International Journal of Advance and Applied Research (IJAAR)
Peer Reviewed Bi-Monthly

ISSN – 2347-7075
Impact Factor – 4.935
Vol.6 No.2 Nov–Dec 2018

A Study of soil erosion using USLE method: A Cast Study of Temghar Catchment area.

Dr. Vilas B. Kamble
Head Department of Geography, Modern College of Arts, Science and Commerce Shivajinagar Pune 411005.

Abstract:

'Land degradation' means reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities. In this paper, universal soil loss equation (USLE), a quantitative method of predicting soil erosion losses from rainfall, and other factors is used. Present study evaluates only the physical factor of Mutha River Catchment in order to arrive at the maximum potential loss, therefore the values of cropping management and erosion control practice factors have been taken as a unity. This paper also studies prioritization of sub watersheds for conservation planning based on soil loss estimation. This study finds that reduction in the soil loss is observed to the areas where dense forest cover patches are in existence. Hill summits, hill fringe slopes are subjected to severe soil loss and accounts for about 1.3871% of the land surface area. For simplification six soil grades have been set up in by combining soils having ranges in Storie index rating. It can be observed from this paper that productivity classes of grade 1 and 2 are almost absent in the study area and productivity from fair to non agricultural land do exist in the study area. Grade 3 and 4 of fair and poor productivity almost comprises 73.74% of the entire catchment area and 84.99% of the total land surface area. It can be therefore said that, soil productivity in the study area is not at all good; however, some of the land facets are amenable and can be regenerated for optimum potential desired land use.

Keywords: land Degradation, universal soil loss equation (USLE), land use, soil erosion, watershed, conservation planning, Mutha River Catchment

Introduction:

Land degradation means reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands

resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as:(i) soil erosion caused by wind and/or water; (ii) Deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation." land degradation primarily relates to a reduction in soil quality and quantity as an input to the production of agricultural crops. But there are also off-site effects, such as loss of watershed function. This section of the chapter related with land degradation pertaining to soil cover loss due to geomorphic process as well as evaluation of land resources which dealt with the assessment of land and soil resources in the study area to infer general restrictions of land and soil resources for optimum utilization this will pertaining to land capability, land suitability classification as well as land productivity assessment. This exercise is thought to be very essential component of the present study which will form the basis for the soil suitability for rehabilitation of the people in the native area. As mentioned earlier, exploratory land resource field studies have been carried out this gives a rapid general appraisal of an area. Normally this is either to determine what further studies are required or to locate suitable sites for specified development.

Study Area:

The area selected for the present study is a catchment area of Temghar lake catchment from western Maharashtra. The Temghar dam commenced in the year 2000. The dam has been constructed keeping in view the increasing population of Pune city and thus linked to Khadakwasla irrigation project. The main purpose of these minor/medium projects is to supply water for Pune city as well as for irrigation in Haveli, Daund, Indapur, and Baramati tahsils.

The present study has been initiated to assess available natural resources in the lake catchment area itself and to ascertain the potential of it to hold these populations in the same catchment.

The dam is located near village Temghar across river Mutha. The study area is a catchment of Temghar dam and located between 18° 47' 00"N to 18° 38' 00" latitude and 73° 27 to 73° 32' 00" E longitude. The study area is located about 50 km to the west of Pune city. It is accessible by road only from Pune via Khadakwasala- Bahuli or via Pirangut - Mutha (S.H-57). The nearest railway station and Airport is at Pune. The Mutha river is a right bank tributary of the Bhima River in main Krishna basin. The Mutha river originates in the main Sahyadri ranges in taluka Mulshi, District Pune and flows through Mulshi and Haveli tahsils before meeting Mula river in Pune. The dam is located at about 13 km. from the origin of the river Mutha. The catchment area is 37.7 km^2. up to dam site including water body and area under water body is 4.99 km^2. The average gradient of the river at the dam wall location is 35 m/km. the average width of the valley is 4km.

Objectives:

1. To find out the soil erosion in the Temghar catchment area.
2. To suggest methods for the soil conservation.

Methods

Estimation of soil erosion using USLE

The universal soil loss equation (USLE) is a quantitative method of predicting soil erosion losses from rainfall, soil and other factors. The factors in the equation and its applicability to some situation in India have been used by Ram Babu et al (1970).

Since the present evaluates only the physical factor in order to arrive at the maximum potential loss, therefore the values of cropping management and erosion control practice factors have been taken as a unity.

