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Change detection analysis of coastal zone features in Cuddalore District, Tamilnadu using Remote sensing and GIS techniques

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Abstract: *Coastal environment is viable to huge changes mainly due to the intervention of humans by urbanization, population and its migration. It is essential to study the landuse/landcover, geomorphology and shoreline using GIS and remote sensing for the Cuddalore coast. Landsat imageries were used for the years 1988, 2000 and 2016. The thematic maps were differentiated and displayed by its evolving changes in coastal zone features. Deltaic plain (53.28%) is dominant in geomorphology class, Agriculture area (33.77 km^2) in landuse class, 37.5% (1.63km^2) of aquaculture practice and mangrove forest (9.75km^2) increased due to its economical and tourism value. The study suggests the use of Landsat imagery for change detection and environmental monitoring assessment of the coast.*

Keywords : *Landuse/landcover, geomorphology, shoreline change, remote sensing, Geographical information system (GIS).*

I. Introduction

The nature of the coastal surrounding is complex because of its periodic changes due to coastal processes like waves, tide, sediment transport, storms, cyclones, etc. It plays a vital role in economic activities in industrial, recreation and business, etc. Such environment is modified and threatened due to migration of people, population and urbanization [1]. Therefore, it is highly important to safeguard the coast to a sustainable growth [2]. Change detection of coastal environment is an essential interface coastal planners for the management of coast at a region specific level [3],[4],[5]. Using landuse/landcover and geomorphology module lead to know the reason for the coastal environment change [6],[7],[8]. This informative map is helpful for understanding the processes, utilization and management of coast [9],[10]. Recent days, the coastal landuse/cover is mainly modified by human interferences. Therefore the land conversion or land degradation occurs due to the enhance of population, which proceeds to land usage without following the management guidelines. These landuse and geomorphology changes interfere the coastal ecosystem [11],[12],[13]. So, detecting landuse/landcover change is highly important to study the developmental sequences of coast over a period of time. Also, according to [14],[15], detecting changes and periodic analysis using traditional practical method are highly impossible. But nowadays geographical information system and remote sensing techniques are easy and less time consuming method to arrive better information in spatial extent of landuse/landcover changes for wide areas [16],[17]. Experts viz., Chenthamil et al. (2014) and Misra et al. (2015) supported that GIS and remote sensing is widely used for long term/short term and real time monitoring of coastal environment[18],[19]. Numerous satellite sensor images are availed to monitor the landuse and landcover maps like IRS[20],[21], LANDSAT [22], IKONOS [23],[24],[25], and QUICKBIRD [26],[27]. The aim of the study is to detect Landuse/ Land cover changes using satellite imagery in Cuddalore coast. Landsat sensors Thematic mapper (TM), Enhanced Thematic Mapper (ETM+) and Object Linear identifier (OLI) data for the period of 1988, 2000 and 2016 were adopted for landuse/land cover and 2016 image was used for coastal geomorphology mapping by human and digital interpretation techniques are supported by field verification.

II. Study area

Cuddalore district (figure 2.1) is situated about 160 kms south of Chennai, the state capital. The area of the district is 3706 km^2. It has 51 village panchayats[28].The headquarters of the Cuddalore district is Cuddalore (11^0 44' 45" N and 79^0 45'56" E), a large industrial town that underwent seaside development at a fast scale.

