## *Original Research Article*

# Effect of land use change on total phosphorus and its fractions in North-Western Himalayas


## ABSTRACT

**Aims:** Conversion of land from forest to cropping has a serious effect on soil phosphorus and its fractions

**Results:** Land use is now widely understood to be a primary factor in environmental change across all time and space scales. The purpose of this research was to ascertain how different land uses affected the concentration of phosphorus in soil. Soil phosphorus (P) reserves are depleted when land is converted from natural vegetation to permanent agricultural cropping. The transformation of North-Western Himalayas from a forest-dominated to a grassland-dominated ecosystem is just one example of the diversity of land significantly less soil aggregation occurred when agricultural land was cleared of its native vegetation. Total organic carbon in soils was reduced when grassland was converted to cropland. Reduced total organic carbon (TOC) concentrations by 62-79% and organic phosphorus (Po) concentrations by 47-53%. Even though, the total silt+clay fraction's contribution was negligible, it contained a significant amount of C and Po reserves and the C/Po ratio has been holding fairly steady, they have proven to be more robust. This impact of cropping on soil P reserves has been demonstrated in research, but changing land use practices can alleviate these problems significantly.



*Keywords:Landuse, Phosphorus fractions, Pasture*


## 1. INTRODUCTION

Phosphorus (P) is a macronutrient that plants need to grow and flourish. However, it is believed that about 5.7 billion hectares (ha) of land around the world has insufficient amounts of plant-available P [1]. Phosphate rock is used in crop production at the current rate of about 150 million tons per year[2]. In addition, global reserves of P are the smallest of the 14 essential plant nutrients[3], and the vast majority of them are located in just one country (Morocco). Understanding P behavior in soils, including its effect on long-term agricultural production, is thus crucial.Despite total P concentrations between 200 and 800 mg $kg^{-1}$ soil [4], only 0.1% of this P is available for plant uptake in the soil solution[5]. Since plants uptake P from the soil solution, which has low P concentrations, that fraction must be replenished to meet plant needs. Labile P replenishes. The first labile pool (Pi) is P in mineral forms that dissolve, releasing P, or P adsorbing to soil surfaces. Plant and enzyme activity mineralizes the second labile pool (Po)[6].

Phosphorus in soil is dispersed among numerous geochemical phases, including soil solution and exchangeable phase, OM phase, Ca-bound phase, and Fe and Al-bound phases. The degree of P association with distinct geochemical forms greatly depends on soil physico-chemical characteristics owing to soil type, climate, and management approaches[7]. Under certain situations, these P fractions can be altered due to their different mobility, bioavailability, and chemical behaviors in soil. In soils, fractionation defines them qualitatively and quantitatively. Bioavailability, P leachability, and chemical form transitions in agricultural and contaminated soils can be predicted using such knowledge. Redistribution among fractions affects P mobility, unlike total P analysis. A high amount of P in labile pools indicates increased plant availability but also greater leaching or runoff [8].

Long-term cultivation and cropping reduce soil P concentrations in low-input agricultural systems [9, 10]. It was reported that both inorganic P and Po concentrations reduced significantly. However, much remains unknown about cropping, along with how land management techniques affect P loss and how soil aggregates sustain and cycle P pools, particularly Po[7, 11]. Only few studies have examined its effects on P forms. Fonte et al.[12]Concluded that despite a 40% increased Po content in productive pasture soils, there wasn't any difference in total P content.

## 2. MATERIAL AND METHODS

### SITE DESCRIPTION

**Study area** The study area is located in the temperate Himalaya of the North–Western part of India between the latitude 34º12' to 34º20' North latitude and 74º20' to 74º34' East longitude with an elevation of 1584 meters and an area of 3353 km2. The region has the high, mid and low altitudes consisting of mountains, hills and valleys. The region has an annual rainfall of 1270 mm and an average temperature of 24° C. The highland is separated by a wide valley which is stretched by the river Jhelum in the eastern and western direction. In the north western part is the Jhelum and in the southern part is Pakistan. The topography of the area steep slopy to moderately slopy with some plain area as well.

