

Estimation of Deforestation Rate for LBA-ECO LC-14 Modeled Deforestation Scenarios, Amazon Basin: 2002-2050 using Fuzzy k-means clustering



Kalaiyarasi Murugesan, Perumal Balasubramani, Pallikonda Rajasekaran Murugan

Abstract: Amazon region plays a very substantial role within the worldwide energy, hydrological cycle and carbon balance. The total area of Amazon forest is 5.5 million km². About 7.3% of the Amazon was deforested between 1976 – 2003 and further 2.6% between 2000 and 2010. PRODES (Amazon Deforestation Monitoring Project) oversees deforestation over satellite images of the categorical deforestation in Amazon. The annual deforestation rate is predicted depends on the desertification expansion identified in every satellite image integument the Brazilian region known as legal Amazon. According to Brazil's National Institute for Space Research (INPE) and Food and Agriculture Organization (FAO), till now totally 768,935 km² were deforested in Amazon Basin. This paper proposes a segmentation approach that enables the estimation of the deforestation rate on tropical forest clearing in Amazonia, South America in the recent, past (2002–2010) and in an exceedingly future (2020–2050) land cover change in the LBA-ECO LC-14 Modelled Deforestation Amazon Basin scenarios.

Index Terms: Amazonia, Deforestation, Segmentation, Land Cover, Fuzzy k-means.

I. INTRODUCTION

Synthetic aperture radar (SAR) images are used increasingly more in various fields [3,10,13] which includes geosciences and climate change research and detection, atmosphere and earth system monitoring, 2-D, 3-D and 4-D mapping, security-related applications and planetary exploration [1]. It is specific in its imaging capabilities such as side-looking imaging geometry, high-resolution, day-and-night time and climate autonomous. SAR image is captured in such away, that the radar framework transfer radar

pulses with excessive power on the objective zone of earth and records the reverberation of the back dispersed signal in a sub sequential manner. Deciphering, aperture radar images are substantial part in evaluating the Earth's surface attributes of the imaged area [14].

SAR image segmentation is imperative in radar image processing. The primary intention of segmentation is segregation of an image into locality sub areas of dissimilar attributes [12]. Mostly aperture radar images are affected by crucial speckle noise. Due to speckle, segmentation of radar image is further difficult than that of other images. Segmentation can be approximately detached into region-based, edge-based methods [7,15], morphological methods [9], clustering methods [2,8] and markov random field [4]. In order to segment the SAR images effectively, nonlocal fuzzy clustering algorithm with edge preservation was proposed. This technique was effective for the SAR images with fewer speckle. In the case of more speckle noise, some characteristics of original image could be lost [5]. A kernel FCM algorithm with pixel intensity and location information was proposed for segmentation, it depends on the geographical and anxiety distances of all adjoining pixels concurrently. Spectral Clustering (SC) is also suitable for image segmentation [6,11]. SAR image generally has multiple regions of interest (ROI) and is encapsulated with non-additive multiplicative noise has mysterious distribution. Number of effective clustering algorithms have been used for SAR image segmentation, among which the k-means clustering is more robust to speckle noise [12]. In this paper, Fuzzy K- Means clustering technique is used for segmenting forestry land cover.

The rest of this paper is standardized as follows. K-means clustering based segmentation is briefly explained in the next passage. Furthermore, the segmented results by employing the fuzzy K-means clustering on LBA-ECO modelled deforested amazon images are presented. Decisively, a few denouements and pertinent deliberations are given.

II. FUZZY K-MEANS CLUSTERING

The K-means clustering is a simple straight forward clustering methodology which uses reiterative method of grouping things into k clusters, here k is the number of pre-picked groups.

