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MEASURING RESILIENCE OF LAND AGAINST DEGRADATION FROM A FARMER'S PERSPECTIVE APPROACH IN KENDUJHAR PLATEAU, ODISHA (INDIA)

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Abstract

Resilience is the capacity or the ability of a system to return to its pre-altered state following change. In the present study, carried in Kendujhar Plateau of Odisha, the resilience of land is assessed against its degradation. The area is experiencing negative effects of land degradation which are visible in the form of low agricultural outputs and benefits. The study uses various indicators to analyse and assess the land resilience from a farmer's perspective approach as they are the direct user of land and the final decisions have to be made by them about land degradation. The result indicates spatial variation in the magnitude of lands resilience due to performance of different indicators. It is concluded that various human activities contribute differently in increasing or decreasing the level of resilience in the study region.

Keywords: *Land Degradation, Agriculture, Farmer, Indicators, Resilience Index*

1. INTRODUCTION

Land is susceptible to degradation. Most of the land have inbuilt capacity to resist exogenous and endogenous factors and to recover its capacity. Actually, this recovery depends upon the magnitude of the problem and intensity of the restoration efforts (Blanco-Canqui and Lal, 2008). In other words, a land possesses an inherent regenerative capacity (resilience), which in interaction with proper management can reverse the land degradation process. Therefore, land degradation is not only determined by its susceptibility but also by the level of resilience. Actually, susceptibility and resilience are measures of the vulnerability of a landscape to degradation (Stocking and Murnaghan, 2001). Susceptibility is the degree to which a land system undergoes change due to natural forces, human intervention or a combination of both. On the other hand, resilience has been defined in many ways like ability, capacity, resistance in analysing the managing aspects of soil erosion and disasters (Lal, 1997; Seybold, Herrick and Brejda, 1999; Zhou et al., 2010). It is also defined as the capacity or the ability of a system to return to its pre-altered state following change.

In the context of agricultural land degradation, susceptibility refers to that how easy it is to degrade the land and resilience means how easily we can restore the land through management efforts (Table 1). How easily means that if the land is highly susceptible to degradation and the resilience is low, land will be easily degraded. But if the resilience is

high with higher susceptibility it will not be easily degraded. Therefore, resilience matters. Here, resilience represents the land management efforts adopted by the individual farmer, community or government in the region. In the study area, Kendujhar Plateau of Odisha, the land is susceptible to various activities like unsustainable agricultural practices, deforestation, unscientific mining etc. On the other hand, very few efforts are taken to increase the capability and resilience of land. However, it is very difficult to measure because till now no efforts have been made in this regard. The data on resilience is difficult to find. No methodology has been developed till today.

Table 1: Susceptibility and Resilience with respect to Land Degradation

Resilience → / **Susceptibility ↓**	**Low**	**High**
High	Easy to Degrade Difficult to restore capability	Easy to Degrade Easy to restore capability
Low	Difficult to Degrade Difficult to restore capability	Difficult to Degrade Easy to restore capability

Source: Adopted and Modified from Stocking and Murnaghan (2001), p. 18.

In the present paper, an attempt is made to measure resilience of land from a farmer's perspective due to various reasons. *First*, farmers are the primary users of land. Farmers are directly affected by susceptibility and the final decisions have to be made by them to control land degradation. They try to increase the land resilience by adopting management techniques. *Second*, farmers have long field experiences. Their observations, understandings, responses and insights gained over years and generations are most significant assessments of the local conditions. *Third* and the most important, is that farmer-perspective assessments are more practical. The results provide a far more practical view of the types of interventions that might be accepted by land users. Farmers experiment in many areas, e.g. they try new varieties of seeds and technology, changes date of sowing seeds, test different fertility treatments and conservation measures etc (Stocking and Murnaghan, 2001, Kumar Shit et al., 2015). Therefore, farmer-perspective assessment is a kind of storehouse of knowledge that could not be gained by any other means.

Through the review of literature review it has been found that at various levels, resilience have been studied in various fields like disaster, ecology, soil science etc in rural as well as urban areas (Greenland and Szabolcs, 1994; Lal, 1997; Blanco-Canqui and Lal, 2008; Zhou et al. 2010). Almost negligible researches are done in this field to investigate the level of problem and to provide information on the resilience of land in order to estimate the optimal planning of the available land resource. To measure the various aspects of resilience different indicators have been used and analysed to assess the soil resilience (Seybold, Herrick and Brejda, 1999; Lal, 1997), its impact on productivity (Adger, 2000; Abdel Kawy and Ali, 2012) in different parts of the world. It is found that most of them were based on physical characteristics of land like soil type, vegetation, climate etc. The present study looks after various human activities which contribute in increasing or decreasing the level of land resilience from a farmer's perspective.

Therefore, the objective of present paper is to measure the level of resilience of land in the Kendujhar Plateau located in the Northern parts of Odisha State in India. Such type of investigations assumes importance in preparation of a comprehensive land policy for the rural areas which will satisfy the growing needs of farmers' which they expect from the land on

which their livelihood depends. Moreover, the results and findings of the present study with respect to Kendujhar Plateau in Odisha state of India would be meaningful, practical and beneficial for rural area land resource management in highlands of India and as well as in the other parts of the world.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The Kendujhar Plateau region falls within the territory of the Kendujhar district located in the northern part of the Odisha (Figure 1). It is a part of land-locked district Kendujhar and stretched between 21°5' to 22°10' North latitude and 85°11' to 86°5' East longitude. It covers an area of 6,863 sq km (82.7 per cent of the total district). The region is as varied as the whole of Odisha with waterfalls, roaring gorges, hills, natural resources and minerals. The plateau is a source of many rivers; most of them are the tributaries of the perennial Baitarini river. The region has humid climate and a prolonged erratic monsoon which is suitable for tropical moist deciduous and tropical semi-evergreen vegetation. The main economy of the region constitutes agriculture, forestry and mining. Rich iron-ore are protected with moderately dense vegetation of predominantly sal and kendu trees.

The study area is experiencing the negative effects of land degradation which are visible in the form of low agricultural outputs and benefits. At the same time farmers often take a short-term approach to increase land productivity which may decrease land quality and also management steps which increases its quality and level of resilience. Mostly farmers of the region are poor, dependent upon traditional methods of agricultural production and poorly informed. Therefore, the measurement of resilience in such areas is very important so that the results of the study can help in decision-making about the farms and farmers livelihood sustainability.

