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Dynamics of shifting cultivation in relation to slope and elevation in parts of Nagaland, India

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Shifting cultivation in North Eastern Region of India is practised along the hill slopes by tribes of the region for subsistence living. The present study was carried out to examine the dynamics of shifting cultivation in relation to slope and elevation in Mokokchung, Teunsang and Wokha districts of Nagaland. Temporal Advanced Widefield Sensor data of Resources I were used to derive information on the changes and spatial extent of shifting cultivation areas in these districts. Slope and elevation parameters were derived from Shuttle Radar Thematic Mapper data. The study found a change in current shifting cultivation lands to regenerating shifting cultivation. All three districts showed an increasing trend in regenerating shifting cultivation and decrease in current shifting cultivation lands. A shift of cultivation plots towards higher elevations was noted. Southern slopes are mostly occupied for shifting cultivation by tribal communities in these areas.

Keywords: Remote sensing, slope, shifting cultivation.

SHIFTING cultivation is an old agricultural system in which plots of land, mainly in slopes, are cultivated temporarily. After losing fertility the plots are left for natural regeneration. Majority of the hill tribes of North Eastern Region (NER) in India practise shifting cultivation along hill slopes. Synonyms of shifting cultivation include terms like swidden[1], cut-and-burn, land rotation, and slash and burn. The widespread practice of shifting cultivation is regionally known as *Jhum* cultivation[2] and locally by different names among different tribes inhabiting the region.

Shifting cultivation is considered a strategy of resource management in which fields are shifted to exploit the energy and nutrient capital of the vegetation–soil complex of the future site[3]. 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[4]. This cultivation is also referred to as an adaptive forest management practice in which hill and mountain lands are productively utilized as well as forest, soil and water resources are conserved. It is ecologically preferable to alternative agricultural and forestry activities[5]. Shifting of fields is cyclical and rotational. The fields are prepared by removal of the fallow vegetation normally (though not

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exclusively) by use of fire[6]. The practice of shifting cultivation is a form of land use among tribal communities, with a rotation of cultivation and fallow in the same unit of land. A large number of indigenous people are dependent on shifting cultivation practice for subsistence living[7].

Shifting cultivation involves clearance of forest areas on high-slope lands. It usually starts before December with the clearing of forest areas. By mid-February to mid-March, before the onset of the monsoon, debris is dried and burnt, followed by planting of crops. Farming of the plot continues for 1–5 years, until the soil fertility declines. After the final harvest, the land is left fallow and cultivators repeat the process in a new plot. The first plot remains fallow till vegetative regeneration takes place then the plot is reused for the same purpose in a cycle. People involved in *Jhum* cultivation are called *Jhumias*[8].

Shifting cultivation is the major agricultural practice in hilly areas in North-east India. Shifting cultivation areas are found in different slopes ranging from gentle slopes (>15%) to steep slopes (33–42%)[9]. Slope and elevation are important parameters that provide varieties of topographical features[10]. Grogan *et al.*[11] focused on the distinctive features of shifting cultivation agriculture in steeply sloped regions of Mizoram state in north eastern India[12]. The effect of slope aspect on agricultural land use is inseparable from physiographic conditions, since at any altitude the agro-climate at micro- or macro-level varies on different slopes[11]. Slope aspect generally refers to the horizontal direction to which a hill slope faces. In the northern hemisphere, slopes facing south are warmer than slopes facing north. East facing slopes are colder while west facing slopes are warmer[13].

Shifting cultivation plays a crucial role in tribal economy and lifestyle. For climatic and geopolitical reasons, shifting cultivation is an unavoidable farming practice in Nagaland state of India[14]. Approximately, 0.39 m ha of the total geographical area (16.15 m ha) is under shifting cultivation in the state[15]. There is a need to monitor the changing pattern of shifting cultivation to better understand changes in land use, forest cover and ecological environments. The present study analyses the dynamics of shifting cultivation in relation to slope and elevation over a span of six years (2005 to 2011) in Mokokchung, Tuensang and Wokha districts of Nagaland.

