Cropping Pattern Analysis of Nagaon District of Assam Using Geospatial Technique

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Abstract: Vast piece of fertile agricultural land remain fallow during major fraction of the year in most of the developing countries due to lack of technology and assessment. Nagaon, a district of Assam falls south of perennial-river Brahmaputra, making it the most fertile land due to alluvial and silt deposits. To demonstrate the agricultural fallow land study has been carried out by computing the cropping pattern of the district using spectral information in respect to crop phenology from Landsat OLI 8 for 3 consecutive crop year. Various crops in different seasons were identified through site investigation. The result of the pilot study uncovers major fraction of cultivable land is left fallow. Post *Kharif* crop *Rabi* area 54% (107593 ha), and post *Kharif* crop *Zaid* area 39% (77399 ha) are identified as a potential area for crop intensification. Finally, cropping system indices (namely, MCI, ADI and CLUI) was used to implement proper planning to increase total productivity and also to identify areas that needs crop intensification, crop diversification or both. Block-wise statistics were prepared for comprehensive development strategies for crop area expansion. This study can be extended to other states/ districts throughout the world as data collected by satellite can be standardized, the data are reliably objective.

Key-words: Cropping Pattern; Cropping system; Cropping system indices; NDVI threshold, Crop Rotation, Crop Intensity.

1 Introduction

Agriculture is becoming a data driven business. Space innovation technology and land based observation has been providing the farmers with regular updates on crop production statistics and inputs to ensure sustainability. Direct observation from ground is subjected to vagueness during monitoring vast area. Remotely sensed imagery with high spatial resolution provides precise classification of crops in to an agricultural land. This classification helps in delineating the cropping pattern of extensive areas, along with understanding the crop rotation and crop intensity of that region. Thus it became evidently easier to identify the potential cultivable areas that remained fallow throughout the year or in seasonal sequence. Satellite based data merged with sophisticated cropping indices helps in comprehending various agricultural problems and implementing proper planning to increase productivity. In this study we try to examine the cropping pattern of an agricultural prosperous district of Assam having 235626 Ha net sown areas [1]. The ever-rising population exerts pressure on the present cropping pattern for higher output in a same piece of land as well as to ensure the sustainability. Despite of government initiative and incentives the process of agricultural development has been very slow and not uniform. Any rotation in the field takes rice as one of the crops, occupying more than 70 percent of the total cropped area during all cropping seasons. Traditional variety of winter rice occupies the land for about 6 months of a year and as such hampers the increase in cropping intensity and creates disincentive among the peasants affecting continuance of crop rotation [2]. Among the other crops, jute, pulses, mustard oil, other oilseeds, potato, other vegetables and tobacco are grown in rotation with rice. Moreover, it is seen that the indigenous peasants have a general belief that yield per hectare of rice in winter will be more, if the field remains fallow in the preceding season [2]. To corroborate the problem statement we examine the cropping pattern of the region using spectral information from remote sensed imagery. Cropping season in Assam is distinguished into three periods- (i) *Kharif* (ii) *Rabi* and (iii) *Zaid*. The *Kharif* cropping period is from July –October (south-west monsoon) and *Rabi* cropping period is from October-March (winter). Crops grown among March and June are summer crops and are called *Zaid*. The crops are grown solo (single cropping) or

double or mixed (mixed-cropping) or in a specific sequence (rotational cropping). Multi-spectral profile of crops provides seasonal-wise crop variation as crop canopy alters from early summer development to late winter season, their reflectance properties also change[3], shown in Figure 1 and Figure 2. The major aim of the research is to develop a threshold technique or an algorithm to identify whether an agricultural pixel is cropped or outcropped within an agricultural land in a given season namely *Kharif*, *Rabi* and *Zaid*, and consequently delineate extent of the agricultural fallow areas. The subsequent objective is to prepare block-wise statistics for expansion of crop area deriving cropping system indices.

