RESEARCH ARTICLE OPEN ACCESS

A Novel Approach To Understand The Spatial And Temporal Pattern Of Shifting Cultivation Fields Using GIS Techniques In Longding Division Of Arunachal Pradesh, India

Rocky Pebam
North Eastern Space Applications Centre, Umiam, Shillong - 793 103, Meghalaya, India
Email: rocky.pebam@gmail.com

ABSTRACT
Shifting cultivation, locally known as jhum, is one of the dominant traditional land use system practiced in the uplands of the hilly states of the northeastern region of India, but there is lack of information on the spatial and temporal dynamics of shifting cultivation landscapes. Some reports are available on the temporal extend of jhum cultivation from few districts intermittently apart from the national level land use land cover and wastelands atlas, but an exhaustive analysis over a long period has not been attempted. In order to generate information on the prevailing jhum cycles and their dynamics in the region, a study was conducted in Longding division of Arunachal Pradesh employing geospatial techniques based on spatio-temporal analysis of time series Landsat data and spatial overlay techniques to identify the jhum cycles. The results revealed that jhum cycle of 9-11 years was found out to be the dominant jhum cycle in the division and the cycle <8 years comprises of only 10% and >9 years dominated (90%) the area. Further, the study found that an average of 37.96 km^2 was cleared annually for jhum affecting an area of 420.54 km^2 (46.28%) of forest area during the span of 16 years period i.e. 2000-2015.
Keywords: northeast India, remote sensing & GIS, shifting cultivation cycle, time series data analysis.

Date Of Submission: 21-09-2018 Date Of Acceptance: 13-10-2018

I. INTRODUCTION

Shifting cultivation is an agricultural practice that is the basis of subsistence for many rural populations throughout the tropics. In this form of agriculture, a piece of forest land is slashed, burnt and cropped without tilling the soil. The cropped land is subsequently fallowed to attain pre-slashed forest status through natural succession. These slash and burn agriculture, locally known as jhum is the main form of agriculture in the hills of northeast region of India. Traditionally, community holds the ownership of the land in a village. The ‘village head’ select the sites for jhum cultivation and then land is distributed among families as per the family sizes and their needs. The farmers clear the forest and burn the plants that were slashed. Once the land losses its fertility after 2-3 years of cultivating a mixture of crops, the farmers then shift to another piece of virgin or secondary forest for the next cultivation. The vegetation in the abandoned land regenerates during the fallow period. After certain number of years depending upon the community, socio-economical, agro-climatic and bio-physical factors the farmers return back to the same piece (or part) of land that was left fallow and the cycle of cropping and fallow continues. This practice was considered to be destructive (Mahafiz-i-Jangal, 1877) and ecologically unsound (Lundgren and Nair, 1983; Sood et al., 2007) but of late, considering as a way of life for a large number of indigenous tribal, other poor and marginalized upland communities armed with robust traditional ecological knowledge evolved, it is now starting to be recognized as one of the most complex and multifaceted forms of traditional agroforestry practice in the world.

Jhum cultivation in the region used to be an appropriate and sustainable land use system when the jhum cycle was within the carrying capacity of a 10-15 years rotation (Tripathi and Barik, 2003) but many workers have reported the decrease in jhum cycle in the northeastern region of India due to increase in population and less land availability thereby unable to meet the growing demand of food. The shortened jhum cycle resulted in decreased crop yield. The fallow period between two successive slashes has been reported to be decreasing with rise in population which results in a very low input-output ratio and therefore become unsustainable. Ramkrishnan (1984) and Ramakrishnan and Patniak (1992) had reported about the concern with the reduced jhum cycle of 4-5 years in areas under large population as compared to longer jhum cycles in remote areas with lesser population few decades ago.

In recent years, many have reported that the jhum cycle in the region has reduced to 3-6 years (Singh et al., 2003), 5-6 years (Sahoo, 2007), 3-5 years (Jeeva et al., 2005; Kumar et al, 2016) even 2-3 years (Tripathi and Barik, 2003; Deka and Sharma, 2010; Das and Das 2014; Sati and Rinawma, 2014) and 3-4 years fallow (Tiwari, 2003).