Three districts of Nagaland – Mokokchung, Tuensang and Wokha (Figure 1) were selected for the study as shifting cultivation is dominant in these districts. These districts are characterized by hilly topography and the elevation in these areas ranges from 100 m to 1500 m above mean sea level. Plain areas are scanty to allow settled agriculture. The area is bounded by Mon district of Nagaland and Assam in the North and West, Kohima and Zunheboto districts of Nagaland in the South and Myanmar in the East. The study area is located from 93°57′18″ to 95°11′20″E, and from 25°55′15″ to 26°45′42″N. The total geographical area under study is approximately 3243 sq. km. The area is dominated by tropical and subtropical evergreen forests.

In the three districts of Nagaland, the dominant tribes practicing shifting cultivation with local names are as follows: (1) Wokha district – Lotha tribe – *Hapoli* (*hapo*–dry, *li* – field); (2) Mokokchung district – Ao Tribe – *Tokong Lu Ayimba* (*Tokong* – dry, *lu* – field, *Ayimba* – cultivation); (3) Tuesang district – 4 tribes: (i) Khiamniungan tribe – *tso ko* (pronounced as *go*); (ii) Chang tribe – *Tangsek*; (iii) Sangtam tribe – *Akunglu*; (iv) Yimchunger tribe – *Akunglu Tiitak*.

Multi-temporal Advanced Wide Field Sensor (AWiFS) data was used to find out the spatial and temporal changes in cropping pattern and other land use and land cover types[16]. The use of remote sensing technology has improved the efficiency of land use/cover mapping and change detection with respect to slope and elevation

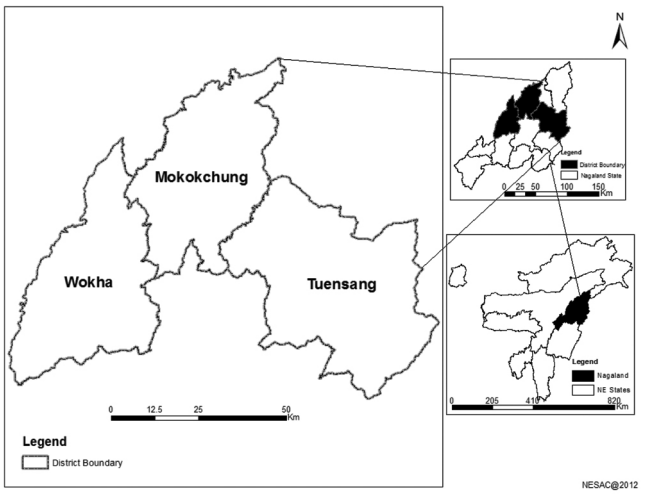

Figure 1. Study area.

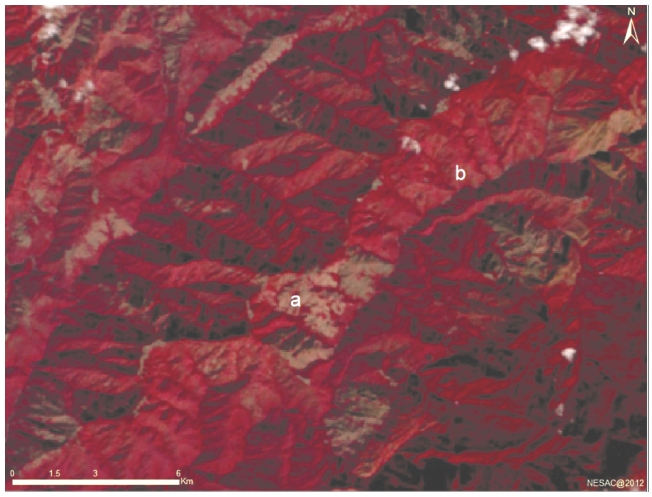

Figure 2. Illustration of current (a) and regenerating (b) shifting cultivations.

