Impact of Urban Sprawl on Land Use in Kole Wetlands of Thrissur District, Kerala

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Abstract

The Kole lands which lie adjacent to Thrissur city, are a unique wetland agro-ecosystem facing severe pressures due to urbanization. This study is an attempt to determine the extent of paddy field lost to reclamation in the recent years, and to determine the impact of the conversion on water flow.

1 Introduction

The Kole wetlands extend from the Chalakkudi river in the south to the Bharathapuzha river in the north, covering an area of about 546 km$^2$. They lie in the basin of Karuvannur and Kecheri rivers. Being submerged for 6 months in a year, they are an important area for inland fishery. Rice is cultivated once a year following the onset of winter, after de-watering the fields.

Enriched by the silt brought by the Karuvannur and Kecheri rivers, the Kole lands are very fertile for rice cultivation. Average yields have often exceeded that of other paddy fields by 2 or 3 times. In fact, the name 'Kole' translates to 'bumper crop’ in Malayalam, and these wetlands are named after their high productivity.

However, the productivity has decreased over the years owing to intensive use of chemicals in agriculture which has reduced the natural fertility of the soil. Increasing costs of production, migration of labour to the Middle-East and to other sectors and declining profitability of rice production means that large tracts of these extremely rich lands are lying fallow today.

When parcels of land lie fallow, cultivated land gets fragmented and it becomes more difficult for the remaining farmers. This becomes a vicious cycle, and the statistics of the Kerala State Agriculture Department show a steady decline in area under rice cultivation in the last 40 years. The real estate sector is attracted to fallow paddy fields because they cost far less than higher ground, often by a factor of ten or more. Small land-owners prefer to sell off their land because agriculture is not profitable any longer.

Paddy fields, especially the Kole wetlands, are not simply the rice bowl of Thrissur district, but harbour a rich flora and fauna. Hundreds of thousands of migratory birds
The Kole lands provide a natural fresh-water reservoir for ground water recharge. They also provide a sink for the large surface run-off from the eastern highlands every monsoon, and keep Thrissur city free from floods.

In the last 20 years, several housing colonies have sprung up in the parts of the wetland in and around Thrissur Municipal Corporation. The episodes of water-logging that these low-lying built-up areas experience every monsoon, though short and relatively harmless, are a harbinger of what is in store for the future in case unchecked reclamation continues in the years to come.

Realizing this multi-faceted significance of paddy fields and wetlands, in 2008 the Kerala State Legislative Assembly passed the Paddy land/Wetland Conservation Act. This Act introduced and proposed to implement stringent restrictions on conversions, and prohibited all conversions except in a few special situations. Even though the Act seems to have been partially successful in slowing down the loss of paddy fields, vested interests with political clout still continue to find ways to circumvent the law.

A comprehensive study on the area of Kerala’s paddy fields and wetlands lost to reclamation still remains to be carried out. Moreover, there is a pressing need for an open information system on paddy lands and wetlands which can empower the civil society and local self-governments to continuously monitor the state of these lands.

Jeena T. Srinivasan’s study on land use changes in the Kole wetlands from 1981 to 2007 is a pioneering effort in this direction. With the help of Survey of India top sheets and IRS imagery, she has come up with revealing statistics on the extent of paddy field lost. She concludes that between 1981 and 2007, the extent of paddy fields in the southern Kole alone has decreased from 181.63 km$^2$ in 1981 to 135.85 km$^2$ in 2007. Most of this decrease in paddy fields is accounted for by a corresponding increase in mixed crop and built up land, with a small but significant increase in water-logged areas indicating fallow land.

In this context, our study focuses on a small part of the Kole wetlands near Thrissur city, to study the land use changes from 2005 to 2015 and determine the extent of paddy/wetland lost during this time. This study is an exploration of the possibilities of using open data and open source tools to do spatial analysis, as a precursor to building an open state-level paddy field information system that can be collaboratively built and maintained.