2.2 Data Collection on Resilience of Land

For sustainable management of land, it is crucial to know the details of actual level of land management efforts and its concentration. However, in most developing countries including India, it is very difficult to collect such information. Therefore, the data for this research are collected mainly from primary data sources. Land degradation in Kendujhar Plateau region is a severe problem in front of the farmers and detailed studies at the village level pertaining to resilience of land at micro-level as a specific case have not been undertaken so far in the district and state as well as in the country. Therefore, the overall research method in the present study is based on interdisciplinary, descriptive and integrated analysis approach. A primary survey pertaining to various aspects related to resilience of land in 16 sample villages was conducted between December 2012 to late January 2013 by means of structured questionnaire. The survey contained both open and close ended questions from the farmers. *Purposive random sampling* method is used to select sample villages. Four sample villages were selected based on four economic activities[1] practiced in the respective villages by the villagers as they are also the reason for land degradation there. These four economic activities are: (i) agriculture, (ii) agriculture and mining, (iii) agriculture, mining and forestry, and (iv) agriculture, shifting cultivation or forestry. Thus, a total of 16 villages have been selected for the primary survey (Figure 2 and Table 2).

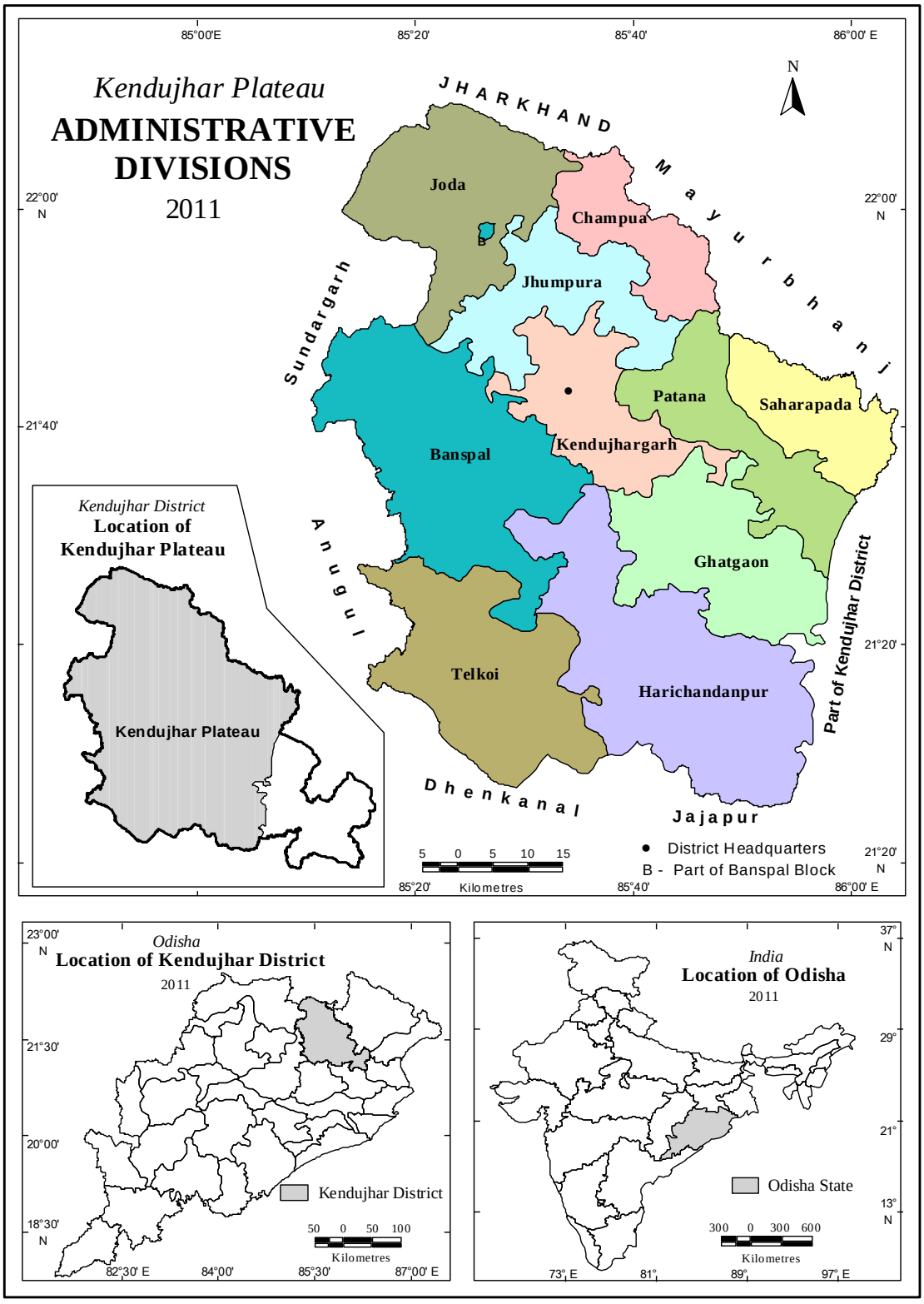

Figure 1: The Study Area

The target respondents were farmers. The questionnaire was administered by the researchers personally via face-to-face interviews with each respondent farmer to be accurate and reduce difficulties encountered in questionnaire item interpretations and therefore minimising the biasness. Data on nine indicators- terracing, land fallowing, local manures,

crop rotation, modern farm implements, other soil conservation measures, chemical fertilisers, inexhaustive/ sketchy agriculture and market-oriented agriculture- was selected. The physical or inherent indicators of land resilience are not taken into consideration as it is difficult to measure them. For example the amount of humus content which increases the soil quality, is difficult to estimate although its contribution to increase the productivity of soil is immense. Therefore, based on the existing land management practices adopted by farmers are selected as indicators to calculate resilience of land.

