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# Evaluating the Soil Quality of Forest, Broom Grass and Cultivated Land Uses in Hilly Agro-ecosystem, Meghalaya Plateau, North East India

**Alok Maurya [a++], Vikash Kumar Yadav [b#*], Thokchom Dorenchand Singh [a++], Abhishek Maurya [c†] and Vivek Kumar Singh [d‡]**

[a] *CPGSAS, CAU (I) Meghalaya, India.*
[b] *Mahayogi Gorakhnath University, Gorakhpur, Uttar Pradesh, India.*
[c] *Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India.*
[d] *Veer Bahadur Singh Purvanchal University, Jaunpur, Uttar Pradesh, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Soil quality can be inferred from selected chemical soil indicators and it may be altered under the impact of changes in land uses (LUS). For achieving sustainable management practices the soil quality indicators (SQI) should be measured. The objective of this study was to compare the soil

[++] *PhD Research Scholar (Soil Science and Agri. Chemistry);*
[#] *Asst. Professor (Plant Pathology);*
[†] *MSc. Research Scholar (Soil Science & Agri. Chemistry);*
[‡] *MSc AG (Agri Chemistry and Soil Science);*
**Corresponding author: E-mail: rvikashyadav@gmail.com;*

quality index in forest, Broom and cultivated land use systems in some areas of Meghalaya, using a completely randomized design at nine different land uses containing Mixed-Forest, Pine-Forest, Broom-Grass, Rice-Potato, Rice-Cabbage, Upland Rice-Monocrop, Lowland Rice-Monocrop, upland pineapple crop and slash-burn cropping system with three replications and two depths. 54 soil samples were collected from the surface and subsurface soil depth of diverse LUS and 9 soil chemical attributes was selected for SQI. Values of SQI deduced using the average factorial deviation from the values of soil quality indicators of diverse LUS site relative to their value of the mixed forest as a (reference) scaled to 100 per cent. The results showed that the pine forest land use had the premier value of SQI (98.99) and poorest in the rice-potato (70.00) land use system in both the depth compared to mixed forest land. It can be concluded that cultivated land use decreases soil quality index such as rice-potato system.

*Keywords: Soil quality; land uses; sustainable management.*

## 1. INTRODUCTION

Soil, a medium for plant growth, is a natural resource and mantle of the earth surface. The world population is expected to reach 0.80 X $10^3$ million by 2030, 0.98 X $10^3$ million by 2050 and 1.12 X $10^3$ million by 2100 [1]. Therefore, meeting the food demands of the current population without significantly disturbing the soil-water-atmosphere equilibrium has become the most challenge for researchers and policymakers. Degradation natural resource such as soil erosion is a natural sensation that poses severe environmental, socio-economic issues etc. [2]. Soil health and function of hilly agroecosystem are closely linked to the quality and long-term utility of soil. Therefore, a better thoughtful of the effects of forest and agricultural LUS on soil quality of Meghalaya plateau can benefit viable options for sustainable development of hill ecosystem. Advancement has been made on the impacts of land uses on soil properties. Conversion of natural forest (mixed forest) to cultivated land use types degrade the fertility status of soil i.e. physical fertility, biological fertility and chemical fertility, soil erosion, water quality [3-5]. [6] evaluated the impact of shifting cultivation on soil quality, in Wokha district of Nagaland, using weighted soil quality index (SQI). The results showed that the high SQI more than 0.70 for two forest soils (FS1 and FS2) and land under shifting/jhum cultivation low quality (<0.5). [6] reported SQI in different land uses in Meghalaya. The results showed that the overall SQI was found to follow the following order: dense forest>shifting cultivation>pine forest>bun cultivation>abandoned land after shifting cultivation.

In Meghalaya, the mean annual loss of surface soil, organic carbon (OC), P and K due to the extent of shifting cultivation/ jhum cultivation up to the extent of 40.9 X $10^3$ kg, 7.03 X $10^2$ kg, 0.15 kg and 7.5 kg per ha, respectively [7].