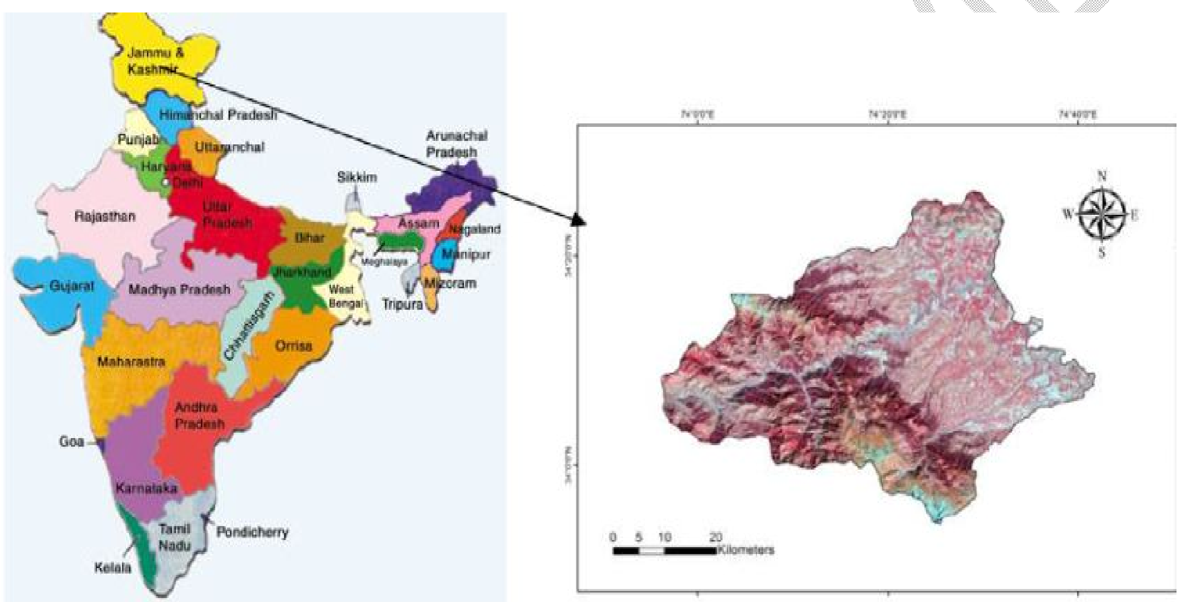


**Fig 1 Gis map of the study area**

### SOIL SAMPLING AND ANALYSIS

All the soil samples were air-dried, polished and pulverized using mortar and pestle and then sieved through a 2mm mesh sieve. The hydrometer method [13] was used to determine particle size distribution. Blake and Hartge's[14]method was used to estimate soil bulk density in which each core of soil sample was oven-dried at 105 °C for at least two to three days. The soil pH was determined potentiometrically 1:2.5 (w/v) soil-water supernatant suspension[15]. SOC was estimated using [16]. Citrate-dithionite-extractable Fe a2d Al were determined using method of Kuo[17]. Concentrations of P within the soil samples were examined using Colwell-P as well as sequential fractionation. For Colwell-P, concentrations were determined following extraction with $NaHCO_3$[18], with P measured using the molybdate blue colorimetric method [19]. Sequential extraction of P was conducted following a modified Hedley fractionation method[20].

## 3. RESULTS

Overall, the pH ranged from 5.5 to 6.8 in the soils of different land uses (Table 1). Soil pH levels were typically lower in areas with forest compared to those in areas where the land had been converted to agriculture (Table 1). The EC of the soils tested ranged from 0.01 to 0.21 $dSm^{-1}$, indicating no salinity hazard. A high percentage of clay was present in all soils, with values ranging from 25 % to 43 % (Fig.1). Average concentration of SOC ranged from 3.2 to 10.3 g $Kg^{-1}$across all land uses with highest in forest soils and lowest in paddy soils. Total nitrogen varied between 0.4 to 7.7 g $Kg^{-1}$ with highest in forest soilsand lowest in paddy soils. $Fe_d$ varied between the land uses form 1.2-15.5 g $Kg^{-1}$ (Fig.2) with lowest in paddy soils and highest in forest soils, similar trend was found in case of $Al_d$among all the land uses(Table 1).

Table 1.Physico-chemical properties under different land uses

| Land use | pH | EC ($dSm^{-1}$) | Bulk Density ($Mgm^{-3}$) | Sand (%) | Silt (%) | Clay (%) | SOC ($g\ Kg^{-1}$) | Total Nitrogen ($g\ Kg^{-1}$) | $Fe_d$ ($g\ Kg^{-1}$) | $Al_d$ ($g\ Kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| Forest | 5.5 | 0.07 | 1.15 | 20 | 15 | 25 | 10.3 | 7.7 | 13.5 | 8 |
| Pasture | 5.8 | 0.01 | 1.21 | 15 | 20 | 41 | 6.7 | 5.6 | 9.4 | 3.2 |
| Paddy | 6.8 | 0.15 | 1.42 | 24 | 25 | 30 | 3.2 | 0.4 | 1.2 | 2.1 |
| Orchard | 6.7 | 0.21 | 1.51 | 30 | 30 | 43 | 4.1 | 1.1 | 1.6 | 2.8 |



