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Study on Shifting Cultivation Cycle (Jhum Cycle) in Mokokchung District of Northeast India Using Multi Temporal Satellite Data

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Authors' contributions

This work was carried out in collaboration among all authors. Author HCK designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author SKB and author PD managed the analyses of the study, perceived concept, review. Author SB and Author VR managed the literature searches, edits and prepared manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Shifting cultivation has a long history that predates the development of agriculture as a whole. Locally known as jhum farming in Northeast India, this system's farmers are referred to as jhummias. The strategy is based on crop planting during the wet season and cutting and burning vegetation during the dry season. After growing crops for two to three years, the land is left fallow for a number of years before being further cultivated. The locations and area under various jhum cycles are currently inadequate. This was the first attempt to use GIS and remote sensing tools to generate data on various shifting cultivation fellow cycle periods in Mokokchung district of Northeast India between 1991 and 2012. To locate moving farmed areas, IRS sensor data for the year 2002, 2005, 2008 and 2012 were used. While for the years 1991, 1993, 1994, 1996, 1997, 1999, and 2000, Land-sat TM satellite imagery was used. ERDAS envision and Arc GIS 10.0 software tool were used to determine the area under different jhum cycles, namely 20, 10, and 5 years, and to create the map. For the purpose of determining the spatial extent of the current shifting agricultural areas over the course of 20 years, visual interpretation of the images has been carried out and verified with field checking. Our findings indicate that the Northeast Indian district of Mokokchung's jhum lands declined from 8.99% to 6.31% of its overall geographic area. The highest jhum area in the research region was likewise estimated to be under 20 years cycle (817.23 ha), followed by 5 years cycle (783.02 ha), 10 years cycle (591.9 ha), and 15 years cycle (684.55 ha). A correct fallow cycle of shifting agriculture may help to increase watershed conservation while maximizing crop productivity, according to the fundamental concept of our work.

Keywords: Shifting cultivation; jhum; fallow cycle; Northeast India.

1. INTRODUCTION

The Shifting Cultivation is also known as "slash and burn" and "bush fallow" agriculture in different parts of the world. It is the most common type of agriculture in North East India [1], which is locally known as jhum farming and the cultivators are known as jhummias [2]. Shifting agriculture is widely practiced in the tropical uplands, encompassing around 280 million hectares of land and likely supporting 200-300 million people [3]. Over 4,40,000 rural families in Northeast India rely on jhum agriculture for a portion or all of their income. [4] The approach entails clearing forest vegetation from a specified plot by cutting and burning, cultivating the area for one or two years, and then abandoning the field as fallow to regain soil fertility through natural vegetation regeneration. Though this farming system is being considered to be major factor responsible for loss of biodiversity and causing imbalance in the ecosystem, but the fact remains that the majority of the world mega biodiversity area coincide with the area occupied by the indigenous people practicing similar system of agriculture [5]. The role of jhum farming is being widely recognized for ecologically sustainable and economically viable form of agriculture [6]. 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 [7]. The length of this fallow period varies considerably and 5-20 years is common. In Northeast India shifting cultivation cycle of 10–15 years over the years has shortened to about 2–3 years, thus leading to ecological imbalance [8] Fallow duration and cultivation periodicity may be influenced by multiple factors, including ecological factors such as precipitation, soil conditions and topography as well as socio-economic factors [9]. Fallow times are severely reduced as populations increase, and the system deteriorate, leading in severe soil erosion and a decline in soil fertility and productivity. A reduction in the fallow cycle lowers the soil fertility and yield, increases soil erosion, and causes watershed siltation [10]. In Northeast India, the dynamics of crop-fallow rotation cycles in shifting cultivation fallows, however, are poorly understood [11]. The most preferred jhum fallows in the region remains 7–11 years [12] against most believed that jhum cycle has drastically reduced. The vulnerability assessment could offer us with a comprehensive examination of the state of ecological sustainability as a result of shifting cultivation at the landscape level. The length of shifting cultivation cycles can be used to determine vulnerability. The length of a shifting cultivation cycle appears as alternating fallow and cultivation seasons. This premise is widely accepted; nonetheless, empirical data of areas in various fallow cycles is limited. The primary goal of our research is to identify the places in

