soil has slightly acid surface horizon followed by neutral subsoil layers. This soil has 0.96 to 0.61 per cent of organic carbon with decreasing depth trends (Table 2). The calcium is dominant on exchange complex showing increasing trends with depth (21.1 to 30.3 cmol / kg). Next to calcium, magnesium is dominant with it contents of 12.9 to 17.49 cmol / kg. Among DTPA extractable elements, zinc in sub soils is in deficient range (0.34 to 0.36 mg / kg).

Soil map: The soil map shows regularity in geographical distribution of soil series and its diversity over given landscape at cadastral level in the study area. The soil map consists of generic characteristics of seven soil series at 23 phases depicted as mapping units (Figure 6, Table 3). The mapping units is defined as per the guidelines of AISLUS (1970) considering texture, series name, erosion and slope class as symbolized: iBk2F (where I = sandy clay, Bk = budkhed series, 2 = moderate erosion and F = >15% slope). This map actually demands appraisal of individual mapping units in terms of their suitability to agricultural crops. Here the top soil variations in each identified series may be helpful in explaining the yield variations of particular crop or different crops within the unit over long term period. The defined 23 mapping units expressed major limitations such as slope, erosion, gravelliness and texture. It is observed that only three mapping units occupied more than 10 per cent of total area in the village viz., iBk3F (96.7ha, 14.6%), mNv2B (78.1ha, 11.8%) and mNv2C (94ha, 14.2%). Regarding depth classes (Sehgal *et al*., 1987), the soil series is arranged as follows: very shallow-Budkhed, Navgaon, Lagadwal, shallow- Lagadwal Thana, moderately shallow- Lagadwal tola, deep-Gaikot and Very deep-Brahmasila. Considering the slope >15 % not suitable for mechanization and stony features in high, mid and low hills, the mapping units are classified under non arable covering 175.1ha (26.4 %). The remaining area under different mapping units evaluated for their suitability to different locally grown crops like sunflower, sorghum, soybean, wheat and chillies (Table 5) and suggested conservation plans such as hill side ditches, stone walls or bunds on high and mid hills.

Photo voice: A photo-voice is a process by which people can identify, represent and enhance their community through a specific photographic technique (Wang and Burris, 1997). The land evaluation studies start with description of biophysical parameters of the land with time related preferences. This can be done with visualization of landscape as a whole with photographs to view variety of scenes for comparison and on site evaluation (Shuttleworth, 1980; Kellomaki and Savolainen, 1984). The photographs provide landscape sociology of farming in difficult and degraded hilly terrain. These photographs clearly identify the production management of hilly terrain keeping aside the conservation on their farms. The study demonstrates the changing landscape management is complex involving financial incentive making conservation as secondary to crop production. The pictures exposed not only the landscapes but also the restrictions to change farming activities of current production mandate (sowing row crops on high hilly terrains with distinct visual signs of erosion and strong stoniness) and supported conservation values to deliberate approach to changing landscapes (subsoil hardening, Figure 4). Farmers face extreme difficulties on these degraded landscapes with limited options and unable to keep up the productive capabilities of their landscapes. The land limitation may be purely physical such as a shallow depth of soil which is adequate for grazing but not for cropping or the limitation which makes the land vulnerable to degradation could be climate, such as low or erratic rainfall.

