Large storage structures in the humid tropics help to optimally utilize the water resources, which show great variability with seasons. With increase in population, rivers became the major freshwater source for domestic and industrial water supply and irrigation in Kerala State. Since water release from the HEPs in the State is not based on any management policy, decisions on the water release downstream after power generation, never take into account the EFR. The present release patterns cause much deviation from the natural flow regime. Added to this, the downstream reaches of these rivers are subjected to excessive sand mining and discharge of sewage and even untreated industrial effluents, which cause degradation of wetlands and the riverine ecosystems.

The daily streamflow data for five decades were systematically analyzed using different time series windows. The statistical time series and trend analysis brought to light the positive impacts of flood moderation and summer flow augmentation by the HEPs.
The utilization of water by different sectors from the Periyar and Muvattupuzha rivers was represented using a schematic line diagram. The study also quantified the surface water utilization by major sectors.

The concept of environmental flows has been introduced which is not in vogue in India. The present study analyzed impact of regulation by the three HEPs in the Periyar-Muvattupuzha river system using IHA framework. The hydrologic alterations from two reference conditions were analyzed. The natural regime of gauging sites in the Periyar river basin were successfully characterized for the reference conditions of the Mullaperiyar and Idukki projects along with the hydrological alteration at each site.

The CPI method, explicit ratio curves and Muskingum methods were used for simulating undisturbed flow regime for the Periyar river.

A separate analysis using normal-year data was done to eliminate climate variability and to highlight the impact of anthropogenic changes. Impacts of interbasin and intrabasin regulations were quantified. These characterizations allow for an improved understanding of the natural hydrologic system as well as the potential hydrologic alterations at each site for different degrees of regulation. The DHRAM scoring was used to classify hydrologic alterations in the rivers.

The study analyzed scenarios of additional water diversion from the two basins. Analyses show that through proper water management, considering the needs in different sectors and the environmental flow requirement, the hydrologic alterations due to regulations can be minimized.

The specific conclusions are given below:

- The statistical analyses show that the interbasin water transfer from the Idukki HEP caused reduction in streamflow in the Periyar river. The analyses also show that as the degrees of regulation increased after the commissioning of
Chapter 8. CONCLUSIONS

Idamalayar and Lower Periyar reservoir (intrabasin regulations), flood moderation and lean flow augmentation in the downstream of the Periyar river improved.

- Interbasin water transfer to the Muvattupuzha river from the Idukki HEP created an eco-surplus condition as the river received an average flow of $45m^3/sec$ of freshwater as diverted flow from the Periyar river basin.

- Improvement in reliable flows supported development of several water dependent sectors in the Periyar-Muvattupuzha system as detailed in the schematic line sketch.

The influence of interbasin and intrabasin controls in the flow regimes of the Periyar-Muvattupuzha river system was systematically studied using IHA framework. Following are the findings from the hydrologic alteration study:

- The impact of Idukki project on the downstream flow in the Periyar river was considerable. But the interbasin water transfer caused substantial alterations in several of the hydrologic indicators in the Muvattupuzha river compared to the cumulative impacts of regulations in the Periyar river basin.

- Hydrologic alterations in the rivers increased with the increase in the degrees of regulation.

- In both the Periyar and Muvattupuzha rivers, the low flow indicators were sensitive to regulations and showed considerable alterations when the degrees of regulation changed.

- Analyses of hydrologic alterations using normal-year data showed higher hydrologic alterations compared to the analysis using complete data set in several
cases. Hydrologic alteration quantified using the streamflow before the Mullaperiyar project as the reference condition was different from the HA values derived using streamflow before the Idukki HEP as reference.

- The DHRAM scoring classifies hydrologic alterations in the Periyar river under the “moderate risk” category and the Muvattupuzha river under the “high risk” category.

- Scenario analyses show that the diversion of excess freshwater from the Muvattupuzha river will reduce the value of non-attainment, but several other factors like water shortage and duration, possibility of conjunctive use of groundwater and surface water to meet future demands etc. have to be looked into before such diversions are attempted. The scenario analysis of water diversion from the Periyar under IIP show that non-attainment will increase once water is diverted for irrigation.

8.1 Scope for future research

Construction and operation of reservoirs for power generation, flood moderation and summer flow augmentation inevitably induce hydrologic alterations in the natural flow regime in a river. This will be one of the main threats to aquatic and riparian biota. An attempt was made to remove possible impacts of rainfall variability on hydrological processes, by focusing attention on the influence of reservoir operations on streamflow regimes. However, with the method used in this study, it is almost impossible to exactly differentiate individual roles of rainfall variability and human activities on hydrologic alterations. Complicated climatic changes along with intensive human activities have the potential to affect the flow regime, which introduces uncertainties into assessments of hydrologic changes.

It is necessary to further quantify and address such uncertainties in the future research works. The current research has shed light on the impact of HEP on
hydrologic regimes. The regional water resources management in the humid tropics will greatly benefit from the research results. Further investigations on the impact of hydrologic alteration resulting from reservoir operations and its impact on the aquatic environment are called for. A multi-disciplinary approach using a systematic data base is needed in such studies. Research on development of such policies for regulated rivers may considerably enhance water availability for the society and sustainability of aquatic and riparian environment in river basins of humid tropics.