Model Development for Assessment of Unmet Irrigation Water Demand in Left Bank Development Area of the Deduru Oya Reservoir Project

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Model Development for Assessment of Unmet Irrigation Water Demand in Left Bank Development Area of the Deduru Oya Reservoir Project

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Abstract*: Rainfall in Deduru Oya basin has a significant temporal variation and thus the Deduru Oya carry flash floods during rainy season and very low flows during dry season. The multi-purpose Deduru Oya reservoir project with a reservoir of a capacity of 75 Million Cubic Meters (MCM) augments water resources in 136 existing tank based irrigation systems in the Deduru Oya Left Bank through a Left Bank (LB) canal and also diverts water to the Iginimitiya tank in the Mee Oya basin through a Right Bank (RB) trans-basin canal. This study is focused on the setting up of WEAP21 version 3.43 (Water Evaluation And Planning) model to study the water management including diversion requirement from the Deduru Oya reservoir through the LB canal to supplement LB irrigation demand. Hydrological Engineering Center-Hydrological Modeling System (HEC-HMS) is used for runoff estimations and CROPWAT model is used to estimate crop water requirements. WEAP model is used for water balance simulations in Deduru Oya LB canal development area and to calculate water requirements from LB canal for the period of recent 10 years. The study reveals that the annual unmet demand varies from 26 MCM to 41 MCM without Deduru Oya reservoir project and from 0.44 MCM to 1.07 MCM with Deduru Oya reservoir project, for the study period from 2000 to 2010. The developed model can be used as a tool for irrigation water management and drought impact assessment in the LB development area of the Deduru Oya reservoir project.*

Keywords*: Deduru Oya, Hydrological Modeling, Irrigation, Unmet demand*

1. INTRODUCTION

The Deduru Oya carries flash floods during rainy season and very low flow during the dry season owing to the significant temporal variation of its basin rainfall. Also, rainfall is the only source of water and there are no trans-basin diversions into or out of the basin at present. It releases about 1600 MCM of water to the sea annually without being much used in the basin. Deduru Oya basin, which has an area of 2620 km^2 is the sixth largest river basin in Sri Lanka flows through Matale, Kurunegala, and Puttalam districts. There are several anicuts across it to divert water for irrigation, but there is no single reservoir intercepting the Deduru Oya except the reservoir at Thunmodara constructed under Deduru Oya project (Figure 1). There is strong requirement to regulate Deduru Oya flow for its optimum use especially for irrigation during dry season. Even though there are 3000 small tanks are scattered all over the basin there is a considerable issue with water scarcity. Figure 2 shows spatial distribution of current water scarcity in Irrigation systems of Deduru Oya basin (Somaratne, *et al*. 2003).