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The grouping is carried out through limiting the Euclidean distances between items and also the relating centroid. A centroid is the centre of mass of a geometrical object of uniform density. K-means approach is an unsupervised clustering calculation that picks the cluster center insightfully and it contrasts with the image pixels depends on their intensity value, characteristics and calculate the Euclidean distance. The image pixel values which are comparative toward the cluster center are allotted to the cluster having the same cluster center. New k' cluster center are calculated and therefore k -clusters are shaped by discovering the image pixels closest toward the clusters. The K-means clustering algorithm is as per the following:

Step 1: Select ' k ' datum points randomly from the dataset.

These data points act as the preliminary cluster centres.

Step 2: Compute the separation between every datum point on the set and cluster centres, and store that data.

Step 3: Update memberships u_{ij} , utilizing the subsequent equation:

$$u_{ij} = \left[(d_{ij})^{1/m-1} \sum_{l=1}^k \left(\frac{1}{d_{il}} \right)^{1/m-1} \right]^{-1} \quad (1)$$

Where, d_{ij} is the Euclidean separation between datum point X_i and cluster representative C_j , k is the number of clusters, m is the fuzzifier parameter should be more prominent than 1.

Step 4: Assign every datum point from the perception into a cluster with the minimum distance between the datum point and cluster centre.

Step 5: Re-process the cluster centre by averaging the majority of the datum points in the cluster. The subsequent formula is employed to update the cluster centre.

$$\mu_c^i = \frac{1}{|K_i|} \sum_{j \in K_i} x^j \quad (2)$$

Step 6: Repeat the above until there is no modification in cluster focuses.

III. REMOTE SENSING DATA

A. Study Area

The Amazon basin is the chunk of South America depleted by the Amazon River and its estuaries. It cover-up an area of approximately 7,500,000 km² ie, roughly 40% of the South American landmass. This district incorporates an area having a place with nine countries. The superiority of the forest is consists 60% of rainforest ,Peru with 13%, Colombia with 10%, and with minor amounts in Venezuela, Ecuador, Bolivia, Guyana, Suriname in addition to French Guiana and a bureau of France. The greater part of basin is protected with the aid of Amazon rainforest, called as Amazonia. The Amazonia is one of the world's biggest and most prominent normal assets. Because, its vegetation ceaselessly reuses carbon dioxide into oxygen, and it produces more than 20% of earth's oxygen. That is why it has been portrayed as the Lungs of Planet. Amazonia gets around 9 feet of rain each year and the wettest area can receive

up to 35 feet, 50% of this return to the atmosphere via the vegetation of forest. The weather is warm and damp, with normal temperatures around 79° F. Over 500 well evolved creatures, 175 reptiles and more than 300 different reptiles' species and 33% of the world's flying creatures live in Amazonia. It is assessed that 30 million creepy crawly sorts can be found here.

B. Dataset

LBA-ECO LC-14 Modeled Business as Usual Deforestation Scenarios 2002-2050 has been used. This data set gives the effects of modelled eventualities for future patterns of deforestation over the Amazon Basin from 2002 to 2050. The Business-as-Usual scenario, which deliberated the deforestation developments throughout amazon and anticipated the deforestation rates by utilizing historical images and their discrepancies from 1997 to 2002 and then brought to that the impact of paving a set of significant lanes. The provided data products incorporate for each year (2002 to 2050) scenarios for an aggregate of 49 files. The metadata of Amazon deforestation scenario is given in Table 1.

Table 1. Metadata for LBA-ECO LC-14 Modeled Deforestation Scenarios, Amazon Basin, Business As Usual Scenario 2002-2050

Dataset	LBA-ECO LC-14 Modeled Deforestation Scenarios, Amazon Basin: 2002-2050
Project	Large Scale Biosphere-Atmosphere Experiment (LBA-ECO)
Projection	WGS 84 (EPSG 4326)
Spatial Extent	N: 8.5660041, S: -19.5051999 E: -41.7940953, W: -79.6301117
Resolution	0.0089278, 0.0089285
Scale Factor	10
Release Date	2013-04-05
Time Period	2002-01-01 to 2050-12-31

IV. EXPERIMENTAL RESULTS & DISCUSSION

The LBA-ECO deforestation scenarios 2002-2050 have been simulated for this experiment. Here 2002 image is taken as reference image. Each image contains three types of land covers such as forested land cover, deforested area and unaffected area. The above land covers are segmented separately using fuzzy k-means clustering technique and converted to binary image to find the forestry and deforestry area. The segmented results are given in figure 1.

