**SpringerBriefs in Water Science
and Technology**

More information about this series at <http://www.springer.com/series/11214>

Noorul Hassan Zardari · Kamal Ahmed
Sharif Moniruzzaman Shirazi
Zulkifli Bin Yusop

Weighting Methods and their Effects on Multi-Criteria Decision Making Model Outcomes in Water Resources Management

Noorul Hassan Zardari
Sharif Moniruzzaman Shirazi
Institute of Environmental and Water
Resources Management (IPASA)
Universiti Teknologi Malaysia
Skudai
Malaysia

Zulkifli Bin Yusop
Water Research Alliance
Universiti Teknologi Malaysia
Skudai
Malaysia

Kamal Ahmed
Department of Hydraulic and Hydrology
Faculty of Civil Engineering
Universiti Teknologi Malaysia
Skudai
Malaysia

ISSN 2194-7244

ISBN 978-3-319-12585-5

DOI 10.1007/978-3-319-12586-2

ISSN 2194-7252 (electronic)

ISBN 978-3-319-12586-2 (eBook)

Library of Congress Control Number: 2014955190

Springer Cham Heidelberg New York Dordrecht London

© The Author(s) 2015

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Contents

1	Introduction	1
1.1	Introduction	1
1.2	Problem Background	2
1.3	Problem Statement	3
1.4	Objectives of the Study	4
1.5	Scope of the Study	4
1.6	Significance of the Study	4
1.7	Chapter Summary	5
1.8	Report Organization	5
2	Literature Review	7
2.1	Introduction	7
2.2	Decision-Making Process	7
2.3	Multi-Criteria Decision-Making	9
2.4	Classification of Multi-Criteria Decision-Making Methods	10
2.5	Characteristics of Different Multi-Criteria Methods	11
2.6	Strengths and Weaknesses of MCDM Methods	12
2.7	How to Select an Appropriate MCDM Method	14
2.8	The Role of Weights and Their Interpretation in MCDM Methods	14
2.9	Classification of Weighting Methods	23
2.9.1	Subjective Weighting Methods	23
2.9.2	Objective Weighting Methods	24
2.10	Popular Subjective Weighting Methods	25
2.10.1	Direct Rating Method	26
2.10.2	Ranking Method	26
2.10.3	Point Allocation	27
2.10.4	Pairwise Comparison Method	28
2.10.5	Ratio Weighting Method	29
2.10.6	Swing Weighting Method	29
2.10.7	Graphical Weighting Method	30

2.10.8	Delphi Method	30
2.10.9	Simple Multi-attribute Rating Technique (SMART). . .	31
2.10.10	SIMOS Weighting Method.	31
2.10.11	Revised SIMOS Weighting Method	32
2.10.12	Fixed Point Scoring	32
2.11	Popular Objective Weighting Methods.	32
2.11.1	Entropy Method	33
2.11.2	CRITIC Weighting Method	33
2.11.3	Mean Weight (MW)	34
2.11.4	Standard Deviation Method	34
2.11.5	Statistical Variance Procedure.	35
2.11.6	Integrated or Combined Weighting Methods.	35
2.11.7	Direct Ranking	36
2.11.8	Qualitative Rating Method	36
2.12	Objective Weighting Methods Used in Past Studies.	37
2.13	Subjective and Objective Weighting Methods Used in Past Studies	37
2.14	Selection of Weighting Method	37
2.15	Weighting Methods Supported by Softwares	54
2.15.1	Pairwise Comparison.	54
2.15.2	Point Allocation Method	55
2.15.3	Ranking Method.	55
2.15.4	Rating Method	55
2.15.5	SMART Weighting Method	55
2.15.6	SWING Weighting Method	56
2.15.7	Trade-off Weighting Method	56
2.15.8	Delphi Method	57
2.15.9	Revised SIMOS Procedure.	57
2.16	Advantages and Disadvantages of Weighting Methods.	57
2.16.1	Pairwise Comparison.	58
2.16.2	Simple Multi-attribute Rating Technique (SMART). . .	59
2.16.3	Point Allocation Method	60
2.16.4	Revised SIMOS' Procedure	61
2.16.5	Trade-off Weighting Method	62
2.16.6	Delphi Method	63
2.16.7	SWING Method	63
2.16.8	Entropy Method	65
2.16.9	Rank Ordering Centroid.	66
2.16.10	CRITIC Method	66
3	Research Methodology and Results	69
3.1	Introduction	69
3.2	Methodology	69
3.3	Survey Questionnaire	71