Soil quality indices/index was decision support tools that effectively integrate a variety of information for multi-objective decision making [8]. A number of soil quality and fertility indices (pH, EC, nutrients, structure, porosity etc.) have been proposed [9] none identifies state of soil degradation that affects its functionality. The SQI frequently integrates some soil indicators which are accompanying with soil functions into a dimensionless value (between 0 and 100) to quantitatively assess the soil quality [10-14]. This method is normally proceeded in different steps: selecting soil indicators, reference land use as 100 (undisturbed), log 100 transform, factorial deviation and integrating the soil indicators into an index [15,16,12]. [16] observed that forest clearance and subsequent cultivation practice, due to land degradation, has a significant negative impact on SQI, i.e. drop of 44.5% of SQI was occurred. Mukherjee and Lal (2014) evaluated SQI at Ohio State, they resulted SQI varied between treatments and soil types and was ranging from 0 to 0.9 (1 being the maximum SQI). Generally SQIs did not significantly differ at depths under any method advising that soil quality did not expressively differ for different surface and subsurface depth. Singh *et al*. 2013 evaluated SQI in Nagaland, and they found the SQI rating was the highest for the least-disturbed land use compared to disturbed/agricultural LUS, i.e., natural forest> grassland> Shifting cultivation> horticultural-based system>cultivated land. Prokop *et al*. (2018) evaluate soil quality in Upper Shillong, Meghalaya they showed that the higher soil quality in pine forest, followed by cultivated land and deciduous forest.

## 2. MATERIALS AND METHODS

### 2.1 Study Area and Soil

The study area represents the North-Eastern Himalayan region of India, lies from 21.57° N to 29.26° N latitude and 87.50° E to 97.30° E longitude with a geographical area of 26.20 million ha in the fragile Eastern Himalayan landscape. The study was carried out East–Khasi Hills district of Meghalaya, which lies between 90055"15-91016" latitude and 25040"-25021" longitude, the total area of East Khasi Hills (2,752 sq. km). The selected area was Upper Shillong**.** The annual average rainfall exceeds 2935 mm with wide orography-led spatial variability (15,00–11,500 mm) and temperature varies from 100 C in December to $30^0$C in July and August, East Khasi hill district experiences different types of climate varies from tropical climate in bordering areas Assam to the temperate climate in the East Khasi Hills district. The bordering areas of Assam found hot-humid climate during summer seasons with an average temperature $30^0$ C, during month of May to July of the year. The soils of the study area is Silty-Loam, the soils developed from shale and sandstone are red and lateritic with very shallow (in steep slopes) to medium in depth and relatively fine in texture. Soils are invariably acidic in reaction, with half of them (53% of GA) are very strong to strong in reaction (pH: 4.5–5.5). Complex interaction of geographic location, high rainfall, and conducive temperature favours luxurious plant biomass production which in turn adds higher organic carbon (98% GA with > 1% SOC) in the soils of the region.

### 2.2 Selection of Land Use Systems (LUS)

Nine land uses (LUS) types were selected based on the following three steps. In the first step, details about past and current LUS were obtained and described. Sites for soil sampling were then identified for each LUS. In the final step, soil samples from the identified areas were collected, and analysed in the laboratory for various soil indicators.

In the first step, a field reconnaissance soil survey along with an inquiry/interview and discussions with local farmers well acquainted with the land use and local farming systems were conducted. Based on the obtained information, nine predominant LUS in the study area were chosen and are described. Terrain characteristics and vegetation types from each LUS were also recorded during sampling. The nine LUS selected for soil chemical properties (1) Jhum-System (2) Mixed-Forest (3) Pine-Forest (4) Rice-Potato (5) Rice-Cole Crops (6) Upland Rice-Monocrop (7) Lowland Rice-Monocrop (8) Upland Pineapple-System and (9) Upland Broom-System.

Soil pH and EC were determined by (1:2.5) ratio of soil and distilled water, and then it mixed 30 minutes by manually and then takes the reading for pH. After 24 hrs the clear suspension we use the measure EC by EC meter. Available N was determined by 0.2 % Alkaline potassium permanganate. Available P was determine by 1:5 ratio of soil and Bray,s-1 extractant (0.025 N $NH_4F$+ 0.03 N HCL), after this we use Brays reagent and stannous chloride and finally we take absorbance 660 nm by spectrophotometer. Available K was determined by 1N NH4OACe solution by using Flame photometer. DTPA cationic micronutrient was determined by 0.005 M DTPA, 0.2 % CaCl2, 0.1 M TEA. 1:2 ratio of soil and DTPA extractant (7.3 pH), shake 120 minutes at 120 RPM. Then filter the soil by Whatman No 42 and measure the wavelength by using AAS [21].

