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Original Research Article

TIME-LINE BASED AERIAL ANALYSIS FOR IMPACT OF RAMPANT URBANIZATION ON LAKES OF BENGALURU (INDIA)

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A b s t r a c t

Urbanization is introducing drastic transitions in the natural landscapes such as open areas, green spaces and water bodies of each and every city. The present study undertakes time-line aerial analysis for 2 decades from 2000 to 2019 to comprehend the effect of urbanization upon the Lakes of Bengaluru. Once famed as the city of 1000 Lakes; its wetlands now pose serious concern in terms of quantity, quality, aesthetics, epidemics and as life support system for native aquatic species. The outcome for the research was arrived at by analyzing the reduction of physical/geographical area of forty-two prominent Lakes by analyzing Satellite imageries, with inferential observations and deductions. Bellandur and Varthur Lakes rank among the most critically effected, having lost 9,87,411 sq.m. & 619416 sq.m. and 1,33,205 sq.m. and 4,19,310 sq.m. owing to scrupulous encroachment & eutrophication respectively.

Keywords: Bengaluru, encroachment, satellite, lakes, urbanization

1. INTRODUCTION

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In the recent past, human race has evolved as a powerful force manipulating nature and its surfaces & corresponding functions [1,2,3,4]. In order to accommodate the growing population and to provide better infrastructure, Lakes are becoming easy prey. In 1537, Bengaluru had around 1000 Lakes, but since then it has witnessed a gradual decline in both quantity and quality. In 1902, there were about 900 Lakes which facilitated domestic and agricultural functions.

Subsequently as an outcome of unsustainable anthropogenic demands, Lakes in due time were impacted by point and non-point source pollution leading to eutrophication, and eventually in dry seasons became sites for disposal of garbage, construction-demolition wastes and untreated municipal-industrial sewage [5]. This has further compounded human environment in the form of depreciation of water quality, rise in epidemics, localized climate change, bio-diversity loss [6,7,8,9] etc. Sadly, today only a handful being healthy serves the original intended natural purpose [5,10,11]. As fresh-water is now a scarce non-renewable commodity, a thorough analysis is warranted to understand the trend to arrest the impending situation and incept remedial measures.

2. METHODOLOGY

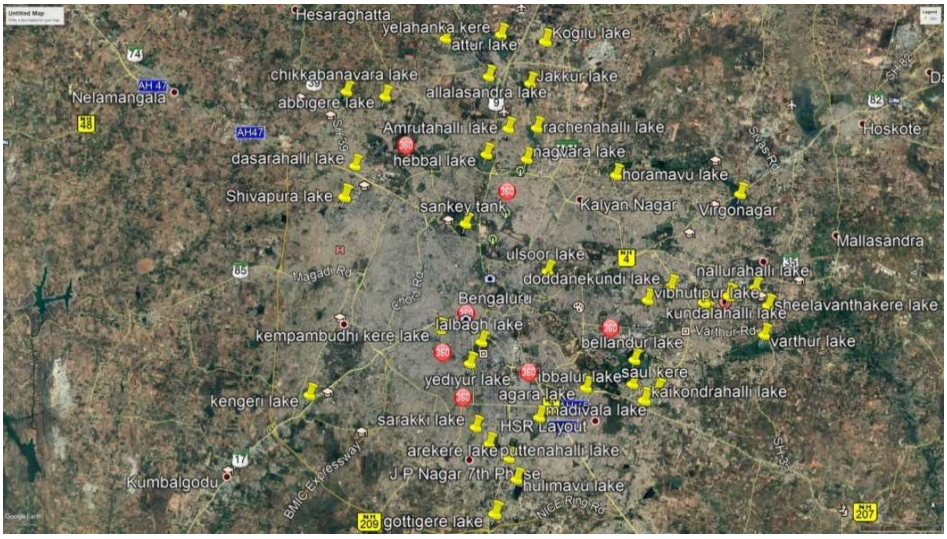

Fig. 1. Study area (Google Image of Bengaluru depicting the 42 Lakes under purview)

Initially, Literature review [12] and Cartographic studies were carried out to identify the existing Lakes of Bengaluru. Further, reconnaissance survey was carried out to confirm their Geographical Positioning and existing condition.