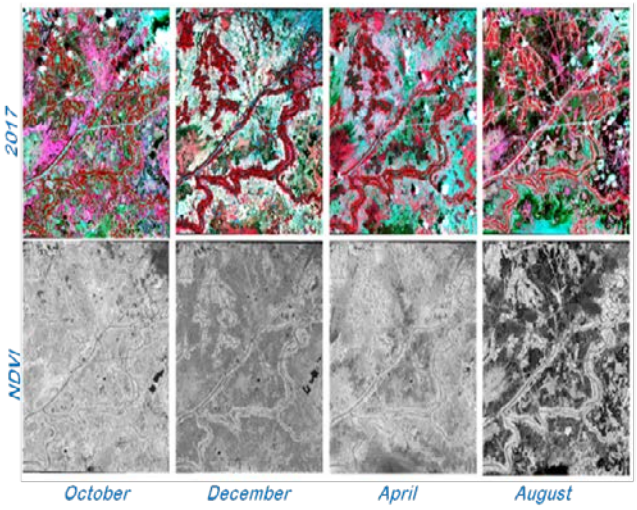

Figure (1) Crops reflectance in FCC band and vegetation index (NDVI)

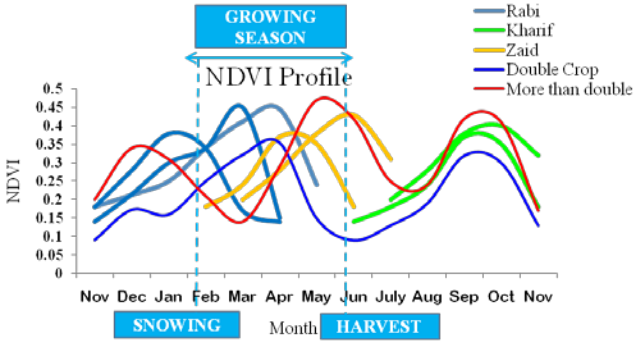

Figure (2) NDVI spectral profile of crops

2 Study area

Nagaon situated in central Assam is one of the largest districts of Assam, extends from 25°45' to 26°45' North Latitude and 92°33'6" East Longitude, sprawling across fertile alluvial plains and thickly forested hills. On the administrative front, Nagaon district has 3 civil sub divisions namely Nagaon, Kaliabor, Hojai with 10 revenue circles as shown in figure 3. Out of the total geographical, 52% percentage of the land is under agriculture. Forest cover occupies only 14% out of the total area. Geologically the soil is sandy new alluvium.

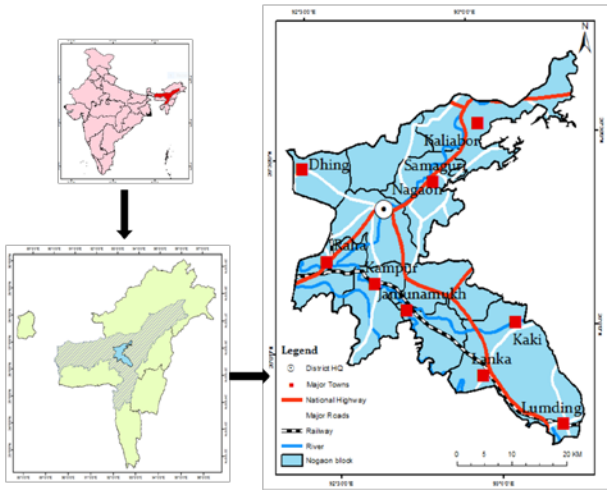

Figure (3) Base Map of Nagaon District, Assam

3 Materials and Methodology

3.1 Satellite Data Used

- Landsat-8 L1C, Temporal Period: July 2015 to June 2018

3.2 Collateral Data Used

- NRC-Land Use Land Cover (LULC) 50K project, NRSC, ISRO
- District and block shapefiles