**Table 1. Methods of soil chemical parameters**

| Sl. No. | Parameters | Methods | Reference |
|---|---|---|---|
| 1. | Soil pH and EC | Soil: water suspension (1:2.5) for pH and 1:5 for EC | [17] |
| 2. | Available Nitrogen | Alkaline potassium permanganate method | [18] |
| 3. | Available Phosphorus | Bray's-1 method | [19] |
| 4. | Available Potassium | Neutral Normal Ammonium acetate method | [20] |
| 5. | DTPA extractable Fe, Mn, Zn and Cu | DTPA extractable followed by AAS | [21] |

## 2.3 Soil Quality Index Evaluation

$$\mathrm{SQI} = 10_{\log}\,\mathrm{m} - \sum_{\mathrm{i}}^{\mathrm{N}} 1\,\frac{\mathrm{I\ logm - logni\ I}}{\mathrm{N}}$$

Where , m is the reference indexed values (each values set to 100%) from adjacent mixed forest soil, n is the measured values as a percentage of the reference and N is the total no. of parameters [22].

## 2.4 Statistical Analysis

All statistical analyses were performed MS-Excel. The statistical significance difference between the groups will be studied by performing one way anova.

# 3. RESULTS

Soil chemical properties (macro and micronutrients) in 0-15 cm depth of diverse LUS in Shillong are shown in Table 2. Values of soil pH was ranging from 4.96-5.34 and the highest value recorded in RCC, whereas lowest in PF. The values of EC (µS/m) ranged from 18.53 to 27.06 and maximum value observed in UBS and minimum in PF. The mean value of soil Avl. N was ranging from 244.39 to 550.00 (kg/ha), whereas highest value was observed in MF and lowest in UBS. The values of Avl. $P_2O_5$ (kg/ha) content ranged from 8.24 to 20.24 while maximum value was recorded in RCC and minimum in PF. Values of Avl. $K_2O$ (kg/ha) content was ranging from 160.61 to 315.98, whereas highest value was observed in MF and lowest in RP. The DTPA Fe (ppm) content ranged from 41.19 to 92.61, however highest value observed in PF and lowest in URM. The value of DTPA Mn (ppm) ranged from 12.08 to 26.43, while highest value was found in PF and lowest in RCC. The range of DTPA Cu (ppm) varied from 0.80 to 4.27. The DTPA Cu was highest in UBS and lowest in JS. Values of DTPA Zn (ppm) ranged from 0.08 to 3.81. The highest value of DTPA Zn was found in MF and lowest in LRM.

Soil chemical properties (macro and micronutrients) in 15-30 cm depth of diverse LUS in Shillong are showed in Table 3. Values of soil pH was ranging from 4.98 to 5.49 and the highest value recorded in JS, whereas lowest in PF. The values of EC (µS/m) ranged from 18.36 to 26.98 and maximum value observed in UBS and minimum in PF. The mean value soil Avl. N was ranging from 164.99 to 454.45 (kg/ha), whereas highest value was observed in MF and lowest in UBS. Values of Avl. $P_2O_5$ (kg/ha) content ranged from 6.71 to 19.95, while maximum value was recorded in RCC and minimum in PF. Values of Avl. $K_2O$ (kg/ha) content was ranging from 158.83 to 270.47, whereas highest value was observed in MF and lowest in RP. The DTPA Fe (ppm) content ranged from 40.30 to 92.02, however highest value observed in SPF and lowest in URM. The value of DTPA Mn (ppm) ranged from 12.23 to 27.51, while highest value was found in PF and lowest in RCC. The range of DTPA Cu (ppm) varied from 0.74 to 4.14. The DTPA Cu was highest in JS and lowest in UBS. Values of DTPA Zn (ppm) ranged from 0.06 to 3.67. The highest value of DTPA Zn was found in MF and lowest in LRM.