Farmer's view on agricultural landscapes: The farmer's in the village have unique perspective on arable agricultural landscapes for signs of farming practices and its impact is dependent on the level of knowledge connecting management practices and the appearance of forms and colours in the fields. The photographic representations show that rural agrarian communities are generally preferred landscapes that have natural, verdant, forested, traditionally cultural, mixed order / disorder, half - open and contain water (Brush *et al.*, 2000). The farmer's view the land as production unit for food and fodder needs of rural dwellers and consider daily practical difficulties in working on agriculture in their individual farms. It is because farmers understand the everyday practices involved in shaping farm landscapes that they are able to interpret and appreciate fully what they are seeing in their conventional production-based farming activities. The field photos provide an opportunity to farmer's to assess their own and other farmers' skills (i.e. embodied cultural capital) from the appearance of the landscape under 'productivist' behaviour (Burton, 2004). The Lagadwal village consists of rolling hills under mixed arable / livestock farming. The agricultural landscapes are subjected to seasonal changes through seasonal production cycles of soybean-sorghum based systems. The bullock drawn ploughed fields are visually attractive because of the regularity of furrow depth, the way in which the topsoil has been turned and the straightness of lines in the field. As season progresses, the evidence of ploughing disappears as crop emerges and trace out the errors if any in skills of ploughing and sowing seeds with visible signs of crop density. The poor crop stand and yield of soybean in midhills and jowar in high hills clearly indicate the difficulties to work on stony soils (> 50%surface stone cover) with lack of machinery skills to work on these landscapes. It is clear from the photographs that the inhabitant tribal farmers are not able to perceive the subtle changes in agricultural landscapes due to their faulty farming practices such as felling of trees in high hills, poor bunding and terracing, signs of high degree of dissections all along the drainage lines, subsoil hardening and opening of landscapes for agriculture. The conservation of agricultural mosaics (of soybean on broad crest slopes of midhills, drainage floors in low hill regions for paddy and wheat through the combination of drainage and leveling with contour bunds (Figures 3a, b) is now regarded as critical and needs landscape initiatives that explicitly increase food production, ecosystem conservation and rural livelihood. The intrinsic value in appearance of landscapes as expressed within local discourse as negative nature (eroded crest slopes of high hills, money driven production systems, illegal logging of trees lack of green cover that livestock eats and lack of scenic value) with barren landscapes symbolizing the connection of farmer's role in nurturing the soil. The soil erosion is accentuated by poor practices of farmers on steep hillsides expose to the direct impact of raindrops on clearing and burning, planting with little attempts at soil preservation (Figures 3a, b). Planting is done up and down the hillsides, so that the inter-row is left bare providing ideal conditions for rill erosion down the hill. There is also no attempt to cover the soil by using mulches or cover crops particularly during the inter-crop period. There was some intercropping seen, but unfortunately this was also planted down the hill. The use of any form of barriers to slow down or stop the movement of soil is also minimal.

The complex nature of farming makes integrated approaches necessary, both in order to improve their understanding and in turn in the implementation of sound management strategies. Indicators used in local agro-ecosystems are both qualitative and quantitative and then multi-criteria algorithmic (mathematical) methods able to deal with mixed information. Some of these techniques employed in integrating soil-land information with photo voice techniques is discussed below for deriving thematic based land evaluation programmes. The AMOEBA, a radar graph shows that various indicators are represented over axes moving away from the center (Figure 7). The numerical values assumed to be the target for each of the various indicators are normalized. They all lie at the same distance from the origin and therefore represent a circumference of a circle used as benchmark. In this way, it is immediately clear which values of the various indicators (characterizing the actual state of the monitored agro - ecosystem) fall short or exceed the target. In this example, various indicators can be represented on the axes moving out from the origin on a standard scale from 0 to 100, where 0 refers to the worst imaginable situation and 100 stands for a ideal situation of agriculture in the study area (Gomiero and giam Pietro, 2005).

The farm data enabled us to identify several potential drivers influencing the agri-landscapes and to determine the potentials of agri - resources in Lagadwal village. The indicators of productivity identified at landscape level are soil depth, soil organic matter, available N P K and soil water status during crop growing period whereas indicators of security includes mean annual rainfall (< 570mm), duration of rainfall, per cent of forest area and indicators of protection includes top soil erosion where > 50% rills are visible, cropping intensity and cropping pattern (Figure 7). These indicators when analyzed for three sections of hills , it is clear that top soil erosion is severe with loss of forest vegetation and seasonally grown coarse grain crops such as jowar and bajra over stony soils. It is opined that the crop yield on mid and low hills is mainly determined by soil depth and soil water status where in general high cropping intensity under well irrigation is observed with cropping systems viz., soybean, onion, chillies and floriculture.

