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# Analysis of Trends of Mithun Populations with corresponding Trends of Forest Coverage and Climatic Factors in Mithun Rearing Districts of Nagaland

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ABSTRACT

National Mission for Sustaining the Himalayan Ecosystem (NMSHE), a component of the National Action Plan on Climate Change (NAPCC), attempts better understanding of the coupling between the Himalayan ecosystem and the climate factors and provide inputs for sustainable Himalayan development. As part of this programme, various data on mithun population status, climatic factors, and area of forest coverage over the years were collected and trends were estimated with a view to check the prevailing situations of these biotic and abiotic factors on mithun population during successive years in three districts of Nagaland (Kohima, Phem and Tuensung) having major mithun breeding tracts.

While mithun population was showing increasing trends in Kohima and Phek and decreasing trend in Tuensung district, none of these trends are statistically significant. At the same time, it is important to note that forest coverage shown overall decreasing trends in all the three districts. On the other hand, trends of annual rainfall and max. temperature were not significant, even if rainfall and max. temperature were having increasing trend.

The present assessment is the first and limited study of this kind whereby efforts were made to find out the trends of mithun population with corresponding forest coverage and climatic factors. While there were no significant trends of mithun population and climatic factors (annual rainfall and max. temperature), overall decreasing trends of forest coverage in the mithun habitats necessitate urgent steps to be taken up to protect forest areas from further degradation, as well as to carry out the age-old jhooming practices with modern inputs to be more sustainable and environmental-friendly in the North Eastern Hilly region for conservation of mithun habitats.

## 1. Introduction

Mithun (*Bos frontalis*) a magnificent bovine species, is distributed in four North Eastern Statesof Arunachal Pradesh, Manipur, Mizoram, Nagaland, and often referred to as “the cattle of mountains". Mithun, reared inside the ever-green rain forest under free range system, is essentially a forest loving animals and is a good example of integration of agro-forestry-ecology, sustenance livelihood, culture, and prosperity among the tribal people of North East India. This animal is well adapted with humid climate and hilly terrains at an altitude of 300 to 3000m above mean sea level. Mithun owners keep this animal in the jungle throughout the year and allow breeding naturally by using the bull of their own herds. Mithun fully depends on natural forages and green vegetation which are abundantly available in these jungles and human inputs in terms of any other feeding is negligible except occasional salt offerings. In other words, mithun is part and

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parcel of forest eco-system and to maintain biodiversity, forest conservation is an important step for maintaining the very existence of mithun population scattered in various remote locations (Nimasow and Apum, 2015).

In recent years, situation is assumed to be alarming due to various biotic and abiotic factors such as rampant deforestation, shifting cultivation (*jhuming*), changing climatic scenario andas the cumulative result of all these factors, the population of this animal is dwindling in many of their natural habitats, thereby causing serious concern for protection of this beautiful species. There is an urgent need to rear this animal under scientific input as well need to conserve the valuable germplasm keeping their traditional system as far as possible intact, it will enhance environment protection, generating income, self employment, better replacement of jhuming cultivation.

Climate is the long-term pattern of weather in a particular area. It is measured by assessing the patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorologicalvariables in a given region over long periods of time. Climate varies naturally on a wholerange of timescales and these variations can have profound impacts on weatherconditions around the world, such as storms and heavy rainfall (Shilpashree,2015).

Rainfall, a natural phenomenon and temperature of any place, being two important climatic factors, directly or indirectly affects the everylife forms on the earth, including mithun.The rainfall and temperature are the most fundamental physical parameter among the climate as it determines the environmental factors of the particular region which affect the agricultural productivity (Chinchorkar et al., 2018).

Mithun needs abundant water bodies in their natural habitat for their proper conservation. However, rainfall is unpredictable with widespread variation in time and space interms of pattern and amount. The lowest and highest annual rainfall in India is less than130 mm over the western Rajasthan and 1,1410 mm at Mausinram in the Meghalaya respectively. More than 75 per cent of rainfall occurs during the monsoon. However, monsoon rainfall is uneven both in time and space.