Development of Soil Quality Index using physicochemical and biological attributes of Various LUS in Shillong. Values of SQI deduced using the mean factorial deviation from the values of soil quality indicators of diverse land use site relative to their value of MF (mixed forest) land use as a (reference land use) scaled to 100 per cent. Soil quality index (SQI) of diverse LUS in surface and subsurface soil in Shillong region of East Khashi hills of Meghalaya demonstrated in Table 4. The SQI value at 0-15 cm soil depth was found to be highest in PF (94.68) and lowest in rice-cole crop (71.87) followed by rice-potato system (75.21) of Upper Shillong region followed pattern as: in surface soil (0-15 cm) PF>UPS>URM>UBS>JS>LRM>RP>RCC and subsurface soil (15-30 cm) very good SQI was observed in also PF (92.74) and poorest in rice-cole crop (68.36) PF>UPS>URM>UBS>JS> LRM>RP>RCC.

**Table 2. Soil chemical properties (macro and micronutrients) in (0-15 cm) depth of diverse land uses in Shillong**

| LUS | pH | EC µS/m | Avl. N kg/ha | Avl. $P_2O_5$ kg/ha | Avl. $K_2O$ kg/ha | DTPA Fe ppm | DTPA Mn ppm | DTPA Cu ppm | DTPA Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| **JS** | 5.27 | 26.60 | 391.48 | 15.70 | 270.50 | 52.72 | 16.53 | 0.80 | 2.19 |
| **MF** | 5.26 | 24.23 | 550.00 | 17.29 | 315.98 | 55.50 | 17.56 | 2.17 | 3.81 |
| **PF** | 4.96 | 18.53 | 416.30 | 8.24 | 281.11 | 92.61 | 26.43 | 2.79 | 2.73 |
| **RP** | 5.29 | 25.22 | 261.66 | 16.45 | 160.61 | 51.46 | 15.98 | 1.20 | 0.11 |
| **RCC** | 5.39 | 20.09 | 263.94 | 20.23 | 181.31 | 46.19 | 12.08 | 0.91 | 0.32 |
| **URM** | 5.34 | 24.15 | 285.85 | 18.07 | 238.63 | 41.19 | 14.36 | 1.67 | 0.51 |
| **LRM** | 5.18 | 21.06 | 269.64 | 12.39 | 200.33 | 63.30 | 20.72 | 2.47 | 0.08 |
| **UPS** | 5.26 | 25.36 | 324.20 | 15.20 | 245.67 | 56.37 | 18.24 | 3.37 | 1.19 |
| **UBS** | 5.09 | 27.06 | 244.39 | 10.43 | 215.61 | 77.14 | 22.17 | 4.27 | 1.81 |
| **S.E (m)±** | 0.04 | 0.06 | 1.27 | 0.78 | 0.58 | 0.40 | 0.01 | 0.28 | 0.03 |
| **LSD** | 0.11 | 0.18 | 3.78 | 2.31 | 1.73 | 1.18 | 0.04 | 0.82 | 0.10 |
| **CV** | 2.17 | 0.76 | 1.14 | 15.64 | 0.74 | 2.01 | 0.24 | 37.90 | 7.33 |

*(LUS= Land Uses, JS= Jhum System, MF= Mixed-Forest, PF= Pine-Forest, RP= Rice-Potato System, RCC= Rice-Cole Crop, URM= Upland Rice-Monocrop, LRM= Lowland Rice-Monocrop, UPS= Upland Pineapple System, UBS= Upland Broom System, ±= Standard Error, LSD= Least Significance difference, SEM= Standard Error of Mean)*