Northeast India that are under distinct fallow cycles. As a result, fallow length could be a powerful predictor of crop productivity and the greatest proxy for measuring system sustainability. As a result, it is vital to bridge this gap by creating a fallow cycle map for this specific region to aid in its plans and management. The study is thus carried out with the goals of i) estimating the areas under different fallow cycles and ii) creating a fallow cycle map for the specific region.

2. MATERIALS AND METHODS

2.1 Study Area

Mokokchung district of Nagaland covers an area of 1,615 sq km which falls under humid sub-tropical climate. It is situated at 94^{0} 30.8078ʹ E longitudes and 26^{0}19.3222ʹ N latitude (Fig.1). It is located at an elevation of 1325 meters above sea level. The annual average rainfall of the district is 250 cm. The maximum rainfall occurs during the months of June and July. Rainfall generally begins from April and continues till the end of September. The area enjoys a cold winter and mild summer. January and February are the coldest months when the night temperature comes down to 2ºC. In summer it is not at all hot; rather it is cold in comparison to the adjoining plains of Assam. The average temperature during summer is 27ºC and the temperature does not rise beyond 32ºC. Soils found in Mokokchung district mainly include alluvial soil, non-laterite red soil and forest soil which are in acidic in nature. The district covers 188.51 square kilometer area under agriculture and horticulture. The main agricultural products of the district are rice, maize, tomatoes, passion fruit, and oranges. The primary method of cultivation is jhum farming and about 70% of the total population is engaged in agriculture only.