3.3 Software Data used

- ERDAS Imagine 2015 and
- ArcMap 10.3

3.4 Data Preparation

For the analysis of cropping pattern, multispectral images from satellite observatory are used. Primarily data acquired is multispectral data (Landsat-8) (30 metre resolution) for the crop year July 2015 to June 2018, for a complete three crop year. Cropping pattern determine through multi-spectral imagery need Normalize Differential Vegetation Index (NDVI) thresholding [4]. Prior to NDVI computation it is important to remove cloud cover from the scenes that satellite imagery suffers from the impacts of climate. In order to avoid cloud mixing in the crop's pixel values manual threshold technique based on certain assumptions has been done and finally crop indices are applied in order to find the intensity of farming and crop rotation in a crop year. The agricultural land (NRC-Land Use

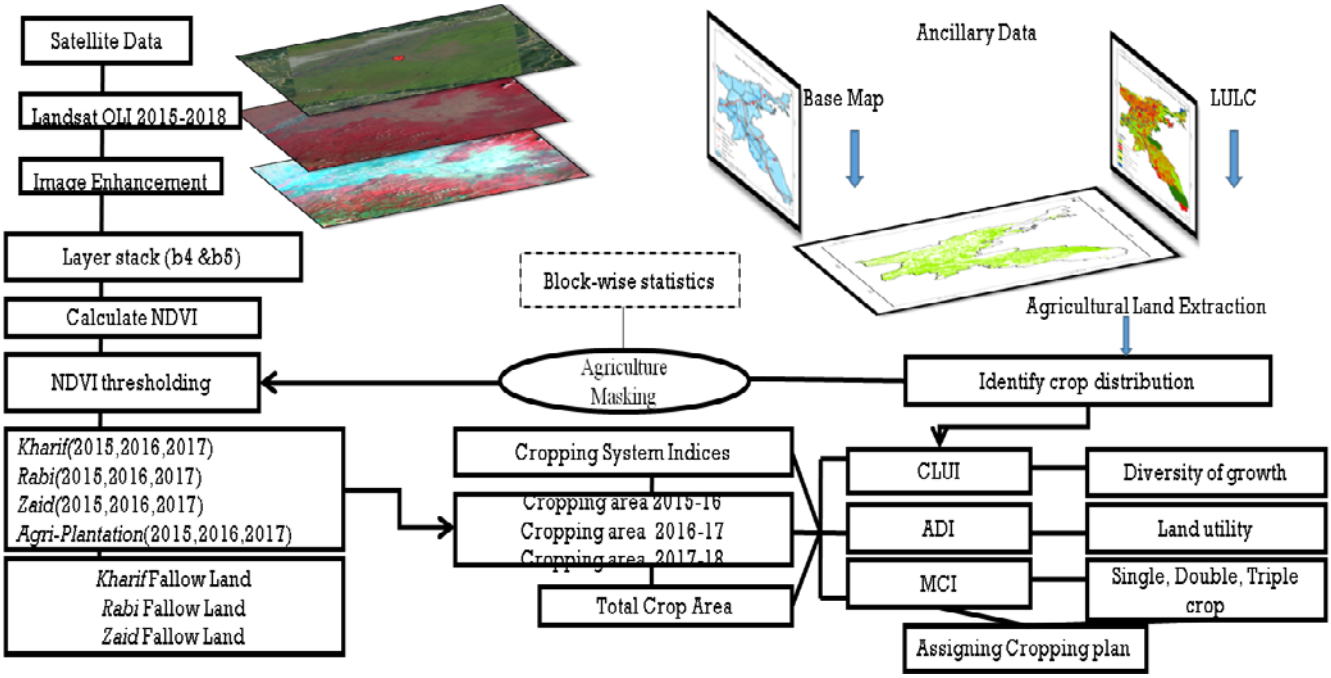

Figure (4) Methodology Flow Chart

Land Cover LULC shown in Figure 5) 50K project, [5] was masked out for each crop year from the layer-stacked NDVI images. The thresholding is done using Knowledge-based method supervised classification. Season-wise spectral analysis is done to extract useful parameters about