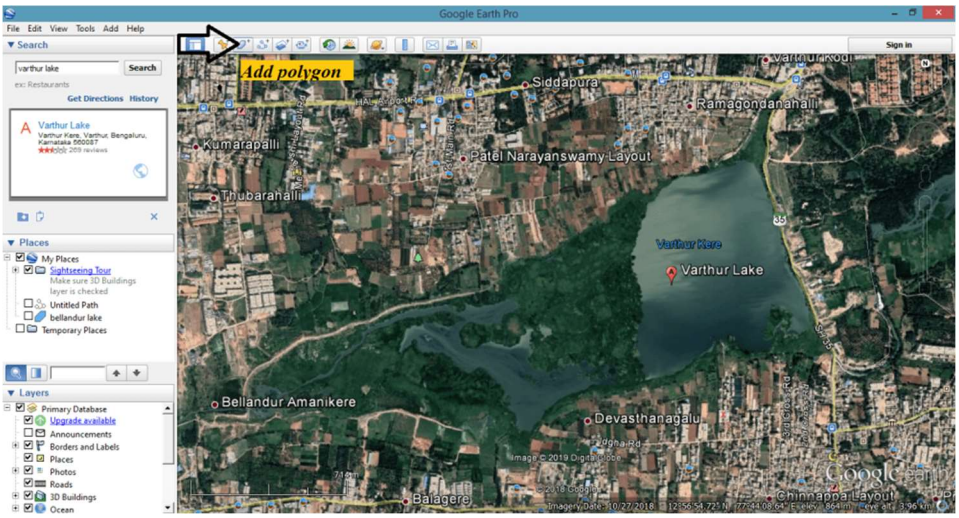

Fig. 2. Selection of Lake for 'area' assessment of Lakes

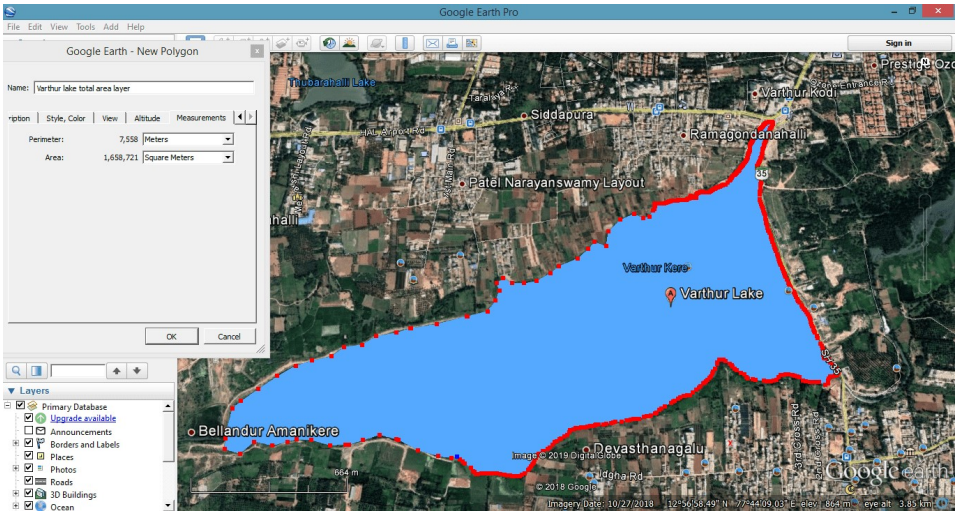

Fig. 3. Marking of Boundaries for 'area' assessment of Lakes

Finally, forty-two prominent Lakes (Figure 1) distributed through-out Bengaluru were fixed for the study, to analyze for the extent of impact of urbanization upon

it. For these Lakes, the different time-scaled Historical Google Satellite Imageries from 2000 to 2019 were downloaded in high resolution and secured. Further Aerial analysis was conducted using Google Earth Pro (Google Earth User Guide) to assess impact owing to eutrophication and encroachment respectively. A compilation of a sample of assessment process for one Lake is depicted through Figures 2, 3 and 4. Using this sequential process, data was synthesized for all the 42 Lakes of Bengaluru. Further analysis was carried out for relative and overall inferential conclusions

