MULTICRITERIA DECISION MODELLING FOR MANAGEMENT OF WATER SUPPLY SYSTEM IN THE PILIYANDALA – KESBEWA WATER SUPPLY SYSTEM, COLOMBO DISTRICT, SRI LANKA

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Degree of Master of Science in Water Resources Engineering and Management

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Thesis submitted in partial fulfilment of the requirements for the degree Master of Science in Water Resources Engineering and Management

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DECLARATION

I declare that this is my own work and thesis 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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Professor N.T.S Wijesekera

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ABSTRACT

Twenty Two management zones spatially distributed in the Piliyandala – Kesbewa Water Supply System (WSS) undergo problems such as frequent pipe bursting, scaling in old pipes, Non Revenue Water (NRW) issues and pressure drops. Importance of managing a water supply system is to provide sustainable water supply with acceptable quality at an affordable price in order to match stakeholder requirements. Managing a water supply system requires a careful consideration of organizational expectations, stakeholder requirements and system sustenance needs etc. Therefore a multicriteria decision support model is most appropriate to manage a water supply system. Piliyandala – Kesbewa WSS (32 km^2) was selected as a case study to investigate the applicability of a multicriteria decision model. The Piliyandala – Kesbewa WSS has 24,309 connections for an approximate population of 106,960.

The present work identified management concerns, evaluated the present prioritisation techniques, and developed a Multicriteria Decision Analysis (MCDA) model framework in order to manage the Piliyandala – Kesbewa Water Supply System. A literature survey and a questionnaire survey among a sample of 78 water supply area management engineers enabled the identification of four main criteria and 15 sub criteria as the model components fulfilling water supply system management objectives.

Analytical Hierarchical Process (AHP) was selected because it provides measures of judgement consistency, derives priorities among criteria and alternatives, while simplifying the determination of preference ratings among decision criteria with the use of pairwise comparisons. Main water supply system management parameters were identified and refined using a survey among experienced water supply system managers.

MCDA models were developed for Overall Management objectives. Model calibration identified weights of 0.64, 0.20, 0.07 and 0.09 respectively for the main criteria namely, Income Generation, System Sustainability, System Losses and System Reliability. Entire set of sub criteria supporting the main set were identified as New Connections, Bill Collection, Operation & Maintenance, Salaries & Overtime, Transport, Non Revenue Water, Low Pressure, No water, Water Quality, Defective Meters, Leaks of Mains, Leaks of Water Connections, Leaks near Meter, Night Time Leaks, and Stop Valve Leaks. Respective sub parameter weights were 0.317, 0.326, 0.142, 0.046, 0.012, 0.064, 0.016, 0.020, 0.024, 0.009, 0.011, 0.004, 0.003, 0.004, and 0.002.

MCDA model with main and sub criteria together with 22 management zones, provided a priority order for overall management. Model verification compared the MCDA priority order with the management priority at field level. The trend line showing the spatial variability of priority from MCDA model closely matched with the Area Engineer's prioritisation exhibiting the satisfactory level of model verification. The AHP model incorporating stakeholder pairwise combinations revealed that average of stakeholder preferences would be a satisfactory starting indicator of the success of MCDA model development.

Priority order of overall management is obtained for management zones. Field identified priority indicators of each management zone differed from the AHP model indicators demonstrating a lack of guidelines for the management at field level and the lack of a clear link of objectives at various levels of management. Very low priority for System Losses and System Reliability reflects a deficiency in System Management.

MCDA model hierarchy and weights provide a clear indication for water supply organisations to evaluate whether management objectives are suitably achieved during system operations. This research clearly demonstrated the suitability and method of development of a AHP Multicriteria Decision Model for Water Supply System Management. However it is recommended to carryout similar studies at other systems while addressing the weaknesses with respect to the guidelines and stakeholder assessments.

Key Words:

Water Management Options, Water Supply System, MCDA, AHP, Multicriteria Model, Stakeholder Assessment, Criteria

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LIST OF ABBREVIATIONS

Abbreviation	Description
AE	Area Engineer
AHP	Analytical Hierarchy Process
CBO	Community Based Organisation
CKD	Chronic Kidney Disease
CP	Compromise Programming
CPIV	Composite Performance Index Value
CR	Consistency Ratio
CWS	Community Water Systems
DOCS	Department of Census and Statistics
EA	Engineering Assistant
EPANET MSX	EPANET Multi – Species Extension
GA	Genetic Algorithms
LAs	Local Authorities
MAE	Mean Absolute Error
MCDA	Multicriteria Decision Analysis
MCDM	Multicriteria Decision Making Technique
NRW	Non Revenue Water
NWSDB	National Water Supply & Drainage Board
O&M	Operation and Maintenance
R&D	Research & Development
SCE	Shuffled Complex Evolution
UNDP	United Nations Development Programme
UWOT	Urban Water Optioneering Tool
WSS	Water Supply System

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