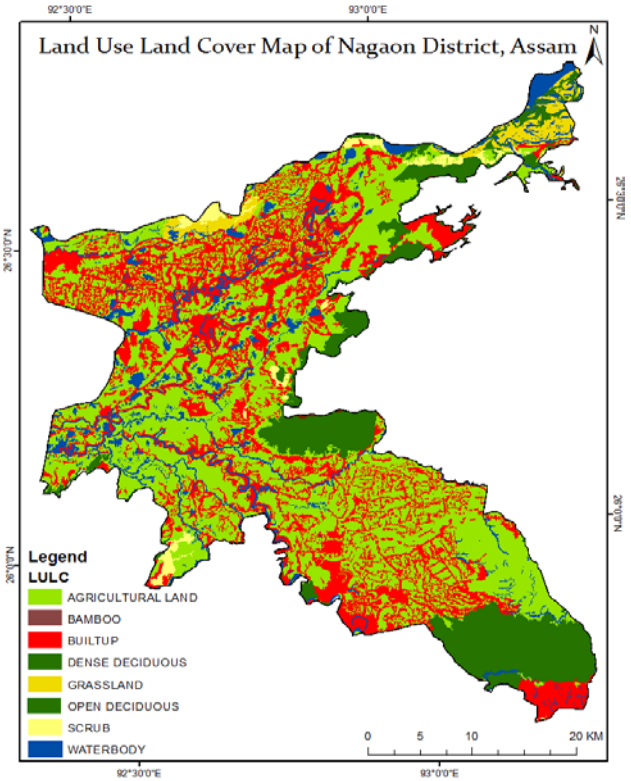

Figure (5) LULC Map of Nagaon District (NRSC)

the vegetation growing season (start of season, end of season, length of growing season, etc.) Sparse vegetation such as shrubs and grasslands or senescing crops results in moderate NDVI values. The phenology stages such as emerged, maturity, and harvest dates are detected from the NDVI curve and its derivatives while other phenological stages that are not characterized by NDVI and its derivatives are indirectly derived from all known information.

3.5 Cropping Pattern and Crop Rotation

Seasonal maps or Individual three crop year *Kharif*, *Rabi* and *Zaid* crop maps are prepared through GIS integration of season wise crop threshold area along with agricultural fallow land and agriculture plantation. Crop Intensity map was prepared through integration of final *Kharif*, *Rabi*, *Zaid* and plantation areas. The area intersecting or overlapped are identified as multiple crop area and cropped area where no overlap is witness can be indentify as single crop area. Crop Rotational Map was prepared taking the following integration of classes in a crop year sequence- Fallow-Fallow-*Zaid*, Fallow-*Rabi*-Fallow, Fallow-*Rabi*-*Zaid*, *Kharif*-Fallow-Fallow, *Kharif*-Fallow-*Zaid*, *Kharif*-*Rabi*-Fallow, *Kharif*-*Rabi*-*Zaid*. After generating seasonal cropping pattern and crop rotation maps, the area statistics for each class was calculated using the cropping system indices. Further block-wise statistics was computed.

3.6 Cropping System indices

The final output of the study is carried out through the application of indices namely-Multi Cropping Index (MCI), Area Diversity Index (ADI) and Cultivated Land Utility Index (CLUI) [6]. These three indices provide with the diversity of crop growth, land utility and intensity of cropping which is very useful in implementing proper planning to increase total productivity and also to identify areas that needs crop intensification, crop diversification or both.

The ideal case is to have high MCI, high ADI and medium CLUI. The values derived helps in proper planning of cropping pattern [6].

Table (1) Threshold values for different indices

Rating	MCI	ADI	CLUI
Low	<130	<2.0	<0.5
Medium	130-160	2-5	0.5-0.6
High	>160	>0.5	>0.6

3.7 Validation:

For validating our study ground data is collected and the result are quite satisfying and validates the research work.