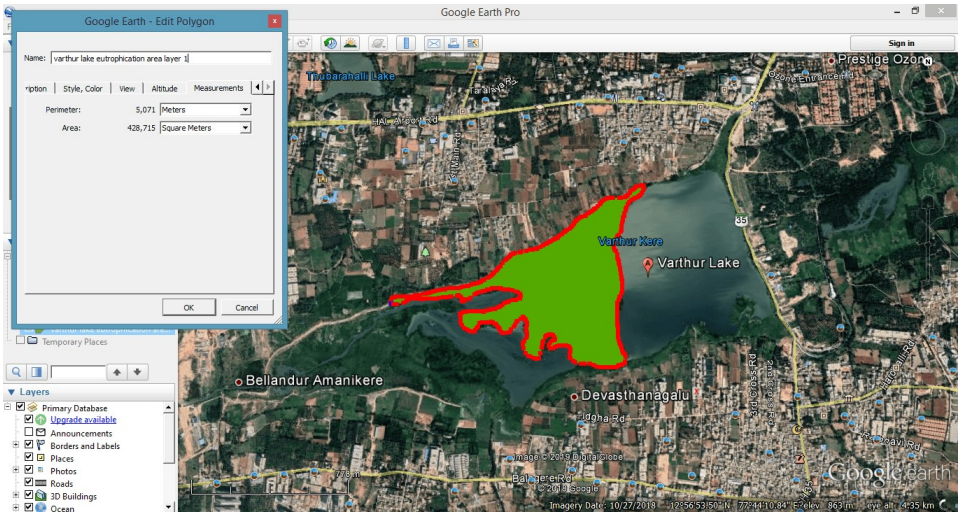

Fig. 4. Delineation of Perimeter for ‘area’ assessment of Lakes

3. RESULTS

Chart 1 showcases the respective geographical area reduction individual percentage area reduction of Lakes for the period of 2000-2019. From the 42 Lakes taken for study, 41 Lakes had been encroached with a total ‘mean’ physical area reduction by 10.33%.

From the 42 Lakes taken for study, 41 Lakes had been encroached with a total ‘mean’ physical area reduction by 10.33%. Bellandur and Varthur Lakes have witnessed the highest decline with encroachment of 9,87,411 sq.m. and 1,33,205 sq.m. respectively.