Maithani (2005) cited lack of information on the systematic survey for estimation of the extent of shifting cultivation in the region, but there have been some reports from various agencies on the extent of shifting cultivation in northeast India over the years. FAO (1975) put the figure at 7.4 million ha while North Eastern Council (1975) arrived at 2.8 million ha and Task Force on Shifting Cultivation, Ministry of Agriculture (1983) fixed the area at 3.81 million ha with 4.43 lakh families practicing it. Another report from FSI (1999) estimated the cumulative area for the period from 1987 to 1997 to be 1.73 million ha out of which the maximum recorded in the state of Nagaland (0.39 million ha) and Mizoram (0.38 million ha). According to wasteland Atlas of India, 2010, the extent of shifting cultivation for the region during the period 2005-06 was 0.042 million ha for current shifting cultivation and 0.046 million ha for abandoned shifting cultivation with maximum area falling under Nagaland and Mizoram.

Despite many studies done on the extent and dynamics of shifting cultivation affected areas in the region (Dwivedi and Ravi Sankar, 1991; FSI, 1999; Mipun, 2001; Deb et al., 2001) no work has been done to understand the shifting pattern of shifting cultivation cycles except few works on landscape analysis by Kumar et al (2006) in the Garo Hills of Meghalaya, changing trend of area under jhum lands in Garo Hills by Sharma et al. (2015). The claim in the reduction of jhum cycle from 15-30 years cycle to 2-6 years cycle has not been properly verified by using archive satellite data and following prevalent techniques of remote sensing and GIS. With a view to understand the dynamics of jhum cultivation, the present paper attempts to capture the prevailing shifting cultivation cycle and also analyse the extent of deforestation in Longding division of Arunachal Pradesh.

II. STUDY AREA

Londing division lies between latitude 26°38'58" to 27°6'24" N and longitude 95°10'52" to 95°30'36"E in the south western most corner of the state of Arunachal Pradesh (figure 1). The division shares its boundary with the Konyak area of Mon district, Nagaland in the west, Sagaing division of Myanmar towards the south, Charaideo district of Assam to the north and Khonsa Division of Arunachal Pradesh in the east. The division has been historically inhabited by the Wangcho people who are culturally similar to the Nagas and because of the low productivity it was considered as one of the most backward area in the state. The Wangcho community practice gun making, wood carving and bead making. They mainly depend on jhum cultivation and many still follow the animism though few have been converted to Christianity. Other tribes like Nocte, Konyak and other Naga tribes also inhabit the division and the division has an estimated population of about 60,000 with a total geographical area of 980 km^2.

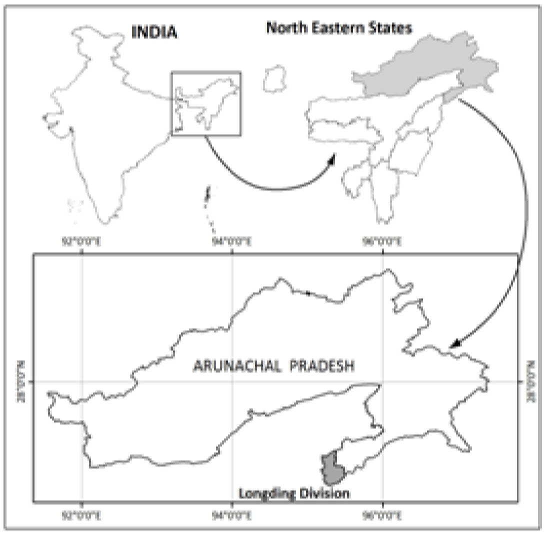

Figure 1: Location of study site.