National Mission for Sustaining the Himalayan Ecosystem (NMSHE), a component of the National Action Plan on Climate Change (NAPCC), attempts better understanding of the coupling between the Himalayan ecosystem and the climate factors and provide inputs for sustainable Himalayan development.Since mithun population, climatic factors and forest coverage are essentially inter-related and mutually dependent due to their cohabitation in the lower Himalaya region, there is urgent need to understand and estimate the trends of various climatic factors and forest coverage of the mithun natural habitats.

The detection, estimation and prediction of trends and associated statistical and physical significance are important aspects of climate research. Trends analysis is important as this provides an indication of the prevailing situation and its outcome gives us direction to which way we should move or plan our programme. Thus, the present study is designed to find out the trends of mithun population, rainfall and temperature along with forest coverage in three mithun rearing districts of Nagaland. We hope this will elucidate the present population trends of mithun and their relation with forest coverage, annual rainfall and temperature of the mithun habitat.

## Materials and methods

### Data Collection

The present study consisted of collection of various data viz. population of mithun over the years (as per last five Livestock Census, 1992, 1997, 2003, 2007, & 2012), area under forest coverage, annual rainfall and max., temperature in three major mithun rearing districts of Nagaland (Kohima, Phek and Tuensung). Data were collected fromboth primary and secondary sources. Primary data relatingto the importance of mithun in the social and economiclife of the people has been collected through questionnaires,personal interview and notes during the field work. Secondary data were collected from different official documents published by various Ministries of Central and State Govt. available in public domain.The Directorate of Land Resources, Animal Husbandry and Veterinary Department, Government of Nagaland etc. were also visited to collect relevant information

Historical weather data for the period from 1988-2015 was collected from the Soil and Water Conservation Dept. keeping the meteorological data of Nagaland and entered in Ms excel sheet-2010.

**Statistical Analysis**

The collected information and data were analysed and interpreted by using various statisticaltechniques anddiagrams. The statistical analysis is performed to determine the measure of central tendency (mean) and dispersion (standard deviation and variance) for climate (rainfall and temperature) data of these three districts. The mean and standard deviation of data of annual rainfall was calculated as follows:

Mean ($\mu$) =$\Sigma$ (Xi/n) …………………………(1)
Standard Deviation (SD) = $\sqrt{((Xi- \mu)/n)}$…….(2)

Where, Xi is the annual rainfall data in $i^{th}$ year (i= 1, 2, 3….. n); n is the total number of year of rainfall data to be analysed.

For testing the significance of various trends statistics, the Mann-Kendall (M-K) test is used. This test is applicable in cases when the data values *xi* of a time series can be assumed to obey the model –

$$x_i = f(t) + \varepsilon_I \quad ………….(3)$$

where *f(t)* is a continuous monotonic increasing or decreasing function of time and residuals $\varepsilon_I$ can be assumed to be from the same distribution with zero mean. It is thereforeassumed that the variance of the distribution is constant in time.

We want to test the null hypothesis of no trend, $H_o$, i.e. the observations *xi* are randomlyordered in time, against the alternative hypothesis, $H_1$, where there is an increasing ordecreasing monotonic trend. In the computation of The statistical test is computed using both S statistics given in Gilbert (1987) and the normal approximation (Zstatistics).

For identifying the trend of all the time-series data (mithun population, forest coverage, rainfall and max. temperature data), the linear regression method of statistical analysis is used. The detection, estimation and prediction of trends and associated statistical and physical significance are important aspects of climate research. Given a time series of (say) rainfall and temperatures, the trend is the rate at which rainfall and temperature changes over a time period. The trend may be linear or non-linear. However, generally, it is synonymous with the linear slope of the line fit to the time series. The null hypothesis is no trend (ie, an unchanging climate). The non-parametric (*ie*., distribution free) Mann-Kendall (M-K) test is used to assess monotonic trend (linear or non-linear) significance. It is much less sensitive to outliers and skewed distributions (Shea, 2014).
To estimate the true slope of an existing trend (as change per year) the Sen's nonparametric
method is used. The Sen's method can be used in cases where the trend can be assumed to
be linear. This means that *f(t)* in equation (3) is equal to

$$f(t) = Qt + B……………(4)$$

where Q is the slope and B is a constant.

To get the slope estimate *Q* in equation (4) we calculate the slopes of all data value pairs-

$$Qi = \frac{xj-xk}{j-k}$$

where $j>k$ .