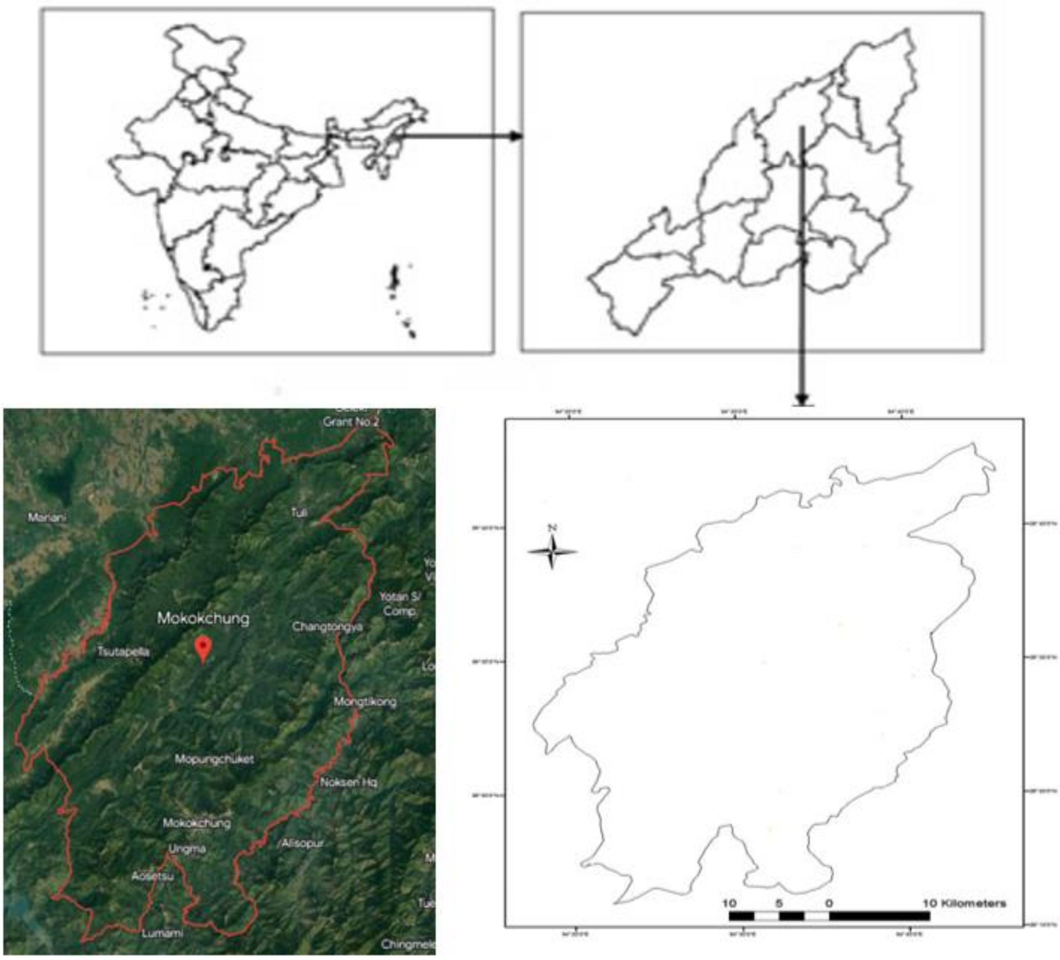

Fig. 1. Study sites of *jhum* cycle in Mokokchung district of Nagaland, Northeast India

2.2 Integrating Remote Sensing, Ground Based Measurements and GIS for Calculating Jhum Cycle

Multi temporal satellite imagery of IRS (Indian Remote Sensing Satellite) LISS-III (Linear Imaging Self Scanning) sensor for the year 2003, 2006, 2009 and 2012 were used to identify shifting cultivated areas of Mokokchung district of Nagaland and observed the changes occurred in those areas. Whereas, Land-sat TM satellite imagery were used for the year 1991,1993, 1994, 1996, 1997, 1999 and 2000 for the study area. The available images (data) were gathered from the NRSC (National Remote sensing Centre) in Hyderabad between 1991-92 and 2011-12. Because the region under long cycle has been reduced in the current circumstances, we collected data for a certain time period that was made available to us. Visual image interpretation technique has been used to identify the shifting cultivated areas and changes occurred during 20 years. Digital processing of the satellite data pertaining to study area during March-April has been done using ERDAS IMAGINE 9.2 image processing software. The jhummias of Northeast India generally slashed the vegetation during the month of March-April and the standard false colour composite (FCC) was generated by assigning blue, green and red colors to visible green, visible red and near infrared bands on 1:50,000 scale, respectively. Visual interpretation of the imagery has been done and verified with field checking for deriving information on spatial extent of current shifting cultivation areas. During the month of April 2013, a field visit was done as the jhummias cleaned and cut the forest biomass. In order to find changes, we gathered a total of 20 sample sites over the course of three weeks using intense adaptive field- or farm-level sampling. To increase the dataset's representativeness, the sampling design was changed in real time as data collecting continued. We also gathered information regarding crop varieties and agricultural techniques from local farmers. All the input vector layers (current shifting cultivation layers) were overlaid in GIS (Geographic Information System) environment and change analysis was done using analysis tools. Analysis tool option is used from Arc tool box window to overlay the layers for calculate the intersect area of jhum. The intersect areas are only considered by erasing repeated jhum areas within cycle. The area under different jhum cycle viz 20, 10 and 5 years were calculated by ERDAS imagines and Arc GIS 10.0 software tool and developed the maps. The brief methodology is presented in the flow chart (Fig.2).

3. RESULTS AND DISCUSSION

Shifting cultivation is the practice of removing a section of forest by cutting it down and burning it, then farming the cleared area for a year or longer before moving to another section. After cropping, each patch is given a number of years to transition back to secondary growth before being cleaned and re-cultivated.

Jhum cycle is the total number of years under agriculture plus the number of years in fallow. The cycle may last only three to five years or up to twenty years. The jhummias cycle varies in Northeast India, ranging from 3 to more than 20 years.