The universal soil loss equation (USLE)

A=RKLSCP where,

A=Soil loss in short tons (2000lb)/acre/year (converted to kg/m^2/yr)

R=Rainfall erosivity factor, K= Soil erodibility factor=Slope length factor

S= Slope gradient factor, C= Crop management factor, P= Conservation practice factor.

Computation of basic inputs parameters in USLE

Estimating **R** factor (Erosivity factor)

The rainfall erosivity factor 'R' in the USLE is the number of rainfall erosion index units (El_{30}) for a particular location. It is defined (Wischmeier 1959) as one hundredths of the product of the kinetic energy of the storm (KE) & the 30min intensity (I_{30}) as the most reliable single estimate of rainfall erosion potential & was termed as (El_{30})

The R factor has been computed applying three methods, Roose (1975 a) Morgan (19740 foster, Lane, Nowlin, Laflen & Young (1981) The mean of these three methods have been given appropriate estimates of erosivity factor, (El_{30}) range from 300 to 800 mm.

Estimating K factor (soil erodibility factor)

This factor relates the rate at which different soil erode due to inherent soil properties. Soil erodibility defines the resistance of soil to both detachment & transport depending upon the physical & the chemical properties of soil. The factor is defined as mean annual soil loss per unit of erosivity for a standard condition of bare soil.

Estimating LS factor (slope length steepness factor)

The factor of slope length (L) & slope steepness (S) is combined in a single index. The high relative relief exhibits a significant variation in the LS factor in the study area ranges from 06 to 58 m. LS factor seems to be the dominant factor in accentuating soil loss in the area. The appropriate values are obtained from the equation.

$LS = L/22.13 (0.065+0.0455+0.0065S^2)$

Where **'L'** is in m &**'S'** in percent

The high relative relief exhibits a significant variation in the LS factor in the study area ranges from 0.98 to 21.28 m.

According to Wischmeier the magnitude of the above values (0.01-0.9) is a function of soil characteristics, vegetal cover, crop residues & other factors.

Estimating C factor (Crop factor):

It represents the ratio of soil loss under a given crop to that from bare soil. In the present study this factor is taken as a unity & based on the % vegetation cover as estimated from FCC image for the Google image 2006.

Estimating P factor (conservation practice factor):

As like 'C' factor 'P' factor is also considered as unity in the present study.

Results and Discussion:

The area comprised of five major land facets viz; hill summits surface, hill fringe surface, rolling pediment & valley floor (plain) surface and escarpments. The information thus generated & results obtained are discussed according to type of land facets in the study area.

Hill summit surface comprises about 16.01381area in km^2 (48.957%) of total land surface mostly cut as runoff zones along the marginal area of the study area. Mean soil loss estimated along this land facet is of varying magnitude and range between 5 to 10 $Kg/m^2/yr^{-1}$. Some pockets of the higher soil loss above 15 $Kg/m^2/yr^{-1}$ are noticed in southern part of this land (Table 1)

Table 1: Extent of the soil loss by Universal Soil Loss Equation

Soil loss in $Kg/m^2/Y^{-1}$	Below 5	5 to 10	10 to15	15 to 20	Above 20	Total
Area in Km^2	**07.09856**	**16.01381**	**05.83911**	**3.30481**	**00.45371**	**32.71**
Area in %	**21.701**	**48.957**	**17.851**	**10.103**	**1.3871**	**100**

Hill fringe surface is a skirt zone of hill summit surfaces marked by sharp to blunt crests with rugged appearance indicating that the surface runoff at the upper reaches of the surfaces has caused rill erosion, & characterized by gully heads & ravenous land. Higher mean soil loss is to the order of 13.89169 $Kg/m^2/yr^{-1}$, has been observed along this land facet. Pediment surfaces have moderate mean soil loss ranges between below 5 to 10 $Kg/m^2/yr^{-1}$.Mean soil losses in the plain surface range is below0.117587 $Kg/m^2/yr^{-1}$.