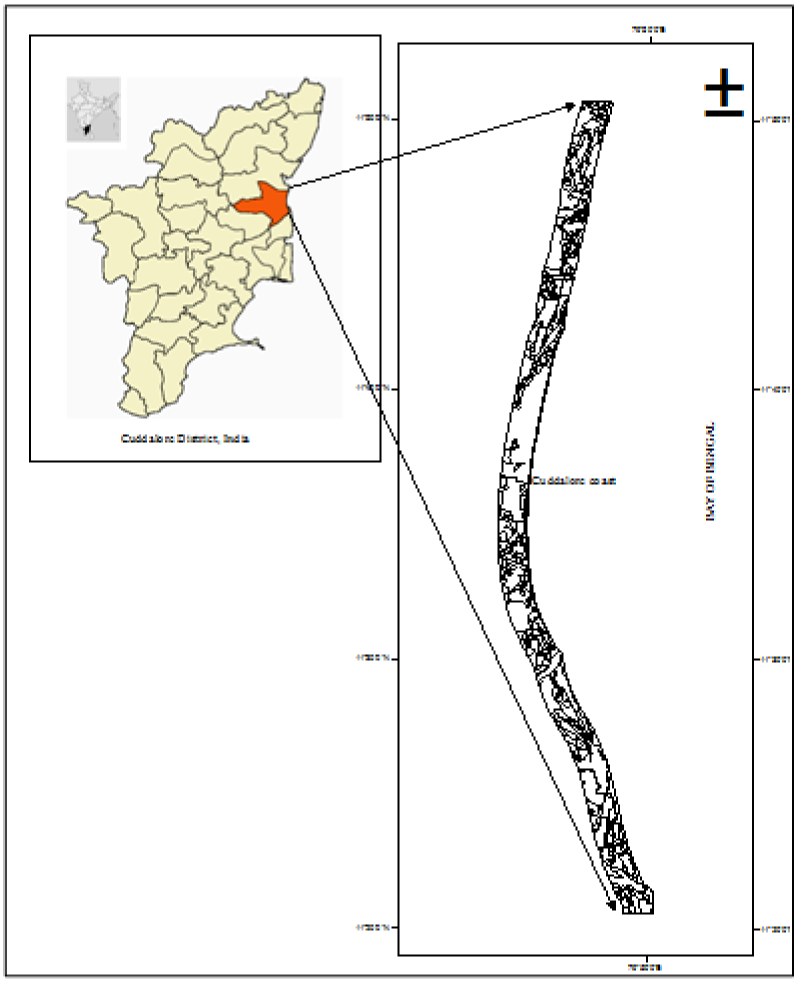

Figure 1 Study area-Location of a map

This district is plain terrain in nature and small elevated up lands and lateritic hillocks and prominent coastal zone. Pennaiyar, Gadilam and vellar are the major river drainages that are present here [29].On the north Cuddalore district is surrounded by the Villupuram district and the Union territory of Puducherry and on the west by the Perambalur and Ariyalur districts and on the south by the Nagapattinam, Thiruvarur and Thanjavur districts are on the east surrounded by the Bay of Bengal. The coastal stretch of Cuddalore extends from Aladimedu in the north to kollidam river mouth in the south and the total length of 75km approximately along the Bay of Bengal. It experiences severe tropical cyclones during the northeast monsoon (October through December), and was worst affected by 2004 Tsunami and also nearly 60 cyclonic storms. An added risk factor is that large parts of this coastal zone are low-lying with a gentle slope, resulting in wide inundation areas that increase the vulnerability of the region [30].

III. Materials and methods

Multi-temporal satellite data of Landsat TM 1988, Landsat ETM 2000 and Landsat OLI 2016 images were used for generate landuse / land cover map [31],[32]. These Landsat satellite image was downloaded freely through the global land cover facility (GLCF) (http://glcf.umd.edu)[33]. The use of multi-temporal satellite data at a large scale, possesses a number of challenges including geometric correction error, noise erasing from atmospheric effect, instrument errors etc [34]. In this study, the geometric and radiometric errors were rectified through image pre-processing techniques. Images were geometrically corrected using ground control points (GCP) and were taken from the SOI toposheets (1978) with an RMS error of less half a pixel value by using nearest neighborhood resampling method [35]. The images were registered with Universal transverse Mercator projection WGS 84 and area of interest was selected and was subsetted using ERDAS Imagine software. The FCC was created for differentiating the landuse/land cover features [36],[37],[38] (Figure 2). Different landuse features were mapped such as settlement, crop land, river, land with and without scrub, vegetation, salt pan, waterlogged area, mudflat and industries and their changes were analyzed with the help of GIS (ArcGIS 10.2) software environment.

IV. Results

1.1 Geomorphology

Coastal geomorphology is the study of the characteristics, origin and development of landforms along the coast. These coastal environments are entitled with numerous geomorphic features viz. beach, beach ridge, paleo beach ridge, deltaic plain, mud/tidal flat, flood plain and mangroves etc[39],[40],[41], which is shown in Figure 3. From the landsat OLI data, the various geomorphic features were identified in the 2km buffered portion and the zooming scale of about 1:15000. The geomorphology map indicates that deltaic plain (61.97km^2) influences the Cuddalore coast. Beach and beach ridge occupied the area of about 4.21km^2 and 11.12km^2. Mud flat/tidal flat occupied 4.29km^2 and it is usually amalgamated with estuaries and backwaters.