The data in Table 1 show that the area under the 5 year cycle varies from year to year. The greatest area was discovered in 2012. This year, it accounted for 7.68 percent of the total jhum area. Between 1991 and 2012, a decreasing trend in jhum area was seen on a 10-year cycle. It was reduced from 21.89 percent to 5.80 percent. In this cycle, the highest area was recorded in 2000, and the lowest was in 2012. In 2006 and 2009, the total area under the 15-year cycle was 756.23 ha and 684.55 ha, respectively. In 2006 and 2009, it was 7.94 and 5.53 percent of total jhum area, respectively. During 2009 and 2012, the area under the 20-year cycle was 814.11 ha and 817.23 ha, representing 6.58 and 8.01 percent of total jhum area, respectively.

The information in Table 1 demonstrates that the Mokokchung district's total current jhum area varies from year to year and has been on the decline since 1991. In the years 1991 and 2012, respectively, the Mokokchung district's total jhum area decreased from 8.99% to 6.31% of the district's overall geographic area. The highest area (14519.54 ha) and lowest area (7337.81 ha) were discovered in 1991 and 2003, respectively. The results showed that in the Mokokchung district of Nagaland, Northeast India, the maximum jhum area is under 20 years cycle (817.23 ha), followed by 5 years cycle (783.02 ha), 10 years cycle (591.9 ha), and 15 years cycle (684.55 ha) (Table 1).

Several researchers also documented a decrease in jhum area and cycle. Several socioeconomic factors may have contributed to the shrinkage of the jhum region [12-16]. The cutting and burning of vegetation is a labor-intensive part of jhum farming [17]. The entire farming process is rain-fed, which increases the likelihood of crop failure. Jhum land generally has relatively low production, especially when the fallow period is shorter [18]. Additionally, the younger generation has a propensity to move away from commercial areas. Moreover, the government and non-governmental organizations pressured the jhummias towards settled farming. According to [19] where instantaneous carrying capacity has been attained in that ecosystem, a bigger population is to blame for the shorter fallow period under jhum farming. The highest theoretical population that can be sustained in a given region with the current technological and ecological conditions of production is known as the instantaneous carrying capacity. However, hill farmers continue to rely on it for their livelihoods, either entirely or partially. With rice, vegetables, cash crops, fruits, spices, etc., it provides staple foods for the majority of the months. This could be the explanation for why jhum farming is regarded as one of the greatest livelihood options in mountainous areas. A sound approach is therefore needed to maintain and enhance the jhum farmer. Many workers come to the conclusion that a longer fallow cycle is crucial for maintaining the farming's environment, but we lack information on the locations that experience various fallow cycles. In regions where jhum farming is still practiced, the findings of total areas under various cycles may be valuable to policy makers for sustainable development.

