Mapping of land use/land cover changes in the selected midland Paddy fields of Kollam District, Kerala, India

ABSTRACT

Land use/ land cover is a key driver of global environmental change. A shift in land use and land cover can alter the human settlement patterns and other economic developments and may finally end up with environmental degradation. The present study appraises the land use and land cover changes in the midland paddy fields of Chathannoor Panchayath, Kerala, South India over the last two decades (2002-2019). The digitized data analysis, interpretation, mapping and lay out preparation were done by ArcGIS10.3. Results of the study show the most distinctive changes like the decrease in area of paddy cultivation and elevation in the area of other crops. The reduction in the area of paddy fields mainly occurred during the period 2002 to 2009, with corresponding increase in the area of other crops. The increasing cost due to hike in wages of labourers and the relative price changes in favour of competing crops were responsible for the less cultivation of paddy fields in the study area. The practice of conversion of paddy lands into cultivation with other crops as well as for non-agricultural purpose increased. Stringent measures should be enacted to control these drastic land changes in the study area.

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Keywords: Paddy fields, Land use changes, Remote sensing, Mapping, GIS

1. INTRODUCTION

Land cover describes the physical land type such as forests, wetlands, agriculture, other land and water types. Land use documents how people use the landscape, either for development, conservation or other uses. Land cover can be determined by examining aerial photographs and satellite imageries. Land use cannot be described from satellite imagery alone. Land cover maps come up with the information to understand the current landscape. By evaluating the land cover map of several years, the possible effects of current land use are calculated. Land cover maps are used to assess urban growth, water quality issues, for predicting floods and storms, wetland issues etc. [1]. Land cover is defined as the attributes of earth's land surface including biota, soil, topography, surface water, ground water and human structures [2]. The conversion of land cover comprises of the substitution of one land cover category to another. Land use refers to the manner of humankind based on natural

attributes of land in order to achieve the desired products or service while land cover is a natural condition of Earth's surface and subsurface. Land use changes at local scales affects and is affected by climate changes, biodiversity changes, and sustainability of human environment [3,4,5].

Paddy rice planting area information is important for a series of issues influencing human well-being, ranging from human food security, water use, climate change, to disease transmission [6]. Sustainable agriculture focuses on the production of food and energy for human beings in a continuous course of action. It confronts with climate change, starvation, water pollution, soil erosion, fertility problems, pest control and depletion of biodiversity [7]. The change in land use and land cover directly make changes in the terrain we live. It can also cause indirect alterations in climate, biodiversity and food security [8]. As the development progresses, the replacement of agricultural lands to residential and industrial areas occurs. Remote sensing is a well-organized tool for recording land use land cover changes. It helps in comprehending and observing land change patterns and processes for generating land use land cover data sets. The fundamental tool for the land resource management is the combination of Geographic Information System (GIS) and Global Positioning System (GPS) data. In particular, Kerala has seen significant landscape changes, during the last few decades. Toward the latter half of the last century, these changes were clearly associated with socioeconomic changes, triggered by the Land Reform Act 1971 [9]. The high spatial resolution data from Google Earth is enough to allow clear visual interpretation of the Land Use/ Land Cover. The aims of our study were (1) to delineate and identify various LULC categories and patterns of LULC changes for 20 years; (2) thereafter conduct mapping, and change detection by using google earth data; and (3) conduct comparisons of various factors like temperature, rainfall, LULC for the last few years.

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2. MATERIALS AND METHODS

This study encapsulates the land use and land cover (LULC) changes occurred over a period of two decades in the paddy fields of Chathannoor, Kerala, South India.

2.1. Geo-environmental setting of the study area

The present study was conducted in the selected midland paddy fields (Kurungal paddy sector) of Chathannoor in Kollam district, Kerala. Kollam district, being located in the South west coast of India, lies between North latitude 9° 10' and 8° 45' and East longitude 76° 25' and 77° 15'. According to the physiographic features, Kollam district is divided into our micro zones – Kollam coast, Adoor rolling plain, Kottarakara undulating upland and Kulathupuzha forest hills. Forest

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covers an area of 81438 ha. Major mineral deposits are ilmenite, monazite, bauxite, graphite and laterite. Sandy, alluvial, laterite and forest soil are the four types of soil cover the whole district. Achenkovil, Kallada and Ithikkara are the main river systems in Kollam district. The total cropped area of Kollam district is 157343 ha. Kollam district has a total area of 2, 48,788 Ha. Out of these, the forest covers an area of about 81,438 Ha, whereas the total forest cover of the state constitutes 10,81,509 Ha. The district has a coastal line which extends to about 37kms [10].