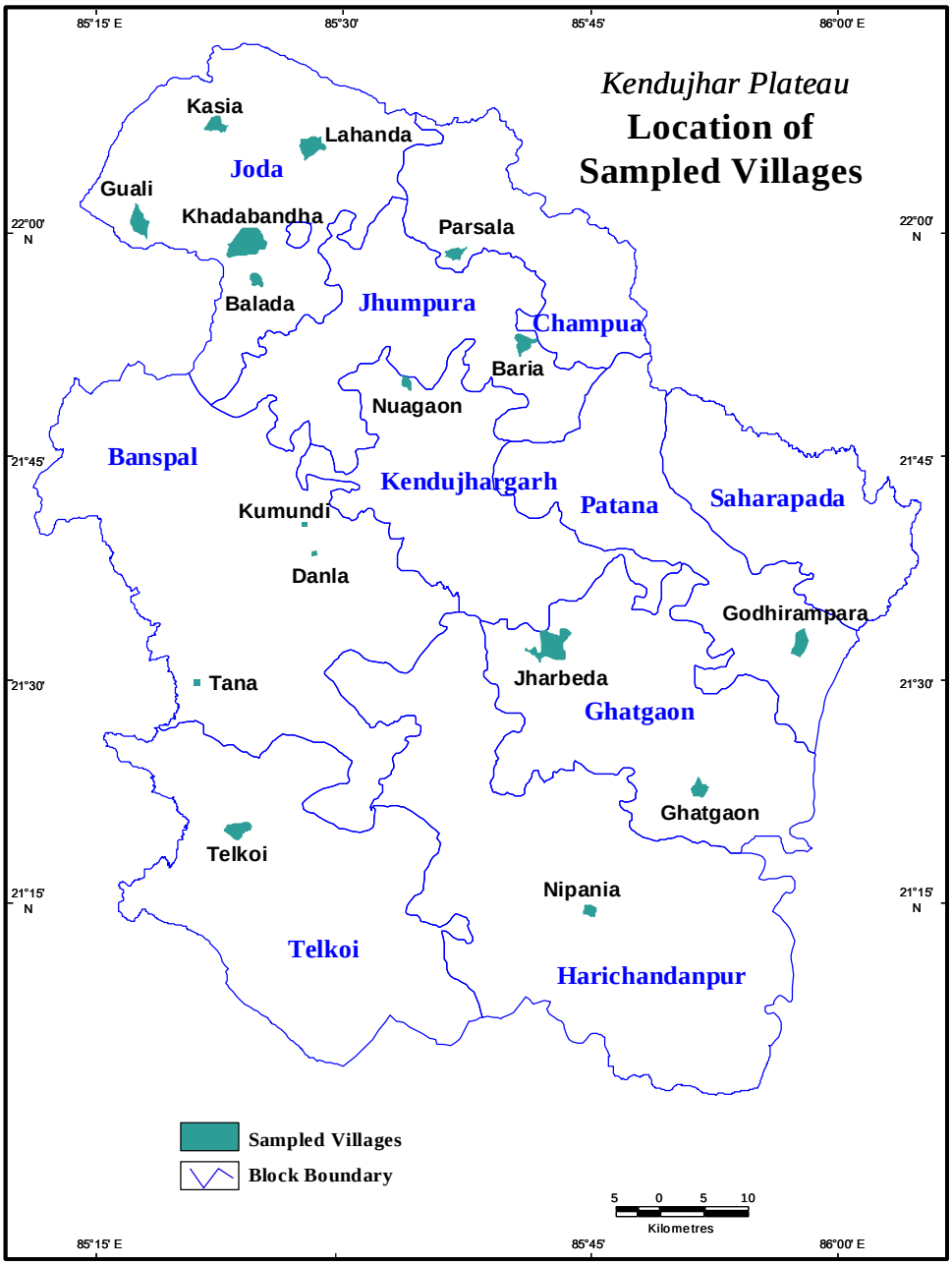

Figure 2: Location of Sampled Villages in the Kendujhar Plateau

During the field survey, no explicit resistance was expressed by the farmers regarding their participation in the survey. However, linguistic issues were faced during the survey since the questionnaire was in English and administered into Oriya, the local language of the state. It took almost 30-40 min per farmer to ask the relevant answers and their observations over the time related to the problem for the questionnaire. Seven households have been selected randomly from each village and a total 112 households have been covered. The sampling frame is chosen in a manner that would provide uniformity over space. The villages have also been selected in such a way that they should fulfil the criteria given above as well as represent different parts of the study region.

Table 2: List of Selected Villages for Field Survey based on Selected Economic Activities

Economic Activities for Selecting Villages							
Agriculture		**Agriculture and Mining**		**Agriculture, Mining and Forestry**		**Agriculture and Shifting cultivation or Forestry**	
1	Nipania (Harichandanpur)	2	Khadabandha (Joda)	3	Guali (Joda)	4	Tana (Banspal)
5	Telkoi (Telkoi)	6	Danla (Banspal)	7	Kasia (Joda)	8	Jharbeda (Ghatgaon)
9	Ghatgaon (Ghatgaon)	10	Kumundi (Banspal)	11	Balada (Joda)	12	Godhirampara (Patana)
13	Parsala (Champua)	14	Nuagaon (Kendujhargarh)	15	Lahanda (Joda)	16	Baria (Jhumpura)

Note: Text in bracket shows the name of Block

2.3 Measurement of Land Resilience

The level of resilience for each sample village has been measured from 9 indicators listed above. Based on the existing land management practices adopted by farmers are selected as indicators to calculate resilience of land. As all the selected indicators of resilience are not equally important, different weights to different indicators have been assigned by using *Proportional Standardized Mean* (Eq.1).

Proportional Standardized Mean or Weight (W) = $\bar{X}/\sigma$ for each indictor ------ Eq 1

Where

$\bar{X}$ = is the average of the series of one particular indicator

σ = is the standard deviation of same series.