Prioritization of sub watersheds for conservation planning based on soil loss estimation studies:

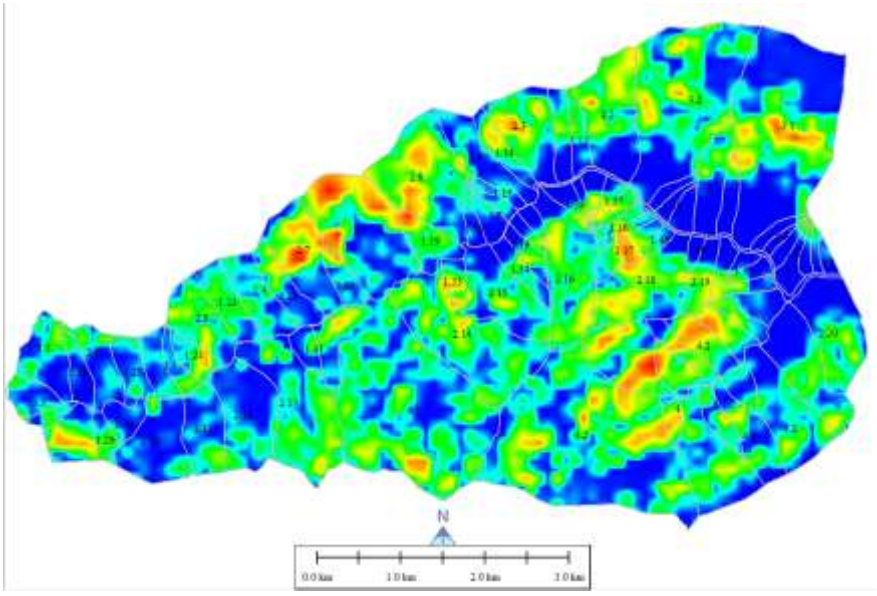
Natural resource development programmes are applied generally on watershed basis and thus prioritization is essential for proper planning and management for sustainable development**.** Watershed deterioration is a common phenomenon in most parts of the world. Amongst several causes, the major ones are improper utilization of of watershed resources without any proper vision. Therefore, drainage basins, catchments and sub- catchments are the fundamental units of the management of land and water. The watershed management concept recognizes the inter-relationships among the linkages between uplands and low lands. Soil and water conservation is key issue in watershed management while demarking watershed. While considering watershed conservation work, it is not feasible to take the whole area at onces. Thus, the whole basin is divided into several units as a watershed and sub- watershed. In the study area (Temghar lake catchment) prioritization of sub watersheds for conservation planning based on soil loss estimation studies has been planned in the following manners.

Grid wise estimation of soil loss:

In order to understand spatial patterns of variations in soil loss of the entire area, an attempt has been made to classify the whole catchment into 90 cells. It can be observed from the figure 4.1 that middle portion of the Temghar lake catchment area is subjected to very high soil loss and it varies between 0.11 to 21.98 tons per acre per year. This part mainly consists of the areas of both the flanks of the reservoir. The middle part of the northern as well as southern flanks heavy soil loss is subjected to summital convexities of hill slopes and gullied ravenous topography of the area. Reduction in the soil loss is observed to the areas where dense forest cover patches are in existence. Hill summits, hill fringe slopes are subjected to severe soil loss and accounts for about 1.3871% of the land surface area.

Sub basin wise estimation of soil loss:

In all five priority levels for conservation planning has been determined.



1. **Priority level I: - Very severe soil loss: (Above 20 kg/m²/year):** About 03 sub basins are noticed to be in this category. 03 fourth order basins namely TEM 4.2.7, TEM 4.2.9, TEM 4.212 covers under this category. Percentage slope variation is between 20 to 35.5% mainly of Sandy Loam and Sandy clay Loam soil covers this area. Main characteristics of this area fall under watershed category of Land use/ Land cover class. This category covers 0.45371 km² (1.38371% areas).
2. **Priority level II: - severe soil loss: (Between 15 to 20 kg/m²/year):** This category between 15 to 20 kg/m2/year covers about 3.30481 km ² (10.103% area) of the total land surface area and covers 01 first order basin, viz TEM - 1.33, TEM -2.5 TEM -2.6 TEM - 2.7 TEM -2.17, total 04 are second order basins while TEM -4.2.10 and TEM -4.2.13 covers fourth order. Very steep valley side slopes with numerous formations of gullies and typical ravenous topography of these basins mainly noticed to fall under wasteland category of land use types.
3. **Priority level III: - High soil loss: (Between 10 to 15 kg/m²/year):** About 16 sub basins comprise this category and covering 05.83911km² (17.851% area) of the total land surface area. Hill slopes with devoid of vegetation, sandy loam dominant soil type with very less infiltration capacities contributes maximum soil loss along with high erodibility index. Slopes in this category range from 15% 30%. In this category in all 16 sub basins have been noticed, i.e. seven first order basins, TEM - 1.14, TEM - 1.19, TEM - 1.24, TEM - 1.41 TEM - 1.42 TEM - 1.43 TEM - 1.44. Seven second order basins TEM - 2.2, TEM - 2.3, TEM - 2.8, TEM - 2.14, TEM - 2.16, TEM - 2.18, TEM - 2.19, two fourth order basins, TEM - 4.2.11, 4.2.14 covers this entire category.
4. **Priority level IV: - Medium soil loss: (Between 05 to 10 kg/m2/year):**

