# OPTIMIZING THE WATER DISTRIBUTION NETWORK CONSIDERING FUTURE DEMANDS IN A SUBURB AREA IN HAMBANTOTA DISTRICT IN SRI LANKA

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Degree of Master of Science

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Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Business Statistics

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# DECLARATION

I declare that this is my own work, and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature: Date:

I.E.Wijesinghe

The above candidate has carried out research for the Masters/MPhil/PhD thesis/ Dissertation under my supervision.

Name of the supervisor: Ms. D.R.T.Jayasundara Date:

Signature of the supervisor:

# ABSTRACT

Water distribution system is a source of hydraulic engineering that conveys water from the source to consumers. Analyzing and designing the optimal dimensions of the pipes and pumps, which distribute water, are essential in order to make the system more efficient and less costly. Therefore, the objective of the research is to design a network to find cost-effective branched water distribution network while satisfying the water demand and pressure at each node.

This study presents two approaches for designing a branched water distribution system that minimizes costs. Three cost functions are considered: cost of constructing the pipe, pumping station cost and the cost of the energy necessary for the pumps. Linear Programming(LP) is an optimization tool used to determine the optimum cost for hydraulic systems.

First model was solved by using LP technique while satisfying all the constraints applied to a rural water supply network located at Lunugamvehera, Sri Lanka. The pipe diameter was regarded as the decision variable, whereas the pipe energy, total length, non-negativity of length, and pumping head were the constraint requirements. Each pipe network's required demand is calculated and anticipated for future population growth. After the model has been developed, the results are compared to the current engineering design. In the obtained optimal solution pipe P-4(300mm and 400mm) and pipe P-5(300mm and 400mm) consists of two segments of differing diameters. As per current specifications, each link's whole length is utilized for a single pipe diameter. Splitting the pipe into two sections has not been considered. According to the analysis, the optimal cost resulted in is Rs. 1 778 443 113.36.

The second model was developed for the water distribution network optimization using Integer Linear Programming (ILP). According to the analysis, 1 935 627 000.00 rupees was the best solution obtained using the ILP method. However, the estimated total cost of the network in accordance with the engineering design is Rs. 2 065 278 912.18.

This study reveals that each link can consist of any number of discrete pipe diameters to optimize water distribution system using LP technique, and pipe diameters and pump characteristics can only be determined using the zero-unity variable by the ILP technique. Therefore, these two models are economically more viable than the existing method used by engineering design. The results indicate that the proposed two models are guaranteed to be the optimal and gives the practical solutions for the integrated water network design.

Key words: Water distribution system, optimal design, optimum solution, engineering design

# DEDICATION

To my daughter, Senuli

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACOA | Ant Colony Optimization Algorithm |
| GA | Genetic Algorithms |
| GRG | Generalized Reduced Gradient |
| HS | Harmony Search |
| ILP | Integer Linear Program |
| LP | Linear Programming |
| MILP | Mixed Integer Linear Programming |
| NLP | Non-Linear Programming |
| PSO | Particle Swarm Optimization |
| QP | Quadratic Programming |
| SA | Simulated Annealing |
| SFLA | Shuffled Frog Leaping Algorithm |
| TS | Tabu Search |
| UNESCO | United Nations Education, Scientific and Cultural Organization |
| WDN | Water Distribution Network |