**Result**

The results of trends analysis of mithun population, forest coverage and climate data from three districts of Nagaland (Kohima, Tuensung and Phek) are discussed. The climate data studied were annual rainfall, and monthly maximum temperature. These three districts of Nagaland are the natural breeding habitat of mithun. This analysis would be very useful for mithun owners and farmers of the region. Over the years in three major mithun rearing district of Nagaland, there has been changes in the population status of mithun. It may be correlated with various biotic and abiotic factors.

**Trends Analysis in Kohima District**

In Kohima district there has been a severe reduction in the population of mithun from 2007 livestock census to 2012 livestock census (5868 vs. 2826 number). However, mithun population had an increasing trend over the years (Figure 1). If we look into the effect of biotic factor on mithun population such as forest coverage, there has been an overall decreasing trends (M-K test) in the forest area in Kohima during the past decade (1995 to 2015, Figure 2).

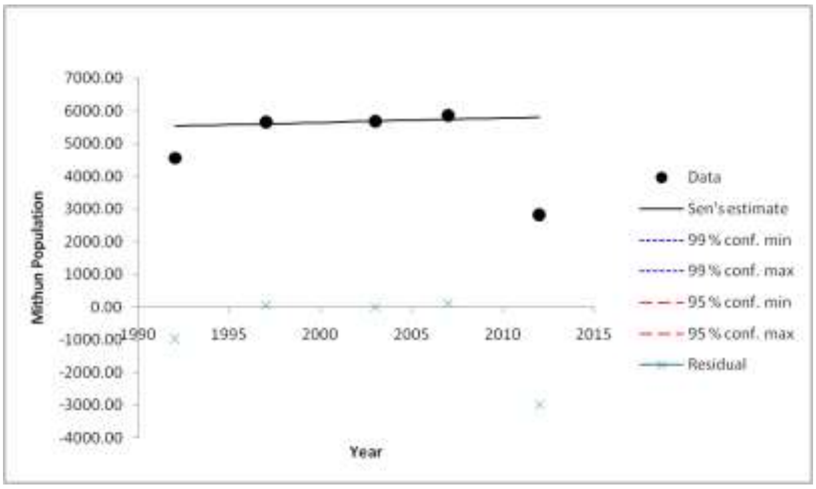


**Figure 1:**Trend of mithun population in Kohima district

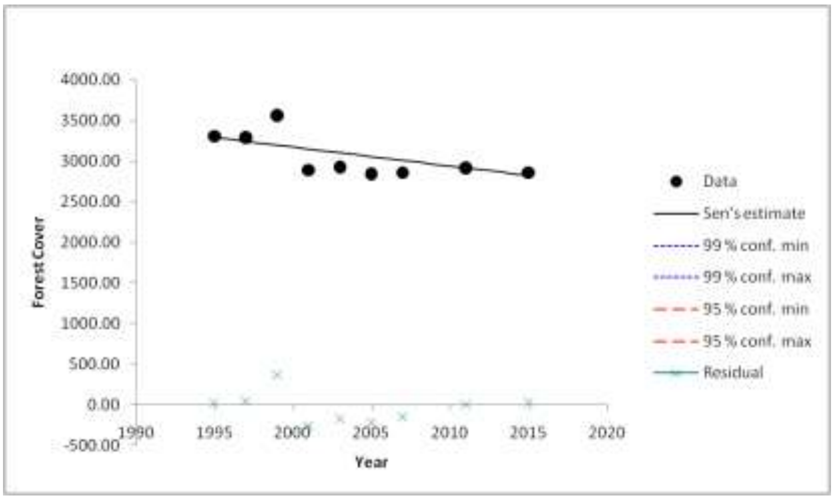


**Figure 2:** Trend of forest coverage in Kohima district

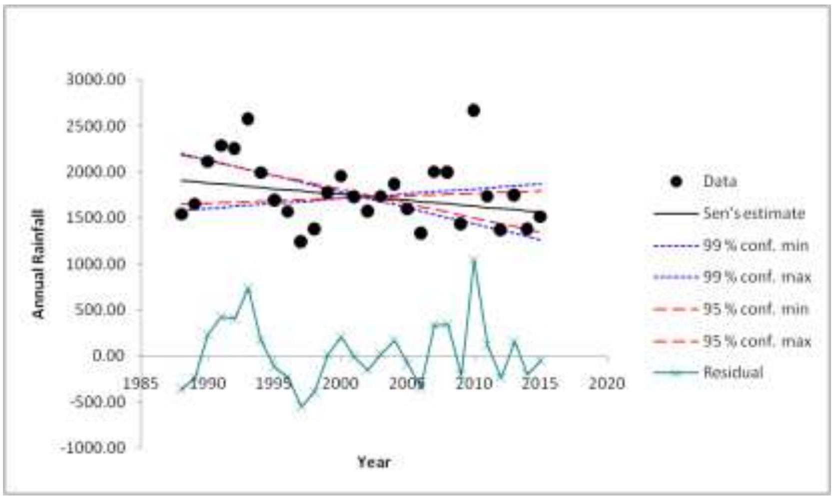