III. METHODOLOGY

In order to understand the prevailing pattern of shifting cultivation practice in the division, a time series analysis of satellite data for a period of 16 years (2000-2015) was considered for the study. Landsat data (LT5 and OLI) for the study period for path and row 134/41 and 134/42 pertaining to February/March/April months were downloaded from the glovis website (www.glovis.usgs.gov). The areas under current jhum cultivation for each year during the period 2000 to 2015 were mapped by employing on-screen visual interpretation techniques. Digitisation was done based on image elements such as tone, size, shape, pattern and association in ArcGIS 10.2. Mapping was done at 1:50,000 scale and area deforested for jhum field in each year as depictable from the False Colour Composite (FCC) of the imagery within the division boundary were delineated. The pre-burnt jhum plots have higher reflectance in the both red and NIR band while the burnt jhum plots have low reflectance in the red as well NIR band (figure 2).

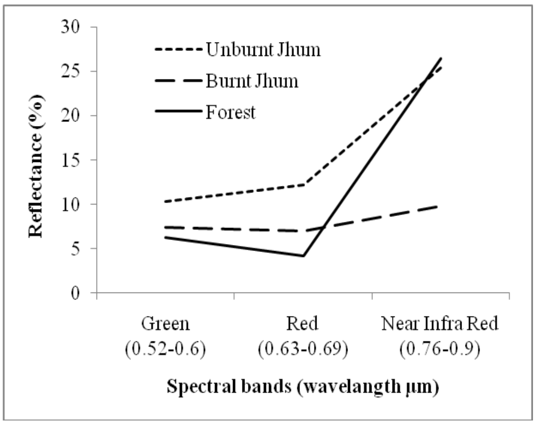

Fig. 2: Spectral properties of jhum fields

The jhum fields appear light grey to dark grey tone amidst the red of forested area. The current year jhum are normally dark grey (pre-burn) or greenish (burnt) tone and jhum fields with second year crop are of lighter grey tone (figure 3). The current jhum with current year crop fields and the current jhum with second year crop could also be identified by referring to the vegetation cover in the preceding imagery of that particular year. The areas under jhum within each year were summed up to get the extent of jhum fields for that particular year and the annual mean area of the polygons were also computed.

The yearly jhum layer (slashed in the current year) for all the 16 years' period were then unioned using overlay tool in ArcGIS (details depicted in figure 4). The multipart to single part correction was done and area calculated. The attribute tables were queried to select polygons which overlap over a period of time and then defined according to the difference in years in between the two periods. This was done by selecting the shifting cultivation polygons of a particular year and checking for overlapping polygons (from previous intersection) with the years preceding it. The year difference in between the two overlapping polygons (two successive slashes in the same plot of land) is the jhum cycle and the years were assigned accordingly for all the overlapping polygons. Care was taken to query and select the polygons in a sequence from the larger year difference to shorter year difference (e.g. 2015 & 2000, 2015 & 2001, 2015 & 2002, ….etc). This was required to make sure that an overlap of shorter year rotation should represent that polygon and not the longer cycle, which may be a subsequent rotation. From the area calculator field of the attribute table, areas under each jhum cycle were summed up and mean area of the jhum fields were computed. The attribute table was exported as .dbf file and were analysed in excel spreadsheet for area statistics of annual jhum land, extent of jhum affected area and area under different jhum cycles.

