MONITORING OF SURFACE WATER OF EAST KOLKATA WETLANDS (1984-2015) WITH GLOBAL SURFACE WATER DATASET

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ABSTRACT: East Kolkata Wetlands (EKW) is the world's most extensive wastewater fed aquaculture system. The EKW Ramsar site is under constant threat due to the increasing pressure of urbanization, change in the quality and quantity of solid waste, sewer, and also due to human negligence about its ecological importance. This study investigates the spatiotemporal change of the surface water of EKW using the Global Surface Water dataset. From the analysis of the dataset, it presents that only 14% of the area had water occurrence more than 60% of the time from 1984 to 2015. According to water occurrence change intensity, around 56% of the area has a total loss of occurrence, despite having approximately 63% of the area with a complete water recurrence on year to year basis. The result also shows that the transition of the surface water to different categories has a negative relation with time.

1. INTRODUCTION:

Surface water refers to the water present on the earth's surface, which includes rivers, lakes, wetlands, and the ocean. Ocean water is usually excluded as it is vast and salty, though smaller brackish water bodies are included(Huang, Chen, Zhang, & Wu, 2018). Between the period between 1984 and 2015, around 94,000 sq. Km of permanent water body has evolved, but the gain in the durable surface water is not geographically concentrated (Pekel, Cottam, Gorelick, & Belward, 2016).

Wetlands are complex and integrated ecosystems in which water, plants, flora, fauna, micro-organisms, and the environmental factors interact with each other(Jana, Mandal, & Jayasankar, 2018). These are some of the essential types of ecosystems because they influence climate change, biodiversity, hydrology, and human health. Wetlands provide several ecological services that benefit human civilization, such as water filtration, groundwater recharge, purification of water, carbon sequestration, recycling and retention of nutrients, storm protection, flood control, recreation, etc. (Jana et al., 2018; Meng et al., 2017).

Wetlands are significant for maintaining ecological equilibrium and environmental sustainability. Anthropogenic activities have a considerable influence on wetlands globally. The essential human activities responsible for wetland loss are infrastructure development, biological invasion, aquaculture, and peat extraction(Baker, Lawrence, Montagne, & Patten, 2007). Natural causes such as sea-level rise, drought, storms, etc. can also be the reason behind wetland loss, but these are less widespread. In the last 150 years, half of the world's wetlands have been modified, degraded or lost, which is likely to intensify due to the increased global demand for land and water and also due to climate change (Sica, Quintana, Radeloff, & Gavier-Pizarro, 2016). So, it became crucial to quantify the spatiotemporal variation of wetlands and to understand the driving factors to find out the sustainable use of wetlands.

East Kolkata Wetland (EKW), earlier known as East Calcutta wetland, is a human-made wetland located east of Kolkata city. EKW is very rich in biodiversity as it contains a large number of plants, mammalian, various threatened reptiles, and bird species, which includes both local and migratory (Bhattacharyya, Sen, Kumar, & Mazumdar, 2008; Kundu, Pal, & Saha, 2008). EKW was recognized as 'wetlands of international importance' under the 'Ramsar Convention' on 19th August 2002 and as 'Ramsar site' in November 2002. The EKW consists of intertidal marshes, salt meadows, sewage farms, settling ponds (Bheris), oxidation basins, etc. Four major types of land use patterns can be seen in this area, which is 1) Substantially water body-oriented area, [5852.14 ha] 2.) Agricultural area, [4718.56 ha] 3) Protective farming area, [602.78 ha] 4) The urban and rural settlement, [1326.52 ha](Bhattacharyya et al., 2008). The sewage water from the city reaches the Bheris through a network of canals. These Bheris are used for the cultivation of fish and also act as natural oxidation pond that naturally treats the city's wastewater. The treated wastewater is utilized in agriculture and pisciculture by efficiently recovering the nutrients (Kundu et al., 2008; Raychaudhuri, Mishra, Nandy, & Thakur, 2008). EKW is the world's most massive ensemble of sewage fed fish ponds. It provides 150 tons of fresh vegetables daily, about 8,000 tons of fish yearly(Raychaudhuri, Salodkar, Sudarshan, & Thakur, 2007). Around 50,000 people directly or indirectly depend on the EKW for their livelihood. This wetland system considered as the kidney of the city, and it is "one of the rare examples of environmental protection and development management where the local farmers have adopted a complex ecological process for mastering the resource recovery activities' according to the Ramsar Convention on Wetlands. Urban encroachment at EKW can have a detrimental consequence, such as changes in ecosystem qualities, loss of livelihood, as well as revenue reduction from a decreased wetland area. Long term monitoring is essential for the sustainable use of this wetland and also for formulating policies regarding the same. The objective of this study is to find reliable information about the water status of the EKW.