Figure (6) Ground truthing for verification

4. Results and Discussion

The temporal threshold values derived from seasonal NDVI for crop year 2015-16, 2016-17, 2017-18 for entire study area are shown in Figure 8. Seasonal Cropping Pattern Analysis: From each images of *Kharif* crop, it can be visibly noticed that during *Kharif* period, the fields are abundantly filled with crop cultivation. It is evidently seen in the Table 2. that the total *Kharif* production came down during the crop year 2017-18 as some of the blocks like Raha, Kampur and parts of Dhing and Rupahi significantly shows absence of crop production. Cultivation of *Rabi* crop is scattered throughout the district and experience the lowest crop production among all the three season, more than 60% of the land remain fallow through each crop year. During *Zaid* period relatively fair amount of area was under cultivation. The Figure 7 shows the occupancy of *Zaid* crop has enhance in the year 2017-18. Stats shows only 32% (67946 ha) of land remain as fallow during this year. Small patches of land are used for agricultural plantation about 6% of the crop area is used for sugarcane plantation. The aggregate cultivation in Nagaon district has seen less variation among the years. The crop area was utilized by 94% (194012 ha) in the crop year 2015-16. The change in cultivation increase by 1% in year 2016-17 as well as 2017-18.

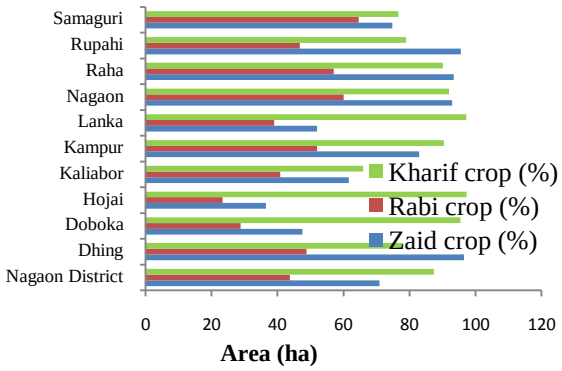

Figure (7) Concentration of season-wise crop

The above graph shows, that Nagaon District having highest concentration of cultivation during *Kharif* period leaving small yet significant amount of land 12% (26058 ha) as fallow during that period. Hojai and Lanka concentrate highest area into cultivation during *Kharif* season. The study area promotes expressively less amount of area into cultivation during *Rabi* period, only 44% (146670 ha) of land is cultivated during that month. The highest cultivation of *Rabi* crop is found in Samaguri and Nagaon block, although 40% of the land stay fallow. However during *Zaid* period, about 70% percent of the land is promoted for cultivation. Rupahi, Dhing, Raha and Nagaon block intensively engage into *Zaid* crop production, occupying more than 90% of block's agricultural area.

4.1 Cropping Pattern and Crop Rotation

The overall cropping pattern of Nagaon has moved towards multiple cropping pattern. More

Area	Geographical Area	Cropped Area	*Kharif*	*Rabi*	*Zaid*	Plantation	*Kharif* Fallow	*Rabi* Fallow	*Zaid* Fallow
Nagaon District	**384617**	**206737**	**180679**	**90379**	**146670**	**12108**	**26058**	**116358**	**60067**
Dhing	22293	12502	9768	6098	12073	0	2734	6404	429
Doboka	32757.036	16360	15620	4718	7778	163.1	740	11642	8582
Hojai	25026	15830	15404	3705	5773	0	426	12125	10057
Kaliabor	57948	21498	14187	8776	13234	6788	7311	12722	8264
Kampur	33245	24428	22096	12707	20261	490	2332	11721	4167
Lanka	84561	41749	40584	16299	21726	99	1165	25450	20023
Nagaon	36960	22817	20976	13702	21198	437	1841	9115	1619
Raha	27642	20155	18166	11506	18819	218	1989	8649	1336
Rupahi	26881	11508	9086	5375	10999	0	2423	6133	509
Samaguri	37305	19531	14964	12617	14616	4111	4567	6914	4915

Table (2) Season-wise area distribution in hectares of Nagaon District

than 67% (131643) of the total agricultural land is cultivated with multiple crops. It is observed that the area where only *Kharif* crop (rice) is mainly cultivated is left fallow during the preceding period, the crop rotation map of Nagaon clearly indicates the agricultural land is left fallow during *Rabi* and *Zaid* period as *Kharif*-Fallow-Fallow predominates