**Figure 3:** Trend of annual rainfall in Kohima district

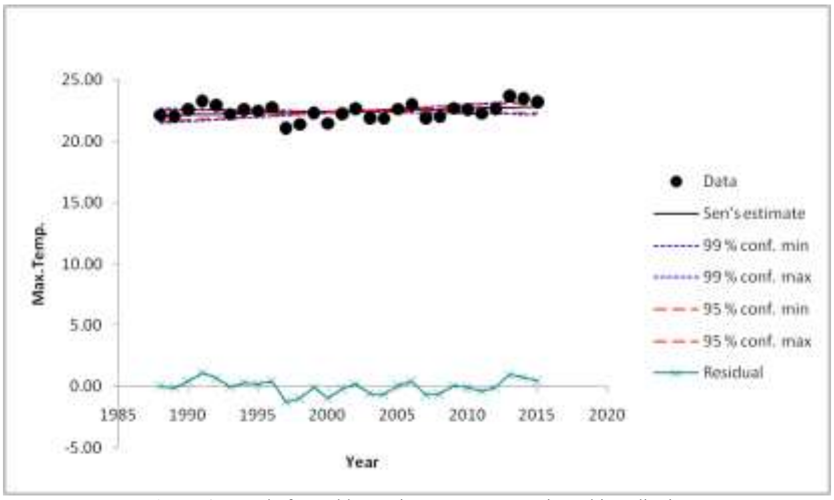


**Figure 4:** Trend of monthly maximum temperature in Kohima district

Average annual rainfall of Kohima district during the last two decades (1988-2015) was 1778.12±68.83 mm (ranged from 1242.20 mm in 1997 to 2675.16 mm in 2010). The rainfall has shown a decreasing trend, however, non-significant as per M-K Test. Average monthly maximum temperature in Kohima district during the same period (1988-2015) was 22.42±0.11$^0$C (ranged from 21.05$^0$C during 1997 to 23.70$^0$C during 2013). The trend of monthly maximum temperature showed an increasing trend, however, non-significant as per M-K test. Looking into the climatic effect such as temperature and rainfall over the past ten years, there has been a constant in the temperature range (Figure 3 & 4).

**Trends Analysis in Tuensung District**

The population of mithun in Tuensang district has been observed to decrease during the period 2003 to 2007 (9693 to 6697 numbers). However as per 2012 livestock census there has been a gradual increase in the mithun population to 7355 individuals (Figure 5). The trends of forest coverage in Tuensang district has been declining, however non-significant (M-K test, $p \leq 0.05$) over the past decade (Figure 6)