2. STUDY AREA:

East Kolkata Wetlands (EKW) is a multifunctional wetland ecosystem which is located in the districts of 24 Parganas North & South, West Bengal adjacent to the eastern part of the Kolkata and border on the Saltlake township on the one side and Rajarhat Township on the other (figure 1). The total area of EKW is around 12500 hectares, which is an inter-tributary mash created by the shifting of the Hooghly River. It is situated at 88° 22'55" E - 88° 30'16" E and 22° 28'00"N - 22° 35'18"N. Around 46% of the total area is human-made wetlands. The rest of the area is a combination of agricultural lands, horticulture, garbage dumping fields, and the growing regions (Parihar, Sarkar, Dutta, Sharma, & Dutta, 2013). The area experiences hot and humid subtropical climate with mean rainfall (June-September) 160cm (IMD 1901-2000). The maximum temperature during summer (April-May) remains around 40°C, and in winter (December-January), the minimum temperature remains around 10°C (IMD 1901-2000). Hydrology of this wetland is unique as it does not have such a catchment area of its own. Approximately 250 million gallons of sewage per day are being introduced to it. There is hardly any aquifer up to a depth of 400 feet. Initially, EKW was saltwater lakes situated between the Bidyadhari River and Hooghly. There is a massive change in the land use pattern since the 18th century, mainly because of the reclamation, silting of rivers, and diversion of wastewater, which result in the marshes being stagnant and disconnection from the Bay of Bengal. It is now acting as a spill basin for Kolkata for both rainwater storage and flood.

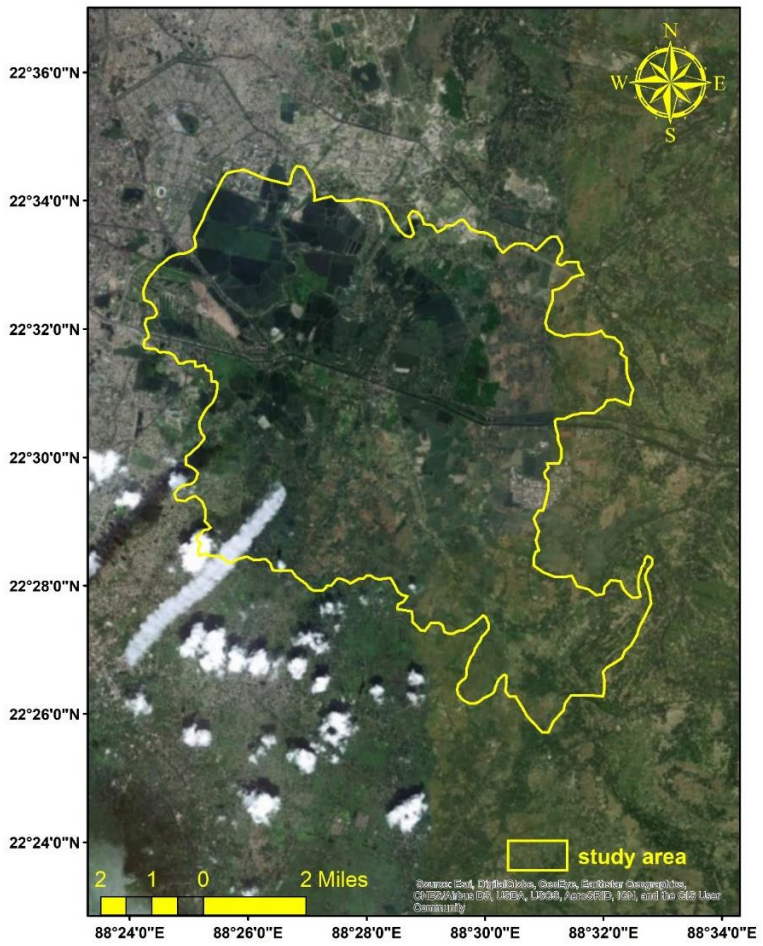

Figure 1, Location of East Kolkata Wetlands

3. DATASET AND METHODOLOGY:

The Global Surface Water dataset is developed by the European Commission's Joint Research Centre (Pekel et al., 2016). This dataset quantifies the changes in global surface water using three million Landsat satellite images over the past 32 years at 30m resolution. The data, along with the ancillary files, are freely available and can be accessed via Google Earth Engine for further analysis and processing.