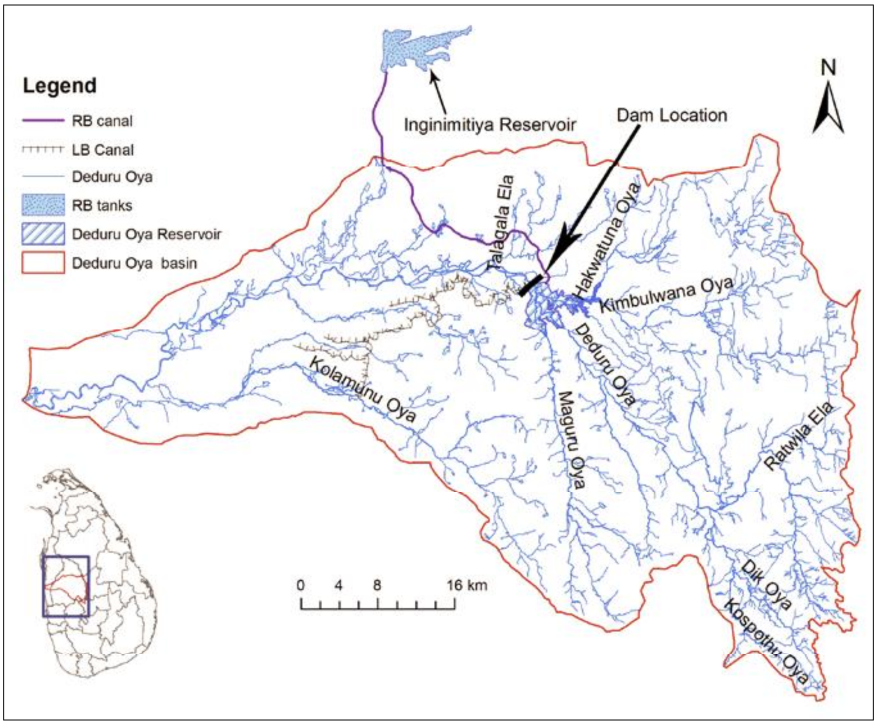

Figure 1 Study area

The Deduru Oya reservoir project is aimed to improve the livelihood of farmers in parts of the North-Western Province by increasing the productivity of its land and water resources by regulating and diverting the water by two main canals. The proposed Left Bank (LB) canal which is 44.1 km long will supply water to augment about 136 existing storage-based minor irrigation systems in the LB of the Deduru Oya (Figure 1). The Right Bank (RB) canal is a trans-basin canal to augment water supply to Iginimitiya reservoir which is located in Mee Oya basin (Figure 1). This study is focused on the setting up WEAP21 version 3.43 (Water Evaluation And Planning) model to study future drought impact on irrigation water availability under different water management scenarios with proposed reservoir project.

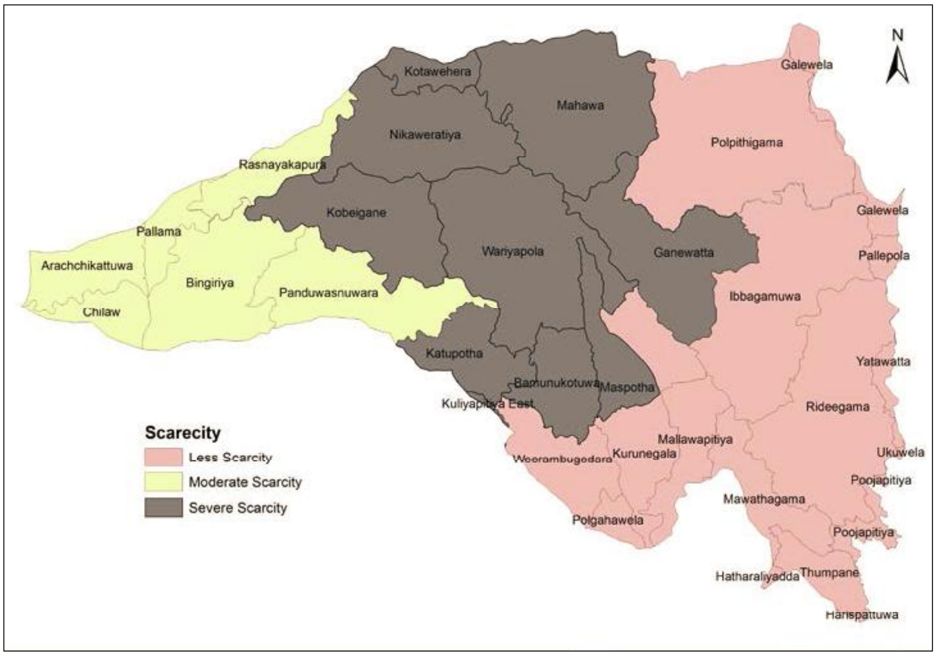

Figure 2 Variation of water scarcity in the basin (Somaratne et al. 2003)

2. METHODOLOGY

WEAP model was developed to Deduru Oya reservoir project and unmet demands of the LB for the period of 10 years from 2000 to 2010. Runoff data and crop water requirements are the model inputs to the WEAP model. As runoff data were not available during the study period, HEC-HMS rainfall runoff model was developed to obtain the runoff data at desired locations for the study period. Crop water requirements were estimated using CROPWAT model (Figure 3).

Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) version 3.0.1 developed by US Army Corps of Engineers in USA (Scharffenberg, *at al*, 2006) was used as rainfall runoff model for each of the catchment. HEC-HMS model was calibrated and verified for the Tittawella Tank in Kurunegala, because of rainfall or runoff data are not available for the rain-fed tanks in LB region. (Sampath, *et al*, 2014). Calibrated HEC-HMS model for the Tittawella Tank and rainfall data at Nikaweratiya and Ridi Bendi Ella stations were used to develop inflows to the minor tanks. Also HEC-HMS model was used to flow simulation of Deduru Oya. Thirty years daily rainfall data from 6 rain gauge stations in the Deduru Oya basin and runoff data at Moragaswewa from 1984 to 1989 together with monthly evaporation data at Mahawa agro-meteorological station was used in the simulation. Diversions, reservoir storages and losses were also accounted in the study (Sampath, *et al*, 2015). Calibrated HEC-HMS model of Deduru Oya and rainfall data at Millawa, Kurunegala, Ridi Bendi Ella, and Wariyapola stations were used to develop inflows to Deduru Oya reservoir.