Contents	vii
3.4 Questionnaire Administration	74
3.4.1 Postgraduate Survey Data Analysis	75
3.5 Weights for the Watershed Management Criteria.	76
3.6 Summary on Criteria Weights.	81
3.7 Surveying Popular Databases for the Weighting Methods.	84
4 Conclusions and Recommendations	101
4.1 Chapter Summary	101
4.2 Conclusions	101
4.3 Recommendations	104
Appendix A.	107
Appendix B.	123
Appendix C.	135
References.	157

About the Authors

Mr. Kamal Ahmed is working as Lecturer at Faculty of Water Resources Management, Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Balochistan Pakistan. Currently, he is on leave for completing his Ph.D. at Universiti Teknologi Malaysia. His fields of research include groundwater modeling, climate change and forecasting, and flood warning systems. Mr. Kamal is currently engaged on a research project that investigates groundwater potential in southern Balochistan where he is using GIS approach to located fresh groundwater resources to meet agriculture and drinking demands for the southern Balochistan population.

Dr. Sharif Moniruzzaman Shirazi is working as Associate Professor at Institute of Environmental and Water Resources Management (IPASA), Universiti Teknologi Malaysia. Dr. Shirazi obtained his Ph.D. in the Department of Civil and Environmental Engineering of Saitama University, Japan. He started his career as an Irrigation Engineer. He obtained his B.Sc. and M.Sc. in Irrigation Engineering from Bangladesh Agricultural University. He worked as a JSPS (Japan Society for the Promotion of Science) Postdoctoral Fellow (November 2007–October 2009) at Geosphere Research Institute of Saitama University.

Dr. Shirazi has 17 years research experience in the area of physicochemical properties of soil, agro-ecological aspects of groundwater utilization, groundwater quality for irrigation, and impact of changes on climatic parameters on crop production. He has about 40 technical papers published in national and international

journals. He is a member of several institutions including American society of Civil Engineers (ASCE), Engineers Institute of Bangladesh (IEB), Japanese Geotechnical Society (JGS), and Institute of Engineering and Technology (UK).

Prof. Zulkifli Bin Yusop is working as Professor at Universiti Teknologi Malaysia. Currently, he is Dean Water Research Alliance. Prof. Zulkifli has research experience of about 30 years. Prof. Zulkifli has published over 100 articles in top international journals. His fields of research include water resources management, non-point source pollution, surface and groundwater hydrology, catchment management, drinking water quality, deforestation, and flood mitigation and management. Prof. Zul has been invited speaker in various seminars, conference, and workshops. He has supervised more than 20 Ph.D. students in his career. Prof.

Zulkifli has secured a large number of national and international grants on different themes of research in water resources and hydrology. He has won many awards in different categories including Best Publication awards.

Dr. Noorul Hassan Zardari works as Senior Lecturer at Institute of Environmental and Water Resources Management (IPASA), Universiti Teknologi Malaysia (UTM), Skudai, Malaysia. His areas of expertise include water resources management, irrigation, groundwater hydrology, decision-making and policy in water resources allocations, integration of land and water resources in watersheds, and urban water supply and management. He is author of over 40 publications.

Dr. Noorul has organized many publication workshops in which academicians, researchers, and postgraduate students from different faculties of the Universiti Teknologi Malaysia were trained on enhancing writing and publication skills. The major objectives of such workshops were to promote publication culture in the university and improve quality of the research. Dr. Noorul has reviewed about 50 journal articles which were submitted into indexed, non-indexed journals and conferences. He is also serving as Chairman of the Publication Committee, Water Research Alliance, Universiti Teknologi Malaysia where many students are assisted in their journal articles and theses write up.

Abstract

This book presents survey results on priority ranking of watershed management criteria. This survey was completed by 30 undergraduate and postgraduate students from Faculty of Civil Engineering, Universiti Teknologi Malaysia. The students were registered in various programs run by the Faculty in Semester 1, 2012. The applications of three weighting methods namely rating, ranking, and ratio are discussed in the book. We have also done data mining on some keywords using three popular scholar databases. These databases include *sciencedirect*, *scopus*, and *sciverse*. Four abbreviated keywords (MCDM, MCDA, MCA, MADM) used to represent multi-criteria decision-making were used and these three databases were searched for different popular weighting methods for a period of 13 years (2000–2012). The findings of data mining are presented in this book. Overall, this book presents a review of weighting methods applied in various multi-criteria decision-making (MCDM) methods.

Keywords Weighting methods • MCDM • Multi-criteria decision-making • Ranking • Water resources