Chathannoor Gramapanchayat, comes under Ithikkara Block Panchayat of Kollam district is located 14 km away from Kollam railway station and is in the banks of Ithikkara river. Ithikkara river is a 56 km long river originating from the Kulathoopuzha hills of Western Ghats flowing through this Chathannoor panchayat and finally emptying into Paravoor Kayal. Chathannoor is bounded on the north and west by Ithikkara river, south by Chirakkara gramapanchayat and on east by Kalluvathukkal Gramapanchayat. The total area of Chathannoor panchayat is 18.57 Sq.km. Ithikkara river flowing through the north of Chathannoor separates it from Adichanalloor Gramapanchayat. The panchayat comprises of eighteen wards, spreads over an area of 1776ha. Chathannoor panchayat comes under the Southern Coastal plain agro-ecological unit delineated to represent the nearly level coastal sands. The climate is tropical humid monsoon type with mean annual rainfall of 2360mm and mean annual temperature of 27.6°C. The dry period is nearly four months. Soil is sandy loam, acidic, well drained with shallow water table in some places. The gross cropped area is 1740ha. The inhabitants of Chathannoor panchayat mainly depends on agriculture, cattle breeding and poultry. The exact location of the study sites is marked by using the Global Positioning System tracker (Garmin, USA). The location map of the study area is given in Fig.1. Chathannoor is bounded on the north and west by the Ithikkara river. Kaolinite or china clay is the primary mineral found in Chathannoor. The inhabitants of the study area mainly depend on agriculture. Paddy (*Oryza sativa*), coconut (*Cocos nucifera*), areca nut (*Areca catechu*), pepper (*Piper nigrum*), cashew nut (*Anacardium occidentale*) are the major crops cultivated in the study area.

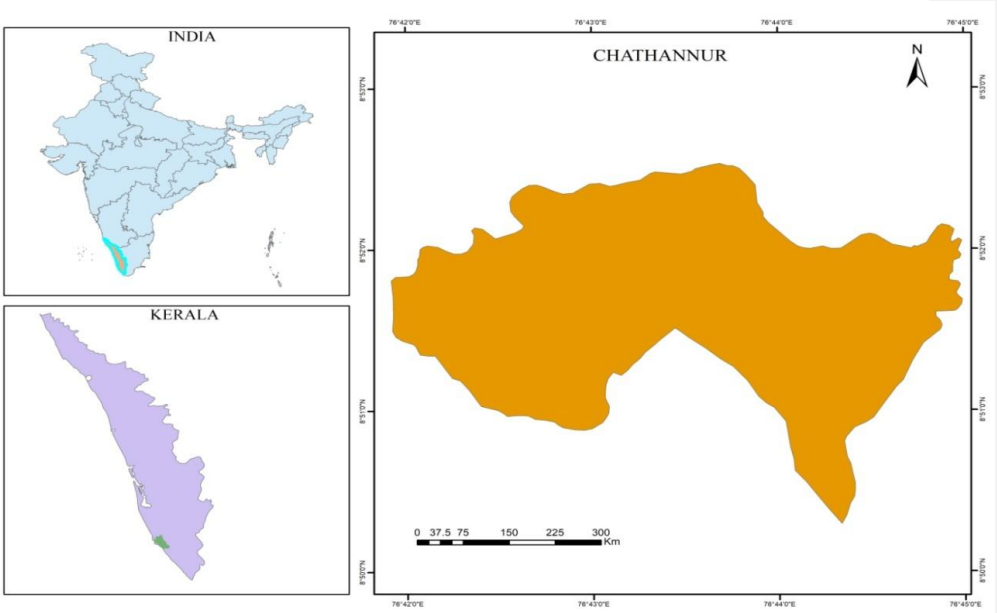

Fig. 1. Location map of the Study area

2.2. Data processing and comparison

The study employed digitized data from Google Earth to map various land use and land cover changes of the paddy fields over the past two decades (2002-2019). Google earth is a practical interactive tool delineating the three-dimensional features of the earth's surface with two-dimensional map space [11]. The study of spatial statistics for data analysis, interpretation and map layout preparation was carried out using ArcGIS10.3. Thematic maps were sketched to provide specific information regarding land use changes in paddy cultivation and to compare the land change patterns over a period of twenty years. Data collection and extraction start from downloaded satellite imagery data of Google Earth as resource data. The satellite image data from Google Earth is mosaicked using ArcGIS software. Land use type from the Google Image was digitized based on 10 m x 10 m square grid and the attribute on every land use types also being collected. After finishing the processing of land use cover data from Google Earth, it is validated. Thus, data of land use cover types were saved in geodatabase storage and processed for each land use cover type using Arc GIS.