**Table 3. Soil chemical properties (macro and micronutrients) in (15-30 cm) depth of diverse land uses in Shillong**

| LUS | pH | EC µS/m | Avl. N kg/ha | Avl. $P_2O_5$ kg/ha | Avl. $K_2O$ kg/ha | DTPA Fe ppm | DTPA Mn ppm | DTPA Cu ppm | DTPA Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| **JS** | 5.49 | 26.38 | 271.93 | 13.77 | 245.45 | 51.19 | 15.52 | 0.74 | 2.10 |
| **MF** | 5.10 | 24.09 | 454.44 | 16.31 | 270.47 | 54.56 | 17.53 | 2.18 | 3.67 |
| **PF** | 4.98 | 18.36 | 326.76 | 6.71 | 220.58 | 92.02 | 27.51 | 2.75 | 2.61 |
| **RP** | 5.05 | 25.12 | 173.21 | 14.66 | 158.83 | 49.23 | 13.52 | 1.05 | 0.09 |
| **RCC** | 5.18 | 19.84 | 182.09 | 19.95 | 175.39 | 44.16 | 12.23 | 0.82 | 0.29 |
| **URM** | 5.13 | 24.08 | 209.49 | 17.87 | 212.48 | 40.30 | 13.88 | 1.61 | 0.49 |
| **LRM** | 5.05 | 20.86 | 191.71 | 11.98 | 178.51 | 60.03 | 19.16 | 2.44 | 0.06 |
| **UPS** | 5.09 | 24.87 | 233.02 | 15.09 | 215.56 | 52.78 | 18.07 | 3.43 | 1.14 |
| **UBS** | 5.02 | 26.98 | 164.99 | 10.19 | 195.74 | 75.65 | 21.10 | 4.14 | 1.71 |
| **S.E(m)±** | 0.04 | 0.10 | 1.38 | 0.49 | 0.49 | 0.35 | 0.19 | 0.38 | 0.23 |
| **LSD** | 0.11 | 0.30 | 4.11 | 1.46 | 1.44 | 1.05 | 0.58 | 1.13 | 0.68 |
| **CV** | 2.10 | 1.30 | 1.69 | 10.48 | 0.70 | 1.83 | 3.32 | 53.72 | 51.04 |

**Table 4. Soil quality index of various land uses in 0-15 and 15-30 cm soil depth Shillong**

| LUS | SQI (0-15 cm) | SQI (15-30 cm) |
|---|---|---|
| **JS** | 82.87 | 82.86 |
| **PF** | 94.68 | 92.74 |
| **RP** | 75.21 | 71.64 |
| **RCC** | 71.87 | 68.36 |
| **URM** | 85.18 | 84.06 |
| **LRM** | 78.74 | 75.03 |
| **UPS** | 88.86 | 85.79 |
| **UBS** | 85.12 | 83.38 |
| **MF** | 100.00 | 100.00 |

## 4. DISCUSSION

Conversion of land use from natural forest vegetation to cultivated land could not only affects soil physico-chemical and biological properties but also change the management system (Hazarika et al., 2014). In Meghalaya, lands are converted into shifting cultivation and cultivated Agricultural LUS from forest land [23]. Several researchers reported that the change of LUS such as shifting cultivation practices can cause significant variations in soil structural quality, terrestrial cycles, reduction of output, soil loss and degradation of soil [6,5]. Under natural environment, soils sustain their quality and equilibrium over the pedogenic progressions [24] Carter, 2002). Though, due to anthropogenic activities i.e. drastic change in land-uses (LUS) and soil management practices as a way to meet the food demand of growing inhabitants have led to the deterioration of soil quality [25].

### 4.1 Impact of Diverse Land Uses on Soil Chemical Attributes and Macronutrients

According to Table 2, the highest proportion of soil pH among different land uses (LUS) was observed in the RCC (5.39) at the surface depth of 0-15 cm and in the subsurface soil of JS land use (5.49), while the lowest pH was recorded in the pine forest (4.96) at the same depth of 0-15 cmInteresting high soil pH obtained in RCC system was due to application of manures i.e. FYM, poultry manure, pig manure, vermicompost and addition of DPA. The higher pH value was recorded in JS due to liming effect of slashed OM and burning [26]. The soil pH was decreased with increasing soil depth. Decline in soil pH was mainly could be due to build-up of exch. $Al^{3+}$, rectangle shaped canopy prominent the rain to big drops consequently augmenting the leaching of bases and by releasing organic acids make organo-metal complex in 15-30 cm soil depth, which is in agreement with the finding of several researchers [27-30].