The composite Resilience Index (RI) is calculated by the following formula.

$$\mathbf{RI} = \frac{X_1 W_1 + X_2 W_2 + X_3 W_3 \ldots\ldots\ldots + X_9 W_9}{W_1 + W_2, + W_3 \ldots\ldots\ldots\ldots W_9} \quad \text{----- Eq 2}$$

Where

RI = Resilience index

$X_1, X_2, X_3 \ldots\ldots X_9$ = Selected 9 indicators

$W_1, W_2, W_3 \ldots\ldots\ldots W_9$ = Weights of each indicator

2.4 Classification of Villages based on Level of Land Resilience

For the purpose of convenient and meaningful analysis, all the 16 villages have been divided into four categories of resilience level (i.e. high, moderately high, moderately low and low) from the Resilience index slabs in descending hierarchy. To explain, if A, B, C, and D denote the lower limits of the intervals in descending order, then A and C were obtained as arithmetical mean values of the composite indices for the villages falling, respectively, above and below the whole region (Kendujhar Plateau) level arithmetical mean (X). The value of B is determined by working out arithmetical means of composite indices for villages falling in the range A – X. The value of D is obviously the lowest value of composite indices across the villages. The four categories, thus, arrived at are constituted by the villages falling between (a) A and above; (b) B and A; (c) C and B, and (d) D and C. This procedure is adopted for dividing villages into four level of resilience. The collected data are arranged, tabulated and analysed with the help of software like MS-Excel, SPSS and ArcView GIS 3.2a. Statistics used in this study were: frequency, percentage, means, standard deviation using SPSS and Microsoft Excel sheets.

3. RESULTS AND DISCUSSION

3.1 Selected Indicators and Their Performance

To assess the level of land resilience nine indicators have been selected. They are grouped into three sets. First set includes four indicators (terracing, land fallowing, local manures, crop rotation) which are traditional measures adopted by the farmers to increase the resilience of their lands. Second set includes three indicators (modern farm implements, other soil conservation measures and chemical fertilisers) representing the modern measures used for increasing resilience. And, the third set represents other measures (inexhaustive agriculture and market-oriented agriculture) which play a significant role in deciding the farmer's initiative to take efforts in increasing resilience of land. The performance of each indicator varies across the villages due to different types of economics activities taken up within a physical, social, economic and political environment. Let us analyse all the selected indicators.

3.1.1 Traditional Measures adapted by Farmers to Increase Resilience

The first selected indicator is terracing**.** Terraces are the narrow strip of land carved out across the slopes for the cultivation of cereals (Mishra and Rai, 2013). It is a practice applied jointly to counteract the erosive force of both water and wind on the soil and hence increasing the capacity of land to produce more. The study area is a plateau region and the physical characteristics do not varies a lot but still large variations among farmers have been seen in adopting this measure. It is expected that higher the use of terracing method (wherever required) creates the land more resilient from degradation point of view and vice-versa. It has been seen that terracing is adapted from 14 per cent to 100 per cent farmers in the sampled villages. In two villages (Danla and Nuagaon), this is not applied at all, which makes the land in these villages least resilient. While in 8 villages, more than 50 per cent farmers use terracing method to control soil erosion and hence increasing the capacity of their farms to fight with land degradation (Figure 3). Second indicator, i.e. land fallowing, is a process under which agricultural land is temporarily allowed to be un-cropped for one or more seasons to restore soil fertility. It was found that presently, farmers use to leave their land fallow due to insufficient availability of water or inaccessibility to the sources of irrigation.

Therefore, farms are not continuously under crops and now farmers leave them fallow intentionally to recover the fertility of land and soil. Several studies have shown that areas with improved fallows are agronomically and ecologically useful (Kaya, Hildebrand, and Nair, 2000; Mercer 2004). The villages having higher percentage of farmers doing regular land fallowing are highly resilient with respect to land degradation process. Primary survey revealed that in 10 surveyed villages, all farmers leave their land as fallow, particularly during the summer season. In total, all villages show the signs of higher percentage of farmer doing land fallowing which makes their land resilient.

The third traditional measure, which farmers are adopting to increase the resilience capacity of their farm is local manures. These are bulky waste substances high in fibre and water content with relatively low levels of nutrients. These are most commonly represented by the mixture of farm animal dung known as farmyard manure (FYM). Composted plant remains, farm slurry and sewage sludge are other examples of bulky organic manure (Royal Horticulture Society, 2002). The use of manure helps to maintain the rich organic matter content of the soil which improves soil structure and water infiltration. Primary survey revealed that almost all the farmers use local manures to increase the fertility of the soil. All farmers in 11 villages use local manures for their fields. In four villages it varies between 71-86 per cent. Its easy availability and cheap price attracts farmers to apply it on their farms. The last indicator under the set of traditional measures is crop rotation. It refers to the raising of crops one after another on the same field in a sequential manner (Reddy, 2016). It has been argued that crop rotation has been used for thousands of years. It was concluded that fertilisers and pesticides can replace crop rotation without decreasing production. But this opinion has changed over time. At present, it is clear that crop rotation increases yield and profit and creates conditions for sustained production (Bullock, 1992). There are various benefits which can be obtained with the help of crop rotation like weed control, improved soil structure, increased soil fertility and decreased soil erosion and so on. The land with such practices is more resilient to land degradation and has capacity to restore its fertility through nitrogen fixation. In the study region, farmers grow paddy. The regular cropping of paddy under rainfed conditions makes the soil vulnerable to degradation in which crop rotation can help. In the study region, use of crop rotation method in agriculture is negligible. It was absent in 7 villages and only 14 to 43 per cent of sampled farmers in 9 villages practice this method. Therefore, almost all the selected villages are less to moderate resilient with respect to crop rotation in the study region.