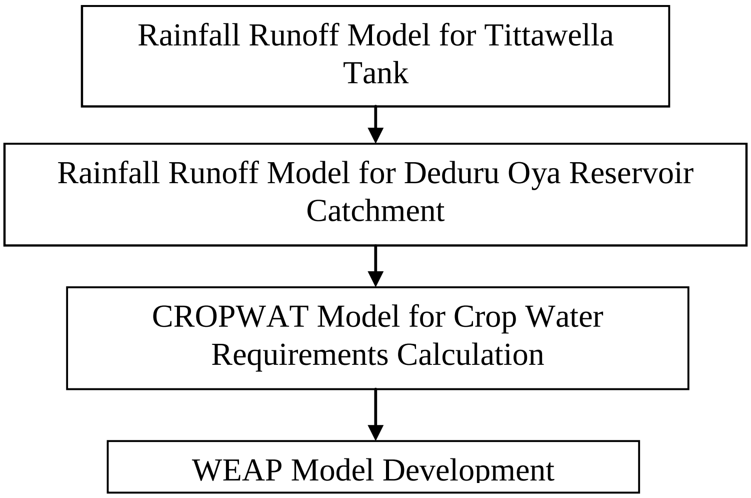

Figure 3 Methodology

The relevant catchment areas, storage areas, natural streams, land use patterns and cascades were identified for each of the 136 rain-fed minor tanks that will be supplied water by the LB canal for modeling the system. Also 12 directly feeding demand sites were identified. Topographic, geology and land use details were collected from the digital data of the Survey Department of Sri Lanka and Arc GIS 9.2 was used as a tool for spatial analysis. In the WEAP model, LB canal was modeled as a "Diversion links" and the minor tanks were connected by "Diversion elements" to LB canal. Demand sites and minor tanks were connected using 188 "Transmission links". Minor tanks were connected to LB canal with 136 diversions. Four types of data viz: Area cultivated annually, Annual water use rate, Monthly variation and Consumption are required at each of the demand sites for WEAP model application. Crop water requirement was calculated using CROPWAT model by assuming 105 day low land paddy will be cultivated. The crop water requirement was calculated on a monthly basis. Rainfall data at Nikaweratiya and Ridi Bendi Ella station in year 2000 to 2010, Mahailuppallama reference crop evapotranspiration rates and crop factors for each growth stage were used for the calculation of crop water requirements. Computations of irrigation water requirements were made using 60% application efficiency and 75% conveyance efficiency. Land soaking and tiling requirement were also taken into account (Pre-feasibility study report, 2000). Calculated crop water requirements and irrigable area data was used to develop demand site 'Annual water use rate' and 'Monthly variation'. Different 'Supply preference' and 'Priorities' were used to model the diversion link and transmission links.

In WEAP model two Flow Requirement elements were used to model RB trans-basin diversion and downstream environmental and irrigation requirements. Annual RB trans-basin diversion water requirement was fixed as 90 MCM. Hydropower requirement was not taken into account in this analysis. The minimum value environmental requirements were used as 3.2 m^3/s (Pre-feasibility Report 2000). Total downstream water requirement was calculated by considering both Ridi Bendi Ella scheme and mandatory release and maximum value was used as downstream irrigation flow requirement.

3. RESULTS AND DISCUSSION

With detailed irrigation demands analyses in LB region, unmet demands in LB region have been investigated. Figure 4 shows the total annual unmet demand from 2000 to 2010 in the LB development area without project. Figure 5 shows annual unmet demand for each demand site with the same scenario. Figure 6 shows that annual total unmet demand with project for each demand sites from 2001 to 2010.