2 Study Area

The focus of our study is a gated township named ‘Sobha City’ that was built on converted land in the Kole wetland falling within Kolazhy Grama Panchayat, near the boundaries with Adatt Grama Panchayat and Thrissur Municipal Corporation (Fig.1). We intend to study the changes in land use within 2 km of this gated township.

This area contains the largest parcel of wetland that falls within Thrissur Corporation. A state highway passes through the middle of the wetland and several pockets on either side of this road have been converted to built-up land. Two major canals flow...
through this area and, in fact, meet at the site where 'Sobha City’ has been constructed. This gated township was constructed on land converted flouting norms set in the Land Utilization Order of 1967 which was the relevant Government of Kerala order regulating paddy field use prior to the legislation of the Paddy/Wetland Conservation Act of 2008. At about 32 hectares, it is easily the single largest conversion that has taken place in the area.

So the study area was chosen considering its symbolic importance, as well as the potential consequences for Thrissur city if the remaining wetlands in the area are also lost.

3 Methodology

3.1 Estimation of converted area

The gated township began being built some time in 2008. The reclamation happened a few years earlier. We decided to analyze satellite imagery from 2005 and 2015 to determine when exactly the paddy conversion happened. A comparative study of imagery from the two years was also planned, to estimate the extent of land use change in the study area during this period.
3.1.1 Supervised Classification

Supervised classification of the satellite imagery was done on the False Colour Composites generated from the Near Infra-Red, Red and Green bands. Maximum Likelihood algorithm was used for image classification.

The image was classified into five Land Use types:

1. Paddy
2. Homestead/Mixed Crop
3. Built up
4. Bare Soil
5. Water

The intention was to perform a local difference operation (pixel by pixel) between classified imagery from different years to highlight and estimate the converted area. However, the crudeness of the classified imagery, especially mixing up of paddy, mixed crop and built up areas, made it impossible to make any conclusions.

3.1.2 Classification by visual interpretation

An alternative classification was done by interpreting the images visually, making use of our familiarity with the study area. This time only two classes were used:

1. Paddy/Wetland
2. Other uses such as Homestead/Mixed Crop/Built up

Images classified in this manner showed a clear trend in the urban sprawl along the state highway.

3.1.3 Use of high-resolution imagery

The outlines of several buildings on converted lands in the area were obtained from OpenStreetMap. The remaining obvious conversions were also digitized, so that an indicative study of converted area could be done.

3.2 Impact on water flow

Another aspect of our study was to analyze the impact of paddy field conversion on water flow.
3.2.1 Conversions near stream network

Stream network was generated from the Cartosat DEM using hydrological analysis. An intersection of the converted land with a 100 m buffer of the streams was carried out, to identify the portions of the streams vulnerable to blockages if the converted area expands.

3.2.2 Conversions near canals

A similar analysis was carried out with the actual canals, the outlines of which were obtained from OpenStreetMap.

3.3 Data sets

The following data sets were used in the analysis:

3.3.1 Satellite imagery

1. Landsat 8 OLI, 29 January 2015
2. Landsat 7 ETM+, 30 November 2001
3. Landsat 5 TM, 01 April 1997
4. Cartosat1 DEM

The initial plan was to analyze and compare imagery taken in 2005 and in 2015. However, malfunctioning of equipment on board Landsat 7 post 2003 meant that images taken in 2005 were distorted. The 2001 image was chosen in place of 2005.

When analysis of the 2001 image indicated that the area of the gated township had already been converted in 2001, we analyzed an earlier image, i.e. 1997.

3.3.2 Vector data from OpenStreetMap

Outlines of roads, canals, railway lines and several buildings in the study area were obtained from OpenStreetMap in vector format.

3.3.3 Bhuvan

The Land Use Land Cover (LULC) 2005-06 and 2011-12 layers which are available through Bhuvan’s Web Map Service (WMS), were used as a baseline to compare our results with.