Sr.no	Average soil loss Category Kg/m²/Year	Description	Area in Km²	Area in %	Sub basin codes
1	Below 5	Low	07.09856	21.701	TEM-1.1, TEM-1.2, TEM-1.3, TEM-1.4, TEM-1.5 TEM-,1.6, TEM-1.7, TEM-1.8, TEM-1.9, TEM-1.10, TEM-1.11, TEM-1.15, TEM-1.16, TEM-1.17, TEM-1.18, TEM- TEM-1.26, TEM-1.27, TEM-1.28, TEM-1.30, TEM-1.31, TEM-1.37, TEM-1.38, TEM-1.46, TEM-1.48, TEM-1.49, TEM-2.4, TEM-2.9, TEM-2.10, TEM-2.11, TEM-2.12, TEM-4.2.3, TEM-4.2.15.
2	5 to 10	Medium	16.01381	48.957	TEM-1.12, TEM-1.13, TEM-1.20, TEM-1.21, TEM-1.22, TEM-1.23, TEM-1.25, TEM-1.29, TEM-1.32, TEM-1.34, TEM- 1.35,1. TEM-36,1.39, TEM-1.40, TEM-1.45, TEM-1.47, TEM-1.50, TEM-2.1, TEM-2.13, TEM-2.15, TEM-2.20, TEM-3.1, TEM-3.2, TEM-3.3, TEM-4.1, TEM-4.2.1, TEM-4.2.2, TEM-4.2.4, TEM-4.2.5, TEM-4.2.6, TEM-4.2.8.
3	10 to 15	High	05.83911	17.851	TEM-1.14, TEM-1.19, TEM-1.24, TEM-1.41, TEM-1.42, TEM-1.43, TEM-1.44, TEM-2.2, TEM-2.3, TEM-2.8, TEM-2.14, TEM-2.16, TEM-2.18, TEM-2.19, TEM-4.2.11, TEM-4.2.14.
4	15 to 20	severe	03.30481	10.103	TEM-1.33, TEM-2.5, TEM-2.6, TEM-2.7, TEM-2.17, TEM-4.2.10, TEM-4.2.13.
5	Above 20	Very severe	0.45371	01.3871	4.2.7,4.2.9,4.2.12.

Soil loss in this category range to vary between 05 to 10 kg/m2/year comprises 31 sub basins out of which 17 are first order basin, viz TEM- 1.12, TEM - 1.13, TEM - 1.20, TEM -

1.21, TEM - 1.22, TEM - 1.23, TEM - 1.25, TEM - 1.29, TEM - 1.32 TEM - 1.34 TEM - 1.35, TEM - 1.36, TEM - 1.39, TEM - 1.40, TEM - 1.45, TEM - 1.47, TEM - 1.50. Four second order basin, TEM - 2.1, TEM - 2.13, TEM - 2.15, TEM - 2.20.Three third order basin i.e. TEM -3.1, TEM -3.2, TEM -3.3.and 07 fourth order basins TEM -4.1, TEM -4.2.1 TEM -4.2.2, TEM - 4.2.4, TEM -4.2.5, TEM -4.2.6,TEM -4.2.8.This category covers maximum area about 16.01381 km^2 (48.957% area) of the total land surface area. In this category it is noticed to be high seems to be due to the hill slopes of mainly scrubland, elongated depression along hill slopes.

Priority level V: - Low soil loss: (Below 05 kg/m^2/year): This category covers maximum area about 07.09856 km ^{2} (21.701% area) of the total land surface area and comprises 32 sub basins out of which 25 are first order basins viz, TEM-1 TEM-1.2, TEM-1.3, TEM-1.4, TEM-1.5, TEM-1.6, TEM-1.7, TEM-1.8, TEM-1.9, TEM-1.10, TEM-1.11, TEM-1.15, TEM-1.16, TEM-1.17, TEM-1.18, TEM-1.26, TEM-1.28, TEM-1.30, TEM-1.31, TEM-1.37 TEM-1.38, TEM-1.46, TEM-1.48, TEM-1.49, 05 second order basins TEM-2.4 TEM-2.9, TEM-2.10,. TEM-2.11, TEM-2.12, and 02 are fourth order basins TEM-4.2.3, TEM-4.2.15. The spread up of these basins mainly noticed along the pediment zone with sandy clay loam soil environment. Which fevers high infiltration as well as area in well marked with medium to dense vegetation cover. Slope is ranging between 5% to 10%.