Different aspects of the spatial and temporal distribution of the surface water from 1984 to 2015, has well captured by the dataset. It has been successful in recording the months and years when water was present, where occurrence changed and what form changes took in terms of seasonality and persistence. The dataset enables the quantitative measurement of the effect of climate change on surface water occurrence and proves how human activities alter the surface water.

The Global surface water dynamics have been recorded from coarse-spatial-resolution satellite observations. Seasonality maps are generated using Landsat satellite imagery at an interval of 5 to 10 years. Spatial variability of global surface water and its long-term changes are captured by using the entire multi-temporal orthorectified Landsat 5, 7, 8 archives from 1984 to 2015. Finally,

each pixel of the Landsat data has been classified into the land, water, and non-valid observation using an expert system. In this study, the following products have been used:

a) Water Occurrence: The water occurrence shows the frequency with which water was present on the surface from 1984 to 2015. It also provides information on overall water dynamics along with the intra and interannual variability and changes.
b) Occurrence Change Intensity: This shows the change in the occurrence intensity between two epochs 16th March 1984 to 31st December 1999 and 01st January 2000 to 10th October 2015 in both the direction. Dataset is prepared by the difference in the occurrence of homologous pairs of months from both epochs and then averaged.
c) Recurrence: This is the measure of interannual variability in the presence of water and the frequency with which water returns from year to year expressed as a percentage.
d) Transition: The transition map provides the changes between different water classes (such as not water, seasonal water, permanent water, etc.) computed for the first and last year.

In the current study, the Global Surface Water dataset is extracted for the East Kolkata Wetland. This freely available data is advantageous to understand the state and change in wetland ecotones and improve the water-management decision-making system.

4. RESULTS AND DISCUSSION:

4.1 Water Occurrence at East Kolkata Wetlands (1984-2015)

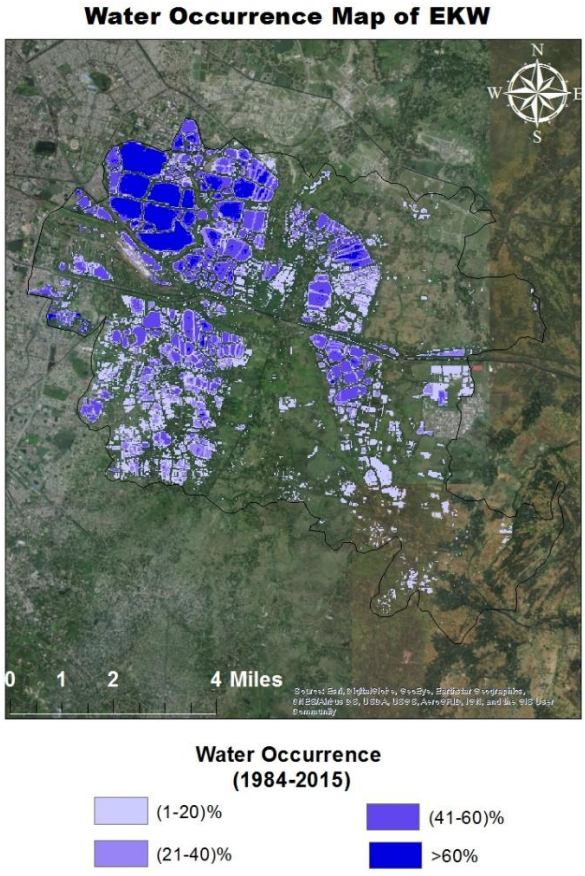

Figure 2, Area wise water occurrence percentage of EKW

The total area of EKW is known to be around 12,500 hectares, of which about 3,300 hectares is found to have water existence. Figure 2 shows the water occurrence percentage in different parts of EKW. It can be clearly observed that the water occurrence is maximum in the northern part of the EKW. On studying the water occurrence concerning the area, it is found that only 460 hectares of the region have the water occurrence percentage higher than 60, which implies that from 1984 to 2015, only 14% of the total area appeared as water for more than 60 % of the time. The majority of the area, i.e., around 1,342 hectares, makes 40% of the total area, appeared as water for less than 20 % of the time. The possible reason for this could be the seasonal rainfall in this area. Furthermore, around 683 hectares of space (25%) appeared as water for 20 to 40 % of the time, and 818 hectares (21%) of the area has 40 to 60 % water occurrence (figure 3).