The matrix diagram is made to integrate landscape elements with indicators and management options for sustainable agriculture in the hill lands of Lagadwal village having two distinct colour boxes indicating the change of themes to work out on these landscapes with discussion of local farmer's (Table 4). Looking into the indicators, the management options are selected based on farmer's opinion by combining and graphically representing as listed indicators and options mentioned to characterize arable land typology as per the structure of themes identified for land evaluation at landscape level. During resource inventory in Lagadwal village, nineteen experienced farmers having an age > 45 years (6 in high hills, 5 in midhills and 8 in low hills) are interviewed with photos of landscapes so as to collect the views and themes to opt for sustainable agriculture. The photo voice of farmer's at high hills shows that the major constraints for farming are unevenness of land surface, effective soil depth, strong slopes and poor condition of forest cover that needs multispecies buffer zones and agroforestry. At midhills, all farmers' agreed upon the poor condition of forest cover but lower level of subsoil compaction problems and have limited options for diverse crop rotations and increase of crop variety and diversity. At low hills, the farmer's expressed that they are not aware of subsoil compaction, top soil erosion, options of cover crops and grass field borders. They are not aware of strip or grasses on contours as conservation measure to check top soil erosion at low hills.

It is clear from amoeba and matrix diagram that the kind of linkages needed for implementing management options for ecosystems services existing in rural landscapes of Lagadwal village (Table 5). There are five ecosystem services viz., erosion control, maintenance of soil fertility, nutrient cycling, wholesome food production and carbon sequestration and 10 management options are considered to assess the degree of links needed for evaluating at landscape level. The results shows strong link of landscape planning with increasing crop variety and species diversity (as not observed at farm level in Lagadwal village), crop rotation and ground cover crops and less important link with strip grasses on contours, agroforestry and grass field borders.

Conservation of rural agricultural landscapes: Rural landscapes are under varying degrees of human influence. Conservation of rural landscapes in this part of Maharashtra is really a challenging task because of its rapid depletion of natural resources and off conventional strategy. The land users grow crops that fetch profit and / or subsistence while conservationists recommended crops for soil conservation. The major concern on steep lands of Lagadwal village is a pronounced dry season with sparse vegetation cover and leaving the soil exposed to intense rains during rainy season, a perfect setting for erosion. These steep lands have fertility problems in addition to erodability. The slope land capability classification shows that the high hills are classified as class-4 class where crop production needs intensive soil-water conservation treatments whereas broad crest slopes in midhills and narrow ridgelines in low hills needs moderate soil-water conservation treatments. It is clear in the mind to say that production oriented agriculture in low hills and agricultural marginalization in high hills have effects on altering habitat and make them barren or abandoned in the period of severe droughts. The shallow soils on steep slopes needs a cost effective conservation treatment like planting tree crops by the use of intermittent terraces (orchard terraces) with one line of trees followed by close-growing cover crop. On gentle slopes (usually up to 2% or 3%), it is usually possible to control erosion by carrying out contour cultivation or by growing alternative crops in strips along the contour (strip cropping), or by dividing up the arable land with strips of grass laid out on the contour (grass strips, Table 6). The landscape-based approach to conservation helps integration of the ecological needs with visual dimensions between people and landscapes. The generation of soil mapping is inseparably related to landscape-focused approaches to visualize spatially-specific landscape conservation needs to local agrarian communities. Agricultural lands should be managed as part of the matrix surroundings by protecting and promoting local crop and livestock diversity, maintaining connectivity between native habitats within agricultural landscapes, planting hedge rows around farm fields, protecting spatially targeted perennial natural and planted vegetation, maintaining continuous year-round soil cover to enhance rainfall infiltration; managing inputs and wastes to minimize agricultural pollution of natural habitats; and designing farming systems to mimic the structure and function of natural ecosystems. The agri-environmental issues emerged from the rural landscape study at lagadwal village for implementation of conservation planning is given under:

Landscape perspective: Agricultural landscapes are mosaics of natural features and agricultural (and other) land uses in a particular geographic region. The activities include are: protecting and promoting local crop and livestock diversity, maintaining connectivity between native habitats within agricultural landscapes and designing farming systems to mimic the structure and function of natural ecosystems.

Community involvement in landscape management is prerequisite for protecting habitats and promoting regional approaches to create bridges between farmers and government policy to bring broader changes at landscape level.

The technological constraints are lack of a sufficiently detailed land resource database where land constraints are systematically identified and interpreted according to up-to-date technology, lack of adequately trained specialists to live and work in steep land areas and lack of well- coordinated technology transfer networks for steep land areas.

Table 1. Descriptive statistics of horizon thickness and elevation for soil.