Figure 2 Geomorphology of the Cuddalore coast

The flood plains are dynamic and it is influenced by the river/stream movement, sudden flooding and sand deposition of sand from the river. The flood plain present in region was 2.31km^2. Mangrove is tropical coastal vegetation and it occurs worldwide in the trophic and sub-trophic region. It occupied 10.95km^2 in the pre-defined buffer boundary of about 2km. The Cuddalore coastline consists of long, curved, low and sandy beaches and occupied 4.91km^2. An noticeable coverage in the study areas are; swale (0.61km^2), water logged region (0.38km^2), etc.

4.2. Landuse / Land cover:

The Landuse/land cover assessment based on visual interpretation for the periods 1988, 2000 and 2016 are derived from Landsat TM, ETM and OLI satellite image respectively (Figures 4 & 5). The result indicate that dominant landuse/land cover categories in 1988 was Agriculture land, which was occupied about 42.04km^2 of the buffered study area, vegetation covering 8.48km^2, settlement (with plantation and without plantation) occupying 6.13km^2, Aquaculture was 0.98km^2, water logged area and scrub forest covered 0.24 km^2, 4.74 km^2 respectively (Figure 3a). While River/stream/Canal was 22.81km2, sandy area was 6.71km^2, land with and without scrub covered 2.26 km^2 and 5.79 km^2 constitute area coverage in the region.

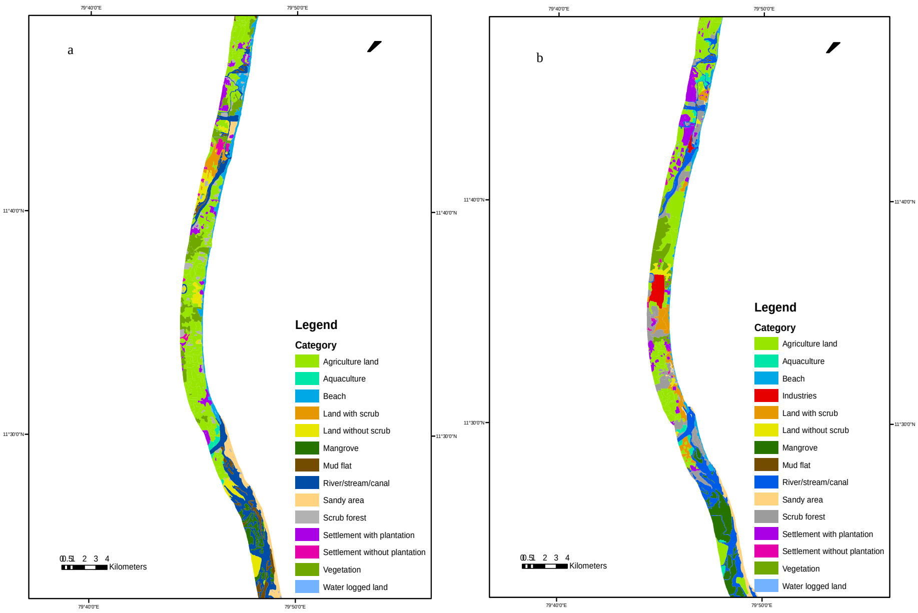

Figure 3a and b indicates the landuse/landcover map of Cuddalore coast during 1988 and 2000

In the year 2000, the agriculture land continued to rule the majority of the area (35.03km^2), here the drastic increment was noticed in the four categories such as Aquaculture (2.32km^2), mangrove (11.13km^2), settlement (8.53km^2) and industries (3.15km^2) due to population migration, worker needed for agriculture and urbanisation. But in the year of 2016, agriculture land was slightly decreased to 33.77 km^2. ie 3.5%. Aquaculture was increased to 2.61km^2 due to its economic credits. Noticeably, there is a further enhancement that was found in the industries, settlement and mangroves. In the same time lands with and without scrub region were reduced to 3.4 km^2. There were three major types of land use changes conversion evidenced from the figure (fig. 3a, 3b and 4) as; agricultural land to settlement areas and industrial, scrub forest to industries and settlement ,area, conversion from agriculture land to and aquaculture.