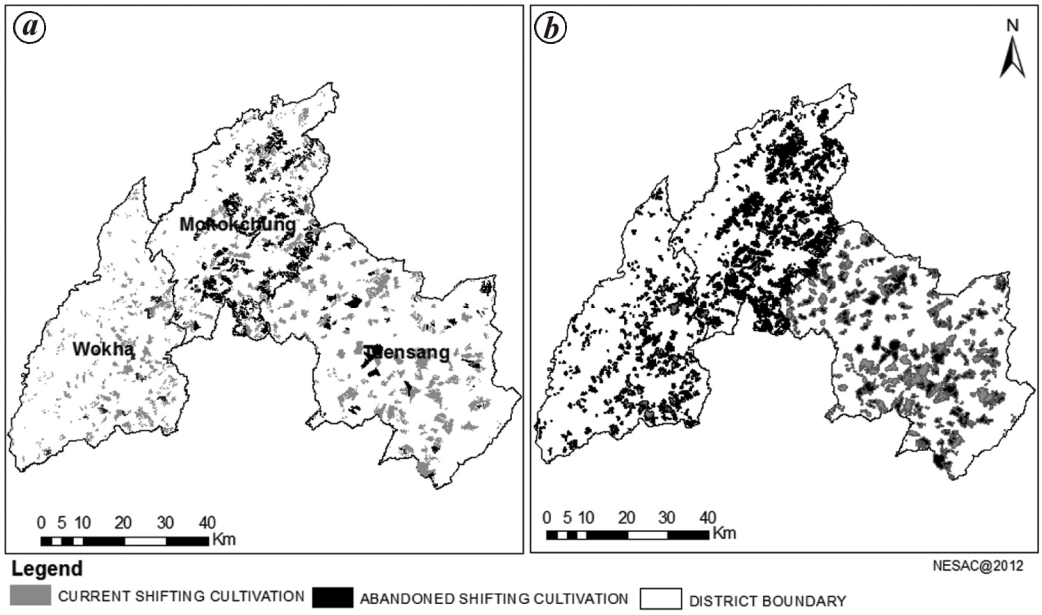

Figure 3. Shifting cultivation of 2005 (*a*) and 2011 (*b*) in Mokokchung, Wokha and Tuensang districts of Nagaland.

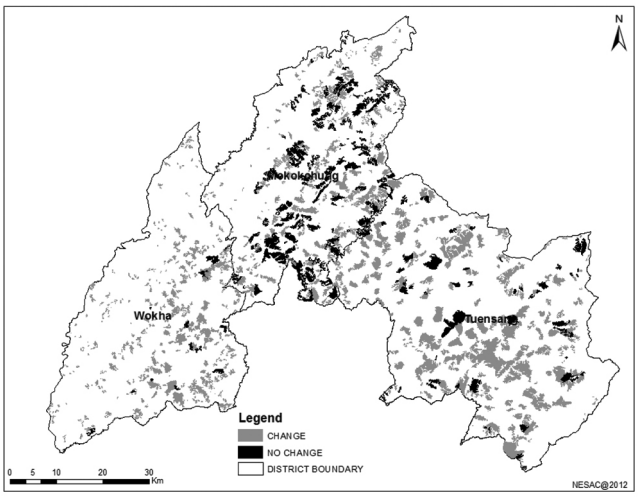

Figure 4. Shifting cultivation change in Mokokchung, Wokha and Tuensang districts of Nagaland.

pattern at landscape level. Digital elevation model (DEM) is a potential tool for terrain analysis at varied spatial and temporal scales[17]. Crop area measurement is a common practice in agriculture. Remote sensing is often used for this purpose because of its strength with regard to spatial extent, temporal density, relative low costs and potential for rapid assessment of spatial features[18].

For data processing, interpretation and analysis, ERDAS IMAGINE 9.2 and ArcGIS 9.3 software were used. DEM data of Shuttle Radar Thematic Mapper (SRTM) was used to generate slope information. In the study area, shifting cultivation patches appear in light yellow or greenish colour in small, scattered patches that are irregular in shape and often non-contiguous and dispersed on hill slopes. These are associated with mountainous/hilly areas, open forest cover and forest cleared areas. Two classes of shifting cultivation are considered in the analysis:

(i) Current *Jhum*: These areas used for cultivation are clearly discernible on satellite image as they are in pre-burnt/post burn condition and appear in green colour.

(ii) Regenerating *Jhum*: These are the areas that were under shifting cultivation, left idle for more than one year but less than 5 years, thereby allowing regeneration of secondary vegetation, especially bamboos or grasses. This category may get mixed with forested areas. Areas that are left idle and appear blurry green or very dark green or almost red are classified as regenerating shifting cultivation.

