Carbon stock assessment in changing land uses of Mon, Nagaland: an important learning for climate change mitigation from North East India

Forests are the most important terrestrial ecosystems on earth, as they have rich biodiversity, provide ecosystems services and have the capacity to offset climate change impact through carbon sequestration. North East (NE) India, one of the 35 biodiversity spots of the world, comprises 8 states and has an area of 171,964 sq. km (65% of the geographical area) under forests[1]. Another major land use in NE India is agricultural land. Although 86% of this area is under 'shifting or jhum' cultivation, it is the main source of livelihood for the local people. In NE India, clearing of forest lands, burning of vegetation and conversion into jhum fields is a common practice. This practice not only increases soil fertility for 1–2 years, but also aggravates issues of soil erosion and carbon loss after the cultivation phase. It is a continuous and repeated cycle – forest areas are converted to jhum lands, and jhum lands into barren or degraded lands. This practice of land-use changes and their contribution to carbon emission is greatest in NE India. The chances of climate change impacts are also projected by the Potsdam Institute for Climate Impact Research in Germany, as follows: 'If man-made carbon emissions continue unabated, some regions in NE India could literally become unlivable by the end of the century due to a deadly combination of heat and humidity during heat waves, recent research has projected'[2]. This is a burning issue, as jhumming practice adds to anthropogenic carbon emissions and thus to climate change.

Nagaland is a small state in NE India, having rich forest resources providing livelihood to majority of the population. The state is located in the extreme North East of the country and lies between 25°10′–27°4′N lat. and 93°15′–95°15′E long. The altitude of terrain varies from 194 to 3826 m amsl. Forest occupies an area of approximately 862,930 ha, of which the Government controls 11.7% and the rest is under the control of Village Councils. The recorded forest area of Nagaland is 56% of its geographical area, while its total forest and tree cover is 13,764 sq. km, which is nearly 83% of the geographical area. The state is a narrow strip of hilly area running northeast to southwest, located in the northern extension of the Arakan Yoma ranges of Myanmar. The geographic area of Nagaland is 1.66 million hectare. It consists of 11 districts, viz. Kohima, Dimapur, Peren, Phek, Kiphire, Tuensang, Zunheboto, Longling, Mon, Mokokchung and Wokha. There are 16 tribes in Nagaland and each district is dominated by a tribe (Naga). The largest tribes and their associated districts are as follows: Angamis (Kohima and Dimapur), Aos (Mokokchung), Konyaks (Mon), Lothas (Wokha) and Sumis (Zunheboto). The term 'Konyak' is believed to have been derived from the words 'Whao' meaning 'head' and 'Nyak' meaning 'black', translating to 'men with black hair'. These Nagas were earlier known for their headhunting practice and tattoos. The present study was carried out in the Mon district of Nagaland, which occupies an area of about 1786 sq. km. The district comprises both hills and plains, with an average elevation of 897.64 m amsl. The climate remains warm and humid throughout the year with mean annual precipitation of 1500 mm. The soils are mainly laterite in hilly areas, while red soils are found in plain areas. In Mon district, jhum cultivation is practised on a large scale and the area under scrub/degraded jhum land is about 354.25 sq. km (ref. 3). To overcome this mismanagement of fallow/degraded

Table 1. Effect of different land-use systems on bulk density and soil organic carbon (SOC) in Nagaland

	Soil property (0–30 cm)	
	Bulk density (g cm^{-3})	SOC (%)
Land use	Mean ± SD	Mean ± SD
Forest	0.89 ± 0.15^{abc}	2.43 ± 0.91
Plantation	0.86 ± 0.14^{ab}	2.14 ± 0.63
Jhum	0.96 ± 0.13^{bc}	2.09 ± 0.55
Fallow jhum	0.82 ± 0.13^{a}	1.86 ± 0.80
Tea garden	0.98 ± 0.05^{c}	2.47 ± 0.84
$Diff._{0.05}$	S ($P < 0.005$)	NS ($P < 0.143$)

S, Significant; NS, Non-significant. Different letters in apex indicate significant differences ($P < 0.05$) among different land uses.

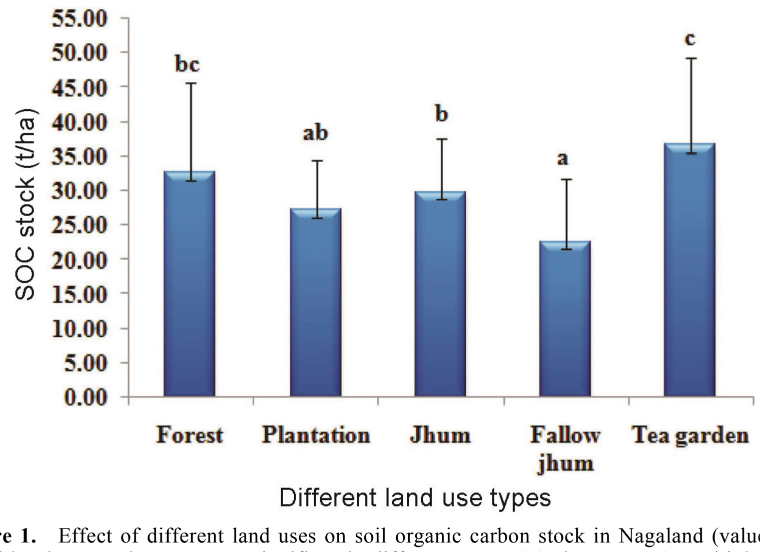

Figure 1. Effect of different land uses on soil organic carbon stock in Nagaland (values followed by the same letter are not significantly different at $P = 0.05$ by Duncan's multiple range test).

jhum, farmers introduced tea cultivation in some areas of district.

