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Assessment of spatio- temporal changes in current Jhum cultivation of *Thysanolaena maxima* in Mawthei village of Umsning Tehsil in Meghalaya

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ABSTRACT

Shifting cultivation or slash and burn agriculture is one of the most practiced forms of agriculture in the North- east as well as other hilly areas of India. A majority of tribal populations depend on this form of agriculture for their sustenance and livelihood; the Khasi and Garo tribes of Meghalaya are extensive practitioners of this form of agriculture in the state. Indian broomgrass [*Thysanolaena maxima* (*Roxb.*) Kuntze] is an important semi- domesticated non timber forest product (NTFP) of Meghalaya that contributes to the state's economy and is currently in high demand in the market. The cultivation of broomgrass in Meghalaya has become an effective instrument for rural development as its cultivation needs minimum input and labour while generating a very attractive economic return; thus the cultivation of broomgrass has become somewhat of a status quo in the state. Over the years there has been an alarming increase in the rate of deforestation and land degradation as vast areas of forest land are cleared and converted to broomgrass plantations. This study aims at utilizing geospatial techniques for understanding the dynamics of the conversion of forest lands into jhum land for the cultivation of broomgrass. The area of interest chosen for this study was Mawthei village in Umsning tehsil of Ri- bhoi district in Meghalaya. This village is extensively known for practicing shifting agriculture for the cultivation of broomgrass. The study aims at determining the current jhum as well as the expansion rate of cultivation of broomgrass annually in the village using clustering analysis as well as on screen visual interpretation techniques along with field visits to confirm the accuracy of clustering analysis. A time series analysis of satellite data was performed for a period of 7 years (2013- 2019) using Landsat- 8 OLI satellite data. The Landsat- 8 OLI has narrower spectral bands, improved calibration and signal to noise characteristics, higher 12-bit radiometric resolution, and more precise geometry, compared to the Landsat-7 ETM. For this analysis, 2013 was chosen as the base year as Landsat- 8 was launched in this year only. The study reveals an alarming and unprecedented rate in the expansion and conversion of forest lands into jhum lands for broomgrass cultivation. With the current existing trend and "business as usual" scenario of expansion of current jhum for broomgrass cultivation, this can bring about a negative impact on the microclimate of the village as well as land degradation due to loss of soil from the exposed fallow lands. Thus, intervention as well as mitigation policies need to be formulated to safeguard the interests of the rural population while establishing sustainable practices for the benefit of the village and the state as a whole.

***Key words** : Mawthei village, Jhum cultivation, Spatio- temporal, Swidden agriculture, Thysanolaena maxima*

Introduction

The tribal economy of India is characterized by poverty and backwardness as the country's resources were not equitably managed since the time of the British Raj, most of the resources were exported to boost the UK's economy and part of it remained for the general population of India. The tribal population generally were excluded as they remained secluded in the forests and lived off the forest as nomads and pastoralists. It was only during the peak rule of the British that when Wildlife Sanctuaries and Reserve Forests were established and tribal populations were forced out of their land did they migrate to major cities at the time in search of labour; their way of living was completely revamped. Nearly 500 million people living in and around forests in India rely on NTFPs as a critical component for their income generation and sustenance (Mallik, 2000; Chopra, 1993). Meghalaya, as per the 2001 Census of India, has a tribal populations of more than 80% of the total population of the state. They mainly live in the rural areas, which cover 99% of the total state area.The main occupation is agriculture, despite the fact that 70% of the land area falls under a steep or moderate slope, which makes it unfit or not feasible for permanent agriculture. Besides agriculture, people also depend considerably on forest resources for their subsistence (Ramakrishnan, 1985; Gangwar and Ramakrishnan, 1990). At least 95 different types of NTFPs are collected in Meghalaya (Tiwari, 2000). Shifting cultivation is one of the most prevalent forms of agriculture practiced by the tribal population of India, it is the practice where a patch of land is cleared of its biomass and burned to add nutrients like carbon, potassium and nitrogen. Shifting cultivation systems are ecologically viable as long as there is enough land for long (10–20 years) restorative fallow, and expectations of crop yield and the attendant standards of living are not too high (Lal, 2005).