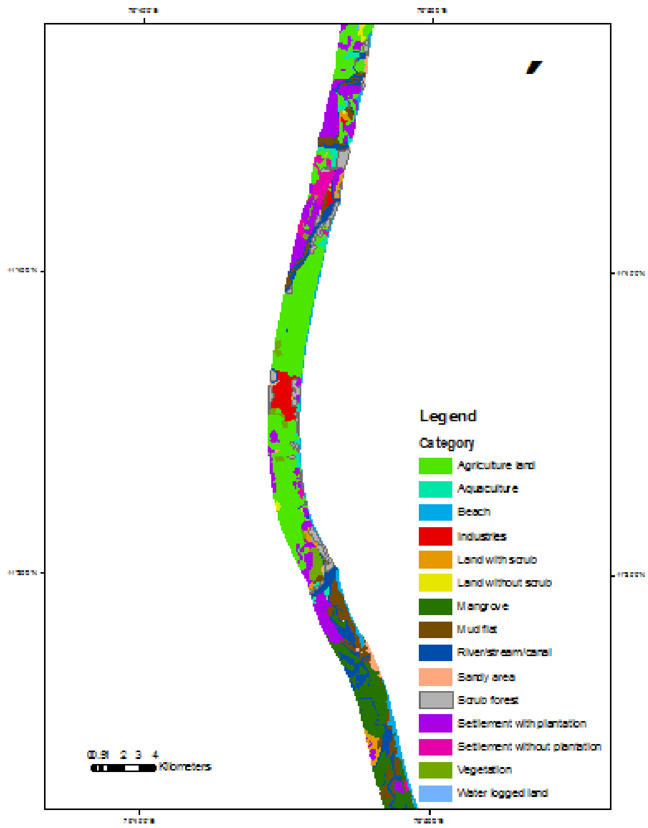

Figure 4 represents the landuse/landcover map of Cuddalore coast for the year 2016

In recent years, aquaculture has become fastest evolving food industry in India. Interest in aquaculture farming started in the late 1980s and was boosted by shrimp production in 1990s in the region (fig.5a). Also, because of expansion and plantation of mangroves, the tourism value increased [42] (fig. 5b). Cauvery tributaries such as Gadilam, Pennaiyar, Vellar river surroundings are suitable land for brackish water aquaculture and also number of small sized aquaculture farm started around this area. As evident from the table 1, the areas for aquaculture was 0.98 km^2 in 1988; further increased to 2.32km^2 (2000) and 2.61km^2 (2016). On the other side 4.0 km^2 of mangroves were increased to 13.75km^2 in the 28 years duration because of its tourist value.