3.3.4 Google satellite

Google satellite imagery was used as a base map to digitize the outlines of buildings not available in OpenStreetMap.
3.4 Software tools

The following software tools were used:

1. QGIS 2.8.1: for digitizing, vector operations and map composing
2. ILWIS 3.3: for image classification
3. SAGA 2.0: for hydrological analysis

4 Results

4.1 Supervised Classification

The images were classified by identifying sample sets for each class and running a maximum likelihood algorithm (Figs. 2,3,4). The considerable mixing up of paddy, built-up and homestead/mixed crop pixels made it impossible to do any change analysis using the classified images.

Still, the area of 'Sobha City' appeared as 'Bare Soil' in both the 1997 and 2001 images, suggesting that the conversion had happened prior to 1997.

4.2 Classification by Visual Interpretation

An alternative classification was carried out by digitization with the help of visual interpretation, making use of our familiarity with the study area (Figs. 5,6). This time
Figure 3: Classified Landsat 7 ETM+ image, 30 November 2001

Figure 4: Classified Landsat 8 OLI image, 29 January 2015
we used only two classes, viz. 'Homestead/Built-up' and 'Paddy/Wetland', since we were concerned primarily with getting an impression of the extent of paddy field lost. When the road network was overlaid (Fig. 7), it was clear that most of the conversions are clustered around the major roads.

4.3 Comparison with Bhuvan LULC

The classified images were compared with the Land Use Land Cover maps prepared by the National Remote Sensing Centre (NRSC) and made available freely through Bhuvan’s Web Map Service (WMS). The LULC maps were available for two years, viz. 2005-06 and 2011-12 (Figs. 8, 9), which showed a considerable increase in the built up area in the intervening 6 years.

One significant difference in our results when compared with Bhuvan was that the area of 'Sobha City' was shown as 'Agriculture, crop land' in Bhuvan’s LULC 2005-06. In our study, the Landsat images from 1997 and 2001 clearly showed that the area had already been converted prior to 1997, even though the actual construction happened much later.

4.4 Digitization from high-resolution imagery

Given the large errors in area analysis when using 30 m resolution imagery for studying a small area, we explored the possibility of using high-resolution satellite imagery as well.
Figure 6: Landsat 8 OLI image classified by visual interpretation, 29 January 2015

Figure 7: Road network layer superimposed on classified 2015 image
Figure 8: Study area in Bhuvan LULC 2005-06

Figure 9: Study area in Bhuvan LULC 2011-12
OpenStreetMap, a collaborative mapping platform, provides several details like the outlines of buildings, roads, canals and railway, in vector format. Anyone who wishes to contribute to it can make use of high-resolution imagery made available to it, like Bing Maps.

One major limitation was that no historical comparison was possible. So, only the obvious conversions surrounded by paddy fields could be identified this way (Figs. 10, 11). Gradual urban sprawl was missed out on. Still, we felt that it would be instructive to study these obvious conversions and identify the ones that are close to streams and canals.

4.5 Hydrological analysis

4.5.1 Using Landsat imagery classified and digitized by visual interpretation

First the stream network was generated from the DEM obtained from Cartosat-1 (Fig. 12). A 100 m buffer of the stream network was created as a vector layer, and then an intersection performed with the converted areas in 2015, to identify those portions of the streams that are vulnerable to blockage (Fig. 13).

This was repeated using canals from OpenStreetMap, instead of the stream network generated from the DEM (Figs. 14, 15).

The high density of streams in the study area and the presence of a fourth order stream, indicated that the area is vulnerable to water-logging in case of blockages.
Figure 11: Digitized map with road network overlaid

Figure 12: Stream network from Cartosat DEM overlaid on visually interpreted Landsat 8 OLI image, 29 January 2015
Figure 13: Intersection of converted areas with 100 m buffer of streams

Figure 14: Canals from OpenStreetMap overlaid
4.5.2 Using digitization from high-resolution imagery

A similar study was done using the outlines of buildings on converted land obtained from OpenStreetMap (Figs. 16, 17, 18, 19).

The area of converted land that came within the 100m buffer of the stream network from DEM and canals from OSM, were 18.38 ha and 10.86 ha respectively.