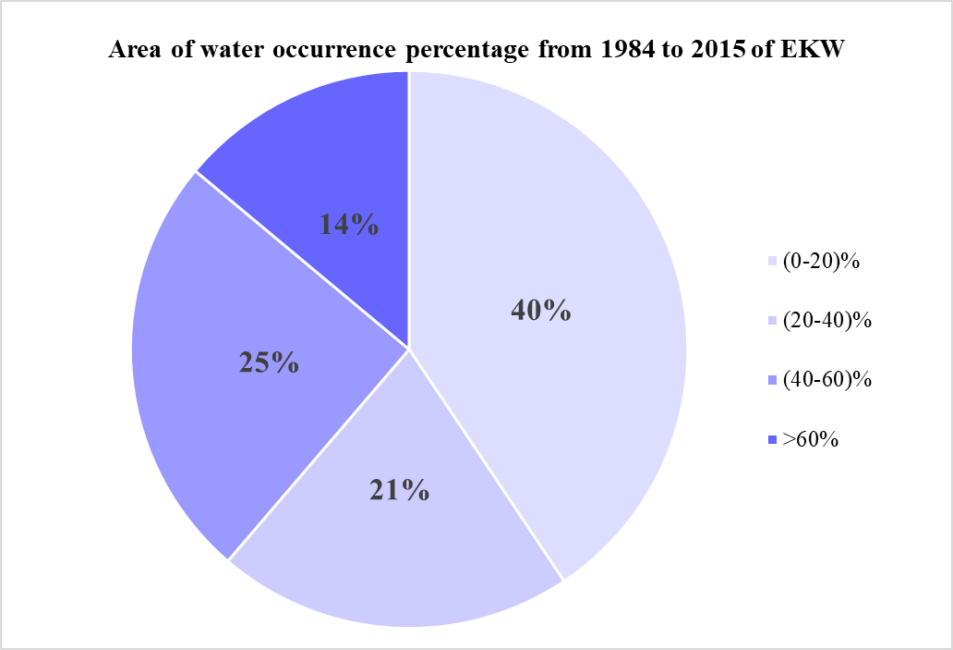

Figure 3, Area of water occurrence percentage from 1984 to 2015 of EKW

4.2 Water Occurrence change intensity at East Kolkata Wetlands (1984-2015)

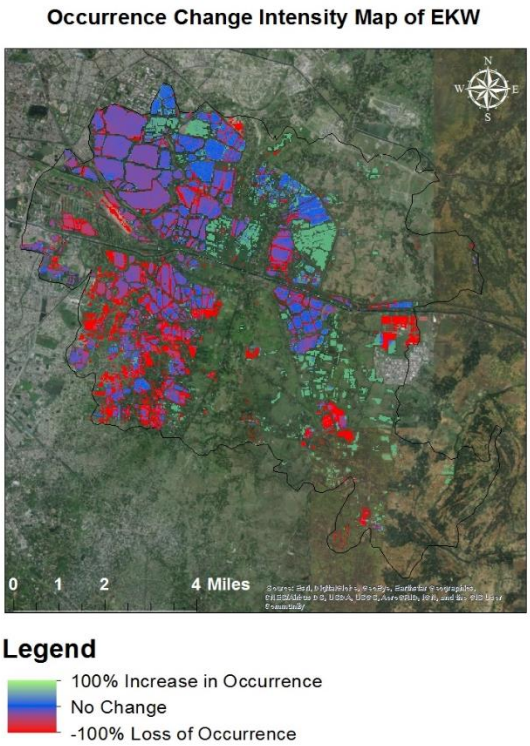

Figure 4, Occurrence change intensity Map of EKW

The change in water occurrence intensity map of the EKW is shown the figure 4. The map shows an increase in water occurrence towards the eastern part of the EKW, but at the same time, it can be observed that there is a loss of water occurs at the majority of the area. On further analysis, it was noted that approximately 473 (36%) hectares of the region have a 100 % increase in the water occurrence. In contrast, around 741 hectares of the area have a 100 decrease in water occurrence. So, at about 270 hectares of water area has been lost, and only 115 hectares of the region remained unchanged (figure5).