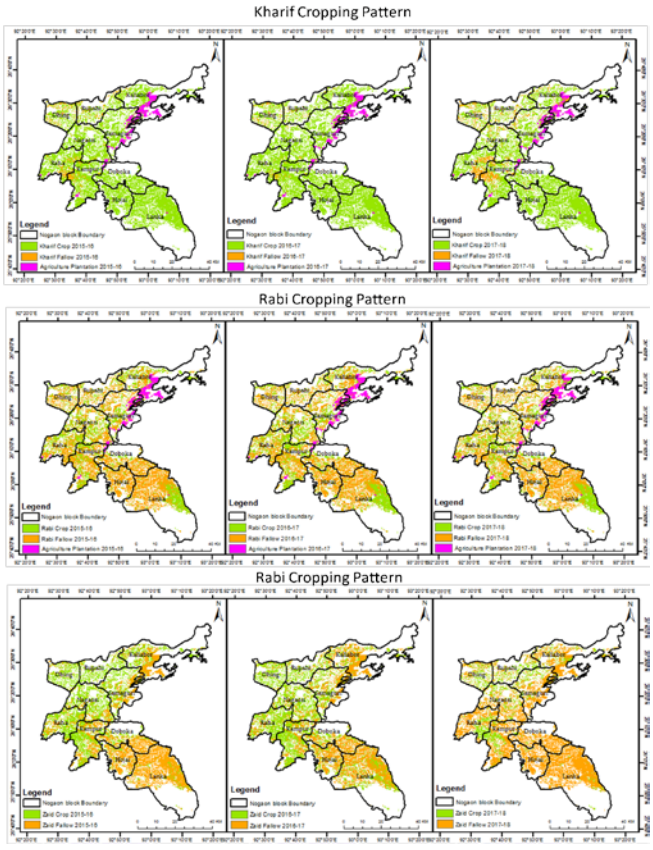

Figure (8) Season-wise distribution of Cropping Pattern

the rotation in single crop region Figure 9. A trend has been seen in conversion of land from single to multiple throughout the time. The *Kharif* fallow land is now utilised for cultivation of pluses and oilseeds during the preceding sessions. Double cropping enhances soil quality as once pulses and oilseeds are grown, the same plot will have more soil nutrients for paddy cultivation as well. Many of farmland is kept idle once the sali paddy is harvested, whereas switching over to double or multiple-cropping can earn them rich dividends.

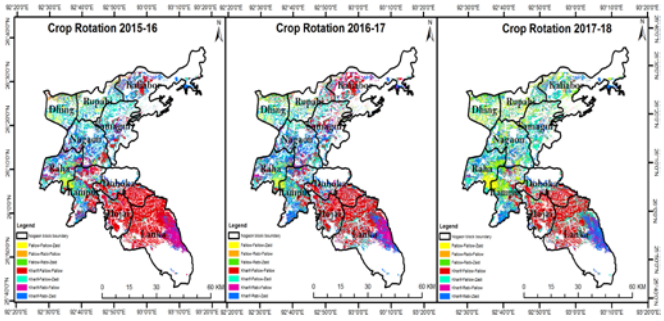

Figure (9) Crop rotational Map of Nagaon

4.2Cropping Intensity

The crop intensity map of Nagaon District, Figure 10 shows more than 67% of agricultural land is under Multiple crop. In more than 38% (73684 ha) of land more than two crops are grown. The intensity of tilting single crop correspond to 33% (65999 ha) out of total agricultural area. From Table 3 it is seen that, single cropping is highest in Lanka followed by Hojai and Doboka. Kaliabor hold

significant amount on land under mono crop. Double crop is practice over 29% (57958 ha) of agricultural land. In Lanka double cropping is highest compared to other blocks. Nagaon block, Raha, Samaguri and Dhing respectively engage more than 5000 hectare of land in double cropping. More than two crops are cultivated simultaneously on 38% of agricultural land. The cropping intensity of more than two crop is high in Nagaon block (12294 ha) followed by Kampur (11015 ha) and Raha (9976 ha).