Shifting cultivation is a form of resource management where the shifting of fields lead to the exploitation of energy and nutrient capital of the vegetation–soil complex of the future site (McGrath, 1987). It is a form of land use characterized by an alternation between a short span of cultivation and a comparatively long span of natural or improved fallow (Fujisaka Hurtado and Uribe, 1996). The fields are prepared by removal of the fallow vegetation by use of fire. The practice of shifting cultivation is a form of land use among tribal communities, having a rotation period between cultivation and fallow for the same unit of land. A large number of tribal population in India, especially north-east India are highly dependent on the practice of shifting cultivation for subsistence living (Kafle, 2011). In NER, this traditional system of agriculture is commonly referred to as Jhumsystem or Jhummia. Shifting cultivation is known by many names such as *swidden* or *bewar* in Madhya Pradesh, *zabo* in Nagaland, *tila* in Tripura and Assam and *bun* cultivation in Meghalaya (Spencer, 1966; Rahman *et al.,* 2008).

Thysanolaena maxima (Roxb.) Kuntze under the family Poaceae, is commonly known as broomgrass or Indian bromgrass, it is an important NTFP and grows in almost all parts of South and Southeast Asia. In the northeastern region of India and in Darjeeling and Sikkim Himalayas, it grows in the wild. This NTFP has highly contributed towards enhancing the livelihood of the people of these regions (Bisht and Ahlawat, 1998; Shankar *et al.,* 2001 and Tiwari, 2001). In Meghalaya, broomgrass was first introduced by the state forest department about three decades ago under a silvi-pastoral system in social forestry plantations for generating income during gestation periods, that is, periods between plantation and harvest of timber. Subsequently, the plant has been domesticated and cultivated on large scale by upland farmers. The tribal population in Meghalaya has resorted to cultivation of broomgrass under jhum owing to the high demand of broomgrass in the market where they are able to meet their basic needs as this cash crop fetches a good price in the market. Studies show that with an increasing population density, the proportion of fallow land is decreasing rapidly, and hence, as a consequence, the length of the fallow cycle has been reduced drastically as well, the regeneration of fertility of soil has been reduced from 13–15 years some 25 years ago to a meagre 3–4 years currently. The present study aims at exploring the dynamics in shifting cultivation of *Thysanolaena maxima* for a particular study period (2013- 2019). The purpose of the study is to highlight the increase of area of broomgrass plantations by determining the current area of jhum for all the years of the period of study, then by analysing these areas, the annual growth rate of expansion of the jhum plantations can be determined.

Study Area

Meghalaya, has a total geographical area of 22,429 square kilometres. It lies between 24°58′ N to 26°07′ N latitude and 89°48′ E to 92° 51′ E longitudes, while, the elevation of the state ranges between 150 to 1,950 m. The average rainfall in the state varies from 4,000 to 11,436 mm. The recorded forest area of the state is about 17,146 square kilometres which is 76.44 % of its geographical area (FSI 2017). Ri- bhoi district is one of the districts in Meghalaya bordering Assam in the north, West Khasi hills district in the southwest and East Khasi hills district in the south. Ri- bhoi district in subdivided into 3 blocks or tehsils viz., Jirang, Umling and Umsning. The tribes of the state are mostly marginal farmers having small land holdings. Any change in climatic conditions in the state makes them more susceptible to vagaries of increasing degradation of environment and shrinkage of common property resources. Shifting cultivation is the main form of agriculture in the state and provides sustenance and livelihood to the farmers (Ramakrishna, 1984). In order to meet the growing food demand due to population pressure the jhum cycle in the state has been shortened resulting in decrease of crop yield from jhum lands. This brings more forested areas under shifting cultivation and has brought in large scale land use change in the region (Barik, 2007; Darlong, 2004) and has been presumed to be an important contributor of CO_2 emissions (Fearnside *et al.*, 2004).