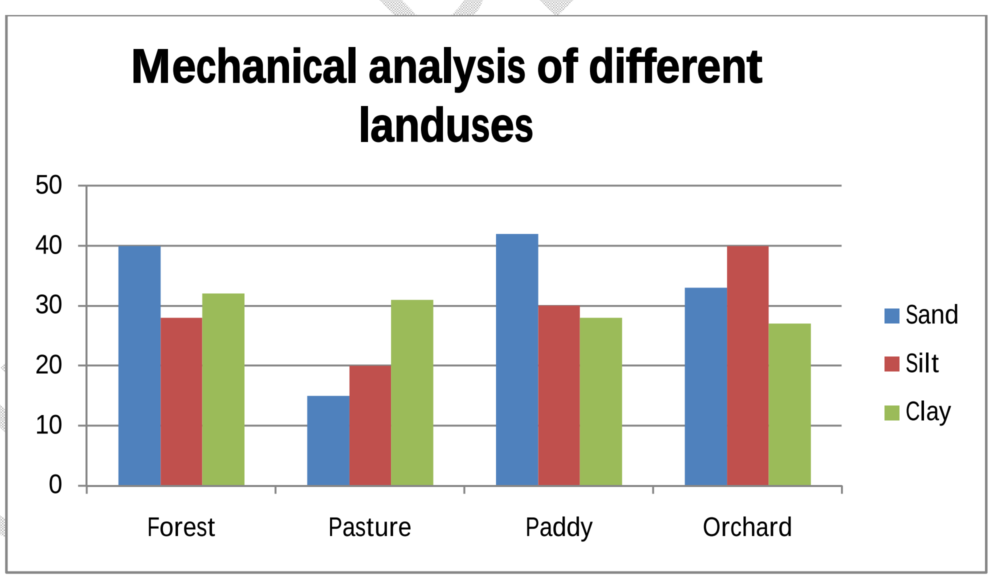


Fig. 1 Mechanical analysis of different land uses

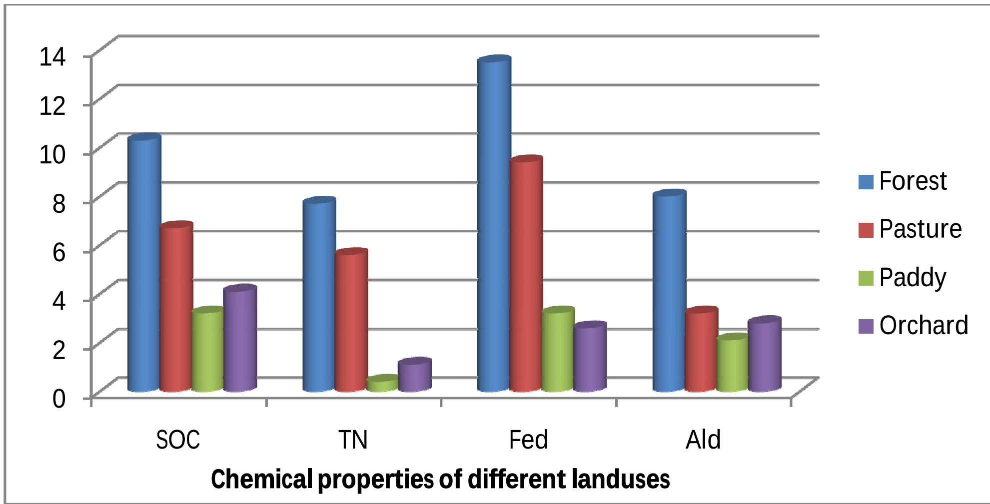


Fig. 2 Chemical properties of different land uses

Total P ranged from 526 to 901 mg $kg^{-1}$ in studied soils. Pasture soils had the highest total P concentration of 901 mg $kg^{-1}$ (Table 2). 65-70 % of P was Pi and 25-50 % Po in all the land uses. Converting forest soils to agricultural production (cropping) affected these P fractions. First, transition of soil to cropping reduced total P concentrations. However, conversion of forest soils to other land uses decreased Po's contribution to total P. In all soils, the C/Po ratio (for Po) also decreased significantly for all land uses for all three soils. Finally, transition from forest to cropping reduced Colwell-P concentrations. These P fractions within the soil were influenced by the transition from grazing to cropping, though the extent of this influence varied across land uses. At first, it was discovered that when land was used for farming (cropping), total P concentrations fell. No matter the land use, it was obvious that conversion significantly reduced the contribution of Po to total P. Similar declines in C/Po ratio (for Po) were observed across all land uses. For any given shift in land use, bulk soil Pi/Po ratios rose, with cropping leading the way and plantation showing the least change. Furthermore, Colwell-P concentrations declined dramatically across all land types.