To estimate soil organic carbon (SOC) stock under different land uses, random sampling was done in the district and 100 soil samples were collected from 0 to 30 cm depth. SOC stock was calculated by multiplying SOC concentrations with bulk density (BD) and thickness of the soil layer. To assess the statistical differences among soil properties, One-way ANOVA test was conducted followed by the Duncan's test ($P < 0.05$). Data presented in Table 1 show significant influence of land-use systems on BD. One-way ANOVA revealed significant differences in BD values ($F = 3.924$, $P = 0.005$). The value of BD ranged from 0.82 to 0.98 g/cm^3. Tea gardens had the highest value and fallow jhums had the lowest value of BD. SOC was found to be highest in tea garden soils, followed by forest soils. However, fallow jhum had the lowest value of SOC and no statistical difference was observed. Figure 1 presents data pertaining to SOC stock under different land uses. SOC stock was significantly influenced by land uses at both the depths. In surface soils, maximum (36.62 t C per ha) value of SOC stock was found in tea garden soil, which is statistically comparable with forest soils (32.56 t C per ha). However, fallow jhum soils had minimum (22.53 t C per ha) amount of SOC stock. The study showed that tea gardens are able to sequester more SOC in comparison to fallow/degraded jhum. An increasing trend in SOC and soil carbon stock under tea gardens suggests the acceptability of this new land use in comparison to fallow jhums. Moreover, this will not only provide improved nutrient cycling and protection of soil from exposure during the new jhum cycle, but also open up the possibility of fallow/degraded jhums as potential carbon sequestrations areas. It will also provide a solution from regular clearing and burning of vegetation, which will reduce anthropogenic carbon emissions and help mitigate climate change.

1. FSI, India State of Forest Report. Forest Survey of India, Dehradun, 2015.
2. http://indianews.worldnewsnetwork.co.in/2018/08/indias-devastating-rains-match-climate-change-forecasts (accessed on 27 August 2018).
3. http://bhuvan.nrsc.gov.in/gis/thematic/tools/document/LULC502/MAP/NL.pdf (accessed on 29 August 2018).

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Islet transplantation: the Indian perspective

In continuation of the comprehensive review on clinical islet transplantation by Saravanan *et al.*[1] that focuses on the global scenario, it is appropriate to consider this important issue in the Indian context. The advantages and safety of islet transplantation in selected patients with type-1 diabetes mellitus (T1DM), experiencing life-threatening episodes of severe hypoglycaemia and in patients undergoing total/partial pancreatic resections, have been well demonstrated in the western as well as in certain Asian countries. Such transplantation is recognized by their national health systems and is reimbursable by their insurance systems[2].

Recent statistics from the International Diabetes Foundation denotes that China with about 100 million and India with about 78 million house the highest number of diabetics in Asia[3]. Amongst total diabetics, T1DM constitutes 10%, affecting young individuals. According to the sixth edition of the International Diabetes Federation diabetes atlas, India accounts for most of the children with T1DM in Southeast Asia, and has three new cases of T1DM/100,000 children in the 0–14 age group[4]. According to WHO projections, India would have 100 million diabetics by 2030 with as many as 10 million individuals with T1DM. Patients with T1DM experiencing life-threatening episodes of hypoglycaemic unawareness are reported to be benefited by islet transplantation.

Diabetes associated with pancreatic exocrine diseases such as chronic pancreatitis classified as type-3c diabetes (T3cDM) by the American Diabetes Association, is of relevance here. It was earlier misdiagnosed as either type-1 or type-2 diabetes, but is now recognized to be a distinct entity in terms of clinical presentation and pathophysiology. This form of diabetes is brittle in nature because of hepatic insulin sensitivity and lack of pancreatic polypeptide response. Since there is no prevalence data, T3cDM is considered to contribute to 4–5% of total diabetics, according to the global working estimate[5]. The prevalence of idiopathic chronic pancreatitis (ICP) is comparatively higher in India; consequently the occurrence of T3cDM would be more. The excruciating pain perceived in the patients draws clinical attention, and those who fail to respond to medical and endoscopic treatments are advocated resection of the pancreas to alleviate pain, which fail to respond to medical and endoscopic treatments. In such patients, autologous islet transplantation is performed to prevent loss of β-cell mass in order to prevent/minimize the occurrence of diabetes.

An initial population-based study in Kerala, confirmed later by a questionnaire-based study in the Asia-Pacific region, has recorded the prevalence of ICP to be 114–200/100,000 individuals in southern India, which is markedly higher than in western and industrialized nations (10–15/100,000). Importantly, patients report initially with diabetes and are then diagnosed for ICP with the mean age of diagnosis being less than 30 years. However, it is noted that about 30–40% of patients with ICP develop diabetes; more than 50% of these individuals will develop diabetes before 40 years of age[6].