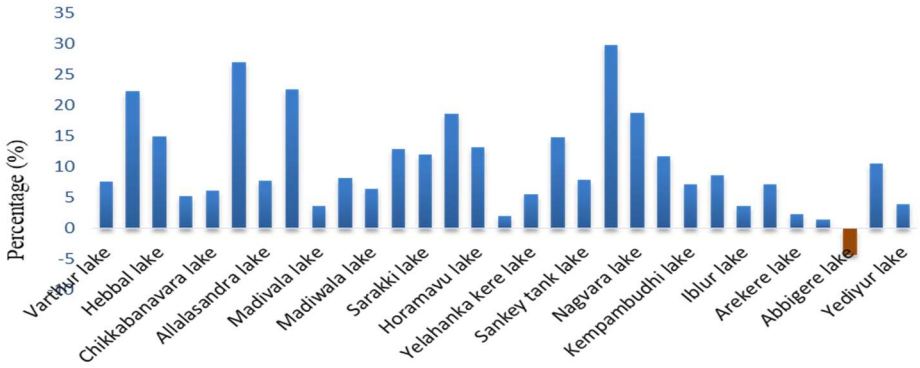

Chart 1. Percentage 'Area' reduction of Lakes of Bengaluru from 2000 to 2019

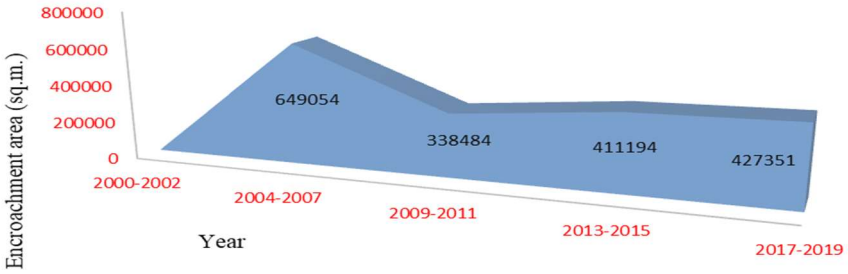

Chart 2. 'Encroached Area' assessment for all Lakes from 2000 to 2019

The area of Abbigere Lake with 4500sq.m, due to re-fixation of Boundary, has observed an increase by 4.2%. A total of 4 Lakes inclusive of Dasarahalli Lake and Puttenahalli Lake had experienced loss in the range of 21-30%. Ten Lakes inclusive of Hebbal Lake, Vibhuthipura Lake and Nagawara Lake had witnessed a reduction in the range of 11-20%. Remaining Lakes had observed a dip between 1-10%, and these prominently include Lalbaugh Lake (8%) and Kengeri Lake (9%) on the higher side; and Munekolala Lake, Arekere Lake and Hulimavu Lake on the lower side with 1-2 %. Chart 2 represents the overall encroachment of the analyzed Lakes of Bengaluru as a whole, for the time scale divided into five different time periods of 3 years each. The difference of Lake Area between two successive time scale categories of all the 42 Lakes was added to find encroachment details for each of the classified time scale. Data of reduced area for 2004-07, was ascertained using data of previous period i.e. 2000-2002.

As a whole, about 182.6 hectare of wetlands w.r.t the 42 Lakes was encroached between years 2000 to 2019, which have decline in ground water levels, aggravated incidents of urban flooding of low-lying areas.

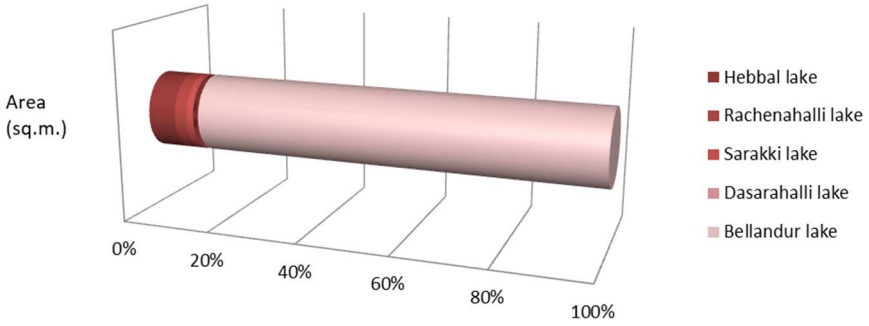

Chart 3. Area' reduction of 'sample' Lakes due to Construction Activities from 2000 to 2019

Fig. 5. Encroachment of Sarakki Lake [Google]

Chart 3 highlights 'area' of wetlands that is being reused for settlements purposes like constructing commercial complexes, setting up of industries and residential buildings etc. While Allalasandra Lake and Yelahanka Lake were intruded for establishing Lake Boundary and creation of a sewage treatment plant; Nursery

was set-up in the encroached area of 64,710 sq.m. of Hebbal Lake. Ironically, while 29,116 sq.m. of Rachenahalli Lake was used by BDA to build layout, private luxury villas came-up on 16,116 sq.m. of Sarakki Lake (Figure 5). While few Lakes such as Putenahalli Lake (Figure 6) lost a small portion of 3,564 sq.m., Bellandur was worst hit with loss of about 88,9153 sq.m. for construction activity of urban infrastructure expansion.

Fig. 6. Construction upon Putenahalli Lake [Google]

During 2004, sharp dip is seen mainly due to prolonged summer, reduced efficiency in feeders, enhanced construction of built-up spaces around Lake Boundaries, and absence of protected-established Lake Boundary. Though there was relative decline in encroachment by up to 48% between the years 2004-07 and 2009-11; it had peeked with 26.25% increase for the last 3 years. It is clearly evident that urbanization was consistently having its negative impact on Lakes as a consequence of release of untreated domestic sewage/industrial waste effluents, fertilizer laden run-off etc., and thereby severely impairing the quality of water [13].