Soil series	Thicknes of horizons(cm)			Elevation(m)	Coefficient of variation(CV%)			
					Thicknes of horizons(cm)			Elevation(m)
	A	B	Solum (A+B)		A	B	Solum (A+B)	
Budkhed	11.7±3.2	-	11.7±3.2	603±3.6	27.5	-	27.5	0.6
Lagadwal	14.0±3.6	-	15.1±5.0	605±18.3	25.9	-	33.3	3.0
Lagadwal thana	12.6±3.5	16.8±16.3	29.5±14.9	613±25.2	27.9	96.9	50.6	4.1
Gaikot	12.0±3.1	129±34.0	132±3.1	648±22.2	24.1	35.0	24.1	3.4
Navgaon	15.2±2.8	48.2±10.8	63.3±11.8	585±11.0	18.4	22.4	18.6	1.9
Lagadwal thola	14.8±2.4	47.8±6.5	62.6±7.6	592±19.2	16.1	13.5	12.2	3.2
Brahmasila	13.8±2.2	133.8±5.4	147.6±4.5	609±27.1	15.7	4.0	3.1	4.5

Values are Mean± SD of replicates.

Table 2. Particle size distribution and selected chemical properties of soil series.

Horizon	Depth(cm)	Paricle size distribution(%)			pH	OC(%)	Exchangeable bases(cmol/kg)		Available K(mg/kg)	DTPA Extractable(mg/kg)			
		Sand	silt	Clay			Ca	Mg		Fe	Mn	Cu	Zn
P_1.Budkhed													
Ap	0-9	25.1	39.6	35.2	6.5	1.05	19.2	10.1	44.8	28.08	52.8	6.92	0.38
r	9-47	23.9	46.3	29.7	6.2	1.03	23.2	18.0	114.2	44.66	61.5	18.0	0.92
P_2. Navgaon series													
Ap	0-16	29.88	60.2	9.9	6.2	1.13	18.8	10.9	118.7	64.4	100.5	18.5	0.98
Bt1	16-41	17.23	57.87	24.9	6.6	1.07	22.2	10.9	125.4	51.92	69.8	13.0	0.48
Bt2	41-63	22.85	56.75	20.4	6.8	0.79	27.6	14.3	114.2	25.94	110.0	12.5	0.88
P_3.Lagadwal series													
Ap	0-8	51.47	38.73	9.80	6.7	0.99	21.7	11.9	107.5	54.8	69.2	14.0	0.72
P_4.Brahmasila													
Ap	0-11	16.87	49.58	33.55	7.20	0.568	26.5	18.9	33.6	52.4	29.4	5.9	0.48
Bw1	11-31	15.35	45.01	39.64	7.22	0.549	32.1	21.2	34.94	48.3	31.2	8.8	0.38
Bss1	31-66	13.50	61.3	25.20	8.17	0.176	30.1	20.4	36.28	46.4	30.4	7.3	0.36
Bss2	66-94	24.11	40.43	35.46	8.24	0.098	29.6	19.6	34.94	45.5	29.8	10.2	0.28
Bss3	94-120	34.07	32.05	33.88	8.30	0.078	24.5	18.7	27.77	50.6	32.6	11.2	0.43
Bss4	120-150	22.22	48.02	29.76	6.34	2.262	27.3	18.0	23.29	48.8	30.7	8.8	0.40
P_5.Gaikot series													
Ap	0-14	12.95	42.6	44.5	3.9	1.07	44.3	36.9	39.87	24.36	66.2	16.2	1.2
Bw1	14-37	22.9	31.1	46.0	7.2	1.08	35.0	42.9	48.83	77.42	49.6	14.2	1.04
Bss1	37-72	10.3	43.8	45.9	7.3	1.18	35.3	39.6	26.43	66.7	47.4	15.2	1.0
Bss2	72-102	33.6	24.83	41.6	7.6	1.1	37.2	48.4	38.52	60.28	27.4	13.6	0.78
Bss3	102-152	14.0	44.7	41.5	7.8	0.29	37.8	41.9	41.21	37.6	43.8	4.8	0.44
P_6. Lagadwal tola													
Ap	0-12	34.53	35.44	30.03	7.05	0.98	25.6	15.4	26.43	48.6	30.6	11.0	0.38
Bw1	12-41	21.75	58.08	25.17	7.38	0.99	28.9	19.4	41.66	46.7	33.7	12.3	0.42
Bss1	41-63	39.20	25.11	35.69	7.58	0.53	30.1	20.1	37.63	50.8	30.1	14.5	0.52
Bc	63-102	28.19	39.03	32.78	7.16	0.71	32.1	12.8	36.73	50.2	28.2	10.6	0.32
P_7. Lagadwal thana series													
Ap	0-16	45.89	39.28	14.97	6.45	0.97	21.1	12.91	73.92	47.86	62.6	8.00	0.84
Bw1	16-32	34.70	50.26	19.49	6.79	0.71	27.2	14.08	85.12	41.14	50.8	8.32	0.36
Bw2	32-65	44.21	40.82	26.12	7.09	0.61	30.3	14.33	56.0	22.86	16.8	3.46	0.34

