ABSTRACT

Lagoons and lakes are important waterbodies on the earth those serve as water resources for countless living beings, and help the nature in keeping the balance of ecosystem. Lakes are natural or artificial inland water bodies, which may contain fresh water or saline. Lagoons are shore parallel coastal semi marine natural water bodies separated from the sea by sand bar’s or barrier spit’s and connected with sea/ocean by one or more restricted inlets. General characteristics of those vary widely depending upon the location, geology, size, depth, inflowing and out flowing drainage systems etc. Various geophysical transformations including changes in morphological, meteorological and hydrological parameters of the waterbodies and the surroundings occur due to population growth, human interventions on the natural systems, change in land use and land cover, degradation of catchment area etc. Hence, study of geophysical changes of these natural water bodies is of great importance. Here, it is intended to carry out detailed study on such a natural waterbody of global importance, the ‘Chilika lagoon, a designated Ramsar site’.

The Chilika, the largest brackish water lagoon in Asia located in the east coast of Odisha state in India, adjacent to the Bay of Bengal, which is sustaining the livelihood of millions, and maintaining ecosystem of the region for ages. The lagoon is fed by number of very small rivers and rivulets from western side of the lake, but it receives its major contribution from the inflow of the rivers Daya and the Bhargovi, the branches of the Mahanadi river system from north/north eastern sides. Changes in flow pattern of the inflowing rivers became a threat of changing the brakish water lagoon into a fresh water one. During 1990’s it was observed (i) the portion of water spread area was converted to landmass because of sedimentation, (ii) average depth of the lagoon was reduced, (iii) the tidal inlet in outer channel shifted to extreme north (iv) the main inlet to the lagoon got silted up reducing exchange of flow, (v) about 40% of brackish water species dissapeared, (vi) the aqua catch was drastically reduced, (vii) the number of nomadic avifauna in bird sanctuary (at Nalabana) reduced, and siltation became also a major concern as it is leading to different geomorphic changes that are affecting various characteristics of the lagoon.

To mitigate the issues few non-structural and structural measures were taken up by the Government. Series of interventions taken up, those are: (i) opening of a mouth in the spit at Sipakuda, (ii) dredging a direct inlet to sea in front of the Magarmunha corridor
(2000), (iii) diversion of flood discharge directly into the Bay of Bengal through the Mangala cut via the Kanchi river, a sub-branch of the river Bhargovi; (iv) the Gobkund cut in the Bhargovi river, and (v) raising and strengthening of levees along the Daya and Bhargovi rivers etc have reduced flood flow and silt flushing efficiency of the lagoon into the sea. Apart from these, the Naraj barrage, a major structure, was constructed in 2004 on the river Mahanadi at the mouth of the river Kathajodi as the most important remedial action to regulate the discharges through its branches, thus siltation, into the lagoon. Notable effects of the operation of the barrage are also observed. Still few hydrologic and morphologic problems persisted and new problems created. Some of those are: (i) shrinkage in lake area due to increased sedimentation in the lagoon by inflow of sediments from the inland rivers, (ii) closure of old tidal inlets and opening of natural ones and their migration, (iii) change in land use and land cover pattern, (iv) decrease in salinity and poor vertical mix, (v) proliferation of fresh water weeds (Ipomea and water hyacinth), (vi) proliferation of phytoplanktons, (Nalagrass) etc.

This warranted for the holistic study of the effect of the Naraj barrage on the entire system. The present work is an attempt at detailed study of the current scenario of the lagoon with special reference to the effect of the Naraj barrage. The following studies are taken up during the study.

Geomorphologic changes in various features of the lagoon proper such as water spread area, barrier spits and barrier islands, closing, opening and migration of the tidal inlets, the inflowing river systems and other various peripheral land features due to effects of different natural processes from aspects of hydrology, hydrodynamics, geomorphology and sedimentation of the lagoon were carried out. Dimensional verification of water surface area, length of different features in the lagoon and the surrounding area were taken up through use of the toposheets issued by the Geological survey of India, AWiFS satellite images of NRSC Hyderabad, Google Earth and USGS Earth Explorer etc.

Rainfall being the most important meteorological parameter, which controls sustenance of the nature, study of rainfall in an area becomes very much essential. Common statistical methods for analysis of hydrologic data adopted are frequency analysis, regression analysis, and screening of time series etc. Frequency analysis is conducted for estimation of occurrences of an inconsistent event and for assessing its
reliability, which is used for determination design precipitation for design of water resources structures. Regression analysis is generally used as an efficient tool for identifying the relations among the hydrologic parameters in separate locations, among various parameters of hydrologic models. Screening of time series is adopted for checking the consistency of data available. With the above objective the rainfall data collected from the different raingauge stations of the study area were analysed. Formation of a large artificial waterbody by the Naraj barrage would affect the futuristic rainfall pattern and quantum of runoff in the inflowing rivers into the lagoon. Prediction of the precipitation of the said area conducted in this study may help further study of the extreme natural events occurring in these area such as; Cyclonic Storm 1999, Phailin-2013 and Hudhud-2014 etc. occurred during the last decade.

Statistical analysis of runoff in the rivers has been conducted based on the available data of daily discharge and sedimentation during Pre and post Naraj barrage period for estimation of future sedimentation in the river Mahanadi. Linear and nonlinear regression models have been developed. The time series curve highlights that the sediment concentration is reducing year after year. The summary of results of observations (sediment and discharge) for monsoon period of the river Mahanadi (1993-2009), the Daya and the Bhargovi for the period 1999-2003 (pre-barrage) and 2004, 2012-2013 (Post barrage) are presented in concerned chapters.

Sedimentation in the lagoon is the major problem that influences all characteristics of the lagoon. Two separate observatories were established in the rivers Daya and the Bhargovi for measuring quantity of sediments. Geotechnical studies of the sediments were carried out in the laboratory to ascertain the quality of the materials. It is observed that sediment concentration has reduced from 0.288 gm/lit to 0.166gm/lit for the river Bhargovi and 0.268 gm/lit to 0.218 gm/lit for the Daya. This result may be attributed to the construction and operation of the Naraj Barrage. Based on the physical data collected, prediction of sediment in the river Daya and the Bhargovi inflowing into the lagoon for the period 2015 to 2050 has been worked out through statistical modelling and Artificial Neural Network (ANN). It is estimated that by 2030 the sedimentation in the Daya and the river Bhargovi shall be 2.41 MMT/yr and 1.47 MMT/yr, and by 2050, the same shall be 8.93 MMT/yr and 5.88 MMT/yr, respectively. It was revealed that though the
concentration of sediments reduced in both the rivers, the annual quantum of sediments increased due to predicted increase in inflow.

The Naraj barrage being the largest intervention in the system that was purposefully constructed to regulate discharges into the lagoon, its effect on the system is studied in detail. To conclude, a suitable operation policy for the Naraj barrage has been suggested after detailed study.