Fig.7. Waste dumping in Chikkakabanavara Lake [Google]

Fig.8. Fire Break-out in Bellandur Lake [Google]

From the present research, it was found that the Lakes of Bellandur, Varthur and Chikkabanavara (Figure 7) had been transformed to illegal waste disposal sites were severely being affected by eutrophication as it was located in proximity to the polluters. Bellandur Lake (Figure 8) is now experiencing forth formation and fugitive fire breakouts due to mixings of various chemical wastes released from industries and sewage disposal from the adjoining communities.

Chart 4 showcases the total eutrophicated area for the analyzed Lakes from 2000-2019, grouped into five periods of 3 years each. It was observed that the rate of eutrophication was highly variable among all the lakes. Chart 5 highlights the plight for a sample set of Lakes. It was highest among Varthur Lake and Bellandur Lake; and least in Dasarahalli Lake. While Dasarahalli Lake as depicted in Figure 9 & 10 and Hebbal Lake were transforming to an 'Oligotrophic' state due to establishment of a Sewage Treatment Plan; Munekolala Lake and Ulsoor Lake were seen to transform from 'Mesotrophic' to eutrophic state. Sadly, certain lakes namely Hulimave Lake and Vibuthipura Lake were so severely impacted that they had transformed into dry grounds for most of the time; owing to non-replenishment by sub-surface flow as an outcome of rampant civil constructions around them, alongside lack of rains. Analysis of this is presented in further segments.

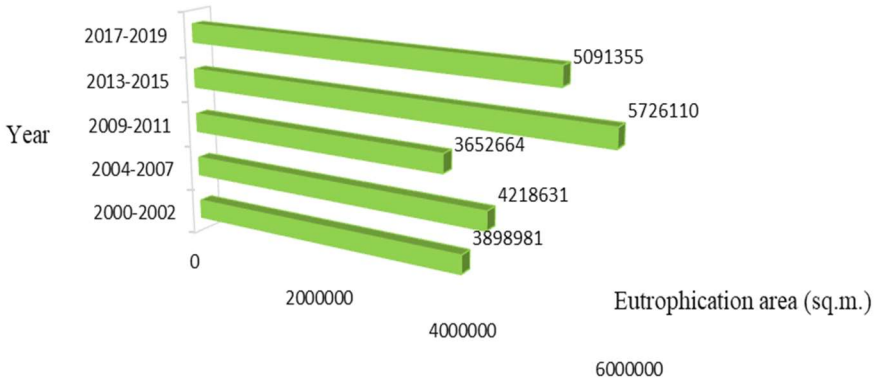

Chart 4. Eutrophicated 'area' assessment for all Lakes from 2000 to 2019

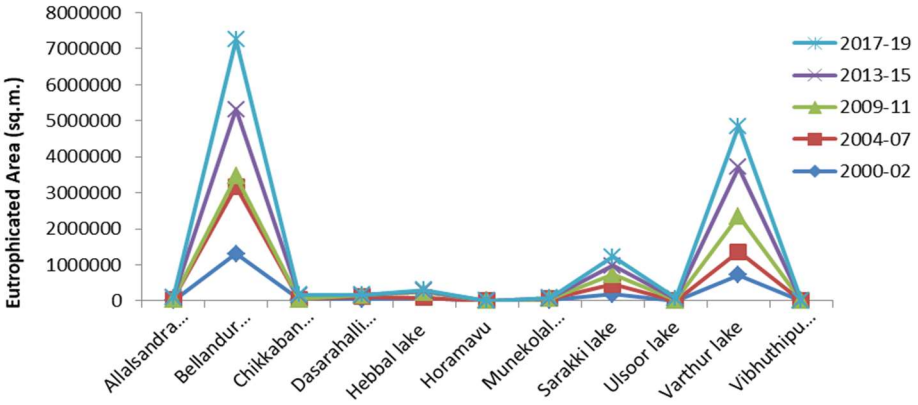

Chart 5. 'Area' reduction in Lakes due to Eutrophication from 2000 to 2019

Fig. 9. Eutrophic' Dasarahahlli Lake [Google]