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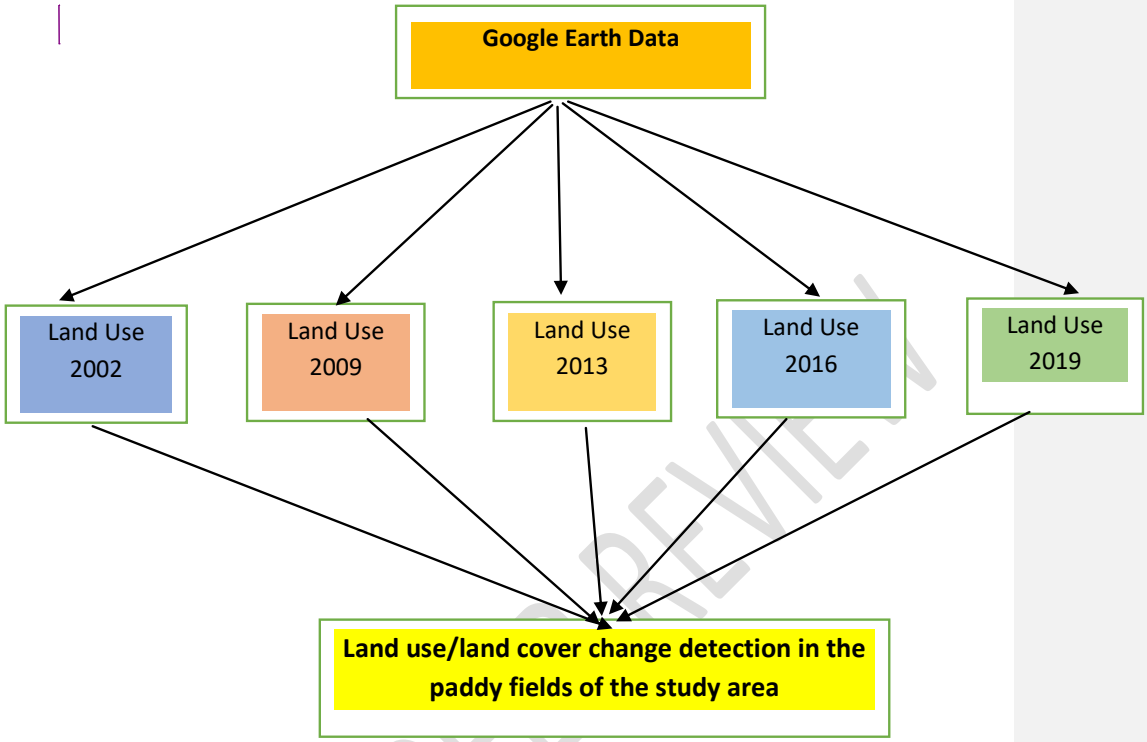

Fig. 2. Flow chart showing the methodology applied

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2.3. Temperature and Rainfall during the study period

Kollam has a tropical humid climate, with severe summer, cool winters and plentiful seasonal rainfall. The period from March to the end of May is the hot season. This is followed by the southwest monsoon season, which continues till the end of September. During October and major part of November southwest monsoon retreats giving place to the north-east monsoon, and the rainfall up to December is associated with northeast monsoon season. The normal annual rainfall of the district is 2428 mm. The major source of rainfall is South West monsoon from June to September that contributes nearly 52% of the total rainfall of the year. The annual rainfall in Kollam District for the years 2005, 2009, 2013, 2016 and 2018 were 2532, 2127.9, 2688.9, 1916, 2653.6 mm respectively.

3. RESULTS AND DISCUSSION

The results of the study depict the land use changes in the paddy fields during the period of 20 years (**Fig. 2 to 6**), details of reduction in paddy field area with increase in labour cost and the features of ayacut area of irrigation project in the study area.

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3.1. Land use – Land cover changes in the Paddy fields

The land use and land cover (LULC) changes in the paddy fields of Chathannoor, Kerala during the periods 2002, 2009, 2013, 2016 and 2019 were estimated (**Table 1&2**). Agricultural lands produce food and fiber for the human community and other living organisms. The category includes crop plants, plantation and fallow lands. Depending on the soil wetness and drainage patterns, agricultural land can be converted into wetland category and vice versa [12].