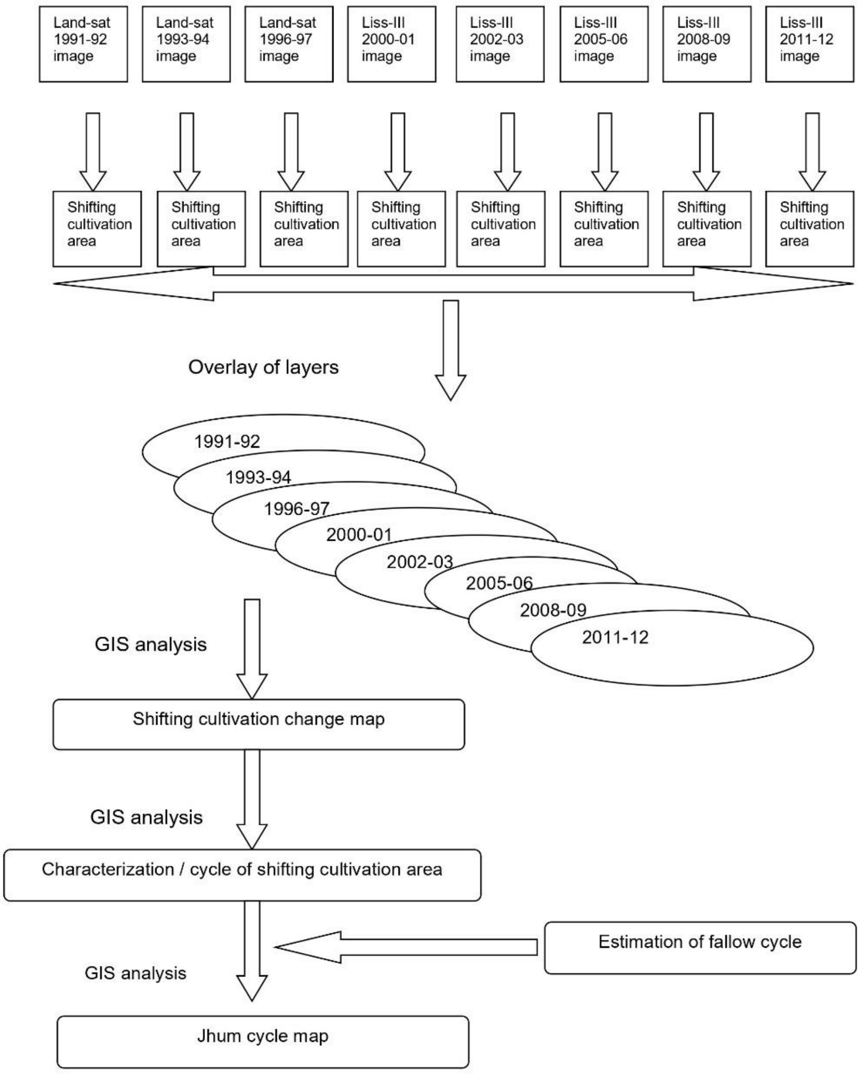

Fig. 2. Flow chart of Methodology for estimation of area under jhum cycle (Mokokchung district)

Table 1. Total area under different jhum cycle in Mokokchung district of Nagaland

Year	Total *jhum* area (ha)	5 years cycle		10 years cycle		15 years cycle		20 years cycle	
		Year	**Area (ha)**	**Year**	**Area (ha)**	**Year**	**Area (ha)**	**Year**	**Area (ha)**
1991	14519.54	1996-2000	739.02 (4.75)	1991-2000	3407.5 (21.90)	1991- 2006	756.23 (7.94)	1991 to 2009-10	814.11 (6.58)
1993	12819.31	2000-01 to 2005-06	555.33 (5.83)	1993-2003	1488.6 (20.29)	1993-2009	684.55 (5.53)	1993-2012	817.23 (8.01)
1996	12617.23	2003-04 to 2009	175.05 (1.42)	1996-2006	874.88 (9.18)	-	-	-	-
2000	15561.63	2006-07 to 2012	783.2 (7.68)	2003-2012	591.9 (5.80)	-	-	-	-
2003	7337.81	-	-	-	-	-	-	-	-
2006	9523.9	-	-	-	-	-	-	-	-
2009	12363.39	-	-	-	-	-	-	-	-
2012	10190.12	-	-	-	-	-	-	-	-

Figures in parentheses indicates is % of total jhum area; - = Not calculated / no data