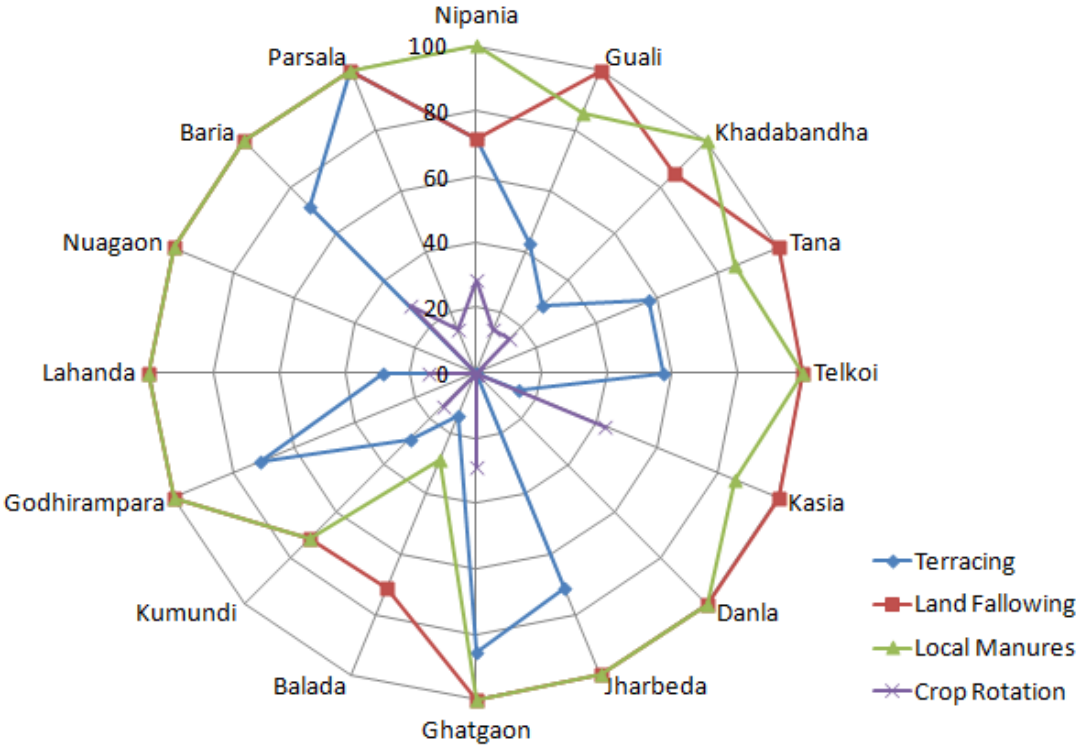

Figure 3: Village-wise Performance of Traditional Indicators to Increase Resilience

3.1.2 Use of Modern Measures to Increase Resilience

The importance of modern tools and techniques of agriculture in land management is immense. Modern farm implements like tractor, threshers, harvesters etc enable farmers to work faster, manage land efficiently and make ready for the next crop. On the other hand, traditional methods take time and huge efforts for farm preparation which increases their susceptibility to land degradation. These traditional method based agricultural practices have also been highly destructive to the soil (Bai et at., 2008). The primary survey revealed the tractor is the major implement which is used for various purposes. The spatial distribution explains that only in 2 villages (Ghatgaon and Nuagaon) more than 50 per cent of the total farmers use these modern farm implements (Figure 4). In three villages, 25 to 45 per cent farmers use modern farm implements for land management. The use of modern method is less than 15 per cent in around three-fourth sampled villages which makes their land less resilient to land degradation. The indicator other soil conservation measures aims at preventing or at least minimising the soil loss excluding terracing method. It includes the agronomic practices like vegetational cover to prevent erosion or agro-forestry, intercultural operations etc. Vegetational covers keep the soil intact to be removed while the inter-cultural operations are lighter and finer operations carried out on the soil between sowing and harvesting time, like weeding, mulching etc. These small operations keep soil fertile and more resilient to get degraded soon (Hurni et al., 2008). In 9 villages the adoption of these measures varies between 57 to 86 per cent while in 4 villages these measures are used by less than 50 per cent farmers. The last indicator under this set is chemical fertilisers. The fertilisers play a significant role in the development of the agricultural sector (Linquist et. al., 2007). Fertilser is used to add nutrients to the soil to promote soil fertility and increase plant growth. The use of fertilisers creates ideal conditions for increasing the level of resilience.

The use of local manure in any quantity is useful for the land but the over application of chemical fertilisers has negative effects on the soil and crop yield (Sharma et al., 2014). Therefore, its rationale use and application is quite important. The consumption of chemical fertilisers in the study region found to be very low. Only in 4 villages, more than 50 per cent of farmer use them to increase the fertility of soil while in 9 villages the percentage is less than 15. In 3 villages, none of the farmers uses fertilisers due to which they are least resilient. Therefore, the study region is overall less resilient as per consumption of chemical fertilsers is concerned.