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Land use data of Kerala state during the period 1998-99 revealed that out of the total geographical area (38.85 lakh ha), the land allocated to agriculture was about 58% and the non-agricultural land comprises of 8.24%. Non-agricultural lands include urban and rural settlements, roads, canals, industries etc. The net cropped area declined from 22.70 lakh ha to 22.58 lakh ha. This drift in area under various crops during this period disclosed the replacement of seasonal or annual crops by perennial crops in the state. Seasonal crops mainly include rice, sugarcane, ginger, turmeric whereas perennial crops are pepper, areca nut, coconut, coffee, tea and rubber. Rubber recorded an increase of nearly 3000ha in 2000 [13].

During the year 2002, the percent total area observed under paddy fields of the study area was 95%, followed by crop lands (3%) and water-logged area (2%). The land use data of the Kerala state during the period 2000-01 was estimated by Kerala State Planning Board (KSPB) [14]. The total agricultural land area of the state during this period was observed to be 56%, whereas that of non-agricultural land is 10.1%. This change in land use for agricultural and non-agricultural purposes from the previous years was an indication of change in cropping pattern executed in the state. This revealed the urge for replacing the seasonal and annual crops by perennial crops (**Fig. 3.**).

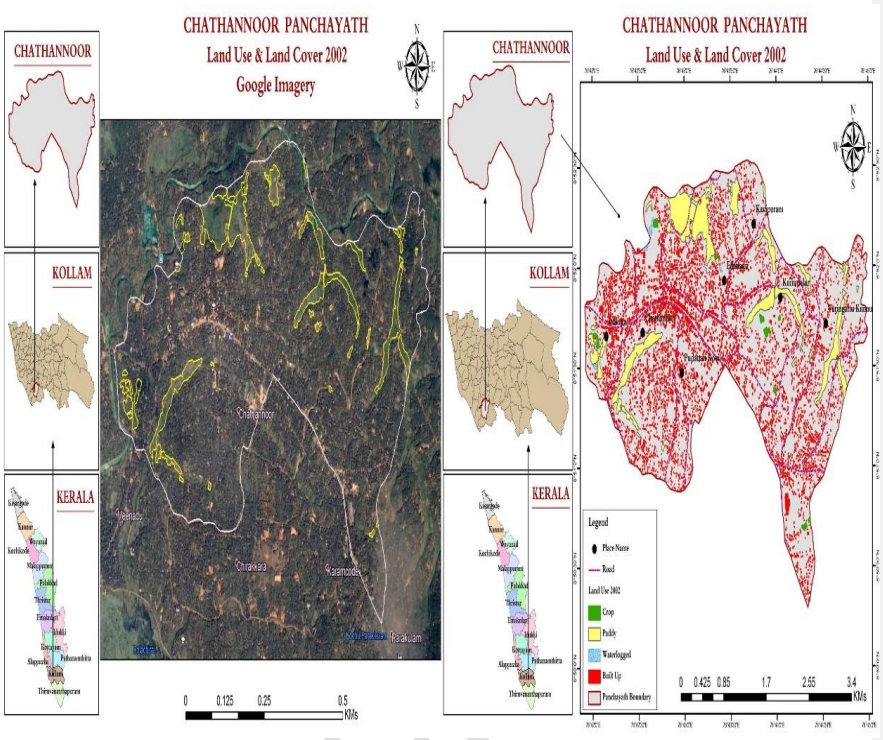

Fig. 3. Distribution of LULC variables in 2002

A steep decrease in the area of paddy cultivation in the study area occurred in 2009. The area of the paddy fields in Chathannoor declined from 95% to 78%, and the area of other crop lands increased from 3% to 14%. Water logged areas in the study area also elevated from 2% to 8%. The reduction in the area of paddy cultivation is the substitution of food crops by perennial crops (**Fig. 4**).