For dynamic analysis of change in area under shifting cultivation, the temporal period between 2005 and 2011 at 1 : 250,000 scale was considered. Visual method of interpretation was followed[16]. Taking 2005 as the base year, shifting classes were generated for 2011 as the existing condition. Description of current and regenerating shifting cultivation features was prepared by referring to the interpretation element, viz. tone, texture, size, shape, shadow, association, pattern, etc. While delineating shifting cultivation, prior knowledge about the study area or features of the study area is important along with the interpretation elements while carrying out on-screen visual interpretation (Figure 2). After delineating the features, area statistics were generated for both years under consideration. SRTM DEM data was used for deriving elevation, slope, and slope aspect information and used for identifying the pattern of occurrences of current and

Table 1. Shifting cultivation change in three districts of Nagaland (area in sq. km)

District	Regenerating *Jhum*			Current *Jhum*		
	2005	2011	Change (%)	2005	2011	Change (%)
Mokokchung	200.77	299.01	(+) 32.85	118.46	36.80	(–) 68.93
Tuensang	61.35	296.83	(+) 79.33	261.02	154.69	(–) 40.73
Wokha	14.91	134.21	(+) 88.89	123.01	32.95	(–) 73.20
Total	277.03	730.05	(+) 62.05	502.49	224.44	(–) 123.86

Table 2. Shifting cultivation change in different elevations in three districts of Nagaland (area in sq. km)

Elevation (m)	Regenerating *Jhum*		Current *Jhum*	
	2005	2011	2005	2011
Mokokchung district				
0–554	38.81	46.68	37.98	6.33
555–980	143.91	203.06	58.15	27.54
981–1457	25.86	48.11	26.6	2.93
1458–2016	–	1.16	0.87	–
Tuensang district				
0–554	–	0.9	0.95	1.35
555–980	3.73	45.44	33.59	26.66
981–1457	43.31	150.81	112.45	53.67
1458–2016	25.63	96.75	79.62	70.79
2017–3441	1.5	5.17	3.23	–
Wokha district				
0–554	7.65	28.13	42.85	2.45
555–980	6.18	78.2	56.71	25.06
981–1457	1.6	27.87	23.51	5.45

regenerating shifting cultivation areas in different slope conditions.

While comparing the areas under shifting cultivation from 2005 to 2011, there were changes in area under shifting cultivation at different elevations.

The total area under regenerating *Jhum* in 2005 was found to be 277.03 sq. km of which Mokokchung had the highest area of 200.77 sq. km and Wokha had the least area of 14.91 sq. km under regenerating shifting cultivation. The total area under current shifting cultivation in 2005 was about 502.49 sq. km of which Tuensang had the highest area of 261.02 sq. km.

Mokokchung had the lowest area of about 118.46 sq. km. In 2011 the total area under regenerating shifting cultivation in the three districts of Nagaland was 730.05 sq. km of which Mokokchung had the highest area of 299.01 sq. km followed by Tuensang with an area of 296.83 sq. km. Wokha had the least area of 134.21 sq. km (Figure 3). The total area under current shifting cultivation in 2011 was 224.44 sq. km of which Tuensang had the highest area of 154.69 sq. km and Wokha had the least area of 32.95 sq. km.

The pattern of change in shifting cultivation from 2005 to 2011 indicated that significant area under current *jhum* changed to regenerating shifting cultivation (Figure 4), while some regenerating shifting cultivation areas reverted to current shifting cultivation. Regenerating shifting cultivation showed maximum change in Wokha district with an increase of 88.9%, followed by Tuensang (79.3%). Mokokchung showed the least increase of 32.9%. Current shifting cultivation decreased during the years. In Wokha, there was a maximum decrease in area of current shifting cultivation of about 73.2% followed by Mokokchung with a percentage decrease of 68.9% and Tuensang with the least decrease in area in current shifting cultivation of about 40.7% (Table 1).