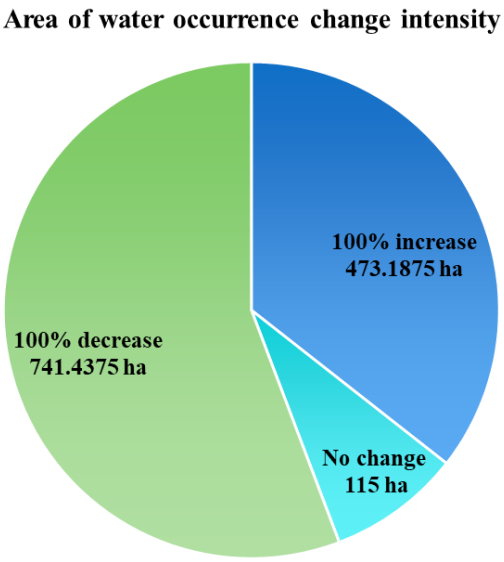

Figure 5, Area of water occurrence change intensity

4.3 Water Transition at East Kolkata Wetlands (1984-2015)

The transition of the water body into the land and vise versa is a common phenomenon in this area due to the fishing practice used. But the results shown here are drawn from a long-term observation that should not have short term influence. The positive change in the water occurrence is evident in the eastern part, whereas the decrease is concentrated in the western part due to the rapid urbanization in this region.

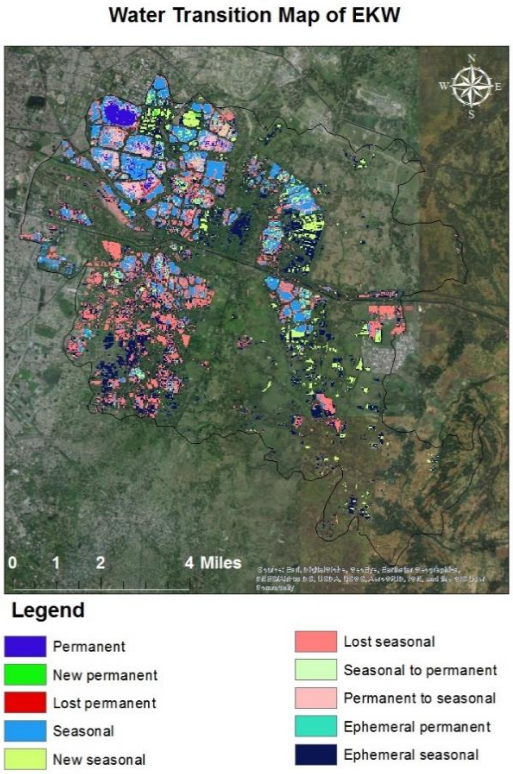

Figure 6, Water transition of EKW

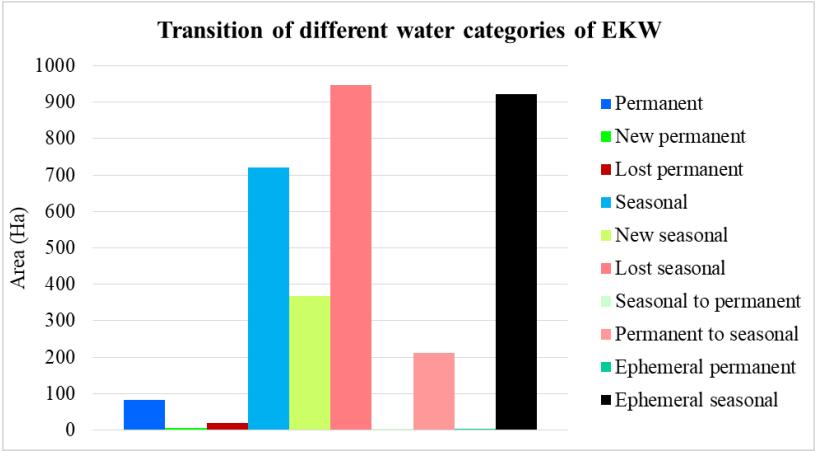

Figure 7, Area of different water categories of EKW

The categorical distribution of water of the EKW is shown in figure 6. The area of the different categories of water is shown in figure 7. It can be observed that the permanent water area of EKW is very less compared to the total area. The presence and absence of water in this region vary due to specific natural and anthropogenic reasons such as floods, fishing practice, etc. The result shows 15 hectares decrease in permanent water. In the southwestern part, an overall reduction in the seasonal pool is also observed. The temporary, seasonal water is quite high in this region. This is due to the fact that the slope of the area is very less so during the monsoon, a massive amount of region is covered by the sudden introduction of the rainwater in this region. A considerable part of the permanent water has become seasonal; on the other hand, the conversion of the seasonal pool into durable is negligible. It is quite evident from the result that the water as a whole has decreased, and the transition of water has a negative relation with time.