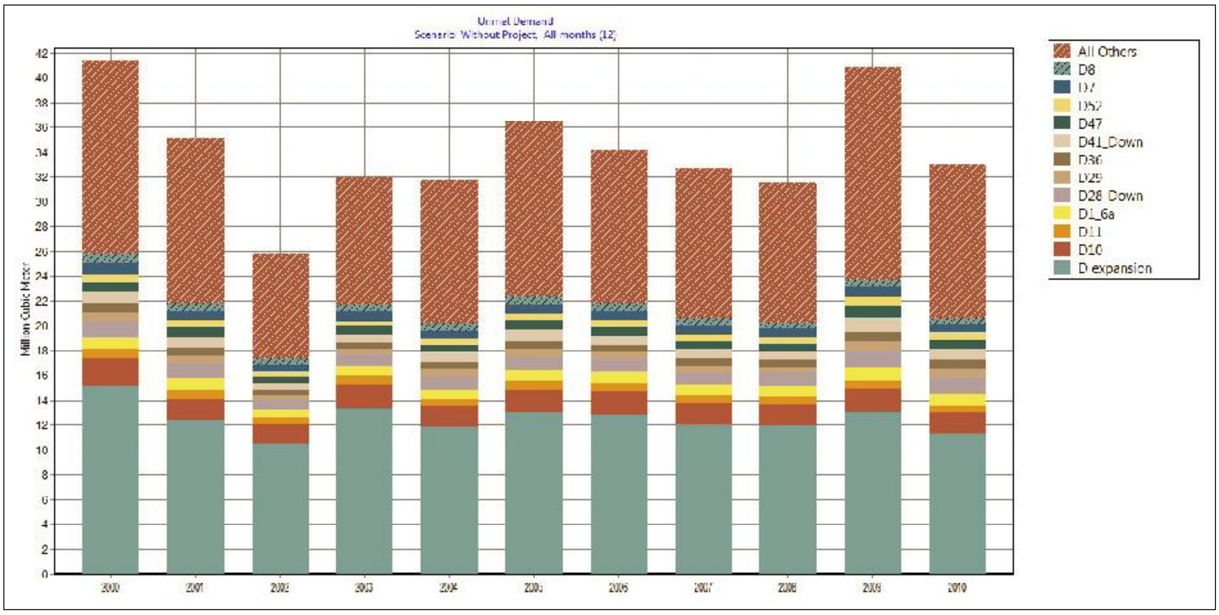

Figure 4 Annual unmet demand without project

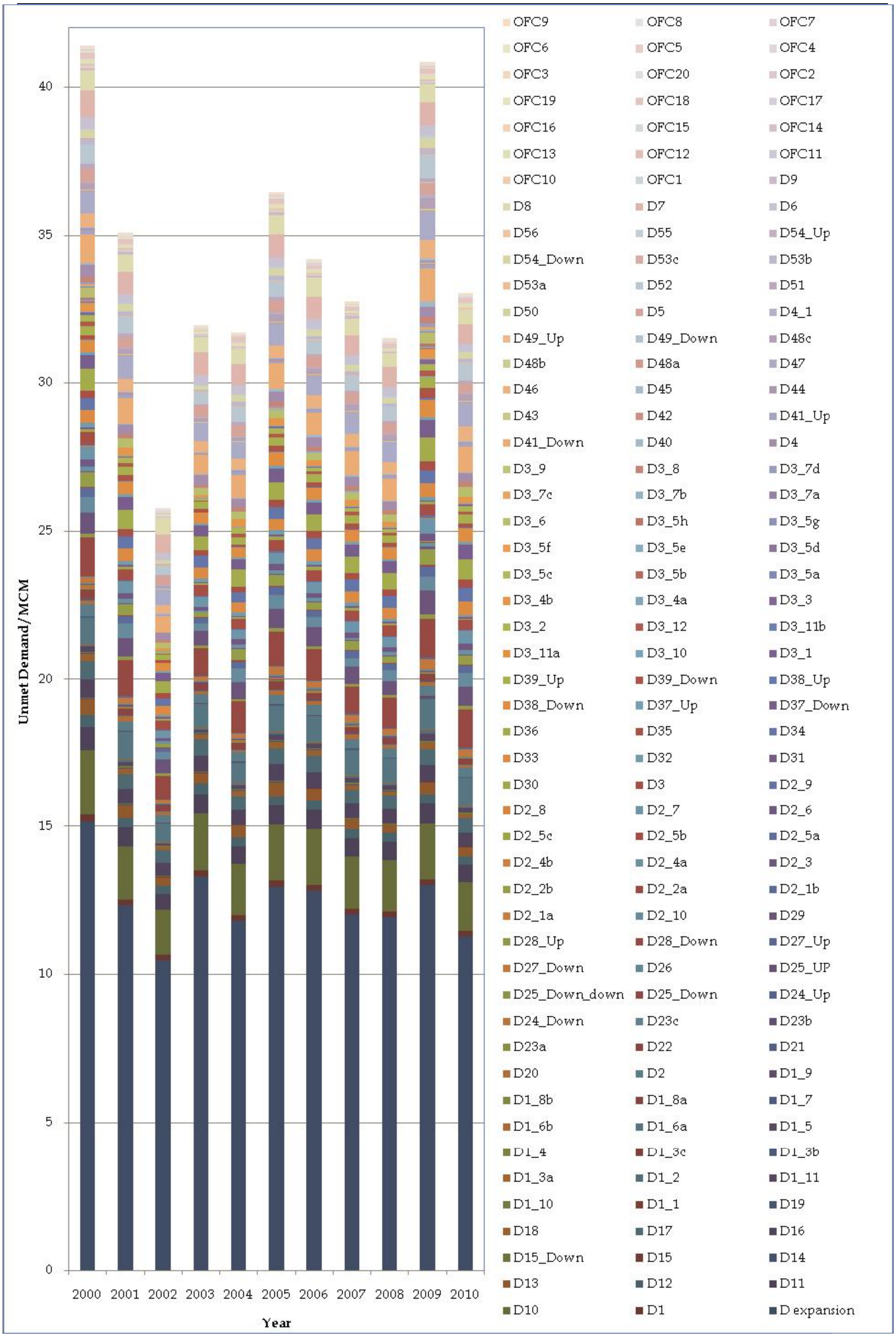

Figure 5 Detailed annual unmet demands during 2000 to 2010

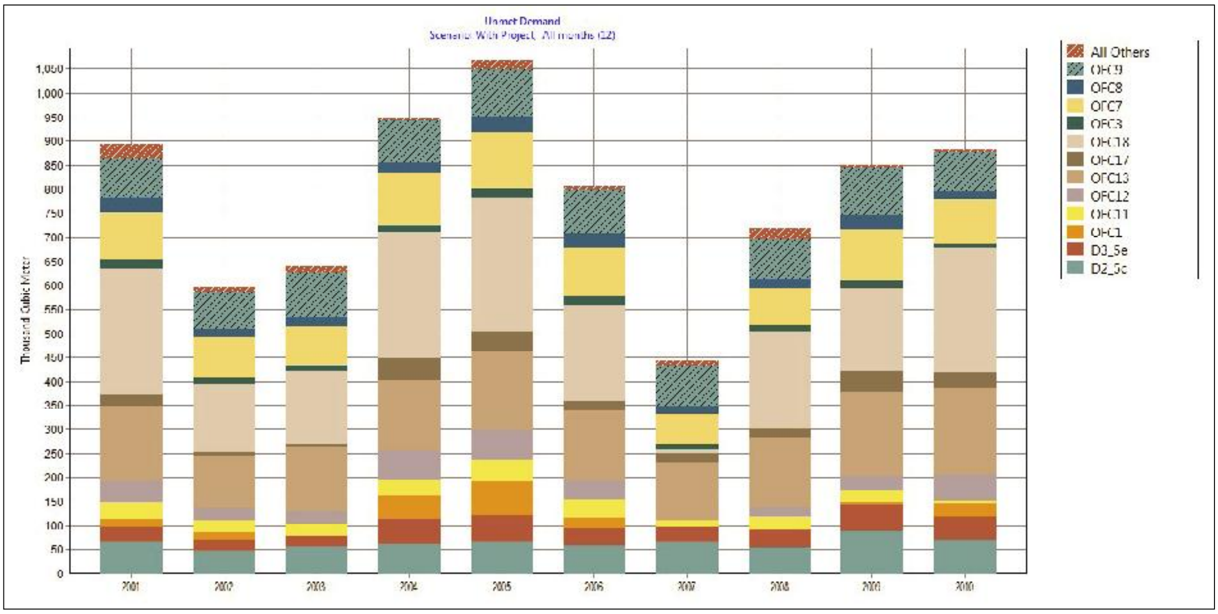

Figure 6 Annual unmet demand from with project scenario

As shown in Figure 4, Annual unmet demand varies 26 MCM to 41 MCM from 2000 – 2010 for 'without project' scenario. Figure 6 shows that annual unmet demand varies 0.44 MCM to 1.07 MCM from 2000 to 2010 for 'with project' scenario. Unmet demand in 'with project' scenario is comparatively less than unmet demand in 'without project' scenario.

The present study uses only recent 10 years for investigating unmet demand from 2000 to 2010 due to changing climate conditions and to demonstrate the model capability. With long term forecast rainfall data, the model with the calibrated parameters can be used for long-term projections of LB unmet demand of the Deduru Oya reservoir project. The model predictions will be useful for irrigation water management and drought impact assessment studies in the LB canal development area of the Deduru Oya reservoir project.

4. CONCLUSION

Analysis of results revealed that annual unmet demand in the LB development area of the Deduru Oya reservoir project varies from 26 MCM to 41 MCM without Deduru Oya reservoir project for the study period, 2000 to 2010. Also annual unmet demand varies from 0.44 MCM to 1.07 MCM with Deduru Oya reservoir project for the same period. The results of the analysis show the important role of the Deduru Oya reservoir project to reduce water scarcity of irrigation systems in the LB canal development area. The developed model can be used as a tool for irrigation water management and for drought impact assessment studies with forecasted rainfall in the LB canal development area.

5. ACKNOWLEDGEMENTS

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