In Mokokchung district, from 2005 to 2011 the maximum area under regenerating shifting cultivation and current shifting cultivation occurred at an elevation of 555–980 m. Current shifting cultivation during 2005 occurred at an elevation of 981–1457 m, whereas current shifting cultivation during 2011 occurred at a higher elevation of 1458–2016 m. In Tuensang district, the maximum area under regenerating shifting cultivation from 2005 to 2011 occurred at an elevation of 981–1457 m. In 2011, current shifting cultivation land occupied areas with height ranging from 1458 to 2016 m. Analysis of shifting cultivation in Wokha district with change and elevation showed that maximum area under regenerating shifting cultivation in 2005 occurred between 0 and 554 m, whereas the maximum area under current shifting cultivation during 2005 and regenerating and current shifting cultivation during 2011 occurred at an elevation of 555–980 m (Figure 5). Maximum area under shifting cultivation occurred between 555 and 980 m (Table 2).

A pattern of change in shifting cultivation with respect to slope aspect is noticeable in all three districts of Nagaland. From Figure 6, it is seen that shifting cultivation was practised in almost all slopes directions, though the area coverage differed. In the study area, shifting cultivation was predominant in the southern slopes followed by west facing slopes. Maximum area under regenerating shifting cultivation was in the south east facing slopes followed by south facing and south west facing slopes, except in Wokha district. There was an increasing trend of regenerating slopes for six years (2005–2011).

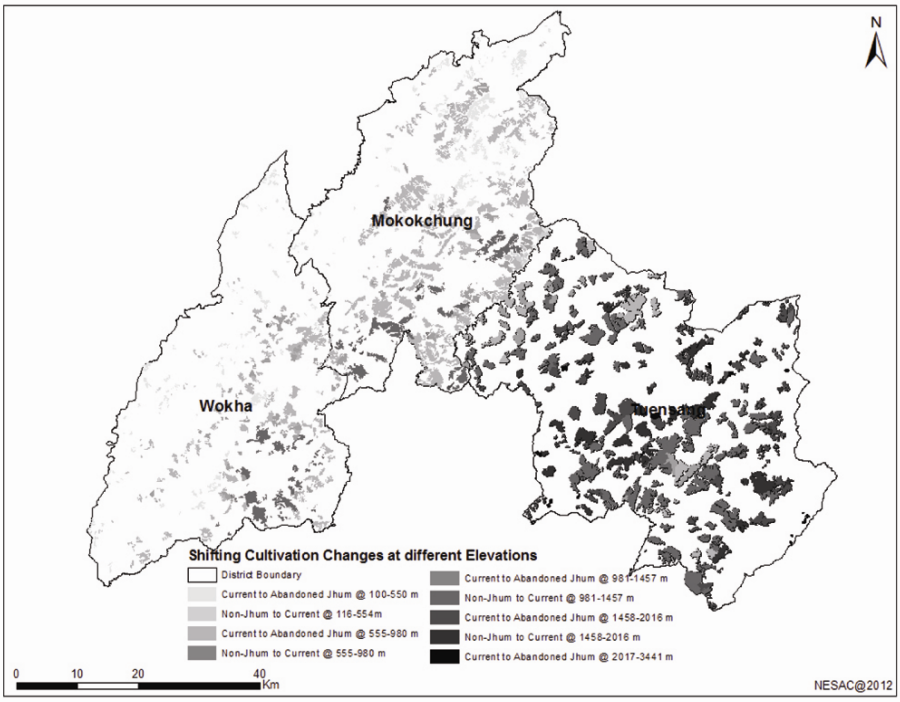

Figure 5. Shifting cultivation changes at elevation in Mokokchung, Wokha and Tuensang districts of Nagaland.