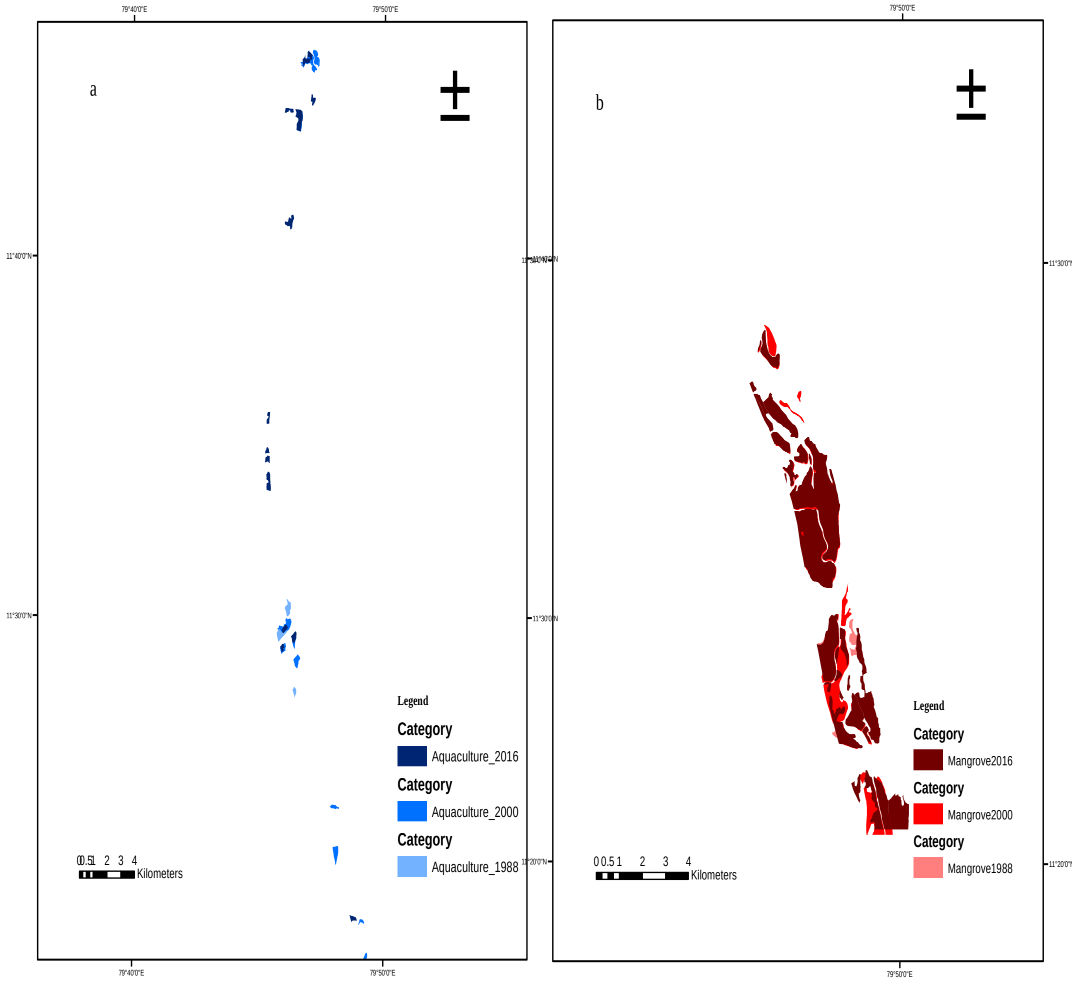

Figure 5a and b Scenario of Aquaculture and Mangroves during 1988, 2000 and 2016.

Table. 1: Geomorphology and landuse/landcover changes of Cuddalore coast

S.No.	Geomorphological classification	2016 (km^2)	Landuse/landcover classification	1988 (km^2)	2000 (km^2)	2016 (km^2)
1	Beach	4.21	Agricultural land	42.04	35.03	33.77
2	Beach ridge	11.12	Beach	6.68	4.25	4.91
3	Coastal plain	1.32	Aquaculture	0.98	2.32	2.61
4	Deltaic plain	61.97	Land with scrub	2.26	6.38	1.91
5	Flood plain	2.31	Land without scrub	5.79	2.47	1.49
6	Mangrove	10.95	Mangrove	4.00	11.13	13.75
7	Mudflat/tidal flat	4.29	Mud flat/tidal flat	5.20	0.54	8.8
8	Paleo beach ridge	4.57	River/stream/canal	22.81	20.31	12.5
9	River/stream/canal	11.81	Sandy area	6.71	4.39	2.23
10	Swale	0.61	Scrub forest	4.74	13.54	5.23
11	Sand spit	2.70	Settlement with plantation	4.71	7.69	18.95
12	Water logged region	0.38	Settlement without plantation	1.42	0.84	3.15
13			Vegetation	8.48	5.91	2.83
14			Water logged area	0.24	0.17	0.27
15			Industries	-	3.15	3.96