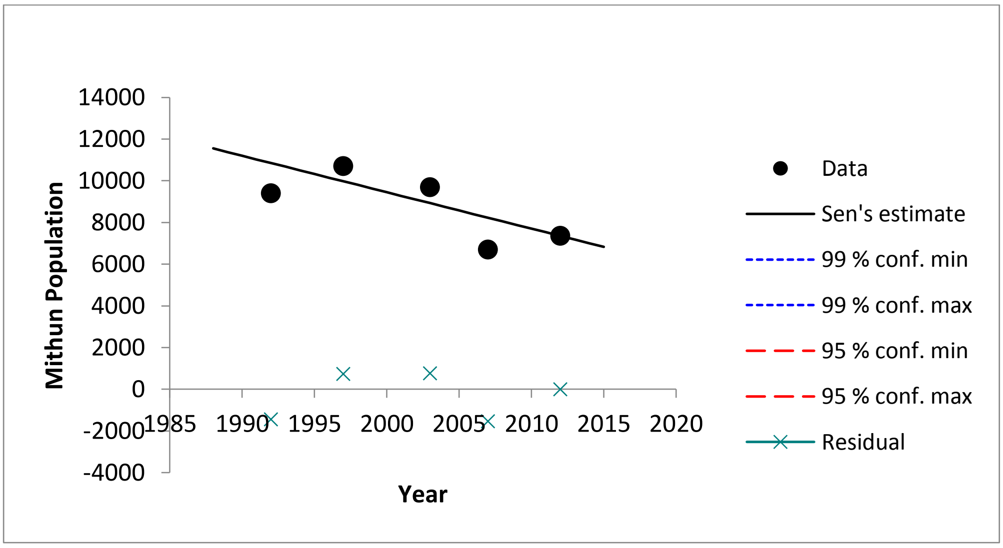


**Figure 5:** Trends of mithun population in Tuensung district

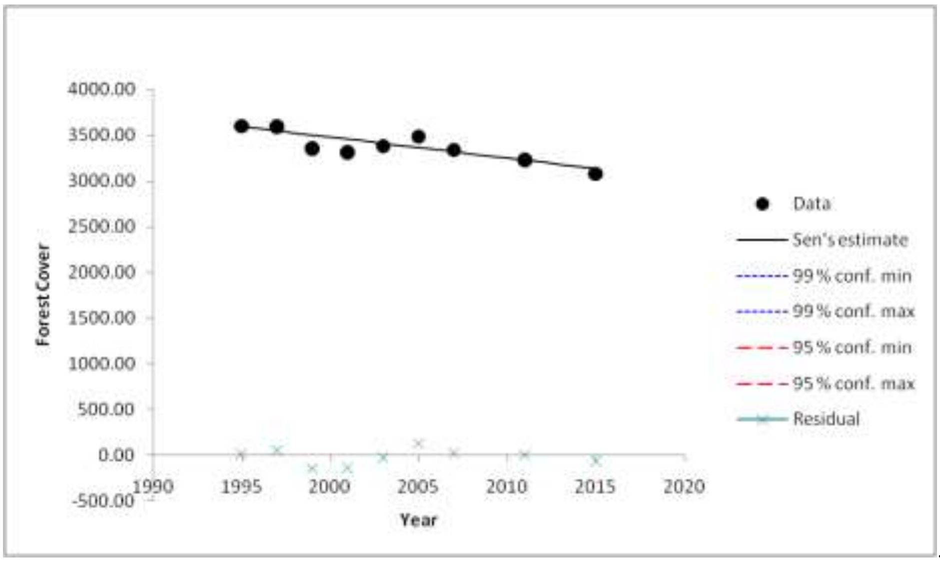


**Figure 6:** Trends of forest cover in Tuensung district

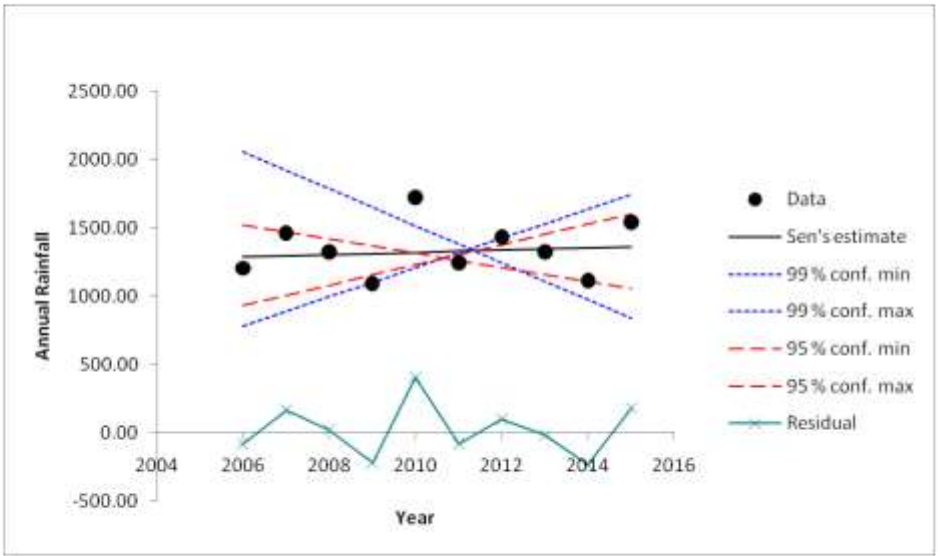


**Figure 7:** Trends of annual rainfall in Tuensung district

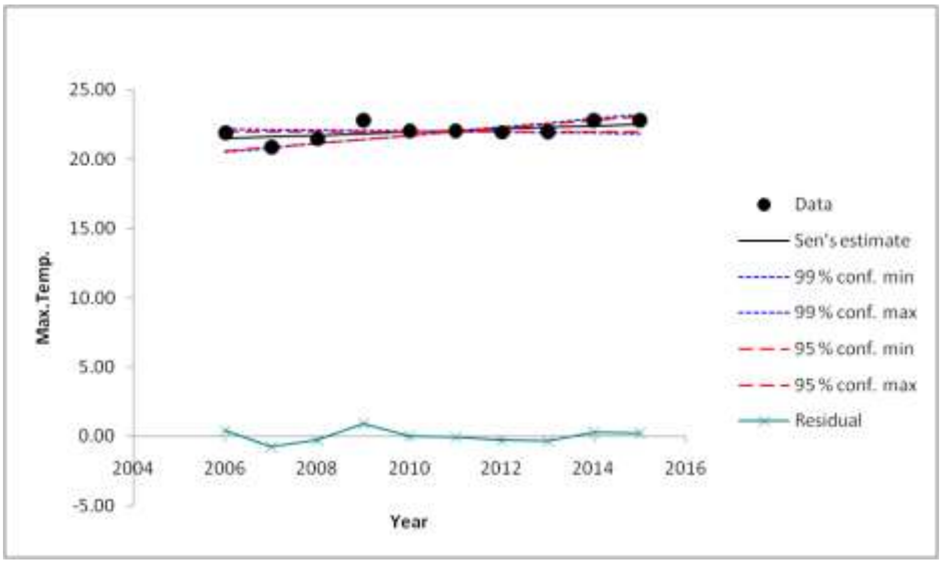


**Figure 8:** Trends of monthly maximum temperature in Tuensung district

Average annual rainfall of Tuensung district during the last decades (2006-2015) was 1343.99±62.47 mm (ranged from 1088.90 mm in 2009 to 1721.81 mm in 2010). The rainfall has shown an increasing trend, however, non-significant as per M-K Test (Figure 7). Average monthly maximum temperature in Tuensung district during the same period (2006-2015) was 22.05±0.19$^0$C (ranged from 20.87$^0$C during 2007 to 22.80$^0$C during 2015). The trend of monthly maximum temperature also showed an increasing trend, however, non-significant as per M-K test (Figure 8). Looking into the climatic effect such as temperature and rainfall over the past ten years, there has been a constant in the temperature range.

**Trends Analysis in Phek District**

Unlike two other districts (Kohima and Tuensung), there has been a gradual increase in the population of mithun in Phek district over the past ten years from 4416 heads in 2003 to 5732 in 2012. It has also observed that there has been increase in the forest coverage area with 1611 sq km in 2003 to 1767 sq km in 2012 (Figure 9). The climatic parameters of Phek district such as Avg temperature has shown a variation with 23.5ºC in 2003 to 22.8ºC in 2007 and 24.9ºC in 2012. The average annual rainfall in 2003 was 1529 cm; 1728 cm in 2007 and a drastic reduce in 2012 with annual rainfall of 1421 cm. There has been an increase in the average humidity in last fifteen years.