Fig. 10. 'Oligotrophic' Dasarahahlli Lake [Google]

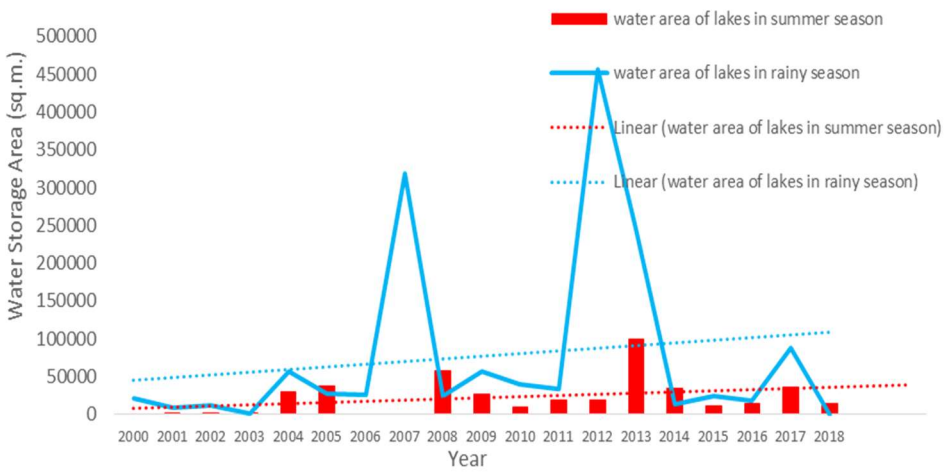

Chart 6. 'Seasonal Variation Assessment' in Water Storage Area of all Lakes (2000 to 2019)

Chart 6 graphically highlights the variation of water storage area in Lakes with respect to various seasons. Especially during dry-spells, in Lakes such as Iblur, Puttenahalli, Horamavu, Vibhutipura etc., the water storage area was totally absent. From the study it was evident that there was positive improvement in the water area during the rainy season, and that the precipitation did have a positive impact on increasing water levels. However not all lakes were not lucky enough, as in spite of water being restored in Lakes during wet-spells, they were unable to sustain on account of unscientific bed dredging, illegal sand mining, unauthorized over-extraction of water, disposal of organic and toxic wastes; and above all lack of maintenance or concern from the authorities.

The same has been further explained with help of a case study of Iblur Lake. Though in 2006-07 and 2012, considerable quantity of rain water was received by Lakes, they eventually overflowed into 'nallas' and caused urban flooding. By 2014, the water ‘storage’ area of Lakes had reduced by 95% in the rainy season itself due to decrease in storage capacity, owing to above causes. In certain cases, the worst had been observed with total loss of lakes. For instance, Byrasandra Lake, once a full-fledged lake has now been reduced into a small pond.

Fig. 11. Iblur Lake as dry land in 2002

Fig. 12. Replenished ‘Iblur Lake in 2009

Fig. 13. Dried-up Iblur Lake in 2018

As represented through Figure 11 & 12, Iblur Lake for instance has witnessed drastic transformation during dry and wet spells. Since lakes are mainly dependent on rainfall and runoffs, its replenishment is seriously disoriented due to rising Urbanisation and sewage outfalls. This eventually paves way for its encroachment and transformation for a built-up space.

As can be seen from Figure 13 & 14, Iblur Lake was encroached upon for outer ring road, reducing its expanse by more than 50%. Off-late bowing to public pressure and proactive action by responsible stakeholders, the lake was restored back to its original glory in 2019. In 2003-04, 80% of Lakes faced drought, and again in 2006-07 they had dried up with no groundwater to recharge it as complimentary capillary action [13].

The case of Jakkarayana Lake and Koramangala Lake is even more dreadful, as they have totally disappeared from the face of Bengaluru; with transformations into urban built-up structures and layouts. The same has been depicted in Figure 15 and Figure 16 respectively.