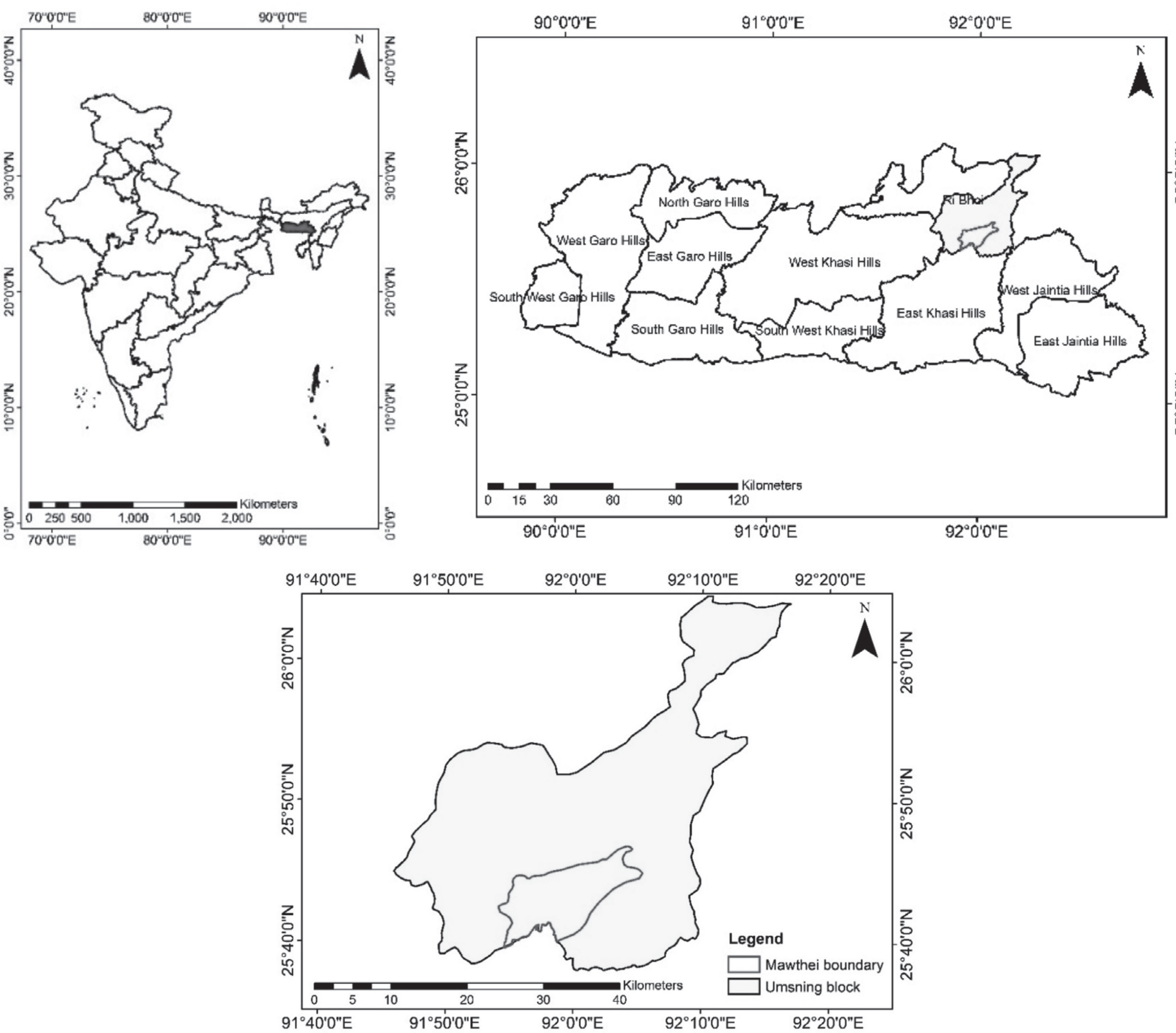

Fig. 1. Study Area

Methodology

A time series analysis of satellite data was done for Mawthei village in order to understand the prevailing pattern of shifting cultivation expansion in the area for the cultivation of *Thysanoalena maxima*. The study period for the satellite data series analysis was for a period of 7 years from 2013 (availability of Landsat 8 data) till 2019. Landsat 8 data with OLI sensor was obtained from USGS (United States Geological Survey) through earth explorer (www.glovis.usgs.gov) with path 136 and row 42 which encompasses the entire area of interest; cloud free data was obtained by limiting the dataset to the dry months pertaining to the months of November, December, January and February. The areas under current jhum cultivation for each year during the period 2013 to 2019 were mapped firstly by using the unsupervised classification technique corroborated with field visits. Ground truthing was performed upon the generated unsupervised (clustering) classified images as well as correlation of the plots with established *Thysanolaena maxima* jhum plots. Similarly, for all the consecutive years the expansion of the jhum plots was determined by uniform pixelated areas representative of *Thysanolaena maxima* jhum plantations. The standard false colour composite (FCC) for all imageries was generated prior to performing unsupervised classification on the imageries, this helped in delineating the expansion of the jhum plantations as the pre-burnt jhum plots showed higher reflectance in both red and NIR bands. The burnt plots showed lower reflectance in red and NIR band and the jhum fields showed slightly greyish blue hues as shown in Figure 2.