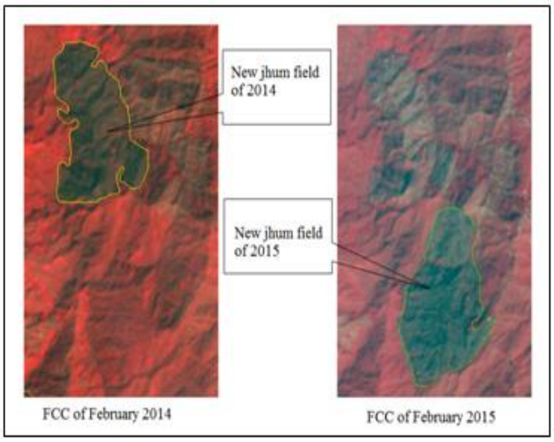

Fig. 3: Identification of jhum fields on FCC

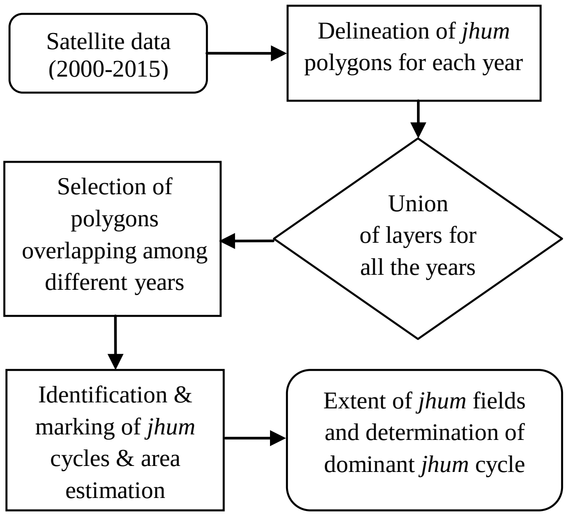

Fig. 4: Method followed for identifying jhum cycles

IV. RESULTS AND DISCUSSIONS

The year by year account of annual area under jhum fields in the division, continuously for the entire study period (figure 5), gives a fair idea about the prevailing condition of jhum practice. Unlike jhum fields in many other tribal districts of the northeast Indian states, the slashed jhum fields in the division were found to be larger in extent. The year wise area cleared-up for jhum cultivation is shown in table 1 and figure 6. Annually an average area of about 3796 ha of the forest/tree land was cleared for jhum cultivation in the division which fluctuates from 2705 ha to 5200 ha during the study period which corresponds to 2.76% to 5.2% of the total geographical area of the district. It appears that, there is slight increasing trend in the jhum cultivation area in the study area.

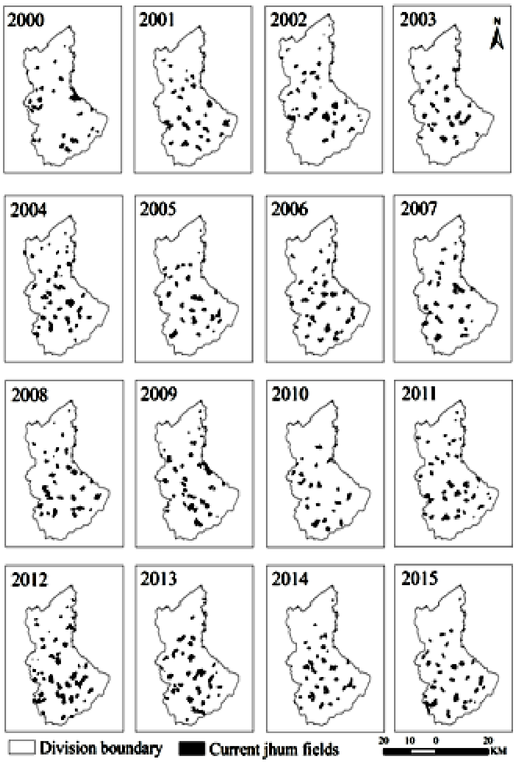

Figure 5: Spatial distribution of *jhum* fields in Longding division from 2000-2015

The sequence of the area fluctuation in the shifting cultivation area was similar to the change in the area statistics for the corresponding years as per the Wastelands Atlas of India 2011 (NRSC, 2011) for the district. The mean jhum patch size varied from 72 ha to 137 ha across the years (table 1). This is slightly higher than the mean patch size of 53.3 ha (2005-06) and 66.6 ha (2008-09) with maximum patch size of 795.3 ha reported as per data available in NEDRP portal (NEDRP, 2016). The annual area cleared showed an increasing trend while the mean patch size of the jhum fields showed a decreasing trend but they were not significant. This increase in the area under annual shifting cultivation may be due to increase in population. The decrease in patch size may be due to scattered patches of jhum fields rather than contagious nature owing to less land availability. The large patch size (jhum plots) may be indicative of the large number of families involved in the jhum cultivation. Teegalapalli and Datta (2016) reported of 12 families practicing jhum cultivation in a group in a large jhum patch with about 1.26 ha plot for each family in their study in Upper Siang, Arunachal Pradesh. The jhum plot also depends on the availability of labour force in the family. The observation is further verified by the available jhum patch size in Mon district of Nagaland, on the NEDRP portal of NESAC. Mon is inhabited by Konyak Nagas who are culturally and ethnically similar to the Wangchos of the Longding district.