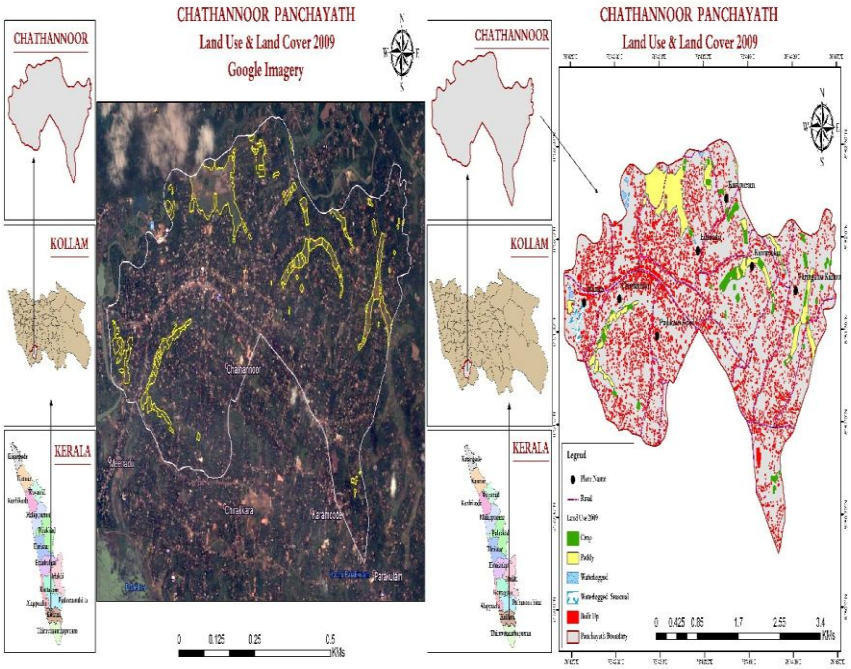

Fig. 4. Distribution of LULC variables in 2009.

During 2013, a considerable progress in the area of paddy fields was diagnosed. The area of paddy fields increased from 78% to 80%. An increase in the area of other crop lands and from 14% to 16% and a decline in the water-logged area from 8% to 4% predominantly drive the increase in area of paddy fields in the study area in 2013 (**Fig. 5**). The Kerala State Planning Board calculated the land use change of Kerala for the year 2012-13 and it was estimated that the area of agricultural lands in the state marginally decreased to 53%. Of these, rice, pulses and tapioca comprise of 10.4% in area. A sudden decline was observed in all crops except rubber, banana and other plantations. After a long period of continuous decline, the area under rice cultivation increased from 2.29 lakh ha in 2007-08 to 2.34 lakh ha in 2008-09. The land use changes in the area of paddy fields in Chathannoor during the period 2009-2013 is in agreement with the results of land use changes in Kerala state, South India as reported by KSPB [15].

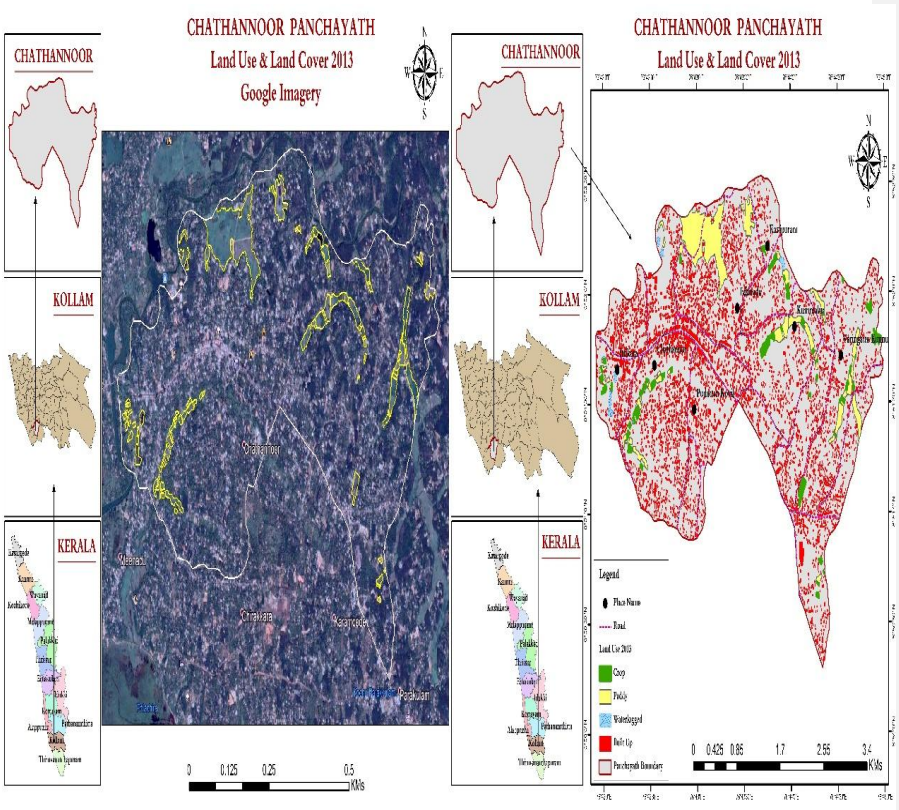

Fig. 5. Distribution of LULC variables in 2013.