A. Deforestation Rate of Amazonia

About 65-70% of the Amazon zone turned into deforested because of cattle ranching, 20-25% due to small-scale subsistence agriculture, 5-10% due to large-scale commercial agriculture, 2-3% due to logging, legal and illegal and 1-2% because of fires, mining, urbanization, road construction and dams. The real rate of vegetation loss is hard to decide. Re-growth likewise called secondary forest is deserted farmland or timber to wind up noticeably backwoods.



The FAO gauges that 53,000 square miles of tropical forestry area have been devastated every 12 months amid 1980s. Also, they appraise that 21,000 square miles were devastated yearly in South America, greater part in Amazon. However, tumbled to 4800 square miles consists with year from 1986-1993. By 1988, 6% of the Brazilian Amazon had been reducing downgraded.

The annual rate of deforestation in the Amazon region significantly expanded from 1980 to 1990. Earlier 1990's

completely 394,250 km² had been deforested in Brazilian Amazon, the estimated remaining forest cover in Brazilian is 3,705,750 km² and 90.4% of Amazon remaining. During 1990's the forest loss is 16, 3427 km² and 86.4% of cover last. About 2000's the forested area loss is 17, 6535 km² and 82.1% of Amazon is remaining. 35,099km² were deforested among 2010-2015, at present 81.2% of forest cover is remaining.