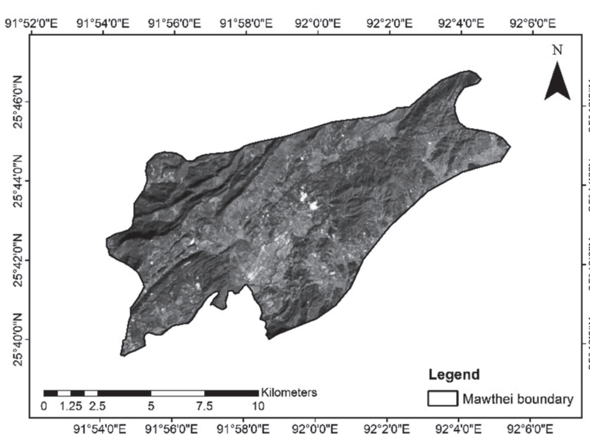

Fig. 2. FCC of Mawthei village

The calculation of the area of current jhum plantations as well as the area of expansion was done through the separate raster layers computed for *Thysanolaena maxima* jhum plantations only. Pixels representative of jhum were computed for the total area of jhum. For determining the annual expansion of jhum, the pixelated areas of two consecutive years was firstly computed, then the overlapping layers were removed by generating a new raster layer representative of the new jhum areas only. The area of annual jhum expansion was then determined by the remaining pixels. This process was repeated for all the consecutive years taking two years at a time, then three years, then four years etc. till the end of the study period.

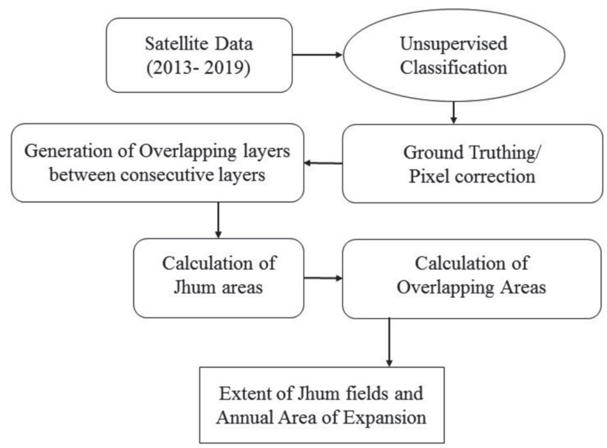

Fig. 3. Methodology flow chart

Results and Discussion

The annual increase in jhum cultivation area throughout the entire period of study entail the prevailing conditions of jhum practice in Mawthei village. From Table 1, it can be identified that at the beginning of the study period, the maximum area under Jhum cultivation was 48.12 hectares determined from Landsat 8 data for that year. For 2014, the total area under jhum cultivation determined from satellite data was 58.63 hectares, this area is the total area under Jhum cultivation between the period of 2014- 2015, similarly the areas under jhum were determined for the other years as shown in the table. The satellite data shows the total area under jhum for all the consecutive years which includes areas under jhum cultivation from the previous years as well.

The overlapping areas under jhum was deter-

Table 1. Area under shifting cultivation (*Thysanolaena maxima*)

Year	Area of Jhum (From Satellite Data) (ha)	Cumulative Jhum Area (ha)	Overlapping Jhum Area (ha)	Area under New Jhum (ha)	Annual Jhum Increase (ha)
2013	48.12	48.12	-	48.12	-
2014	58.63	106.758	26.334	80.424	32.304
2015	52.50	159.267	38.262	121.005	40.581
2016	56.09	215.358	42.12	173.238	52.233
2017	65.90	281.262	35.706	245.556	72.318
2018	54.68	335.943	43.566	292.377	46.821
2019	51.12	387.072	49.206	337.866	45.489

mined for all the consecutive years, the overlapping areas are the areas of jhum that already existed in the subsequent years prior to the expansion of the jhum plantations over the coming years. Thus to estimate the new areas under jhum for a particular year, the overlapping areas of jhum for every year was removed from the cumulative jhum area to determine the actual area of new establishment of jhum area for every year. Thus the area under new jhum as depicted in Table 1 shows the actual increase of jhum cultivation in Mawthei, in 2013, the area under jhum cultivation was 48.12 hectares, by the end of study period, i.e. 2019, the total area under Jhum cultivation expanded to 337.86 hectares. Table 1 also shows the annual increase in the expansion of Jhum plantations, 2017 had the highest expansion growth during the study period from 2013-2019.