4.4 Water Transition at East Kolkata Wetlands (1984-2015)

The recurrence map (figure 8) shows the reappearance of the water on year to year basis. Approximately 2286 hectares area in the northern part has a complete recurrence, which is about 63% of the neighborhood (figure 9). Moreover, the repetition is comparably low in the southern part of the region, where mainly seasonal water is present.

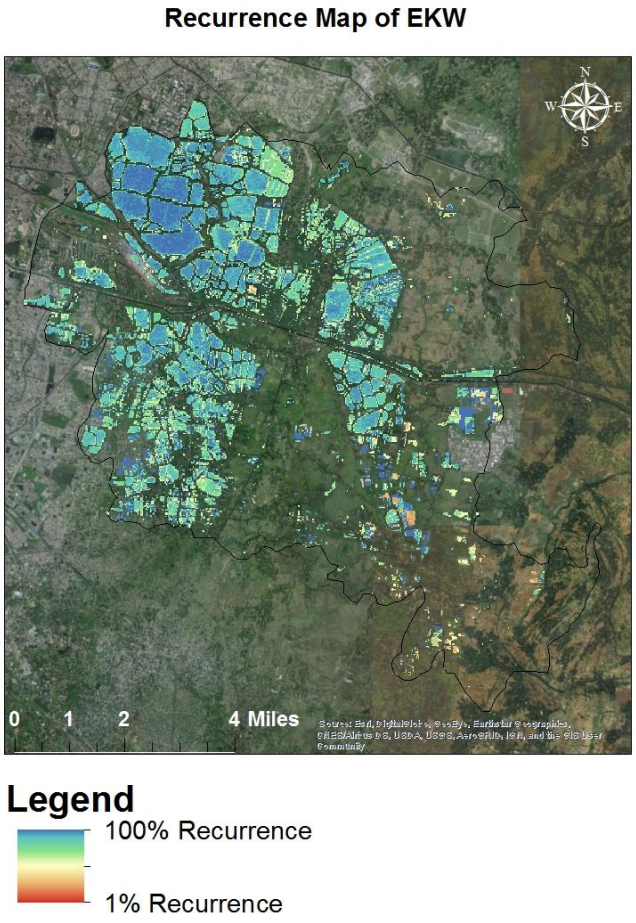

Figure 8. Surface water recurrence map of EKW

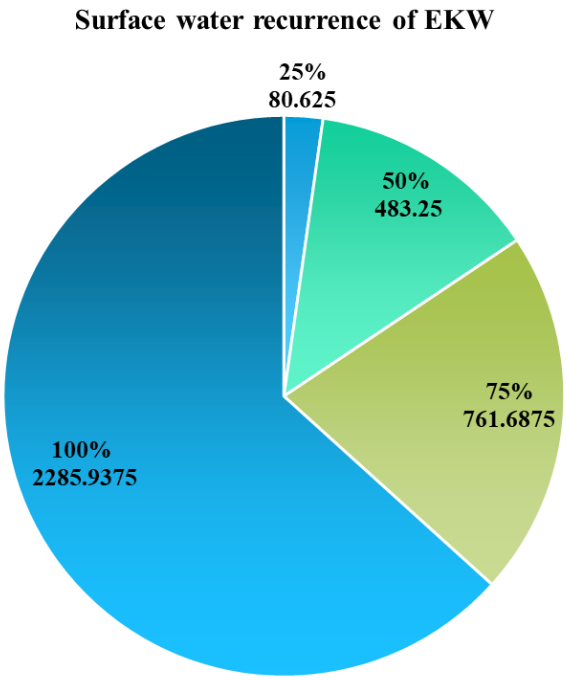

Figure 9. Area of Surface water recurrence map of EKW

5. CONCLUSIONS:

The Global Water dataset helps understand the wetland dynamics and understand the trend of surface water change. From the analysis of the dataset, it is evident that the surface water area of EKW has decreased considerably. The surface water status of EKW is dynamic, and its spatial extent is different at different times of the year. The result also shows that the transition of the surface water has a negative relation with time. The effect of losing surface water is maximum near the science city part of the EKW.

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