Table 2 P concentrations influenced by land use, including for total P, inorganic P (Pi), organic P (Po), and the Po as a proportion of total P

| Land use | Total P (mg $Kg^{-1}$) | Total Pi (mg $Kg^{-1}$) | Total Po (mg $Kg^{-1}$) | Colwell-P (mg $Kg^{-1}$) |
|---|---|---|---|---|
| Forest | 975.3 | 536.2 | 439.1 | 65 |
| Pasture | 1193 | 665.5 | 527.5 | 53 |
| Paddy | 528.1 | 402.5 | 125.6 | 36 |
| Orchard | 760.8 | 485.5 | 275.3 | 42 |

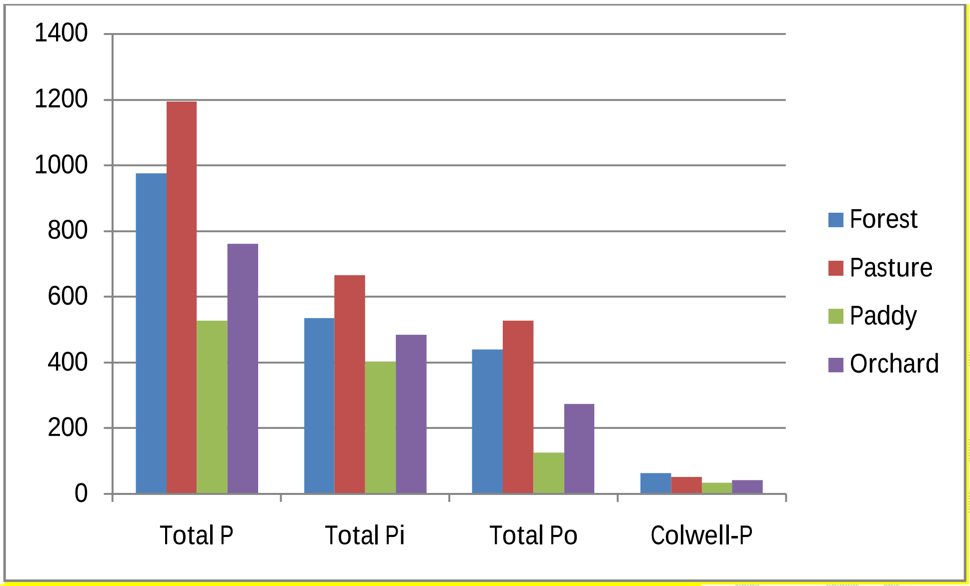


Fig. 3 Phosphorus fractions under different land uses

## DISCUSSION

Changes in both total P and Pi were found to be highly site-specific. However, cropping consistently reduced Po compared to soil with forest soilsStutter et al. [21], who analyzed five Australian cropping soils, found that Po decreased significantly for four of them, on average by 28%. Without fertilizer addition, Pi and Po did not change in the surface layer but showed depletion deeper within the soil profile. Total organic carbon (TOC) decreased by 45 percent after land was converted from forest to other land uses, but neither total P nor P fractionation were affected [22].However, a shift from cropland to pasture led to a 94% increase in both total P and Po. Although Pi decreased by 31%, the total P and Po were barely impacted by the conversion of this pasture to other land uses (Figure 2). Previous research has shown that after afforestation, total P and Po often decrease while plant-available Pi can increase[23].

Before being used for grazing, the soil in the pastures was cropped. Firstly, it was seen that the Po fraction was reduced by 63% after cropping, but then increased to almost the same levels as in the soil with native vegetation after being converted to pasture or plantation. Switching from grazing to cropping resulted in a significant drop in total organic carbon (85% in the bulk soils due to net mineralization. Total organic carbon (TOC) concentrations were higher in soil that had been converted from cropland to pasture, but not to pre-farm levels. Finally, related to the preceding points, we noticed that converting cropland to pasture also partially restored values for C/Po and Pi/o to levels closer to those for the soil with forest landuse which might be attributed to the higher organic carbon, clay content compared to other land uses[24, 25].

## 4. CONCLUSION

We analyzed how different types of land use affected the amount, fractionation, and distribution of phosphorus throughout the North-Western Himalayas. In addition to a 45% drop in soil C, we discovered that shifting land uses significantly altered P distribution. Changing the land use from forested to agricultural resulted in significant reductions in total organic carbon, total nitrogen, and phosphorus. More research into the impact of management practice on increasing P availability in these soils is needed.

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