Conclusion:

Reduction in the soil loss is observed to the areas where dense forest cover patches are in existence. Hence it can be said that forest cover is essential to decrease the soil loss. Natural resource development programs are applied generally on watershed basis and thus prioritization is essential for proper planning and management for sustainable development**.** Watershed deterioration is a common phenomenon in most parts of the world. Amongst several causes, the major ones are improper utilization of of watershed resources without any proper vision. Therefore, drainage basins, catchments and sub- catchments are the fundamental units of the management of land and water. The watershed management concept recognizes the inter-relationships among the linkages between uplands and low lands. Soil and water conservation is key issue in watershed management while demarking watershed. While considering watershed conservation work, it is not feasible to take the whole area at once.

In view of the site suitability for rehabilitation of the project affected people in the native area itself detailed study of land and soil resources is essential; therefore, land evaluation of the study area can be performed and land capability, suitability and productivity assessment can be done.

References

1. Abhalaxmi Singh (1985): "The problems of Wasteland in India" B.R.Publishers,New Delhi.
2. Abrol E.D. & H.S.Gill. (1986): "Problems and prospects of afforestation of salt affected soils" Dimentions of wasteland development, concept publishing company, New Delhi.
3. Adams.W.M. (1993) "Development's Deat Ear: Downstream users and Water Releases from Bakalori Dam, Nigeria."World Development, vol21 (9):1405-1416.
4. ADB (Asian Development Bank)(1995) Involuntary Resettlement, printed by Asian Development Bank. Available at http://www.abd.org/Document/Policies/Involuantary-Resettlement/involuntary-resettlement.pdf 2004-09-08.
5. ADB (Asian Development Bank)(1998) Handbook on Resettlement-A Guide to Good Practice, printed by Asian Development Bank. Available athttp://www.abd.org/Document/Policies/Involuantary Resettlement/involuntary-resettlement.pdf 2004-09-08.printed by Asian Development Bank. Available at http://www.abd.org/Document/Policies/Involuantary-Resettlement/involuntary-resettlement.pdf 2004-09-08
6. Agnihotri.A (1996) The Orissa resettlement and Rehabilitation of Project Affected Persons Policy, 1994-An analysis of its robustness with Reference to the Improvement Risk Model,in A.B.Ota and Anita Agnihotri (Eds.) Involuntary Desplacement in Dam Project, Prachi Prakashan, New Delhi.
7. Agnihotri.A (1996) The Orissa resettlement and Rehabilitation of Project Affected Persons Policy, 1994: Some Critical Issues, in Mohapatra,A. B.Ota and R.N.Mohanty(Eds.) Development Induced Displacement and Rehabilitation, Prachi Prakashan,Bhubaneswar.
8. Annals of the National Association of Geographers, Balaji K., Raghavswamy.V., Rammohan, Nagaraja R., Gautam N.C. India, Vol. XV, No. 2, (December1995) 121-125.
9. Ashaq Hussain Sheikh,Sarvesh Palria and Akhtar Alam (2011) Integration of GIS and Universal Soil Loss Equation (USLE) for Soil Loss Estimation in a Himalayan watershed. Recent Research in Science andTechnology,
10. Bavisker.A. (1995) In the Belly of the River: Tribal Conflicts over Development in the Narmada Valley.Delhi: Oxford University Press.
11. Beek K.J, De Bie.K and Driessen P.(1997) " Land information and land evaluation for land use planning and sustainable land management.Current Science,Vol.96, No.4,25 february 2009.