Table 3. Area and description of soil mapping units.

Mapping Unit	Mapping unit description	Area	
		(ha)	%
1.IBk3Ff	Budkhed: sandy clay, severe erosion with 15-25% slope, moderately gravelly	96.7	14.6
2.gmBk2E	Budkhed: gravelly clay, moderately erosion with 3-5% slope, very gravelly	54.8	8.3
3 .iBk3E	Budkhed: sandy clay, severe erosion with 10-15% slope, slightly gravelly	4.7	0.7
4. mNv2B	Navagaon: clayey, moderate erosion with 1-3% slope	78.1	11.8
5 .mNv3E	Navagaon: clayey, severe erosion with 10-15% slope, moderately gravelly	3.8	0.6
6 .mNv2C	Navagaon: clayey, moderately erosion with 3-5% slope, slightly gravelly	10.9	1.7
7 .iNv3F	Navagaon: sandy clay, severe erosion with 15-25% slope, very gravelly with wide gullies	3.0	0.5
8 .hNV2C	Navagaon: sandy clay loam, moderately erosion with 3-5% slope, slightly gravelly	7.8	1.2
9 .mNv2E	Navagaon:, clayey, moderate erosion with 10-15% slope, narrow gullies	46.6	7.0
10 .mNv2C	Navagaon: clayey, moderate erosion with 3-5% slope, narrow gullies	94.0	14.2
11 .mLg2B	Laghadwal: clayey, moderately erosion with 1-3% slope, moderately gravelly, poor terraced	10.4	1.6
12 .hLg2C	Laghadwal: sandy clay loam, moderate erosion with 3-5% slope, very gravelly, poorly bunded and single cropped	8.3	1.3
13 .mLg3E	Laghadwal: clayey, severe erosion with 10-15% slope, very gravelly, thin forest	24.2	3.6
14 .mLg2C	Laghadwal: clayey, moderate erosion with 3-5% slope, moderate gravelly, double cropped	30.4	4.6
15 .mLg2B	Laghadwal: clayey, moderate erosion with 1-3% slope, terraced and double cropped	21.0	3.2
16 .hLg2D	Laghadwal: sandy clay loam, moderate erosion with 5-10% slope, moderately gravelly, terraced and single cropped	15.8	2.4
17 .mBr2B	Brahmasila: clayey, moderate erosion with 1-3% slope, double cropped	25.0	3.8
18 .mGa2B	Gaikot: clayey, moderate erosion with 1-3% slope, poorly bunded and single cropped	15.8	2.4
19 .mGa2C	Gaikot: clayey, moderate erosion with 3-5% slope, moderate gravelly, poor terraced and single cropped	24.0	3.6
20 mLgt1B	Laghadwal tola: clayey, slightly erosion with 1-3% slope, double cropped	18.7	2.8
21 .hLgt2B	Laghadwal tola: sandy clay loam, moderate erosion with 1-3% slope, double cropped	11.9	1.8
22 .mLgh2C	Laghadwal thana: clayey, moderate erosion with 3-5% slope, slightly gravelly, poorly bunded land includes newly open lands occurring on different slopes	11.5	1.7
23 .mLgh2E	Laghadwal thana: clayey, moderately erosion with 10-15% slope, narrow gullies, poorly bunded land, slightly gravelly	6.6	1.0
Total		663.8	100.0

Table 4. Identification of themes and change in level of details.