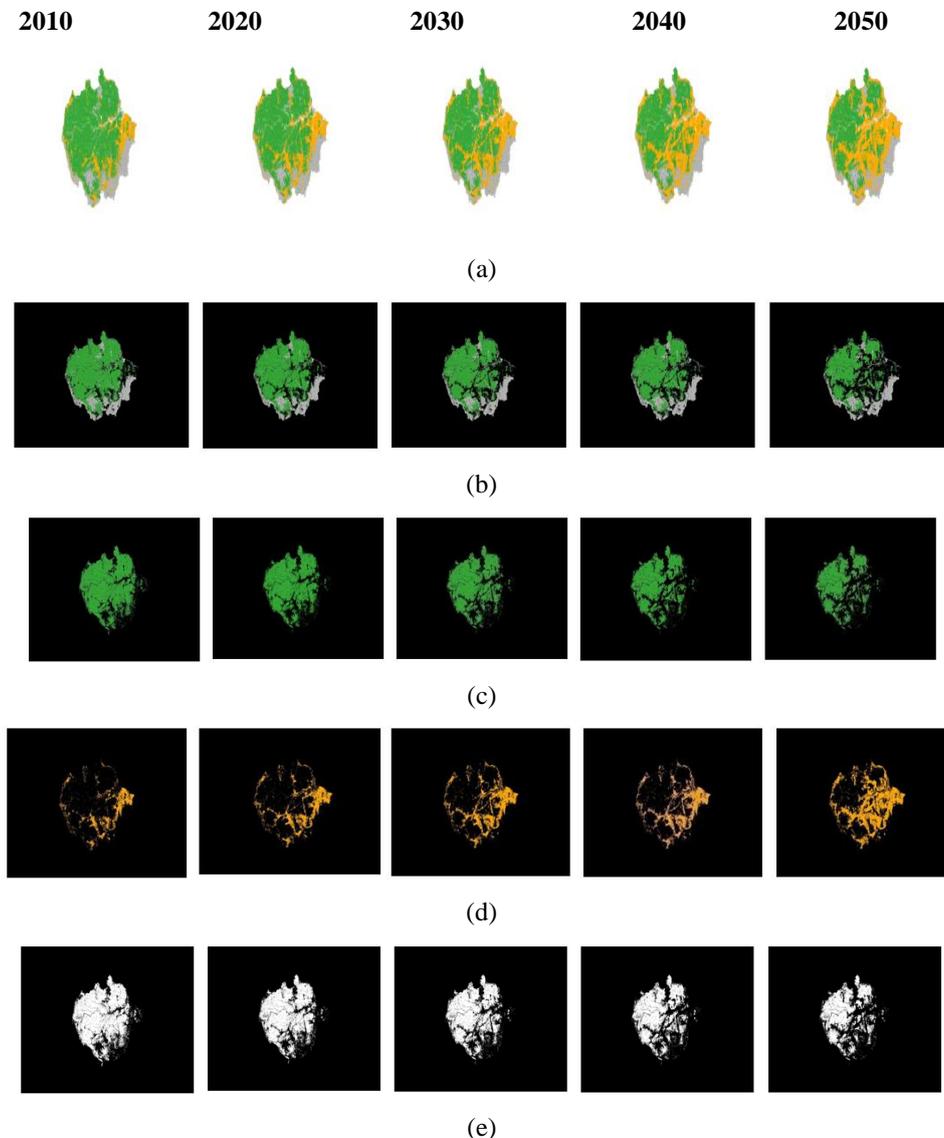


Figure 1. Step by step segmentation results obtained through Fuzzy K-means Clustering a) Some of the original images b) Segmented images c) Forest land cover d) Deforested land cover e) Binary image of forest land cover.

INPE discovered that, about 7,989 km² forestry area were destructed from August 2015 to July 2016 and just 81% of Amazon is accessible in view of the satellite symbolism. The below mentioned formula is used to calculate the deforestation rate of Amazon, it is given by,

$$DeforestationRate = \frac{1}{t_2 - t_1} \ln \left(\frac{A_2}{A_1} \right) \quad (3)$$

Here, t_2 and t_1 are the two different time period that the SAR images have taken. A_2 and A_1 are the area of forested land cover at different time period.

The estimation of Deforestation Rate, Percentage of Annual deforestation and Total deforestation of Amazon Scenarios are given in Table 2. The annual deforestation rate of 2050 is not calculated, because it needs 2051 scenario. This paper utilizing 2002-2050 deforestation scenarios.

Table.2 Estimation of Deforestation Rate, Percentage of Annual deforestation and Total deforestation of Amazon Scenarios.

Image	Estimated Remaining Forest Cover		Annual Forest Loss		Total Forest Loss		Annual Deforestation Rate
	Pixels	%	Pixels	%	Pixels	%	
2005	50736	68.7135	306	0.4144	9607	13.0110	-0.00657
2010	49062	66.4463	357	0.4834	11281	15.2782	-0.00697
2015	47281	64.0342	369	0.4997	13062	17.6903	-0.00918
2020	45187	61.1983	402	0.5444	15156	20.5262	-0.00965
2025	42896	58.0955	454	0.6148	17447	23.6290	-0.01128
2030	40625	55.0198	460	0.6229	19718	26.7047	-0.01209
2035	38329	51.9102	483	0.6541	22014	29.8143	-0.01136
2040	36097	48.8874	445	0.6026	24246	32.8372	-0.01218
2045	33918	45.9363	388	0.5254	26425	36.8569	-0.01142
2046	33533	45.4149	385	0.5214	26810	39.7882	-0.0677
2047	31338	42.4421	2195	2.9727	29005	36.2824	0.043919
2048	32745	44.3476	-1407	-1.9055	27598	37.3769	-0.01173
2049	32363	43.8303	382	0.5173	27980	37.8942	-0.01297
2050	31946	43.2655	417	0.5647	28397	38.4590	NA

B. Future of Amazonia

The total area of Amazon is 73837. In that unaffected area is 13494. In 2002, the total forested area is 51614, estimated total deforested area is 8729 and the deforestation rate is -0.00558. The estimation is performed in terms of pixels. 11.82% of forested area was deforested in 2002. 0.4% of forested area was deforested in 2005 and 0.5% of forested area will be deforested in 2020. Totally, 20.52% of Amazon will be deforested in 2020. According to our method and LAB ECO scenarios, 39.78% of forest will be deforested in 2046 and the annual deforestation is 0.52%. The highest deforestation occurs at 2046; due to this some reforestation will be performed in 2047. At 2047, there is no deforestation instead of that the reforestation rate 0.04. At 2050, only 43.26% of forestry land cover will be left out and 38.45% of amazon forest will be deforested.