In this study maximum EC was recorded in UBS (27.06 µS/m) at surface and lowest in PF (18.53µS/m) at surface soil (0-15 cm). The lower value of EC was due to exch. $Al^{3+}$, and organic acids, whenever high EC was due to accumulations of soluble salts in UUBS. Similar results also was found by [31,12].

Avl. N is found to be present in the highest amount in MF (550.00 Kg/ha) at surface (0-15 cm) as related to the further land use studied, whenever UBS was observed lowest amount 244.39 Kg/ha. Our study also supported by finding of [10] forest soil have more N than cultivated soil. The avl. N content was higher in the surface soil and it decreased with soil depth in diverse LUS. The litter availability in mixed forest resource availability on the forest floor that can be colonized, decomposed and mineralized by the soil microbes, and also retains moisture on the forest floor which may lead to decomposition SOM and nutrient mineralization in the soil [32] Maithani et al. 1998). Cycling of N is altered by anthropogenic activity [33]. Avl. N are most vulnerable to surface change, where physical alterations such as removal of live vegetation and forest floor litter, exacerbate erosion, runoff, and the leaching of soluble N ($NO_3^-$) not taken up by plant roots [34]. The available $P_2O_5$ content was greatest found in RCC (20.23 Kg/ha) and least amount was recorded in PF 8.24 Kg/ha at surface. Low availability of P in PF attributed to soil pH, in Khasi pine the chemical composition of pine needle (modified leaves) and its sluggish decay rate [35]. The higher availability of P is could be due to regular application of FYM, poultry manure, recycling of crop biomass, the residual effect of DAP applied to RCC, and the release of plant nutrients on mineralization of organic manures that favoured the enhancement of a labile pool P in the soils and resulted increase in pH [36,37]. At high pH the availability of $Al^{3+}$, $Fe^{2+}$ and $Mn^{2+}$ less soluble, and SOM form chelate, whereas at low pH they were combine and make unavailable to plants [38]. Neina, 2019). The available $K_2O$ in the studied sites was varies from medium to high. The lowest $K_2O$ content in 0-15 cm soil depth in RP and highest in MF LUS, the considerable low content of $K_2O$ was due to Potato is high K feeder crop, whenever highest amount in BMF was due to absence of anthropogenic activity, increases higher amount of SOC and plant biodiversity [39,40]. Differential build-up of available N, P and K content in diverse land use systems in Meghalaya have also been reported by [39]. The available N, P and K in different LUS decreased with increasing soil depth [39].

### 4.2 Impact of Diverse Land Uses on DTPA Cationic Micronutrients in Soil

On conversion of evergreen forests (Mixed-Forest, Pine-Forest) to upland agriculture (settled-agriculture and jhum-system) and plantation crop, Cu, Mn, and Zn contents declined significantly. Lowland-Paddy and grassland (Broom-System) had comparable Fe, Mn, and Cu concentrations (except Zn). The DTPA extractable cationic micronutrients (ppm) *i.e.* Fe, Mn, Cu and Zn in all diverse land use systems in superficial soil depth were ranging from 20.62-111.95, 8.18-29.34, 0.51-4.27 and 0.07-3.08 ppm, respectively however increasing the depth status of micronutrients was decreases. Among micronutrients Zn was found in deficient to sufficient ranges in subsurface. Very low amount of Zn in lowland rice system could be the result of solubility of minerals, continuous removal of this element by crop, without its replenishment through fertilizers except some probable addition through recycling of crop residues [39]. There was substantial Fe and Mn build-up in all different land uses in all study sites. The maximum content of Fe and Mn in Mixed-Forest and Pine forest suggesting better recycling of these plant micronutrients system through leaf litter and weed biomass decomposition. DTPA extractable Cu also increased marginally in all the land uses. The highest amount available Cu content was recorded in UBS system. All the cationic micronutrients showed decreasing order from surface to subsurface soil depth. Considering the critical limits of DTPA extractable micronutrients (ppm) like as Fe (4.50), Mn (2.0), Cu (0.20) and Zn (0.060) in acid soils, the soils of all diverse land uses were sufficient in available Fe, Cu and Mn and deficient in available Zn. [41] found similar results in Dimapur and Wokh distrct of Nagaland in different land uses. The available Fe, Mn, Cu and Zn content of different land use soils was well within the range as reported by [42,43,41]. [44] also reported that DTPA extractable cationic micronutrients such as Fe, Mn, Cu and Zn content varied widely from 0.665 to 257.10, traces to 93.4, 17.1, and 34.20 ppm, respectively in diverse land uses in Meghalaya. The above study thus revealed the diverse land use systems are better alternative to the Rice-Potato, Rice-Cole cropping system in hill region of Meghalaya. All the land use systems maintained better fertility status of the soil as compared to Rice-Potato and Rice-Cole crop.