Table 1: Area under shifting cultivation in Longding

Year	**Area cleared for jhum (ha)**	**Mean size of each patch (ha)**
2000	3404	106
2001	3970	137
2002	3320	85
2003	3396	117
2004	4083	102
2005	3565	127
2006	3926	106
2007	3399	117
2008	3730	106
2009	4043	77
2010	2705	97
2011	3944	89
2012	5200	72
2013	4310	92
2014	3366	90
2015	4377	132

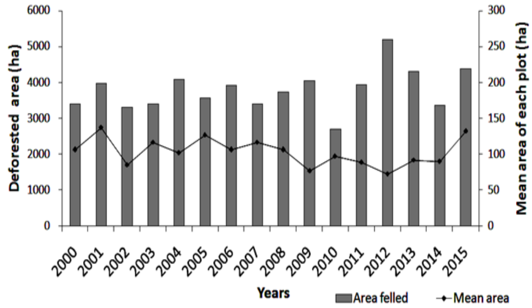

Figure 6: Histogram showing annual area under jhum and mean patch size of jhum fields

The total area affected by jhum in the division was found to be 42054 ha i.e. 46.28 % of the total geographical area. This is not the cumulative figure of the annual area under jhum, rather it represents the spatial extent of all the jhum fields during the study period. Since some of the jhum fields in some years overlapped with the previous year's jhum fields, the above figure is less than the cumulative total. The remaining area (53.72% of the total geographical area) is actually the non-jhum areas. This indicates that 46.28% area of the division has been cleared for jhum during the study period of 16 years.

Table 2: Jhum cycles in Longding division

Cycle (yrs)	Sum of area (ha)	% of cumulative jhum area	Sum % of years group
3	23.12	0.14	0.91 %
4	29.96	0.18	
5	70.14	0.42	
6	29.18	0.17	
7	423.05	2.51	8.74 %
8	1049.24	6.23	
9	6403.50	38.05	**84.79 %**
10	5502.57	32.69	
11	2364.81	14.05	
12	492.99	2.93	4.74 %
13	304.92	1.81	
14	79.28	0.47	0.82 %
15	58.50	0.35	

The area under different jhum cycles in the division (overlapped polygon areas between different year's combinations) is shown in table 2. The jhum cycle between years 3 and 15 were analyzed regarding their prevalence during the study period. The area under jhum cycle below 6 years comprised < 1% of the cumulative total area under different jhum cycles, while the area under jhum cycle of 9-11 years covered 84.79 % of the cumulative total area (table 2 and figure 7). Figure 7 indicates that jhum cycle of 9-11 years was the most prevalent in the area during the study period. This result contradicts the reports about reduced length of jhum cycle by many authors (Tripathi and Barik, 2003; Singh et al, 2003; Tiwari, 2003; Jeeva et al, 2005; Sahoo, 2007; Deka and Sharma, 2010; Das and Das 2014; Sati and Rinawma, 2014; Kumar et al, 2016, etc.). The shortening jhum cycles have been widely talked about by the various policy makers, field researchers and also seemed to be opined about by some of the farmers, but the present work investigated the annual process with time series analysis of historical satellite data, to actually capture the prevailing scenario. This result is also in close range with the reports of fallow period of 10-16 years about two decades ago from Arunachal Pradesh by Borang (1997). The present jhum cycle of 9-11 years in the division may also be due to the low population density (about 30 persons per km^2). The jhum cycle in other areas with higher population density may have shorter cycle. In their study in Upper Siang district, Teegalapalli and Datta (2016) had also reported about the prevailing jhum cycle of 12 years (10 year of fallow with 2 years of cropping) and only 4.2% of their respondents agreed about declining fallow periods.