The total deforestation occurs in LBA-ECO Amazon deforested images are graphically represented in Figure 2. It can be noticed that, the total forest loss increasing every year by certain percentage, so that the forested area gets down in every year by that same percentage. It could with ease be considered a worst-case scenario for the fate of the world's biggest rainforest, an investigation directed by Brazil's National Institute of Special Research discovered that the span of the Amazon could be diminished 50 percent by 2050, the tipping point for when it will progressively shrink away totally.

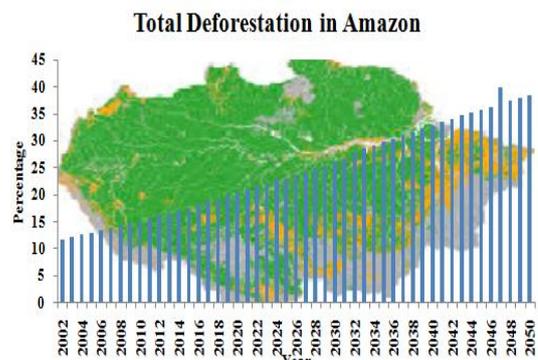


Figure 2. Total Deforestation of LBA-ECO Amazon deforested images

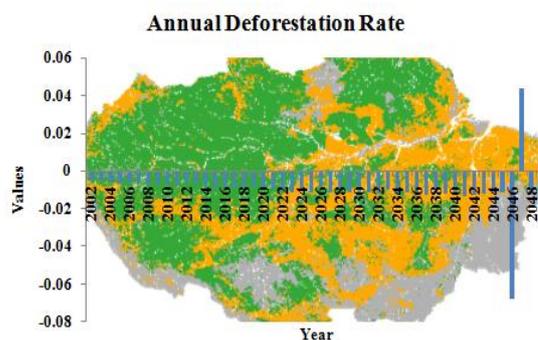


Figure 3. Annual Deforestation Rate of LBA-ECO Amazon deforested images

The graphical representation of deforestation rate for the deforestation scenario is given in figure 3. Utilizing the 2005 deforestation rates, it was assessed that the Amazon rainforest would be diminished by 40% out of two decades. The deforestation rate is currently abating; premiums of forest loss in 2012 were the slowest on record. Regardless, the forest is up till now contracting.

It can be noticed that, the deforestation rate is -0.0677 in 2046.

This is the highest rate in amazon scenarios. Due to this highest deforestation, it goes to $+0.0439$ in 2047. The sign $+$ represents reforestation, that means reforestation occurs only at 2047. It can be discovered that, the cycle of forest loss will likely be most articulated if the forests in eastern Amazon keep on being lost. As per Sampaio, alterations to the atmosphere of this locale will prompt expanded temperatures and reduced rainfall all through whatever is left of the continent. The report broadens this tipping point level of forest loss could occur as quickly as 2050.

V.CONCLUSION

According to LBA ECO scenario, the forested area of amazon is reduced about half of the Amazon. The vegetation destruction can be deliberated using satellite imagery and geographical analysis. The annual deforestation rate is forecasted by correlating the area covered by forest cover in the same zone at different occasions. If the current rate of deforestation remains, the world's forest will dissolve within 100 years, causing unknown effects on global climate. This paper conveys that certain unique forest ecosystems and unified watersheds will apparently be badly disgraced over the later 45 years.

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