# Water Level and the Potentials for Wetland Formation and Sustainability in Lower Ogun River Floodplain, Nigeria

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**ABSTRACT:** Identification, delineation and monitoring of wetlands which requires the understanding and application of their ecological characteristics are critical factors in wetland management and conservation. This study assessed the potentials of wetland formation and sustainability in the lower Ogun river basin by determining the levels of surface and ground water. The study area was divided into 1 km$^2$ grids of 67 units using 0.052 % sampling intensity for the assessments in dry and wet seasons. Monthly water table levels were assessed in 50 cm soil pit while inundation levels were measured during the flooding event using staff gauge. Assessment was carried out for one year during which frequency and periodicity of water table and inundation events were recorded. Results revealed that low water table level ranged from 5 to 45cm of soil depth and occurred between August and September within 6 grids. Water table and surface water was recorded within a period of 2 – 10 weeks during the rainy season. The peak of water levels coincided with the peak of precipitation (> 200 mm) ranging from 30 to 280 cm between September and October while covering 28.75 km$^2$. Conclusively, surface and groundwater levels were recorded during the rainy season having direct variation with the volume of precipitation for a duration that is long enough to support the formation of wetland hydrophytes and hydric soil.

Wetlands are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (Department for Water Affairs and Forestry, DWAF 2010). Hydrology is considered the master variable of wetland ecosystems, driving the development of wetland soils and leading to the development of the biotic communities, it can determine plant species composition as well as the distribution of species within a wetland, their productivity and capacity for nutrient uptake (Fennessy *et al*. 2004). Prolonged presence of water in wetlands is a fundamental determinant of soil characteristics and species composition. It describes the patterns of water storage and movement within and across the wetland's boundaries which could have strong seasonal patterns, largely as a result of changing rainfall and sunshine intensity and is said to determine the flora and fauna, biogeochemistry and productivity of wetlands (Greater Wellington Regional Council, GWRC 2005). Alteration of hydrology could lead to the decline and eventual death of wetlands in general. Many areas, like river basins that are presumed to have wetlands because of their proximity to water bodies could lose their wetland status due to hydrological modifications or change in precipitation patters. It is such a critical factor that has great cause and effect consequence as explained by Turner and Lewis (1997) on how about 20 hectares area of mangrove trees were killed when a road was built across a natural channel leading to the gulf of Mexico in Clam Bay, Collier County, Florida. The changes appeared to be due to hydrologic modifications from a road that reduced freshwater fluxes into the area and produced hypersaline conditions that was lethal to mangroves. Similar situations were recorded in Laguna Boca Quebrada, Porto Rico and South Lousiana (Turner and Lewis 1997). The hydrological status of many wetlands are not determined having a reputation based on longstanding assessment or even an assumption. Studies involving the description of wetland hydrological system are important for conservation and easy detection of hydrological modifications which could help in restoration effort in the advent of reconstruction of degraded wetlands. This study

assessed the potentials of wetland formation and sustainability in the lower Ogun river basin by determining the levels of surface and ground water being the primary ecological drive force.

## MATERIALS AND METHODS

*Study area:* The Ogun River is within latitudes 6º 26' N and 9º 10′ N and longitudes 2º 28′ E and 4º 8′ E Southern Nigeria, with about 2% of the basin in Benin Republic, having a land area of 23,000 Km$^2$, with a generally low relief with the gradient in the North-South direction (Bhattacharya and Bolaji, 2010). Opeki and Ofiki Rivers are the main tributaries while Eriti Forest and the banks of Ogun River are the main ecosystems. The study area is a freshwater forested floodplain which is a section of the Lower Ogun River basin. It is located in Obafemi - Owode Local Government Area of Ogun State, Nigeria and which falls in the humid tropical rainforest zone on latitude 6º 50′ N to 7º 50′ N and longitude 3º 18′ E to 3º 32′ E (Fig. 1). It covers an estimated area of 153 Km$^2$. The map of the study area was premised on a national baseline survey conducted by Cedar Groove Management Company (CGMC, 2008).
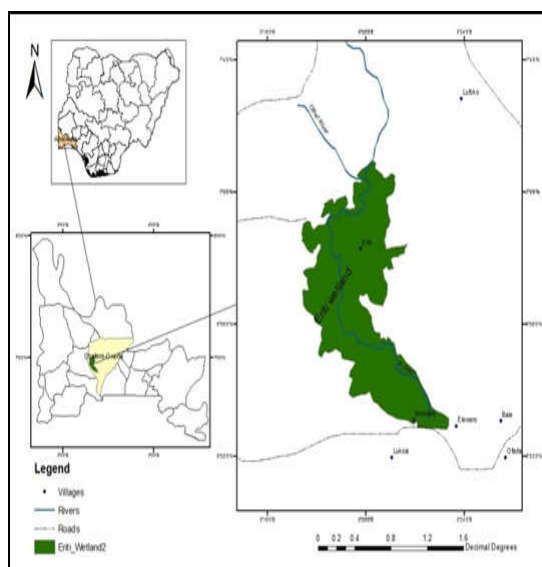