12. Bisht S.R. & Kothyari B.P. (2001) 'Land Cover Change Analysis of Garur Ganga Watershed Using GIS /Remote Sensing Technique', Vol. 29, No. 3 (September 2001) 137-142.
13. Brady Niles C. (1995) 'The Nature and Properties of Soils', (Tenth Edition) Prentice Hall of India, New Delhi.
14. Briggs Davis (1977) Edited by Morgan M.A. 'Sources & Methods in Geography Soils',
15. Butterworths London. Brown, L. R. and E. C. Wolf. 1984. Soil Erosion: Quiet Crisis in the World Economy. World-watch Paper 60. Worldwatch Institute, Washington, D.C.
16. Census of India (2011) District Census Handbook, Director, Government printing and stationary, Maharashtra Government, Photozinco press, Pune.
17. Cernea.M.M.(1990).Poverty risks for population displacement in water resources development," Development Discussion Paper 355 (Cambridge,Massachusetts, Harvard Institute for Iternational Development).
18. Cernea.M.M.(1996)"Public Policy responses to Development induced population displacement," Economic and Political Weekly, vol.31,No.24,pp.1515-1523.
19. Cernea.M.M.(1996)" Development, displacement and Rehabilitation-Special Issue," Economic and Political Weekly, vol.31,No.(24),June 15.
20. Chattopadhyay Mahamaja and Shakuntala C. (1987) 'Landuse and Its Relation with Terrain Characteristics: A case Study in Wayanad Plateau, India', Annals of the Association of Geographers India Vol. VII, No. 2, (December 1987) 1-12.
21. Chattopadhyay Srikumar and Salim M.B. (1985) 'Morphological Classification of Land and Assessment of Its Suitability for Various Uses: A Case study on Bovalipuzha – Aralampuzha Drainage Basin', Transactions of Indian Institute of Geographers. Vol. 7, No. 2, (July 1985) 105-112.
22. Colchester.Marcus (2000) Sharing Power: Dams, Indigenous Peoples and Ethnic Minorities. Report Prepared for the World Commission on Dam. Website: http://www.dams.org.
23. Coline Clark. (1970): " The Economics of Irrigation " Pergamon press, New York.
24. Colson.E. (1971) The social consequences of Resettlement: The impact of Kariba Resettlement upon the Gwembe Tonga. Manchester University Press.
25. Daji J.A. revised by Kadam J.R. (1996) 'A Textbook of Soil Science', Media Promoters and Publishers Pvt. Ltd., Bombay.
26. Das T.H., Sarkar Dipak and Singh D.S. (1994) 'Land Evaluation for Different Uses in Sikkim: A Case Study in Perhumid Subtropical Region', Landscape Systems, Vol. 17, No. 2. 96-100.

27. Dent David and Young Anthony (1981) 'Soil Survey and Land Evaluation', George Allen and Unwin (Publishers) Ltd. London.
28. Gerrard A.J. (1981) 'Soils and Landforms – An Integration of Geomorphology and Pedology', George Allen and Unwin (Publishers) Ltd. 40, Musecum Street, London.
29. D.Martin and S.K.Saha.National Bureau of soil survey and Land use planning, Regional planning centre, IARI Campus, New Delhi. Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed
30. .Dreze,J.M.Samson and S.Singh.(1997) The Dam and the Nation: Displacement and Resettlement in the Narmada Valley. Delhi and New Yark: Oxford University Press.
31. Driessen P.M.and Konijn N.T. (1992) Land use systems analysis.Wageningen: Wageningen Agricultural University , Department of Soil Science and Geology.
32. .Economic and Political Weekly (1996) "Development, Displacement and Rehabilitation-Special Issue," Vol.31 (24) June 15.
33. Fahim.h.m. (1981) Dams, People and Development: The Aswan high dam case, Oxford: Pergamon Press.
34. Fernandes.w.and Thukral (ed.) (1989) "Development, Displacement and Rehabilitation. Indian Social Institute, New Dehli.P.195.
35. Fernandes.w.and Vijay Paranjpye (ed.) "Rehabilitation Policy and Law in India. A Right to Livehood. Indian Social Institute, New Dehli.Econet,Pune P.559.
36. Fox.J. and L.D.Brown (ed.) (1998) The Struggle for Accountability: The World Bank, NGO's,and Grassroots Movement .Cambridge,MA and London:MIT Press.
37. Fisher. W.F.(ed.) (1995) Working Towards Sustainable Development. The Damming of the Narmada River in Western India. Armonk,NY:M.E.Sharpe.
38. Ganopadyay.T. (1983) Katkhadi, Studies on Rehabilitation of Submerging Villages, Centre for Social Studes,Surat.
39. Goldsmith.E andN.Hilyard. (1984). "The Social and Environmental Effects of Large Dams". Vols.1 and 2 Cornwall, UK: Wadebridge Ecological Centre.
40. Government of India. (2004) National Policy on Resettlement and Rehabilitation for project affected families-2003. Gazette of India, Extraordinary Part I, Section I, No-46, 17 February 2004.
41. Government of Maharashtra (2005). Report: Pune District Réhabilitation Centre; Publication.
42. Gaikwad Sunil w. (2003). The significance of Geomorphic Analysis in the evaluation of land resources: A study of Khadakwasala lake catchment, A minor research project.
43. Haberern, J. 1992. A soil health index, J. Soil and Water Conservation. 47:6.