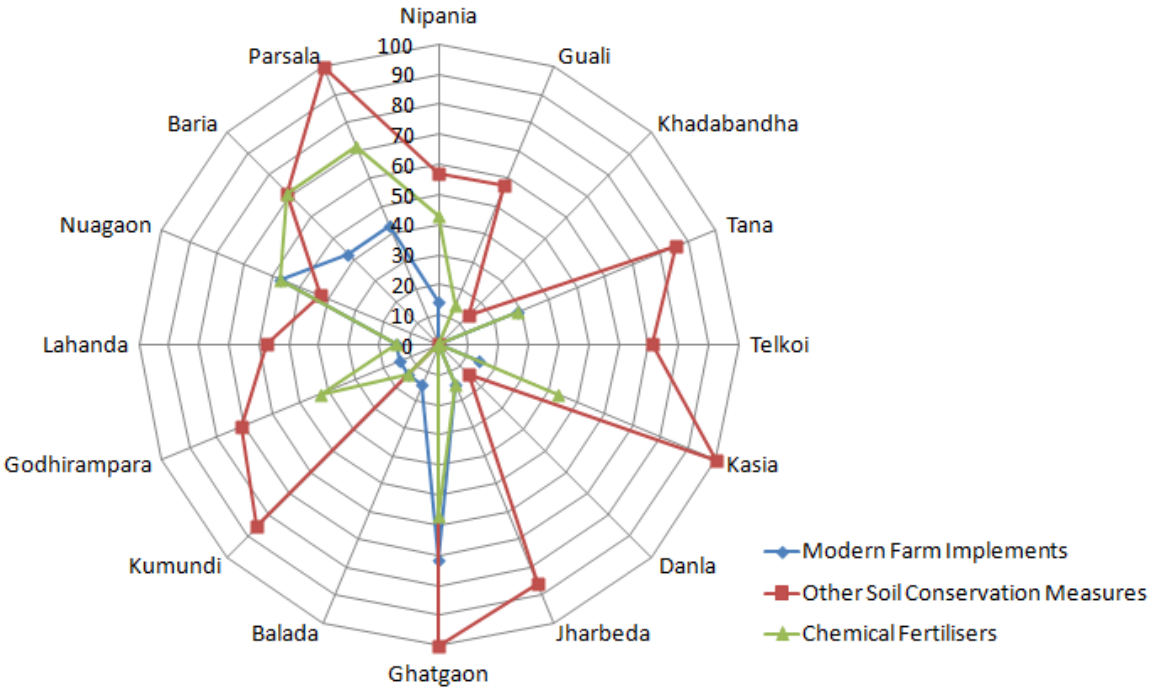

Figure 4: Village-wise Performance of Modern Measures to Increase Resilience

3.1.3 Other Measures adapted by Farmers to Increase Resilience

Inexhaustive agriculture indicates the extensive agriculture which does not affects the land greatly. Its opposite can be intensive cultivation which degrades land quickly by mining nutrients from the soil (Mythili and Goedecke, 2016). Here, it represents that farmer use to take a single crop in whole year and leave their land vacant in the other seasons due to various reasons. This type of agriculture is quite prominent among the farmers having large lands because they are unable to cultivate the whole land and land remains fallow, therefore, also different from land fallowing indicator. Thus, higher the percentage of farmers using this type of land are more resilient and vice-versa. It has been found that in 7 villages mostly farmers leave their land vacant and are highly resilient. Eight villages show more than 50 to 86 per cent farmer practice this type of agriculture (Figure 5). In least land resilient villages, farmers are engaged in intensive agriculture and creates sensitive environment for their land to get degraded. Overall the region is highly resilient as high percentage of farmers leaves their land vacant. Another indicator is market-oriented agriculture. It is now recognised that resultant profit from market-oriented agriculture encourages farmer to manage their land properly (Gebremedhin et al., 2010). In the present case, it is assumed that, modern and

market-based type of farming increases the ability of farmer towards their effort on land management and therefore, the lands resilience is enhanced. Out of total surveyed villages, 6 villages have more than 55 per cent and 8 villages have less than 30 per cent farmers are practicing market-oriented agriculture. Therefore, overall, the study area is less resilient with respect to market-oriented agriculture.

The above discussed factors are cumulative and interactive. Further, they are also positively related with the level of land resilience. They all contribute in increasing or decreasing the level of resilience in the study region.

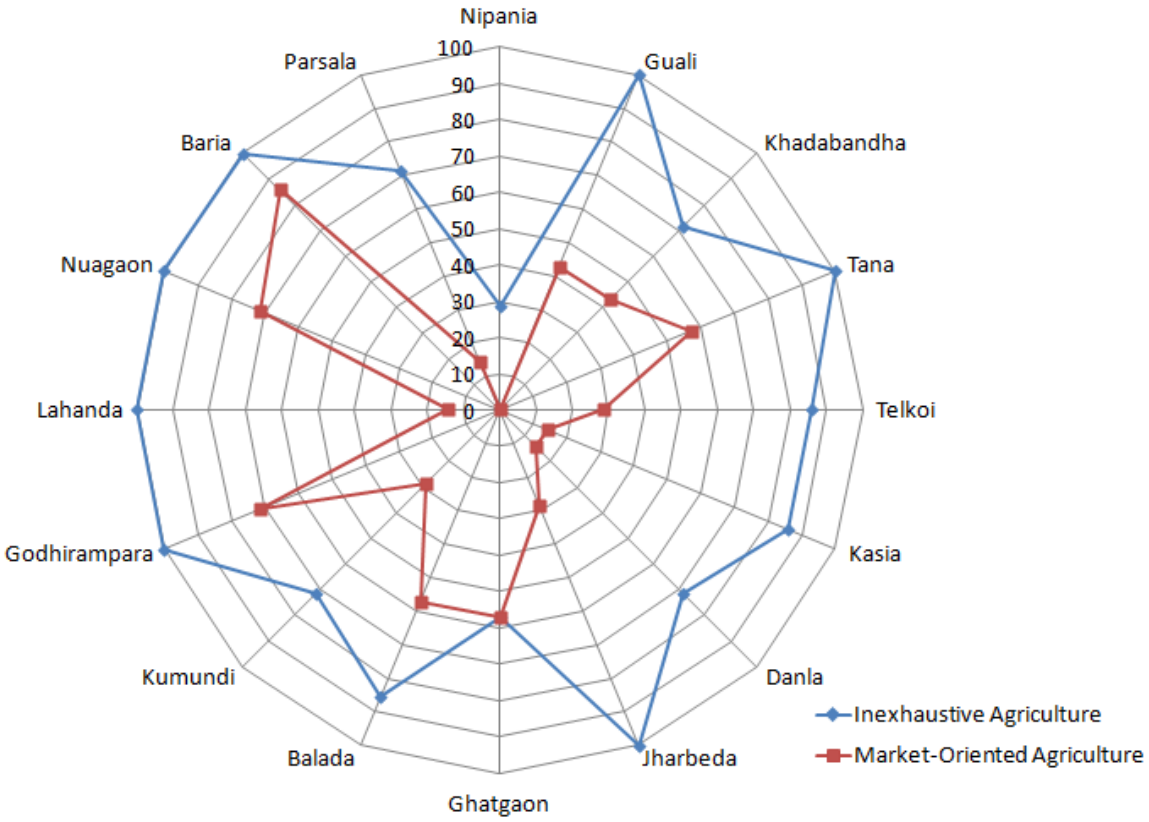

Figure 5: Village-wise Performance of Modern Measures to Increase Resilience

3.2 Level of Land Resilience

The above discussed nine indicators, selected for measuring the resilience of land, are cumulative and interactive. All contributes differently in determining the level of resilience in the 16 sampled villages of the study region. The whole study region has been divided into four levels of resilience: high, moderately high, moderately low and low resilient villages (Figure 6).