### 4.3 Impact of Land Uses on Soil Quality Index

The development of soil quality index in the locality of study site of diverse land use systems in East-Khasi hills located in Meghalaya plateau under humid subtropical hilly ecological unit is very important since there are certain degradation signs indicating how their sustainability is being susceptible.

Understanding soil quality is very important to improving sustainable land use system and management practices [15] providing early warning signals of adverse conditions in soil quality change, identifying problematic areas of soil quality [45] and providing a valuable basis for the subsequent rational use and improvement of soil. The term soil quality was used on different perspectives in both agricultural and environmental point of views [46]. To develop soil quality, there is a complexity of the subject involves due to diversity of physic-chemical and biological attributes and their integrative relationship [12,13].

To develop soil quality index (SQI), suitable assessment methods and reasonable SQI are great importance [47]. Undisturbed adjacent mixed forest site represent a balanced soil physic-chemical and biological quality from stable ecosystem which can be used as standard for soil quality assessment [48,10]. The objectives of using agricultural land in order to build SQI should be taken into consideration while choosing the criteria [49].

Depending on how much of the variability in soil quality is represented by each SQ indicator, it is difficult to explain how changing land uses and subsequent intense farming affects soil quality across different time scales. SQ governed by cumulative responses of soil fertility attributes to management induced factors. So, these variations in SQI amongst different places, land uses and depths are often analyzed by engaging principle component analysis where fluctuations in values of soil quality indicators are measured at a time.

SQI of surface soil (0-15 cm) were found higher compare to subsurface soil (15-30 cm) in site. In the surface and subsurface soil of study area greatest SQI was observed in Pine forest system (94.68-98.99) but lowest in Rice-Potato (67.46-70.60) and Rice-Cole crop (68.36-71.87). In the subsurface soil of different LUS followed decreasing trends in different land uses. The higher SQI value was due to less anthropogenic activity such as no till practices, which allow to accumulation of leaf litter and diversity of weeds and other vegetation’s in Pine system. The lowest SQI values in Rice-Potato and Rice-Cole crop could be induced tillage practices which enhances disruption of soil aggregates and decomposition of SOM and decreases other fertility parameters. Our results similar to [50] they reported SQI rating was the highest for the least-disturbed soils and the lowest for most intensively cultivated land. They followed in the sequences Natural forestland>Grassland> cultivated low land> plantation land>cultivated upland terrace land uses in Dimapur, Nagaland. [10] reported in India, they were found that the soil deterioration index higher for orchard soils relative to undisturbed forest site designated that orchard s2oils were in the grave state of degradation in terms of chemical characteristics and the degree of decline of soil quality increased with the increase of orchard age. [12,13] also reported SQI in Arunachal Pradesh they were found that the highest SQI in forest soil relative to rice-fish farming system.

## 5. CONCLUSIONS

The conversion of mixed forest to cultivated land caused a decline in the parameters of soil quality, more severe in traditional agriculture (Jhum cultivation, Rice-Potato etc.) than natural mixed forest. This current study suggests that pine forest reduce the deterioration of soil fertility status, which enhances SQI in hill ecosystem of Meghalaya. SQI were found higher in Forest system than the cultivated system. Thus, finding of this study clearly showed that the proper selection of land uses according to the state of soil quality index for better soil sustainability such as Pine forest, pineapple system,upland rice monoculture, jhum sytem etc. Further higher soil quality was observed in Pine-Forest system.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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