44. Hornick, S. B. 1992. Factors affecting the nutritional quality of crops. Amer. J. Alternative Agric. 7:63-68.
45. Horowitz.M.M.et.al. (1993) Resettlement at Manantali,Mali:Short-term success, Long term Problems. In: Cernea and Guggenheim.
46. ICID (International Commission on Irrigation and Drainage) 2004:Task Force (TF 5)Appropriate Decision Making Procedures for New Dams particularly for irrigation, Drainage and flood management, New Delhi, India.
47. -Dr. Sunil W.Gaikwad (2003) "The significance of geomorphic analysis in the evaluation of land resources, study of Khadakwasala Lake Catchment, Western Maharashtra." The miner research project, UGC,Western Zone Pune.
48. Jadhav Ambadas S. (2001) Landform analysis around Kolhapur based on remote sensing techniques. The Deccan Geographers Vol.39 No 2(July December 2001).
49. J.R.Benites, F.Shaxson, M.Vieira-Land condition change, indicaters for sustainable land resource management. Pp 1-10.
50. K.Anilkumar. (2009) "Dams and displacement: A Review. Centre for economic and social studies.Begumpet, Hydrabad 500016.
51. Land resource evaluation: 23 rd Course Professional Master, IAO 2003.
52. Detailed soil survey report: Government of Maharashtra, Department of agriculture.
53. Larson, W. E., G. R. Foster, R. R. Allmaras, and C. M. Smith. 1990. Research Issues in Soil Erosion/Productivity - Executive Summary. Published by University of Minnesota, St. Paul, Miunesota. 35 p.
54. Lokrajya, (1986) Rehabilitation of the Project Affected Persons. Lokrajya, 42(10):6-8 and 12.
55. Maharashtra Shasan Krishi Vibhag- Mrud Survekshan and Mrud Chachani. Krishi Bhavan, Shivajinagar, Pune-5.
56. Massee, T. W. 1990. Simulated erosion and fertilizer effects on winter wheat cropping inter-mountain dryland area. Soil Sci. Soc. Amer. J. 54: 1720-1725.
57. Majot J. (ed.) (1997) Beyond Big Dams: A New Approach to Energy Sector and Watershed Planning.Berkely: International Rivers Network.
58. Mathur H.M. and Marseden (eds) (1998) Development Projects and Impoverishment Risks: Resettling Project-Affected People in India.New Delhi: Oxford University Press.
59. Mathur H.M. (1999). The Impoverishment Potential of Development Projects: Resettlement Required Risk Analysis.
60. Mitchell Bruce-(1979) Geography and resource analysis. Longman Publishers, New York.

61. Modi R (2004) Sardar Sarovar Oustees: Coping with Displacement, Economic and Political Weekly, March 13, pp.1123-1126.
62. (1995) 'Remote Sensing Analysis of Landuse / Landcover of Proposed Tuticorin Refinery Site: An Input for Environmental Impact Assessment',
63. Moharana P.C. and Vats P.C. (1998) geomorphic evaluation of landform for sustainable landuse planning in Western Rajasthan. Indian Journal of Geomorphology vol. 3, No. 2, (July-December 1998) 221-2321.
64. O.Challa, S.Vedivelu, J.Sehagal (2008). Soils of Maharashtra for optimizing Land use National Bureau of Soil Survey and Land Use Planning. Nagpur. Training Course on soil survey and mapping. February Organized by: National Bureau of Soil Survey and Land Use Planning. Nagpur Soil Annual, Department of Agriculture, Government of Maharashtra.
65. Panda Damodar (2000) 'Land use/Land cover mapping of the Rukshikulya basin – A remote sensing approach', The Deccan Geographer Vol. 38, No. 1 and 2. (January-December 2000) 1-16.
66. Paranjape Suhas, Joy K.J., Machado Terry, Varma Ajaykumar, Swaminathan S. (1998) 'Watershed based development' – A source book, Bharat Gyan Vigyan Samithi, New Delhi.
67. Parasuram S. (1994) Summary of the findings of the status of R and R of Reservoir Displaced People in Maharashtra. Tata Institute of Social sciences, Mumbai. July, 1994, Mimeo. P.17.
68. Patridge W.L. (1990) "Involuntary Resettlement in Development Project,"Journal of Refugee Studies,Vol 2 (3):373-384.
69. Pawar C.T. and Pujari A.A. (2000) 'Soil degradation in sugarcane farming: A micro level analysis', Transactions, Institute of Indian Geographers Vol. 22. No. 1 (January 2000) 25-34.
70. 22. No. 1 (January 2000) 25-34.
71. Pillai Rekha Oleschak (1996) "Sardar Sarovar Injustices. Email: rekha. Oleschak@ using.cli
72. Ram Babu Mallavarapu.(2006)Development Displacement and Rehabilitation: An Action Anthropological Study on Kovvada Reservoir in West Godvari Agency of Andra Pradesh, India.
73. Reddy I.U.B (1993) Rehabilitation.Mittal Publication, New Delhi.P .213.
74. Rossiter D.G.(2003) Biophysical Models in Land Evaluation. EOLSS Publishers Co.Ltd.U.K.
75. Ray Parshuram (2000) Development Induced Displacement in India.SARWATCH Vol.2.