From the year 2013 to 2016, a rapid reduction in the area of rice cultivation in the paddy fields of study area took place. The area went down from 80% to 72%. The area of other crops in the study area increased from 16% to 23% (**Fig. 6**). The practice of conversion of paddy lands into cultivation with other crops as well as for non-agricultural purpose increased. This is due to the low profit outcome from paddy cultivation. The increasing cost due to hike in wages of labourers and the relative price changes in favour of competing crops were responsible for the less cultivation of paddy fields in the study area [16]. The land use data of 2015-16 given by Kerala State Planning Board indicated that the state is dominated by cash crops. The net area of agricultural land in the state was 52%, whereas the area of non-agricultural land was 11.8%. Rice, tapioca and other pulses constituted 10.21% of the total agricultural land area and cash crops constituted 62.8%. The total crop area of rice in the state during this period reduced to 7.46%.

A marginal increase in the area of paddy cultivation was noted in the year 2019. The area of paddy fields in the study area increased from 72% to 74%. The decrease in area of other crop lands from 23 to 22% and a decline in the area of water-logged lands from 5% to 3% were observed. Apart from the previous year land use changes, a current fallow land (1%) was identified in the study area (**Fig. 7**).

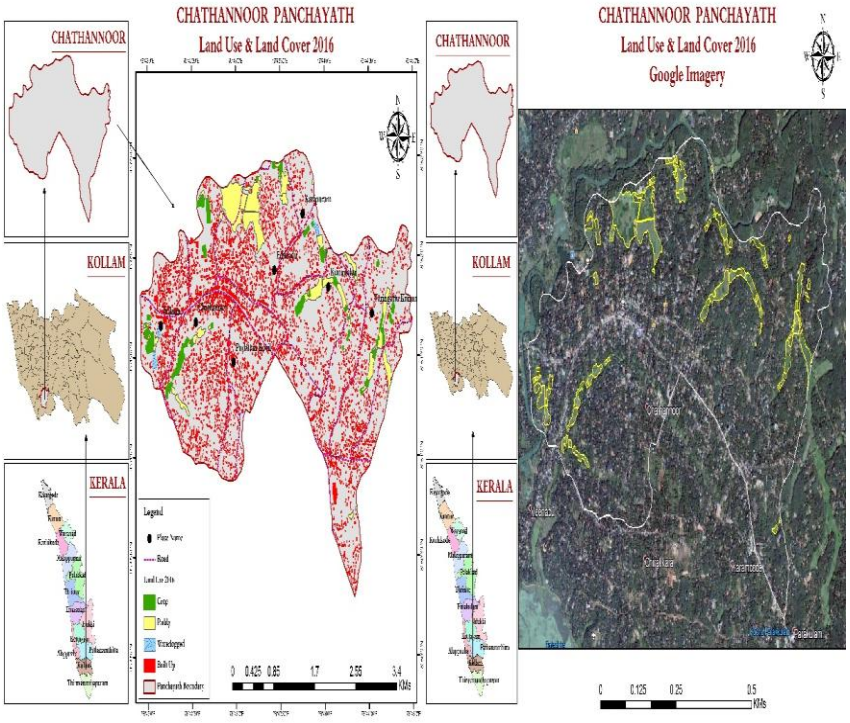

Fig. 6. Distribution of LULC variables in 2016.