**Fig. 1** Map showing the location of the study area

*Sampling method:* The study area of approximately 67 Km$^2$ was divided into 1Km by 1Km Grid (Fig. 2) which gave a total of approximately 67 Grids. Based on a sampling intensity of 0.052 %, assessments were carried out within 14 randomly selected grids. Four 25 m by 25 m plots were randomly placed within each of the 14 grids where assessments of saturation and inundation were done within each plot. Within each grid, four (4) randomly placed sampling plots were used but where it became necessary due to constraints,

initial plot positions were re-adjusted to a new position on the field. Therefore, all assessments were carried out within 56 sample plots of 25m x 25m each.
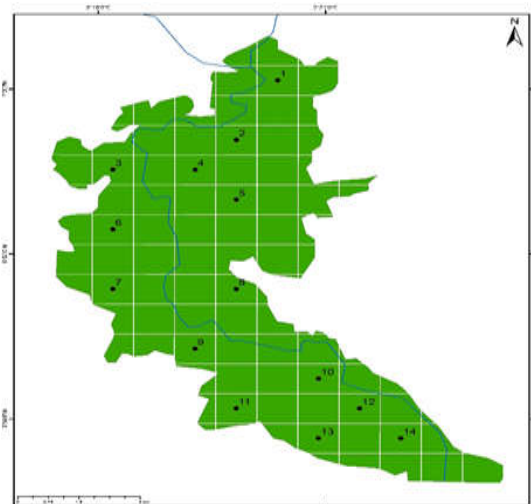

**Fig. 2** Randomly selected grids based on 0.052 % sampling intensity

*Assessment of Saturation and Inundation:* Assessments were carried out in 2016 within 14 randomly selected grids. Within each grid, four (4) sampling plots were randomly selected with a minimum distance of 40 m. However, where it became necessary due to constraints, initial plot positions were re-adjusted to a new position on the field while maintaining the distance. Therefore, all assessments were carried out within 56 sample plots of 25m x 25m each. Ground water was assessed by digging a soil pit to a depth of 60 cm and observing the level at which water stands in the hole after sufficient time has been allowed for water to drain into it. In instances where water was observed at the bottom of the hole but has not filled to the top, the side of the hole was examined and the shallowest depth at which water is entering the hole was recorded. Water levels in soil pit were measured with standard 30 cm ruler and the values were recorded with negative values to differentiate it from surface water values. Sample plots within which water was found at a depth ≤ 50 cm from the ground level were noted as saturated. This assessment was conducted monthly from January to December. Surface water levels were measured with staff gauge at some accessible locations while the general height and areal extent of inundation was derived by interpolating the measured values for other areas using the interpolation technique of ArcGIS. The duration and frequency of inundation were also recorded. The presence of ground water and or surface water was taken as a positive indicator of wetland hydrology.

Precipitation data was obtained from secondary data source (Nigerian Meteorological Services) while topography, slope and drainage maps were analysed and generated using hydrogeomorphology tools of ArcGIS 10.0.

## RESULTS AND DISCUSSION

There was no groundwater and surface water in Grids 1, 10, 12 and 14 while saturation value of 30 cm was recorded in Grid 2 in October. Despite a lack of groundwater, Grids 4 and 5 were inundated between September and November with peak inundation values of 12 cm and 210 cm respectively occurring in October. Groundwater was observed in August at the depth of 30 cm, 20 cm and 45 cm within Grids 6, 7 and 9 respectively and by September at a depth of 5 cm, 40 cm, 40 cm and 45 cm within Grids 9, 3, 8 and 11 respectively (Fig. 3).

Saturation was overtaken by surface water in October at the heights of 115cm, 192 cm, 118 cm, 280 cm and 90 cm within Grids 6, 7, 8, 9 and 11 respectively. Meanwhile, by November, water levels had dropped significantly where varied levels of groundwater or surface water occurred at 45 cm, 46 cm, 34 cm and 42 cm within Grids 6, 7, 9 and 11 respectively however by December, water levels had dropped deeply below 50 cm of the soil depth leaving all grids in total dryness as illustrated in Fig. 1 and Plate 1. Surface water analysis showed that Grids 3, 4, 5, 6, 7, 8, 9 and 11 were inundated from September to the end of November from a height of 30 cm to 280 cm while interpolation showed that approximately 28.75 Km$^2$ (41.93 %) of the entire study area were also inundated.

The interpolated extent of surface water is illustrated in Fig. 4. This is similar to the findings of Acreman and Miller (2007) where water discharges from the La Mancha aquifer when groundwater levels are high but when groundwater levels are low the direction of groundwater flow is reversed and water moves downwards from the wetlands to recharge the aquifer. Groundwater and surface water lasted for about sixteen weeks (112 days) which is long enough for the growth of hydrophytic vegetation and development of hydric soil, (USACE ; DWAF, 2010). It is known that during this period, the soil would be subjected to oxidative pressure leading to the formation of gleying or mottles while hydrophytic plant species which are more adapted to the condition will begin to thrive.