5 Discussion

5.1 Conclusions

The analysis of Landsat imagery by supervised classification could not conclusively show the loss in paddy fields, since there was considerable mix-up of pixels between built up, paddy and homestead/mixed crops. Interestingly, the focus of the study area, ‘Sobha City’, appeared as bare soil in both the 1997 and 2001 imagery, suggesting that the conversion had taken place prior to 1997.

The images classified by visual interpretation gave an indication of the direction of spread of the converted areas, clustered around the major roads.

The intersection of the footprints of buildings on converted lands with the streams and canals showed a significant converted area falling within 100 m of streams and canals. 100 m was taken as an arbitrary buffer, to highlight portions of streams and canals vulnerable to blockage in case the converted area expands further.
Figure 16: Stream network from Cartosat DEM overlaid

Figure 17: Intersection of converted areas with 100 m buffer of streams
Figure 18: Canals from OpenStreetMap overlaid

Figure 19: Intersection of converted area with 100 m buffer of canals
5.2 Lacunae

The study failed in the attempt to carry out a comparative area analysis to find out the extent of paddy field lost between 1997 and 2015. This was mainly due to thecrudeness of the image classification method used. It would be possible to do a more accurate classification using improved image processing methods, as well as the use of bands other than NIR, R and G.

The classification done by visual interpretation can only be used for forming general impressions, not area analysis, since it is likely to be biased.

Analysis using digitized polygons from high-resolution imagery is also only indicative, since no historical comparison is possible. Also, in this method, only obvious conversions could be identified, not gradual urban sprawl.

5.3 Scope for further work

5.3.1 Study of Thrissur City

In spite of the limitations of this study, it certainly indicates a worrying trend of paddy field conversion in the study area. It also indicates the risk of water logging in case of further expansion of converted areas.

In this context, a comprehensive study of Thrissur City needs to be carried out, including reported occurrences of water logging during the monsoon. An analysis of converted lands and instances of water logging needs to be carried out to develop a predictive model of possible future water logging in case the converted areas expand.

5.3.2 Paddy Field Information System for entire Kerala

Looking at the larger plight of the paddy fields and wetlands in Kerala, there is a pressing need for a state-wide information system.

The 2010 Paddy/Wetland data bank created by the Government of Kerala at the Panchayat level, though a commendable effort, has severe limitations:

1. It was a one-time effort documenting the extent of paddy fields and converted areas at that point in time, but we keep losing paddy fields every day. There needs to be a system to continuously monitor the situation.

2. The Data Bank contains several errors, even though the process is supposed to have been carried out in consultation with local people.

3. The Data Bank is in the form of a table in a PDF file, not amenable to any kind of spatial analysis.

In the light of these limitations, we propose to set up a different kind of open, collaborative platform that can fill this vacuum and help the cause of continuously monitoring the health of the paddy fields of Kerala.
The People’s Paddy Register (PPR) will be a web GIS platform. It will have the following features, and more:

1. A base layer showing approximate boundaries of paddy fields and wetlands in Kerala. This can be created with the help of Bhuvan and satellite imagery.

2. Administrative boundaries of panchayats, blocks, villages, taluk etc.

3. Roads, canals, railway lines, etc.

4. A portal for contributing volunteered geospatial information through mobile GIS
   (a) Location and contact details of local farmer groups
   (b) Converted areas
   (c) Organic farms, heirloom seeds
   (d) Kudumbashree groups doing farming
   (e) Boundaries and other details of padashekharams (paddy field clusters) etc.

5. Information from the Govt. Data Bank.

6. Agriculture Department statistics etc.

The intent is to have a continuously updated data base on paddy fields, that integrates various socio-economic and physico-geographical information. This can enable different kinds of analysis to be done which can feed into a long-term perspective plan on paddy fields.

For example, conversion happens most rapidly along major roads. An intersection of the paddy field layer with the road network can be done to extract the most vulnerable areas. Or if a certain Village Panchayat is interested in finding the risk of water-logging, they can clip only the local paddy fields using the Panchayat boundary and do a stream network analysis. The possibilities are enormous.

The availability of robust open-source tools means that such a platform can be set up with minimal cost.

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