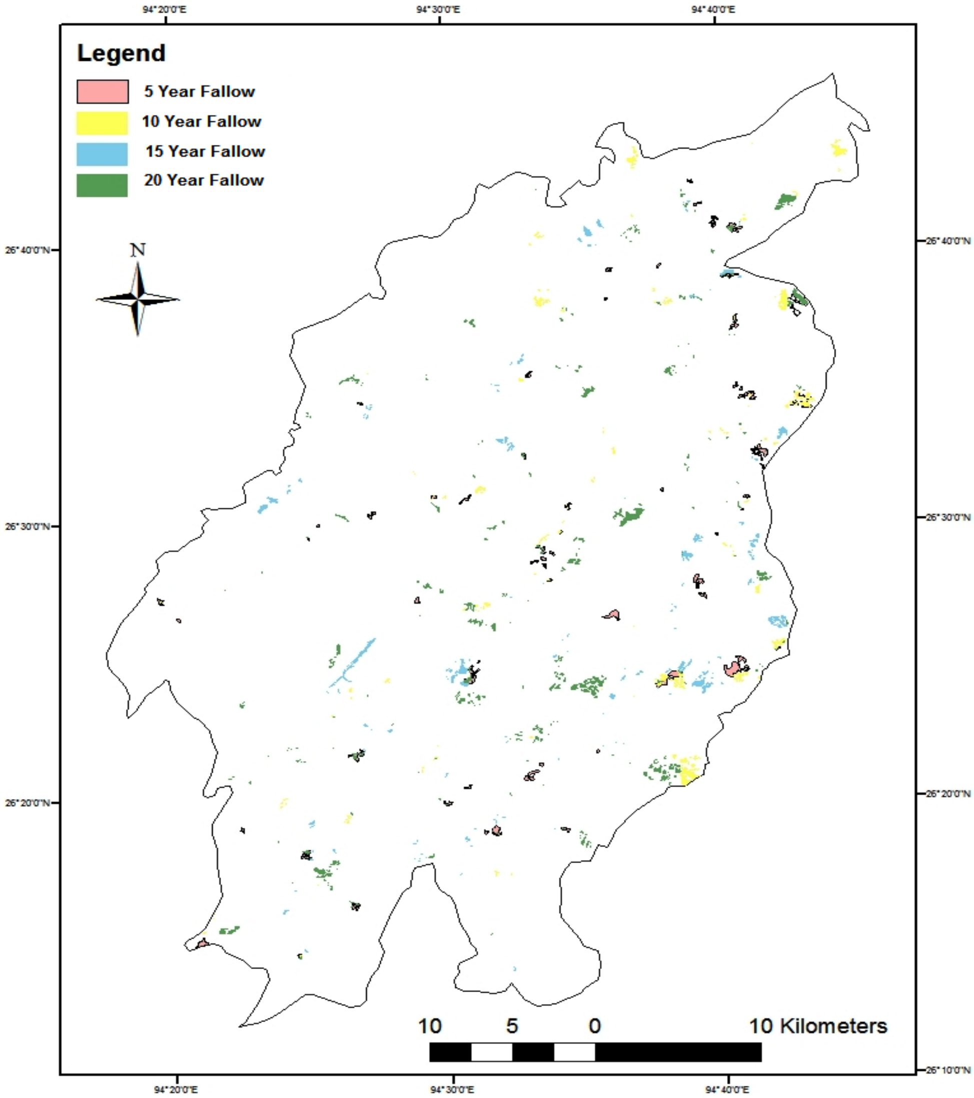

Fig. 3. Maps depicting the fallow cycle over 5, 10, 15, and 20 years in Nagaland, Northeast India

3.1 Mapping of Jhum Fields over the Years

For identifying and defining of jhum fields from the multi-temporal Landsat data, LISS-III, and Land-sat TM Imagery of 1991 to 2012, the visual interpretation and on-screen digitization approaches were used. The images were taken every year between March and April, when jhummias trim and clean the plant vegetation for jhum farming. With the help of time series analysis of satellite data, mapping techniques, and overlaying, the jhum field's fallow age was ascertained (Fig. 3).

4. CONCLUSION

Jhum, or shifting farming, is a key economic activity of the humid tropics in India's northeastern areas. Jhum is environmentally friendly as long as the fallow cycle is long enough to replenish the forest and soil nutrients lost during agriculture. According to our findings, the overall jhum area in Nagaland's Mokokchung district has been declining since 1991. However, the highest area of jhum cultivation in Mokokchung district is under a 20-year cycle, which is a good sign for jhum forest eco-restoration. The estimated jhum cycle data may be useful for good strategic jhum farming management in the region.

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COMPETING INTERESTS

Authors have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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