The first level, highly resilient, shows that the human efforts are maximum to keep the land in good shape to avoid the land degradation process and these efforts are least in the last resilience level category. There are 6 villages in this category (Baria, Godhirampara, Ghatgaon, Parsala, Jharbeda and Tana), 5 in moderately high (Nuagaon, Lahanda, Kasia, Telkoi and Guali), 3 in moderately low (Danla, Khadabandha and Kumundi) and 2 in least resilient category (Nipania and Balada) (Table 3). The land in highly resilient villages responds quickly to human effort which increases its ability to resist from degradation. The

use of terracing, land fallowing, local manures and other soil conservation methods is quite high. The land in these six villages is also supported by rich forest cover to certain extent also. The large field size and gentle slope supports the use of modern farm implements like tractor, threshers which further helps in increasing the level of resilience. The lands in moderately high resilient villages are very near to the mining areas of the Kendujhar Plateau region and are surrounded by dense forests. Here, the income from mines helps the farmer to invest in agriculture through various ways like to purchase modern farm inputs and implements e.g. tractors, chemical fertilizers, seeds etc. The dense forest cover helps in increasing soil fertility by providing humus and nutrients to the soil. Therefore, when farmer make efforts in managing their land from degradation, these lands are easily managed.

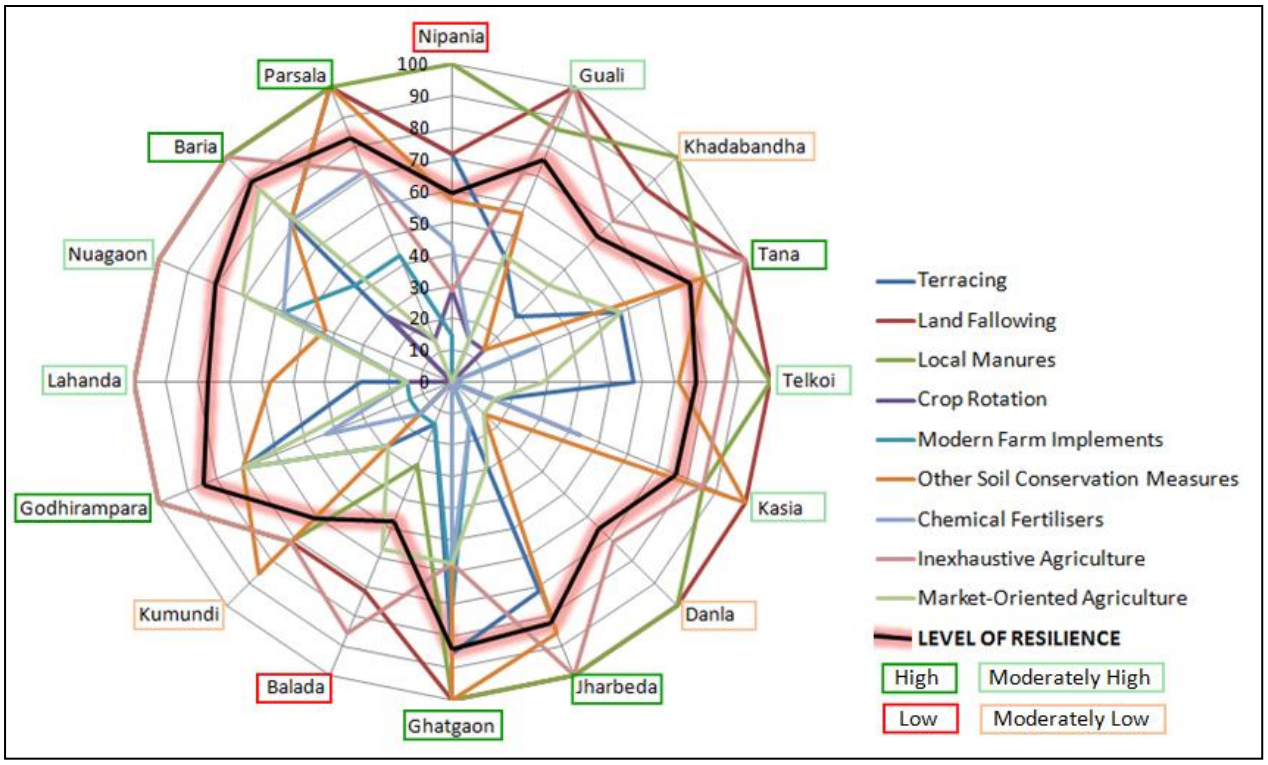

Figure 6: Performance of Various Indicators and Level of Resilience

The land in moderately low resilient villages are characterized with moderate use of local manures, land fallowing and inexhaustive agriculture while the application of chemical fertilizers, terracing, crop rotation, modern farm implements is very low. Further, the low production and consequently low benefit further contributes in the reluctance of farmers to invest in land management practices. All these factors contribute to have moderately low resilience of land in these villages. The lands with low resilience are characterized with least use of soil conservation methods method on sloppy areas, local manures, land fallowing etc. The use of modern farm implements is also low due to which production is also very low. The low production also restricts the scope for market-oriented agriculture. Therefore, the analysis highlights the different levels of resilience in the study region at different locations.

In the study, it has been found that methods like land fallowing, local manures and inexhaustive agriculture are most popular among the farmers to increase the resilience. They are practiced by maximum and in almost all the villages. On the other hand, the use of modern methods of farming and land management particularly, modern farm implements, crop rotation technique, chemical fertilizers are least popular and adopted by the less number

of farmers. However, in highly resilient villages, these are practiced to some extent. The individual villages are also analysed with respect to the economic category practiced here. In villages where mostly people are engaged in agriculture, forestry/ shifting cultivation based economic activity; the resilience of farmlands is high. On the other hand, the impact of mining activities is clearly visible on resilience of land in the form of more degradation process and low resilience.

Table 3: Resilience Index: Classification of Villages

S. No.	Village	Block	Criteria*	RI**	Level of Resilience
1	Baria	Jhumpura	D	88.99	Highly Resilient
2	Godhirampara	Patana	D	84.64	
3	Ghatgaon	Ghatgaon	A	83.86	
4	Parsala	Champua	A	83.38	
5	Jharbeda	Ghatgaon	D	81.83	
6	Tana	Banspal	D	81.19	
7	Nuagaon	Kendujhargarh	B	80.48	Moderately High Resilient
8	Lahanda	Joda	C	76.65	
9	Kasia	Joda	C	76.45	
10	Telkoi	Telkoi	A	76.30	
11	Guali	Joda	C	75.92	
12	Danla	Banspal	B	65.16	Moderately Low Resilient
13	Khadabandha	Joda	B	64.55	
14	Kumundi	Banspal	B	60.43	
15	Nipania	Harichandanpur	A	59.33	Low Resilient
16	Balada	Joda	C	47.38	

* Criteria: *A – Agriculture, B- Agriculture/Mining, C- Agriculture/Mining/Forestry, D- Agriculture/ Forestry or Shifting Cultivation*

** RI*: Resilience Index*

Therefore, it is clear that the farmer's activities and actions play a critical role in increasing or decreasing the level of land resilience. The villages having high land resilience are capable of producing more while maintaining land capability. The sustainability of land resource is positively related with high land resilience. As we know that land and water are the most important bottleneck and determinant of sustainability of agricultural production (Forouzani, 2011), therefore, it is suggested that more focus should be given to the use of modern agricultural methods. These will increase the farmer's capacity to enhance the resilience of their land and will help in achieving the livelihood security of the farmers and sustainability of land.