From Figure 2, it can be seen that the expansion of jhum plantations is an annual phenomenon where every plantation expands their area of cultivation. Figure 3 shows the rate of expansion every year from the beginning of the study period till the end of the study period (2013- 2019), it was determined from the pixel size of the area of interest that the average rate of expansion of the plantations is around 48.26 hectares annually. From this study it can be concluded that Mawthei village is currently observing an unprecedented dangerous expansion of jhum plantations of *Thysanolaena maxima*, there is a dire need for some intervention policies to be introduced by the government to prevent the ill effects of microclimate changes in this area from affecting the rural population, more importantly, the vulnerable members of this society such as women and children. This study also revealed that this technique of analysis is suitable for small areas of interest only and has been found to be cumbersome and insignificant for large areas as the results will show multiple errors, hence this technique is recommended for small areas of study only.

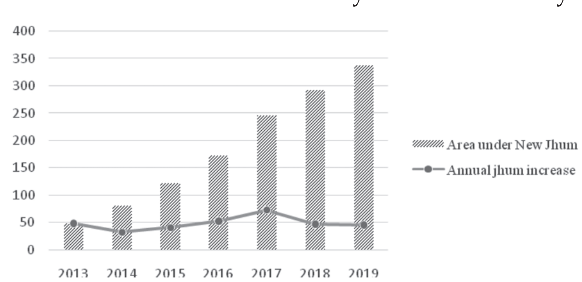

Fig. 4. Histogram showing increase in jhum cultivation and annual increase of jhum from 2013- 2019

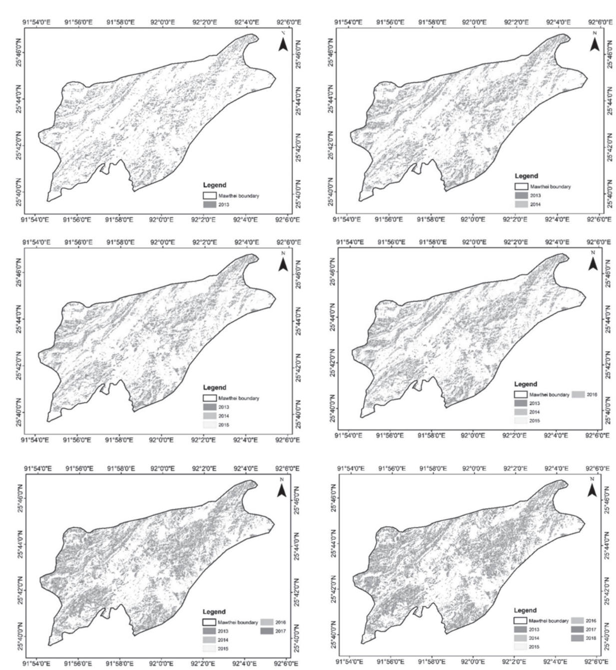

Fig. 5. Expansion of *Thysanolaena maxima* Plantations in Mawthei Village from 2013- 2018

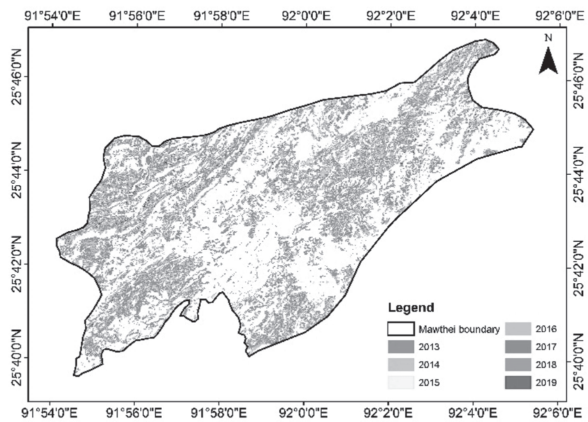

Fig. 6. Expansion of Jhum cultivation of *Thysanolaena maxima* from 2013- 2019

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