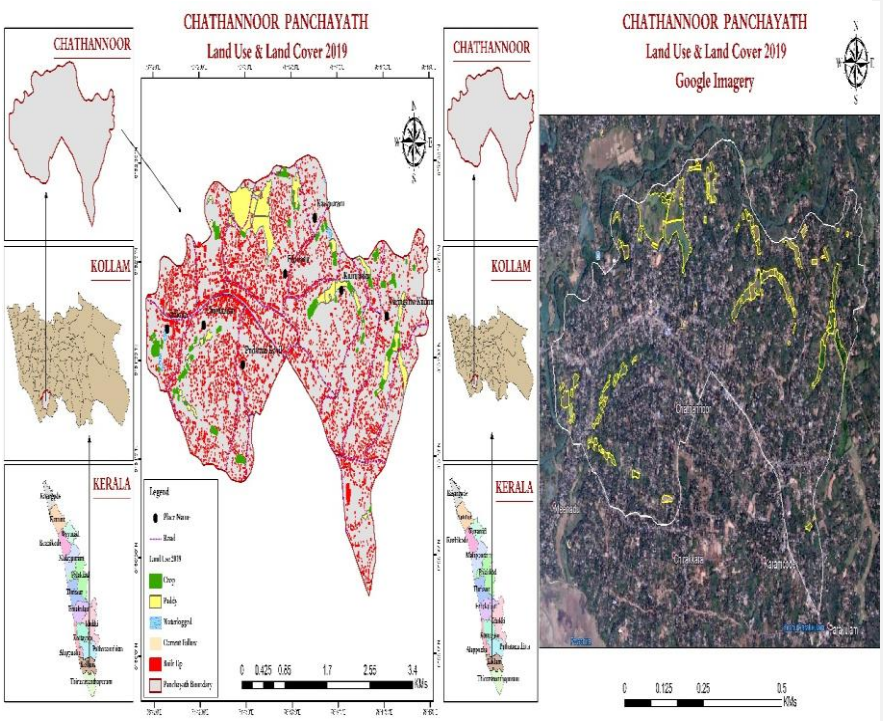

Fig. 7. Distribution of LULC variables in 2019.

Table 1. Land use classes or 2002, 2009, 2013, 2016, and 2019

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Land use	2002	2009	2013	2016	2019
	Area in %				
Paddy	95	78	80	72	74
Crop	3	14	16	23	22
Water logged	2	8	4	5	3
Current fallow	-	-	-	-	1

Table 2. Change in area (%) during different periods of land use

Land use	2002-09	2009-13	2013-16	2016-19	2002-19
	(Area in %)				
Paddy	-17	+2	-8	+2	-21
Other Crop	+11	+2	+7	-1	+19
Water logged	+6	-4	+1	-2	+1
Current fallow	-	-	-	+1	+1

The land left without cultivation for one year or less than one year to regain the fertility is normally called current fallow. The land use data of 2017-18 set by KSPB shows that the state has 52% of agricultural land area and 11% non-agricultural land. The area of food crops in the state was 10.12% and cash crops were 61.6% of the total agricultural land. The area of rice cultivation contributes 7.3% of the agricultural land in Kerala state during 2017-18. The Google imageries pointing the changes in the land use in Chathannoor and the increase in built ups (**Fig. 8 and 9**) clearly defines the drastic land use changes occurred in the study area [17].

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Fig. 8. Google imagery showing LULC changes over 20 years.