**Plate 1** Gradual increase in saturation levels within different grids (a, b, c) and water levels before (d) and during (e and f) inundation
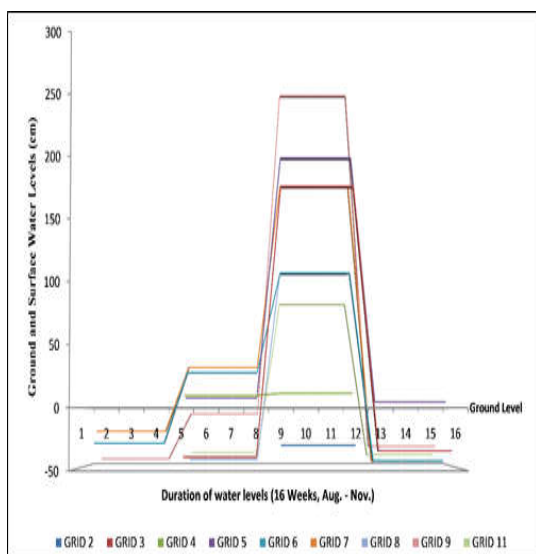


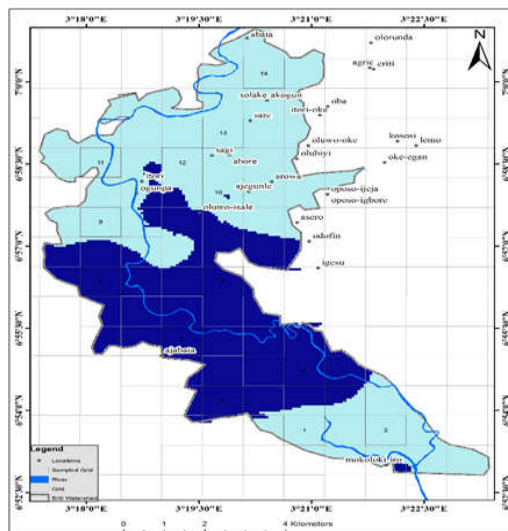**Fig. 3** Hydrograph showing duration of groundwater and surface water levels in Grids



**Fig. 4** Map of study area showing extent of flooding (**Source:** Nigerian Meteorological Services 2017)

Hydrology was primarily driven by the intensity of precipitation as shown in Fig. 5.
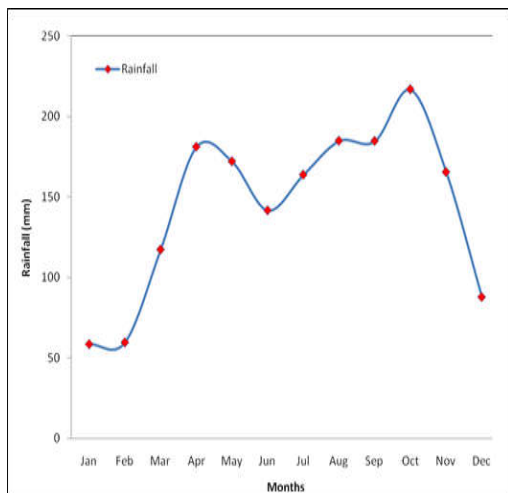


**Fig. 5** Monthly variation of rainfall for the year 2016

Groundwater levels were near the surface as precipitation reached about 200 mm in August. This continued till September when surface waters were recorded in 4 grids due to poor drainage of the area. There was a sharp rise in surface water level reaching up to 280 cm in a grid. This occurred due to over-bank flow from the river at the peak of rainfall (225 mm) in October. This implied that the formation and sustenance of wetlands within this river basin largely depends on rainfall pattern and volume. Unlike some wetlands fed by underground water and aquifer, this floodplain is majorly fed by precipitation. The level, extent, timing, frequency and duration of surface and groundwater depends on the intensity and duration of annual rainfall. If the early rain had a higher volume, there was the possibility of having high water table and even surface water as early as April (Fig. 5) within the same year. Also, high groundwater and surface water levels may not exist, unless a high volume of rainfall is recorded. This means that wetland hydrology can be influenced by climate change because in the event of a prolonged dry spell or a period of low rainfall, the wetland soil could become dry and parched. In such situation, hydrophytic species may be succeeded by upland species while wetland fauna might be forced to migrate. If such situation continues, the wetland might be eventually lost.

*Conclusion:* The study area is a poorly drained flat-lowland. The groundwater is rain-fed while most of the surface water through overbank flow is rain-induced. The formation and continued existence of wetlands is contingent on the level and duration of ground and surface water which depends on rainfall. This study finds that with or without flooding, high level of rainfall could be sufficient for wetland development and sustenance in a poorly drained floodplain as opposed to the belief that flooding is necessary.

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