4.3 Shoreline change analysis:

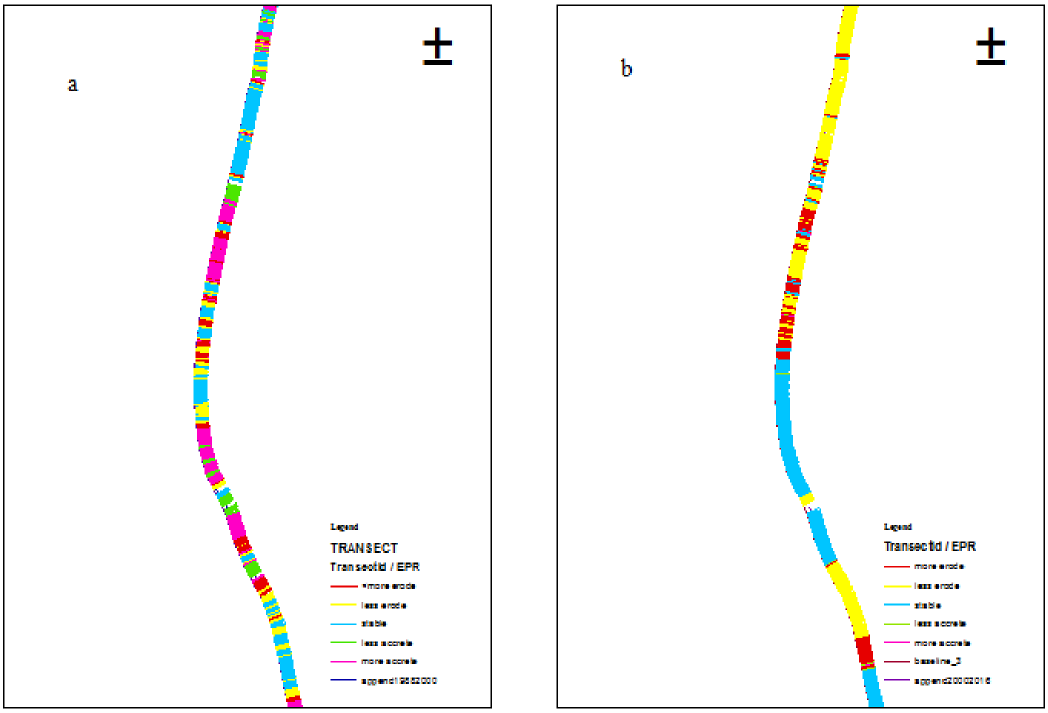

Figure 6a and b shoreline change map during 1988-2000 and 2000-2016

Shoreline defines the meeting place of land and water. Shoreline changes its shape and position continuously due to dynamic environmental conditions[43],[44],[45]. The dynamics in shoreline was mainly associated with waves, tides, winds, periodic storms, sea level change, the geomorphic processes of erosion and accretion and human activities[46],[47],[48]. The survey of India toposheets 1978 and satellite data from 1988 to 2016 were used to assess the changes in the shoreline of the Cuddalore coast using Digital shoreline analysis system (DSAS) tool in ArcGIS software. It is used for knowing shoreline change rate in terms of accretion and erosion[49]. The parameter involved in this analysis was End point rate(EPR), which is the distance of shoreline movement elapsed by the time duration used between oldest and the recent shoreline[50]. The analysis duration was split into two types: 1988-2000 and 2000-2016 respectively. As seen in the figure 6a, 1988-2000 Low to high erosion was noticed for madalpattu to north side of the Cuddalore port. In the south side of the Cuddalore port, a high accretion zone was identified. Also an accretion transects were found in the parangipettai zone. A high accretion transects were found in the northern side of the kollidam river mouth similarly, a high erosion zone was noticed in the south side of the kollidam river mouth. In the year 2000-2016, it showed that the High erosion and accretion was noticed in the north and south side of the parangipettai beach. Both the sides of the kollidam river mouth have undergone an accretion. Also, lower to higher accretion transects were found in the north and the south sides of the Cuddalore port (fig. 6b). These changes were influenced due to developmental activity of Cuddalore port like extension of breakwater, jetties and movements of sediments. Also the shoreline protection measures were adopted in mouth of the kollidam river and parangipettai beach as a result of shoreline accretion.

V. Conclusion

The present study shows the satellite image that has the unique capability to detect the changes in landuse/land cover quickly and accurately. From the analysis, it is found that the satellite data is very useful and effective for getting the results of temporal changes. With this effective data, it is found that the landuse changes are mostly caused by rapid population growth, development of aquaculture farm and industrial development. The satellite imagery also confirms that Cuddalore coast still retains more agricultural land when compared to all other landuse/land cover features. This will help in maintaining the ecological balance and improving microenvironment of the region. But in the mean time, there is remarkable development in industries like oil refinery, chemical industries and port development activity. At same time, coastal protection structures like breakwaters, casuarinas plant should be taken up to stabilize the shoreline and beach. It can be concluded that the use of Landsat imageries for coastal features change analysis in the Cuddalore coast provided a good result. However, it is recommended to derive change analysis studies on regular interval and the information could be updated through time.

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