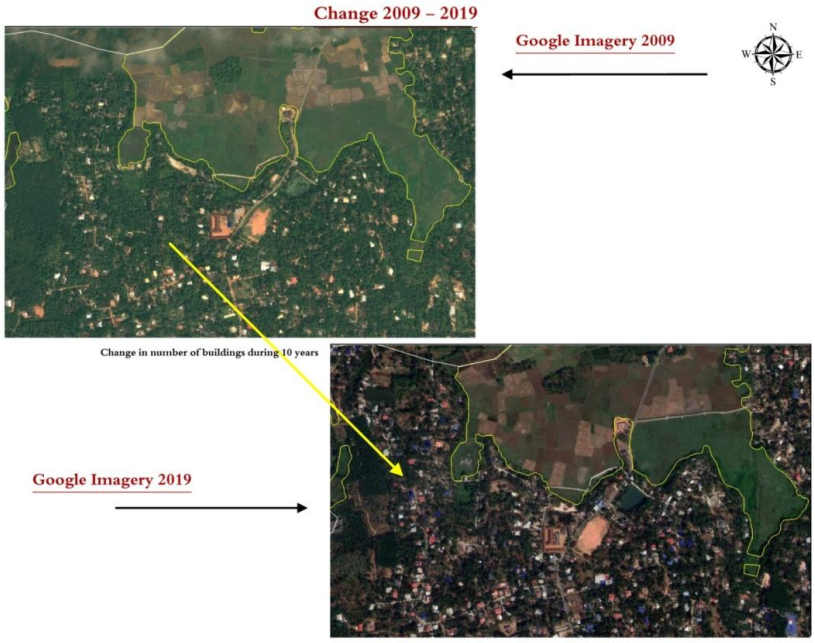

Fig. 9. Increase in the number of built ups from 2009-2019

3.2. Reciprocity of paddy field area and labour cost of the state

Kerala is a fairly high-income state in India. In 2019-20, the average annual per capita income in Kerala was 1,49,563 rupees. The average daily wage rate of skilled workers has increased year after year. The average daily wage rate of male unskilled workers in 2007-08 was 195.97 rupees and that of female unskilled workers was 137.42 rupees. Now, in 2019-20, the wage rate has drastically increased by 275% to 735.31rupees and that of females increased by 280% up to 522.08%. The hired human labour cost per hectare during the past two decades in the autumn, winter and summer seasons of paddy cultivation was scrutinized (**Table 3**). A steep increase in the human labour cost per hectare from 29,872 rupees in 2000-01 to 75,964 rupees per hectare during 2017-18 was found out.

The mapping of the paddy fields in the study area shows a pattern of decline in the area of cultivable paddy lands. It also clearly proves the conversion of paddy wetlands to other crops. Similarly, the entire state conveys its agreement with the particular study area by following the criteria of decline in paddy field area. In 1960-61, the area of paddy fields was 7.79 lakh hectares. It got reduced to 3.47 lakh hectares in 2000-01 and continues to decrease by 1.91 lakh hectares till 2019-20 (**Table 4**).

The study focused on the changes occurred in the land cover and land use in the selected paddy fields of Kerala. The accelerated growth of the built-up area, toward 2013, was due to the increasing trends in urbanization. Socio-economic factors, population growth and economic upliftment are the main reason for the shift of the land use pattern in the study area. With the elevation in human population, and the built-up lands, mixed vegetation also increased, as it is Keralite tradition to have plants, trees, herbs and other home-based cultivation for domestic usage, on their residential premises. This type of cultivation was more practiced at the most areas of the district. A well-constructed plan should be implemented for the use of land, which is unavoidable for the harmonious ecological balance and sustainable development. A strategic land use plan should be established, focused on control of developed land that encroaches on paddy fields, waterlogged area and water bodies. Persons giving importance to ecological protection should be weaved into management of land use and land cover, to preserve eco-friendly biodiversity.

Table 3. Hired human labour cost per hectare in Kerala (2000-18)

Year	Hired human labour cost per hectare (in rupees)			
	Autumn	**Winter**	**Summer**	**Total cost per year**
2000-01	10571	8615	10686	29872
2001-02	12456	9528	11742	33726
2002-03	10642	9544	10705	30891
2003-04	10463	9784	9359	29606
2004-05	9542	9663	9976	29181
2007-08	10265	12517	12252	35034
2010-11	16833	20202	17211	54246
2011-12	18605	18382	22398	59385
2012-13	18336	20700	20738	59774
2013-14	30689	25246	29040	84975
2014-15	28511	25652	28477	82640

Source: Economic Reviews 2020, Government of Kerala

Table 4. Changes in the paddy fields area of Kerala state from 1960-2020

Year	Paddy field area ('000 hectares)
1960-61	779
1970-71	875
1980-81	802
1990-91	559
2000-01	347
2012-13	197
2017-18	189
2018-19	198
2019-20	191

Source: Economic Reviews 2020, Government of Kerala

4. CONCLUSION

The comparative study on the land use pattern of the midland paddy fields of Chathannoor, Kerala or the past two decades was done using remote sensing and GIS techniques. There has been a drastic change in the area of paddy fields during the last two decades (2002-2019). The most distinctive changes include the decrease in area of paddy cultivation and elevation in the area of other crops. The reduction in the area of paddy fields mainly occurred during 2002 to 2009, with corresponding increase in the area of other crops. The increasing cost due to hike in wages of labourers and the relative price changes in favour of competing crops were responsible for the less cultivation of paddy fields in the study area. The practice of conversion of paddy lands into cultivation with other crops as

well as for non-agricultural purpose increased. As the development increases, the replacement of agricultural lands by residential and industrial areas occurs. The steep decrease in the area of paddy fields in the state is in close agreement with the land use changes in the paddy fields of the study area. These activities strengthen the deterioration of the quality of environment. Therefore, the present study reveals that the land area of midland paddy fields of Chathannoor in Kerala has experienced immense changes in the land use patters over the past two decades. Thus, the land use changes in the study area have a clear impact on the socio-economic balance of the study area and a shift in the agricultural sustainability of the area.

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