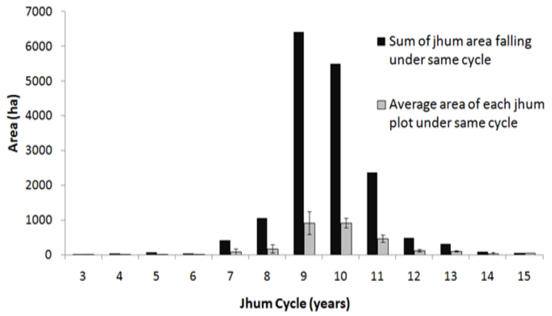

Figure 7: Histogram showing distribution of area under *jhum* cycles mean patch size of *jhum* fields

V. CONCLUSION

Shifting cultivation which is an important farming system in the uplands of the hilly humid tropics of the northeastern states of India is still prevalent in most of the states in the region. The paucity of accurate statistics leads to poor understanding of the exact scenario of jhum cultivation in the region. Apart from the quinquennial country level land use land cover and wastelands mapping by NRSC, few works has been done for generating district level information intermittently for few years. Since shifting cultivation is an annual process, without capturing the area under jhum land for each year over a long period of time, it would be difficult to understand the exact nature and pattern of this process. The present work has attempted to capture the jhum cycle and was able to determine the dominant jhum cycle, which earlier works had failed to address. This method can be replicated to other districts with different population densities or in different settings with urban and remote districts to further understand the changing process better.

Acknowledgements

The author wishes to thank former Director (Dr. S. Sudhakar) and Shri. PLN Raju, Director, NESAC for their encouragements and Mr. Fazlul Wahid for his help in parts of the mapping work.

REFERENCES

[1]. C.F. Mahafiz-i-Jangal, Jhooming in Russia, *India Forester*, *2*,1877, 418-419.
[2]. Lundgren, B and PKR Nair, Agroforestry for soil conservation. *Proceeding of 2nd International Conference on Soil Erosion*

and Conservation, Honolulu, Hawaii, USA. Jan 16-22, 1983.

[3]. Sood, K.K., P. Handique and B Singh, Agroforestry systems and practices prevailing in Arunachal Pradesh, their constrains and potentials, in: Sunil Puri and Pankaj Panwar (Eds.), *Agroforestry: Systems and Practices* (New India Publishing Agency, 2007) 385-402.

[4]. Tripathi, R.S. and Barik S.K. Shifting cultivation in North East India, in: BP Bhatt, Bujarbaruah K.M., Sharma Y.P. and Patiram (Eds.), *Approaches for increasing agricultural productivity in hill and mountain* (Umiam, Meghalaya: ICAR-RC-NEH, 2003) 317-322.

[5]. Ramakrishnan, P. S., The science behind rotational bush fallow agriculture system (jhum). *Proceedings of the Indian Academy of Science (Plant Science) 93*, 1984, 379-400.

[6]. Ramakrishnan, P.S. and Suprava Patnaik, Jhum: slash and burn cultivation, *India International Centre Quarterly, 19(1/2):* 1992, 215-220.

[7]. Singh, J, IP Bora and A Baruah, Changes in the physico-chemical properties of soil under shifting cultivation with special references to Karbi Anglong district of Assam. *Indian Journal of Forestry, 26(2),* 2003, 116–122.

[8]. Sahoo, U.K. Agroforestry systems and practices prevailing in Mizoram, in: Sunil Puri and Pankaj Panwar (Eds.), *Agroforestry: Systems and Practices* (New India Publishing Agency, 2007) 367-383.

[9]. Jeeva S, RC Laloo and BP Mishra, Traditional agricultural practices in Meghalaya, North East India, *Indian Journal of Traditional Knowledge, 5(1),* 2006, 7-18.