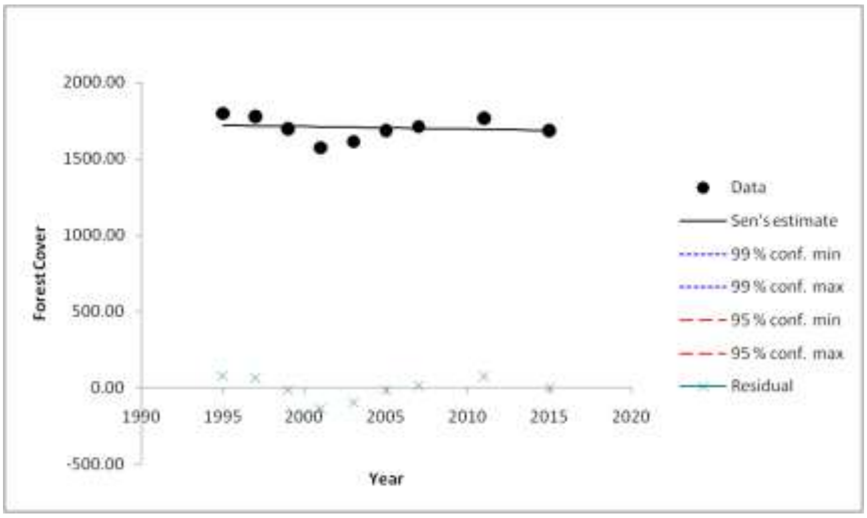


**Figure 9:** Trends of forest coverage in Phek

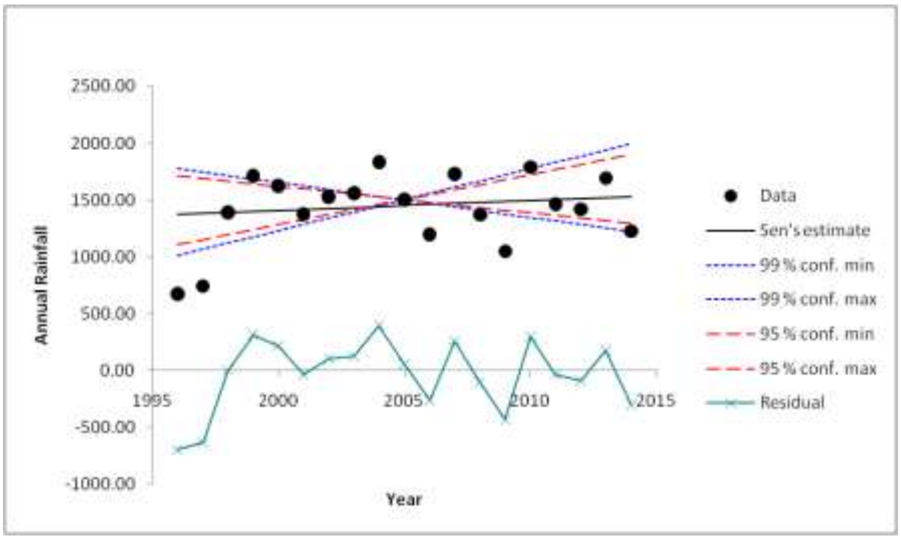


**Figure 10:** Trends of annual rainfall in Phek

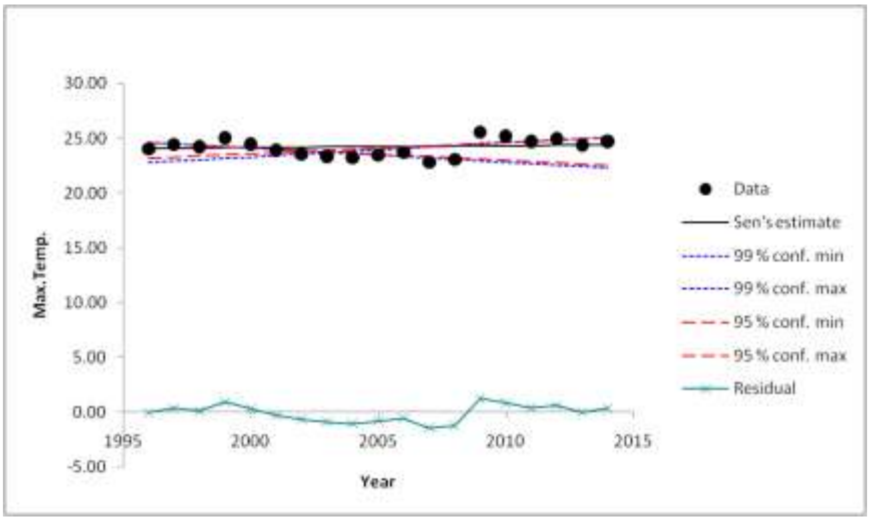


**Figure 11:** Trends of maximum temperature in Phek

Average annual rainfall of Phek district during the last decades (1996-2014) was 1416.01±74.48 mm (ranged from 672.50 mm in 1996 to 1836.80 mm in 2004). The rainfall has shown an increasing trend, however, non-significant as per M-K Test (Figure 10). Average monthly maximum temperature in Phek district during the same period (1996-2014) was 24.14±0.18$^0$C (ranged from 22.83$^0$C during 2007 to 25.54$^0$C during 2009). The trend of monthly maximum temperature only showed an increasing trend, which was significant as per M-K test ($p \leq 0.05$, Figure 11). Looking into the climatic effect such as temperature and rainfall over the past ten years, there has been a fluctuating trend in the climatic factors.

**Discussion**

Mithun population is reported an overall 12.98% growth in India during 2012 compared to 2007 (Livestock Census, 2012). However, mithun population is scattered among many remotely located hilly terrains in the NEH region and there is urgent need to check the trends of mithun populations in these small scattered locations along with the forest habitat and climate change so that proper planning and management could be taken up as per needs. In this present study, trends of mithun population of three mithun rearing districts were taken up along with corresponding trends of forest coverage, annual rainfall and max. temperature of the area. While mithun population was showing decreasing trends in Kohima and Tuensung and increasing trend in Phek district, none of these trends are statistically significant. At the same time, it is important to note that forest coverage shown significantly decreasing trends in all the three districts. On the other hand, trends of annual rainfall and max. temperature were not significant, even if rainfall and max. temperature were having increasing trend. Similar findings were reported by other workers. The trend analysis of annual rainfall during 1991 to 2010 revealed that annual rainfall increased over the past two decades. The monthly maximum temperature showed a positive trend of increase at a rate of 4.2$^0$C per 100 years in Bapatla, Andhra Pradesh (Dash and Kumar, 2017). Trend analysis of rainfall data series for 1871–2008 in the North East India did not show any clear trend for the region as a whole, although there are seasonal trends for some seasons and for some hydro-meteorological subdivisions. Similar analysis for temperature data showed that all the four temperature variables (maximum, minimum, and mean temperatures and temperature range) had rising trend (Jain et al., 2012).

Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales rangingfrom decades to millions of years. These changes can be caused by processes internal tothe Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities (Shilpashree, 2015). The first step towards mitigation and/or adaption to expected climate change is to determine whether there is evidence that the climate is already changing. For this purpose, estimates of trends of climatic factors is the standard procedure (Livada et al., 2018).

It is quite alarming that forest coverage was showing significantly decreasing trends in all the mithun habitats under present study. Mithun being a component of forest based production system, it needs to be strengthened by incorporating some other component with it to make it a viable and sustainable forest based integrated farming. For this we need to develop water bodies in the mithun natural habitats, which can be utilized further for fish culture. The forest area can be further supplemented with fodder trees consumed and preferred by mithun. This will also to help to conserve the forest by discouraging destruction.

Therefore conservation of biodiversity will largely depend on creating condition to revert to traditional long fallow jhuming through finding suitable alternative to *jhuming*, or a combination of both. For example, the Government of Nagaland is presently discouraging jhum cultivation and has identified the unique economic contribution of mithun as alternative to jhuming cultivation which would also directly or indirectly prevent global warming. Mithun also help to conserve some rare plant species having medicinal plant species only in mithun rearing areas (Kesing, 2012).

The present assessment is the first and limited study of this kind whereby efforts were made to find out the trends of mithun population with corresponding forest coverage and climatic factors. While there were no significant trends of mithun population and climatic factors (annual rainfall and max. temperature), overall decreasing trends of forest coverage in the mithun habitats necessitate urgent steps to be taken up to protect forest areas from further degradation, as well as to carry out the age-old *jhooming* practices with modern inputs to be more sustainable and environmental-friendly in the North Eastern Hilly region for conservation of mithun habitats.

**Acknowledgement**

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