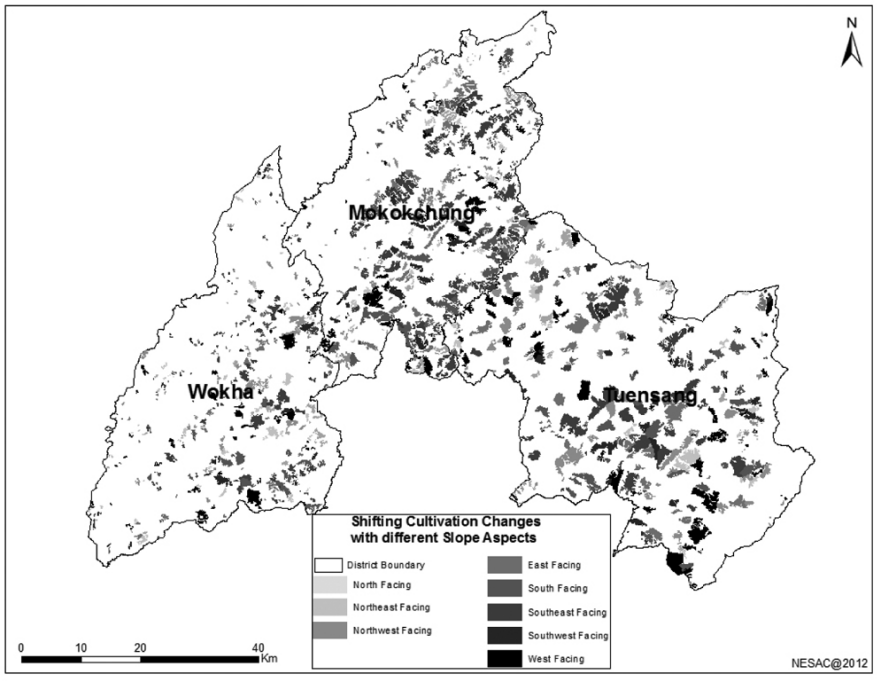

Figure 6. Shifting cultivation changes and slope aspects in Mokokchung, Wokha and Tuensang districts of Nagaland.

However, there was a decrease in current shifting cultivation areas in all three districts (Table 3).

Changes in shifting cultivation from 2005 to 2011 in the three districts of Nagaland were carried out on a mapping scale of 1 : 250,000. The following were the findings: (a) Mokokchung had the highest area under shifting cultivation followed by Tuensang. Wokha had the least area under shifting cultivation that constituted only 8.53% of the total area of the district. (b) There were changes in shifting cultivation within a span of six years. In most cases, the area under regenerating shifting cultivation in 2005 was less when compared to current

Table 3. Area under shifting cultivation in different slope aspects in three districts of Nagaland (area sq. km)

	Regenerating *Jhum*		Current *Jhum*	
Slope aspect	2005	2011	2005	2011
Mokokchung district				
East facing slopes	25.46	36.64	11.47	6.2
North facing slopes	6.61	14.5	8.26	1.8
Northeast facing slopes	4.13	11.87	12.24	0.16
Northwest facing slopes	2.86	17.83	12.81	4.13
South facing slopes	50.22	61.29	26.91	6.93
Southeast facing slopes	77.98	87.94	23.67	11.58
Southwest facing slopes	27.63	30.85	11.42	2.94
West facing slopes	13.67	38.08	16.83	3.06
Tungsang district				
East facing slopes	3.44	52.47	32.76	5.72
North facing slopes	0.77	16.41	21.12	7.29
Northeast facing slopes	5.7	11.81	10.62	3.64
Northwest facing slopes	8.97	42.5	43.51	23.87
South facing slopes	15.52	27.73	24.23	34.92
Southeast facing slopes	19.9	45.87	35.06	50.72
Southwest facing slopes	4.65	26.74	11.32	14.82
West facing slopes	15.23	70.96	51.22	11.47
Wokha district				
East facing slopes	1.19	9.29	10.02	2.17
North facing slopes	1.64	16.41	10.99	1.79
Northeast facing slopes	–	7.92	6.99	2.15
Northwest facing slopes	4.43	19.37	19.85	2.09
South facing slopes	3.39	21.48	19.45	4.04
Southeast facing slopes	–	28.2	29.87	9.33
Southwest facing slopes	1.55	11.26	7.84	2.09
West facing slopes	3.22	20.28	18.06	9.29

shifting cultivation in the same year. However, in 2011, the area under current shifting cultivation was less when compared to regenerating shifting cultivation. This may be due to urbanization. (c) Changes with elevation of the shifting cultivation areas were observed in elevations of around 0–1500 m. In Mokohchung, shifting cultivation was carried out at much higher altitude. (d) In the study area, it was seen that south and west facing slopes were more preferred for cultivation. Shifting cultivation was practised in large areas on these slopes. On the other hand, the north and the east facing slopes have also been exploited, even though these areas were considered unfavourable owing to less intense sun rays and colder temperature that is not suitable for growth of crops. (e) Limitations were faced during the study. High resolution data can be used for identifying smaller patches of shifting cultivation.

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