76. Roy Arundhati. (1999).The Greater Common Good. Bombay: India Book Distributors (Bombay) Ltd.
77. Sahai V.N. (1996) Fundamentals of Soil. Kalyani Publishers, Ludhiyana and New Delhi.
78. Sarma V.V, L.N., Murali Krishna, Hema Malini B. and Nageswara Rao K. (2001) 'Land use/land cover change detection through remote sensing and its climatic implications in the Godavari delta region', Journal of the Indian Society of Remote Sensing, Photonirwachak, Vol. 20. No. 1 and 2. (2001). 85-92
79. Scudder T.and E.Colson (1982) "From Welfare to Development: A conceptual framework for the analysis of dislocated people." In A.Hansen and A.Oliver Smith,eds,
80. S.Srinivasa Vittala,S.Govindaiah and H Honne Gowda (2008) Research Article on " Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using, GIS and socio-economic data. Current Science, VOL.95 No.03.
81. Soil Science Society of America. 1984. Glossary of Soil Science Terms. Soil Science Society of America, Madison, Wisconsin. 37 p.
82. Sumitra Shinde. May (2008).Land resource management: A Case study of Mutha valley catchment
83. Surendra Singh (1996) 'Geomorphology in the Appraisal of Natural Resources for Integrated Sustainable Landuse Planning of an Arid Environment', Indian Journal of Geomorphology, Vol.1, No.1. (January-June 1996). 47-76.
84. Tapeshwar Singh (2002) 'Land use and Land cover Change in Global Context', The Deccan Geographer, Vol. 40, No. 2, (July-December 2002) 27-44.
85. Training Course on soil survey and mapping. February 2008. Organized by: National Bureau of Soil Survey and Land Use Planning. Nagpur.
86. Soil Annual, Department of Agriculture, Government of Maharashtra
87. Young Autonym (1989) 'Agro forestry for Soil Conservation', C.A.B. International, Wallingford Oxon U.K.
88. Viswas Patil (1983) Zadazadati Phadake prakashan, Pune.
89. W.G.Sombroek, Land and Water Development division, FAO.Rome, Italy.Land Resources Evaluation and the roll of land-Related Indicators.
90. Report: Pune District Rehabilitation Centre; 2005 Publication,Government of Maharashtra.
91. Detailed soil survey report: Government of Maharashtra, Department of agriculture.
92. Maharashtra Shasan Krishi Vibhag- Mrud Survekshan and Mrud Chachani. Krishi Bhavan, Shivajinagar, Pune-5.

93. Soil of Maharashtra for optimizing Land use.O.Challa, S.Vedivelu, J.Sehagal.National Bureau of Soil Survey and Land Use Planning. Nagpur.. Training Course on soil survey and mapping. February 2008. Organized by: National Bureau of Soil Survey and Land Use Planning. Nagpur.
94. Soil Annual, Department of Agriculture, Government of Maharashtra.
95. Ramprasad (1988) Technology of waste land development. Associated publishing company, New Delhi.
96. S.C.Sharma (ed.) (1990) Utilization of wasteland for sustainable development, wastelands definition and classification.Concept publishing company, New Delhi.
97. Shafi M. (1968) :The problem of the wastelands in India, Geographer, NoXXI, Aligarh.
98. Shankarnarayana S.K. (1986): Agroforestry the key to rehabilitation of wasteland, Pro.ICAR sponsored summer institute (CAZRI) Jodhpur.
99. Rekha Oleschak Sardar Sarovar injustices, FMR 26, Sardar Sarovar injustices