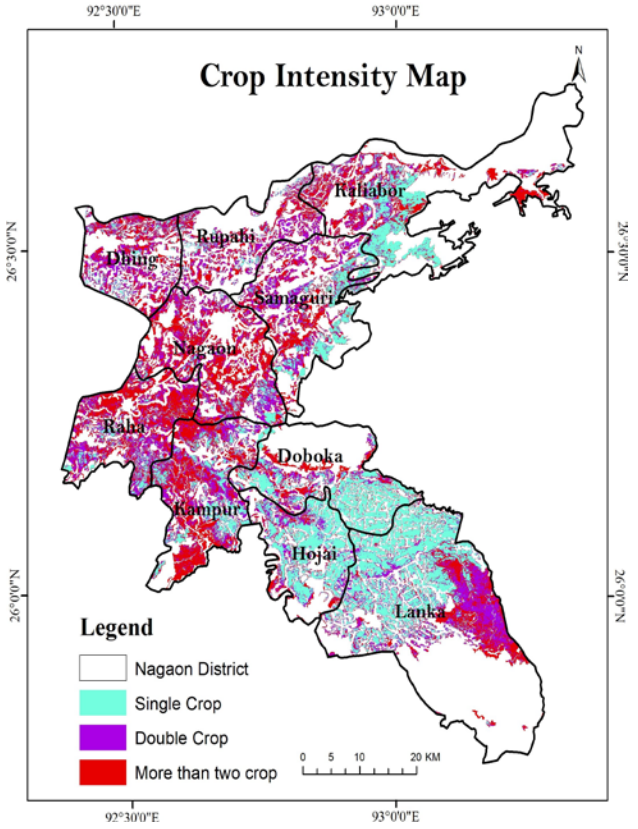

Figure (10) Crop Intensity Map of Nagaon District

4.3 Cropping Patten Indices

The overall cropping pattern indices of the three consecutive year indicated a high MCI (179.4), low ADI (0.86) and medium CLUI (0.53). A high MCI denotes that the agricultural land is intensively cropped but with mono cropping pattern since the value corresponds to 1. ADI signifies the diversity of crops grown in an area. A low ADI is found for overall crop area of Nagaon District. Block-wise MCI,ADI and CLUI is given away in Table 4.

This specifies the crop plan advocate crop diversification planning with intensive cropping as a prior plan during *Rabi* and *Zaid* period for adopting sustainability. In Nagaon District most of the crops are grown with traditional methods using traditional variety of seeds, which occupies the land for longer period of time. This results in a medium CLUI. A medium CLUI is ideal when MCI and ADI are high. But in this scenario a medium CLUI means the land needs to be resourcefully utilized with specification to intercropping and relay cropping.

Table (3) Block-wise intensity of crop distribution

	Single crop	Double crop	>Two crop	Major crops
Nagaon District	65999	57958	73684	Rice and Oilseeds
Samaguri	5087.34	6358.05	7086.15	Rice and Oilseeds
Rupahi	1554.48	4338.72	4698.45	Fibers, vegetables, spices and pulses
Raha	2506.14	6817.59	9976.5	Varities of traditional Rice
Nogaon block	2252.7	7127.37	12294.5	Rice, Nuts and oilseeds
Lanka	20281	11083.5	9229.59	Pulses, Sugarcane, Fruits, Vegetables, Nuts and Spices
Kampu	5429.7	7137.27	11015.2	Rice
Kaliabo	8601.39	4194.72	7816.95	Fruits, Nuts and vegetables
Hojai	9595.8	3194.64	2564.1	Rice, pulses, fruits, vegetables, oil seeds
Doboka	8988.75	2827.98	3922.47	Rice, vegetables and pulses
Dhing	1702.08	4878.63	5080.77	Fibre, pluses, vegetables and oilseeds