Indicators	**High hills**					**Midhills**							**Low hills**						
	Number of farmers interviewed																		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1. Soil depth(cm)	+	0	0	+	-	+	-	+	0	0	0	-	0	-	+	-	0	0	-
2. Soil surface uneveness	+	+	+	-	+	+	+	-	+	-	+	-	0	0	-	+	-	+	-
3. Slope/aspect	+	0	0	+	0	0	0	0	+	0	+	-	0	-	-	0	-	0	-
4. Level of subsoil compaction	-	0	-	0	0	-	-	0	-	0	-	-	0	-	0	-	-	-	-
5.Condition of forest(poor)	+	+	+	+	+	+	+	+	+	+	+	0	+	-	0	+	0	-	+
6.Top soil erosion(rills >50%)	0	-	+	-	-	+	0	-	+	0	-	-	-	-	-	-	-	-	-
Management options (Themes added)																			
1.Grass field borders	-	0	-	+	0	-	-	+	+	-	0	-	+	-	0	-	-	-	-
2.Multispecies buffer (shrubs/ trees)	-	+	+	+	0	0	-	-	+	0	0	+	0	-	-	+	-	-	-
3.Ground cover crops	-	-	0	-	-	0	-	0	0	-	-	-	-	-	-	-	-	-	-
4. Minimum tillage	-	-	-	-	-	0	-	0	-	-	0	-	-	0	-	-	0	-	-
5. Diverse crop rotatons	-	-	-	-	-	0	-	0	-	-	0	-	0	-	-	0	-	0	-
6. Strip of grasses on the contour	-	+	-	-	-	0	0	0	+	-	-	+	-	0	0	-	+	-	-
7. Agroforestry	0	0	+	0	0	+	0	0	+	+	-	-	-	-	-	-	-	-	-
8. Increase of crop variety and diversity of species	-	0	0	-	0	-	0	-	0	-	-	0	+	+	0	0	+	+	0

The direction of change in level of details : + = high level of details , 0 =same level of details , - = lower level of details, light gray = one theme added, dark gray = three or more themes added.

Table 5. Thematic links between management options and ecosystem services in Lagadwal village.

Ecosystem services **Management options**	**Erosion control**	**Maintain soil fertility**	**Nutrient cycling**	**Healthy /wholesome food production**	**Carbon sequestration**
Grass field borders	***	-	-	-	-
Multispecies buffer (including trees/shrubs)	***	*	**	-	*
Ground cover crops	***	***	***	**	**
Minimum tillage	**	**	*	*	*
Strips of grasses on the contour	**	*	*	_	_
Agroforestry	*	*	*	-	*
Increasing crop variety/species diversity	***	***	***	***	**
Landscape planning	***	***	***	***	***
Standard organic agricultural methods	-	-	*	*	*

Note: ***-----Strong link, **-------moderate link, *----less important.

Table 6. Integration of landscape components for conservation plans.

Landscape components	**High hills(>620m)**			**Mid hills(620-600m)**				**Low hills(<600m)**	
Land forms	Summits	Steep side slopes	Narrow shoulder slopes	Broad crest slopes	Round crest side slopes	Gently undulating uplands	Ridge lines	Drainage depressions/ Foot slopes	
Slope(%)	1-3	15-25	3-8	3-8	8-15	3-8	3-5	1-3	0-1
Soil series	Budkhed		Lagadwal	Navgaon	Lagadwal thana	Gaikot	Lagadwal tola	Brahmasila	
Soil taxonomy	Lithic Ustorthents		Typic Ustorthents	Typic Haplustalfs	Typic Haplustepts	Typic Haplusterts	Leptic Haplusterts	Chromic Haplusterts	
Area(ha) / per cent	57.78 /8.3	96.7 /14.6	44.7 /6.7	244.2/36.9	18.1/1.7	39.8/6.0	30.6/4.6	25.0/3.8	
Stoniness /erosion	Strongly gravelly, moderately to severely erosion		Slightly gravelly, moderate erosion	Slightly gravel-ly, slight to moderate ero-sion	Moderately gullied, slight-ly gravelly	Slightly eroded, moderately gravelly	Moderately eroded, mod-erately gravelly	Slightly eroded	
Slope land capability*	Class -5/ 6(land for conservation and reserves)			Class-3(A3-intensive soil-water conservation)		Class-2 (A2-moderate soil-water conservation)		Class-1 (A1-unrestricted agricultural use)	
Soil-site sutablity	Marginally suitable for soybean-wheat			Marginally suitable for wheat, moderately suitable for soybean-sorghum		Moderately suitable for soybean-wheat		Suitable for sorghum -soybean-wheat	
Conservation methods	-Stone wall, Hill side ditches			Hill side ditches, stone walls		Bench terrace, grass strip, stone wall		bench terraces and broad based terraces	