[10]. Kumar R, M.K. Patra, A. Thirugnanavel, D. Chatterjee and B C. Deka, Towards the natural resource management for resilient shifting cultivation system in eastern Himalayas, In: Bisht**,** J.K., Meena**,** V.S., Mishra, P.K., Pattana-yak, (Eds.), *Conservation Agriculture, An Approach to Combat Climate Change in Indian Himalaya* (Springer, 2016) 409-436.

[11]. Deka P K and D Sarmah, Shifting cultivation and its effects in regarding of perspective in Northern India, *International Journal of Commerce and Business Management, 3(2),* 2010, 157-165.

[12]. Das Suman and Madhushree Das, Shifting cultivation in Tripura – a critical analysis, *Journal of Agriculture and Life Sciences, 1(1)*, 2014, 48-54.

[13]. Sati, VP and P Rinawma, Practices of shifting cultivation and its implications in Mizoram, North-East India: A review of existing research, *Nature and Environment, 19(2)*, 2014, 179-187.

[14]. Tiwari, B.K. Innovations in shifting cultivation, land-use and land cover change in higher elevations of Meghalaya, India, in: P.S. Ramakrishnan, K.G. Saxena, S. Patnaik, and S. Singh (Eds), *Methodological issues in mountain research: A socio-ecological systems approach* (New Delhi: Oxford & IBH Publishing, 2003) 163–175.

[15]. Maithani, B.P., *Shifting cultivation in north-east India* (New Delhi: Mittal Publications, 2005).

[16]. FSI, *State of Forest Report 1999* (Forest Survey of India, Dehradun: 2000).

[17]. Dwivedi, RS and T Ravi Sankar, Monitoring shifting cultivation using space borne multispectral and multitemporal data, *International Journal of Remote Sensing, 12(3),* 1991, 427-433.

[18]. Mipun, B.S. Application of Remote Sensing and GIS in detecting shifting cultivation areas of Garo Hills, *Environment Resources and Development*, (Geographical Society of the North Eastern Hill Region, Shillong, 2001) 98-104.

[19]. Deb, T.K., Shaho, N.C., Saini, K.M. and Das, S.N. Mapping of jhum land using Remote Sensing Technique for restoration of Ecosystem- A case study of Garo Hills, Meghalaya state. *Jour. Agril. Physics*, *1(1),* 2001, 25-27.

[20]. Kumar A, Marcot B G and Roy P S, Spatial Patterns and Ecology of Shifting Forest Landscapes in Garo Hills, India, in: R. Lafortezza and G Sanesi (Eds) *Patterns and Processes in Forest landscapes. consequences of human management*, (Springer Science Business Media B.V:2006)

[21]. Sharma P.K., Al Huda E, Baruah B, Mipun B.S. and Talukdar K, Assessment of Changing Trends of Shifting Cultivation in Garo Hills Landscape of Meghalaya-A Geo-Spatial Approach, *International Research Journal of Environment Sciences*, *4(11)*, 2015, 1-7.

[22]. NRSC, *Wastelands Atlas of India 2011*, (Hyderabad: National Remote Sensing Centre, 2011).

[23]. NEDRP, *North Eastern District Resource Plan*, North Eastern Space Applications

Centre, Meghalaya, Scale 1:50,000, http://www.nedrp.gov.in/longding/longding.phtml {accessed on 27.11.2016}.

[24]. Borang, A., Shifting cultivation among the Adi tribes of Arunachal Pradesh. *Journal of Human Ecology, 6,* 1997, 145–151.

[25]. Karthik Teegalapalli and Aparajita Datta, Shifting to settled cultivation: Changing practices among the Adis in Central Arunachal Pradesh, north-east India, *Ambio, 45*, 2016, 602-612.

Rocky Pebam "A Novel Approach To Understand The Spatial And Temporal Pattern Of Shifting Cultivation Fields Using GIS Techniques In Longding Division Of Arunachal Pradesh, India" 'International Journal of Engineering Research and Applications (IJERA) , vol. 8, no.10, 2018, pp 61-67