Table (4) Block-wise yearly distribution of MCI, ADI and CLUI

		2015-16	2016-17	2017-18
Nagaon District	MCI	173.71(High)	182.26(High)	182.32(High)
	ADI	0.90(Low)	0.83(Low)	0.86(Low)
	CLUI	0.52(Medium)	0.55(Medium)	0.53(Medium)
Samaguri	MCI	186.42(High)	177.86(High)	199.35(High)
	ADI	0.93(Low)	1.02(Low)	0.75(Low)
	CLUI	0.60(Medium)	0.57(Medium)	0.61(High)
Rupahi	MCI	203.50(High)	185.92(High)	177.69(High)
	ADI	0.64(Low)	0.77(Low)	0.80(Low)
	CLUI	0.57(Medium)	0.53(Medium)	0.49(Low)
Raha	MCI	200.50(High)	214.99(High)	196.05(High)
	ADI	0.70(Low)	0.60(Low)	0.71(Low)
	CLUI	0.57(Medium)	0.62(High)	0.55(Medium)
Nagaon Block	MCI	217.87(High)	217.69(High)	203.25(High)
	ADI	0.60(Low)	0.60(Low)	0.67(Low)
	CLUI	0.63(High)	0.63(High)	0.57(Medium)
Lanka	MCI	137.5(Medium)	166.77(High)	173.23(High)
	ADI	0.92(Low)	0.81(Low)	0.79(Low)
	CLUI	0.42(Low)	0.50(Medium)	0.51(Medium)
Kamrup	MCI	184.82(High)	207.26(High)	187.6(High)
	ADI	0.80(Low)	0.65(Low)	0.80(Low)
	CLUI	0.54(Medium)	0.60(Medium)	0.53(Medium)
Kaliabor	MCI	176.11(High)	156.70(High)	203.35(High)
	ADI	1.18(Low)	1.41(Low)	0.78(Low)
	CLUI	0.60(Medium)	0.55(Medium)	0.64(High)
Hojai	MCI	130.2(Medium)	144.95(Medium)	139(Medium)
	ADI	0.96(Low)	0.90(Low)	0.97(Low)
	CLUI	0.40(Low)	0.44(Low)	0.42(Low)
Doboka	MCI	147.9(Medium)	151.55(Medium)	156.4(Medium)
	ADI	0.91(Low)	0.90(Low)	0.92(Low)
	CLUI	0.45(Low)	0.46(Low)	0.47(Low)
Dhing	MCI	193.01(High)	197.63(High)	175.42(High)
	ADI	0.73(Low)	0.68(Low)	0.81(Low)
	CLUI	0.54(Medium)	0.56(Medium)	0.48(Low)

5 Conclusion

The present study introduces a method for analysis of cropping pattern of a single crop year. Cropping system analysis is essential for studying the sustainability in agriculture. The cropping system indices applied in the study, evaluate and compare the efficiencies of different cropping systems both in time and space domain. NDVI was the key to comprehend the phonological events in crops. Multispectral remote sensing data Landsat8 used to distinguish radiation in wide wavelength groups, providing reliable information on crop diversity and crop phonology. Mapping of different crops serves the purpose of forecasting grain supplies (yield prediction), season-wise crop distribution pattern, collecting crop intensity statistics and facilitating crop rotation records. The study revel agriculture in Nagaon district is *Kharif* based producing varieties of rice in low lying areas. Mustard, wheat and sugarcane are the major crops in *Rabi* season, although more than 55% of the land remain fallow during that period. During *Zaid* jute, pulses, gram, sesame, and vegetables are grown mainly in the central part of the district. However intensity of cropping is also less during *Zaid* period as 30% of the land remains fallow. These fallow areas are potential zones for introducing crop intensification plan. Nevertheless the district shows a movement from single- mono cultivation to adopting multiple cropping patterns but intensification with short duration crop is necessary for releasing the land from remain occupied for longer period of time.

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