Fig. 14. Iblur Lake restoration in 2018 [Google]

Fig. 15. Lake Loss of Jakkarayana Lake

Fig. 16. Loss of Koramangala Lake

To summarize for a sample set, Chart 7 showcases how the physical area has varied annually for 11 among the 41 Lakes owing to variety/combination of aforementioned factors. It clearly depicts that every Lake has been impacted either more or less, in proportion to its total area.

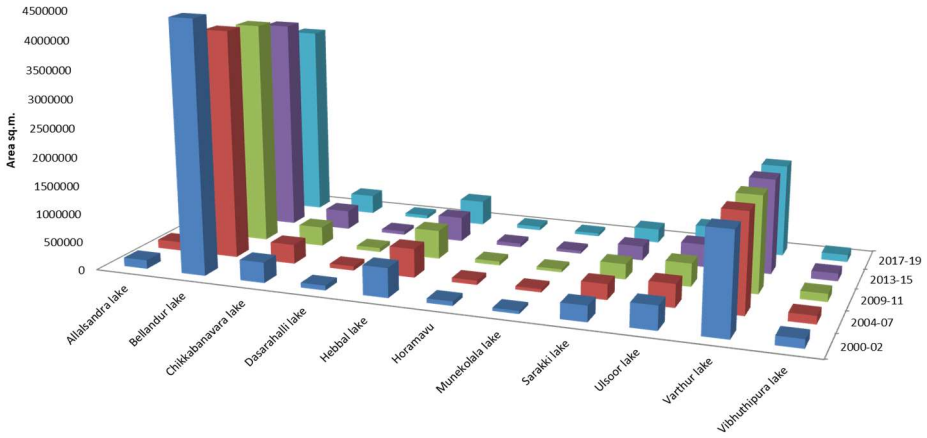

Chart 7. Variation of Actual Lake Area from 2000 to 2019

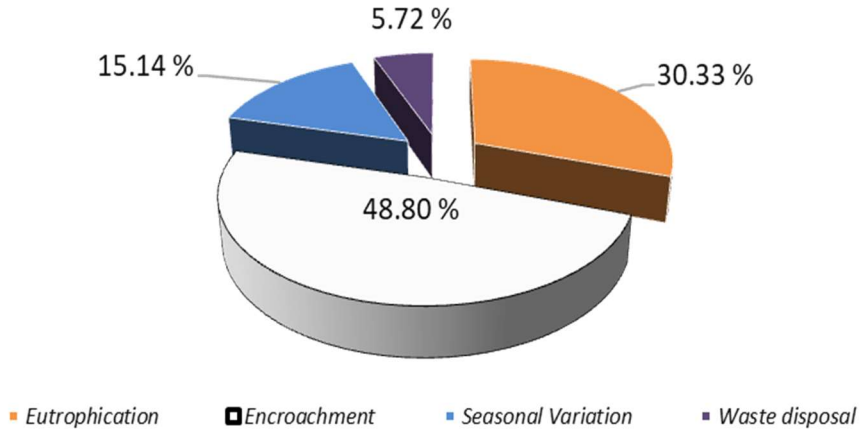

Chart 8. Percentage contribution towards reduction in Lake Area from 2000 to 2019

Pie-chart (Chart 8) represents percentage contribution of the causative factors that contributed in the loss of Lakes. It can be observed that the major cause remained as encroachment for the construction of public/private residential enclaves, facilities, government infrastructure projects, industrial space etc. [14].

4. CONCLUDING REMARKS

The research reveals that about 90% of Lakes under purview of present study were encroached by an average of 7.39%. The loss of about 9 lakh sq.m. of Bellandur Lake's bed area to accommodate urban settlements is most disturbing, alongside the fact more than 40% of the Lakes were impacted by eutrophication, a clear indication of being receiver of untreated sewage. About 6% of Lakes were being unceremoniously used as dumping grounds for construction debris and waste disposal such as Chikkabanavara Lake. Since 2000 to-date, about 1826500 sq.m. of Lake area has been encroached, with another 50 lakh sq.m. getting eutrophicated. Totally about 10,46,846 sq.m. of water area w.r.t lakes under purview has depreciated in the past 2 decades, transforming Lakes into a dry bund. Remedial measures must include implementable policies, alongside real-time monitoring for point and non-point sources of pollution.

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