4. FINDINGS AND CONCLUSIONS

The spatial variation in lands resilience shows a very complex pattern. The variables selected like terracing, land fallowing, local manures, crop rotation, modern farm implements, other soil conservation measures, chemical fertilsers, inexhaustive agriculture and market-oriented agriculture proved to be very logical in analysing the lands resilience in the study region. It is found that highly resilient villages are quite efficient and capable to restore the land easily. On the other hand, low resilience signifies that it is very difficult to restore the land in short term. Thus, it is concluded that various human activities contribute differently in increasing

or decreasing the level of resilience in the study region. The level of resilience helps in understanding that different areas are under critical conditions or least affected conditions. Further, it provides a base to the decision-makers for designing suitable land management policies for the region.

NOTES

[1]In a particular village the villagers may lead their lives based on one type of economic activity or combination of two or three economic activities. Like in a village, many villagers may practice agriculture, others may practice mining and few may practice forestry. In the other way, a person may practice agriculture in agriculture season and mining in agriculturally off season. All these activities affect the level of resilience. So, 4 different economic activities, i.e. single or combination of two or three economic activities such as agriculture, mining, forestry are practiced in this region, have been taken.

REFERENCES

Abdel Kawy WAM and Ali RR. 2012. Assessment of soil degradation and resilience at northeast Nile Delta, Egypt: The impact on soil productivity. *The Egyptian Journal of Remote Sensing and Space Sciences*. 15:19-30.

Adger WN. 2000. Social and ecological resilience: Are they related. *Progress in Human Geography*. 24(3): 347-364.

Bai ZG, Dent DL, Olson L, and Schaepman, ME. 2008. *Global Assessment of Land Degradation and Improvement*, Report 2008/01, ISRIC-World Soil Information Report, Wageningen.

Blanco-Canqui H and Lal R. 2008. Soil resilience and conservation. In *Principles of soil conservation and management*, eds. H. Blanco-Canqui and R. Lal, 425-447. Dordrecht: Springer.

Bullock, DG. 1992. Crop rotation. *Critical Reviews in Plant Sciences*. 11(4): 309-326.

Dwivedy, N. 2011. Challenges faced by the agriculture sector in developing countries with special reference to India. *International Journal of Rural Studies.* 18(2): 1-6.

Forouzani K. 2011. Agricultural water poverty index and sustainability. *Agronomy for Sustainable Development*. 31(2): 415-431.

Gebremedhin B, Woldewahid G, Dessalegn Y, Gebey T. and Teka W. 2010. *Sustainable land management through market-oriented commodity development: Case studies from Ethiopia*. IPMS of Ethiopian Farmers Project Working Paper No. 21, International Livestock Research Institute, Nairobi.

Greenland DJ and Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. *Proceedings of a Symposium held in Budapest, 28 September to 2 October 1992*, including the *Second Workshop on the Ecological Foundations of Sustainable Agriculture* (WEFSA II). CAB International.

Hurni H, Herweg K, Portner B and Liniger H. 2008. Soil erosion and conservation in global agriculture, In *Land use and soil resources*, eds. A.K. Braimoh and P.L.G. Vlek, 47-71. Dordrecht: Springer.

Kaya B, Hildebrand PE and Nair PKR. 2000. Modelling changes in farming systems with the adoption of improved fallows in Southern Mali. *Agricultural Systems*, 66(1): 51–68.

Kumar Shit P, Sankar Bhunia G and Maiti R. 2015. Farmers' perceptions of soil erosion and management strategies in South Bengal in India. *European Journal of Geography*. 6(2): 85-100.

Lal R. 1997. Degradation and resilience of soils. *Phil. Trans. R. Soc. Lond. B.* 352: 997-1010.

Linquist BA, Phengsouvanna V and Sengxue P. 2007. Benefits of organic residues and chemical fetiliser to productivity of rainfed lowland rice and to soil nutrient balances. *Nutr. Cycl. Agoecosyst*. 79: 59-72.

Mercer D. 2004. Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems*, 61(1-3): 311-328.

Mishra PK and Rai, SC. 2013. Use of indigenous soil and water conservation practices among farmers in Sikkim Himalaya. *Indian Journal of Traditional Knowledge*, 12(3): 454-464.

Mythili G and Goedecke J. 2016. Economics of land degradation in India. In *Economics of land degradation and improvement: A global assessment for sustainable development*, eds. E. Nkonya, A. Mirzabaev, J. von Braun, 431-469. Cham: Springer.

Reddy PP. 2016. Crop Rotation. In *Sustainable Intensification of Crop Production*, ed. P.P. Reddy, 95-107. Singapore: Springer Singapore.

Royal Horticulture Society. 2002. Fertilisers and manures. *Conservation and Environment Guidelines*, November, *p.* 2.

Seybold CA, Herrick JE and Brejda, JJ. 1999. Soil resilience: A fundamental component of soil quality. *Soil Science*. 164(4): 224-234.

Sharma U, Paliyal SS, Sharma SP and Sharma GD. 2014. Effects of continuous use of chemical fertilizers and manure on soil fertility and productivity of maize–wheat under rainfed conditions of the western Himalayas. *Communications in Soil Science and Plant Analysis*. 45(20): 2647-2659.

Stocking M and Murnaghan N. 2001. *Handbook for the Field Assessment of Land Degradation*, London: Earthscan.

Zhou H, Wang J, Wan J and Jia H. 2010. Resilience to natural hazards: A geographic perspective. *Natural Hazards*, 53(1): 21-41.