Recommendations: The soil and land resource information at farm level is generated based on scientific understanding of soil-landscape mapping techniques and evaluating the land units according to its capabilities / suitability's to locally adopted crops. The landscape is a base for exploration of old ideas in new ways and construction of new theories (Morphy, 1993). The photographs provide landscape views of farming on difficult degraded hilly terrain and provide insight management responses against production mandates of crops. The soil-landscape information and its evaluation clearly showed that out of 663hectares of land in Lagadwal village, 175 ha is no arable with limited agricultural value having defects of extremely stony, steep gradients, severe erosion and restricted to poor grazing. The data further reveals that 9.8 per cent of class 1 land suitable for wide range of crops with well drained soils having at least 60cm depth, good water holding capacity, slightly stony (up to 5%) and moderate slopes whereas 64.2 per cent of class II and III land for narrow range of crops with wide variability of yield for crops like soybean, sunflower, jowar and maize. The soil survey acknowledges the utility of geo information for agri development at farm level but needs revision and reorientation of theme based strategic research programmes at landscape level through integrated multi layered analytical tools to improve the rural land evaluation programmes. The sustainable agriculture in a conventional mode of farming on these degraded rural hill landscapes should focus on agro-ecological approach for establishing network and integrating agricultural resource management with community development. The study strongly recommends conservation agriculture in rainfall scarcity zone as in study area that features little or no soil disturbance, no burning, direct seeding into previously untilled soil, crop rotation, and permanent soil cover, particularly through the retention of crop residues (Harrington, 2008). In CA, interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level. There is a lack of farm level evaluation of soil mapping units adjudged as suitable for two or more crops and working out crop equivalent ratings so as to monitor the yield variation in class II and class III lands. The soil series must be used as an index of soil information to transfer agrotechnology of that particular agro-ecology.

Conclusions

An attempt was made in the present study to describe the agricultural landscape changes as evidenced by photographs and field survey. The results offered an insight into the landscape transformation processes with natural constraints of stoniness, hard and compact sub soils, effective rooting depth, slope, low crop productivity and agriculture oriented towards small productions. This area comes under disadvantaged area (less favoured areas scheme) with conventional conservation of stone bunds (low cost and less skill labour job) and decreasing diversity of cultivated crops (soybean and sorghum). The integration of conservation plans with landscape elements were made with the application of slope land capability classification and suggested suitable conservation treatment in accordance with soil capability and suitability to modernized the farming activities in the region. The capability analysis showed that 46.1 per cent of total area under high hills (>620m) is classified as class 4 lands which needs conservation treatments such as bench terraces and stone walls for short term crops whereas broad based terraces and bench terraces for mid and low hills. The seven soil series identified in the study will serve as index of soil information in terms of using the soil in support of a particular type of agriculture or land use. Often, such a first designation of a soil series, however, can expand and also become more specific as soil scientists consult with local users of the soils to cross-check observations and recognition of advantages and disadvantages of a particular series. The aim of this exercise was to assess the sustainability of smallholder farmers in sloping uplands of Lagadwal village, Maharashtra.

The specific landscape indicators were developed to characterize sustainable land management practices. The landscape scenario's provided general measures such as change from monoculture to diversified use and proposed to achieve continued agricultural production. As the study area falls under rainfall scarcity zone, the steep sloppy lands must be covered with grass or strip buffer zones for checking top soil erosion and go for wide range of suitable crops in each mapping unit. The validation of indicators is not easy due to complexity of sustainability and needs medium to long term evaluation. The feedback from farmer's helped to increase level of confidence among researcher's to adapt the prototype in other parts of basaltic terrain of Maharashtra. The basic generic structure of integrating landscape with perceptions of local farmer's was used with change to suit the agro - ecological and socio-cultural systems. Farmer's opined that there should be a provision of incentives for organic farming practices, for farmers to revegetate buffer zones and to establish natural habitats on their land. Environmental education and good extension services in tribal areas are proposed as ongoing strategies to achieve participants' long term vision.

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