

TABLE OF CONTENTS

PREFACE	V
1 INTRODUCTION	1
1.1 Objectives of This Study	1
1.2 Fuzzy Mathematical Programming Problems	2
1.3 Classification of Fuzzy Mathematical Programming	5
1.4 Applications of Fuzzy Mathematical Programming	8
1.5 Literature Survey	10
2 FUZZY SET THEORY	14
2.1 Fuzzy Sets	14
2.2 Fuzzy Set Theory	19
2.2.1 Basic Terminology and Definition	20
2.2.1.1 Definition of Fuzzy Sets	20
2.2.1.2 Support	21
2.2.1.3 α -level Set	21
2.2.1.4 Normality	22
2.2.1.5 Convexity and Concavity	22
2.2.1.6 Extension Principle	23
2.2.1.7 Compatibility of Extension Principle with α -cuts	23
2.2.1.8 Relation	24
2.2.1.9 Decomposability	24
2.2.1.10 Decomposition Theorem	25
2.2.1.11 Probability of Fuzzy Events	25
2.2.1.12 Conditional Fuzzy Sets	27
2.2.2 Basic Operations	27
2.2.2.1 Inclusion	27
2.2.2.2 Equality	27
2.2.2.3 Complementation	28

2.2.2.4	Intersection	28
2.2.2.5	Union	29
2.2.2.6	Algebraic Product	29
2.2.2.7	Algebraic Sum	29
2.2.2.8	Difference	29
2.3	Membership Functions	30
2.3.1	A Survey of Functional Forms	31
2.3.2	Examples to Generate Membership Functions	34
2.3.2.1	Distance Approach	35
2.3.2.2	True-Valued Approach	40
2.3.2.3	Payoff Function	45
2.3.2.4	Other Examples	48
2.4	Fuzzy Decision and Operators	48
2.4.1	Fuzzy Decision	49
2.4.2	Max-Min Operator	51
2.4.3	Compensatory Operators	53
2.4.3.1	Numerical Example for Operators	56
2.5	Fuzzy Arithmetic	58
2.5.1	Addition of Fuzzy Numbers	58
2.5.2	Subtraction of Fuzzy Numbers	61
2.5.3	Multiplication of Fuzzy Numbers	63
2.5.4	Division of Fuzzy Numbers	65
2.5.5	Triangular and Trapezoid Fuzzy Numbers	66
2.6	Fuzzy Ranking	72
3	FUZZY MATHEMATICAL PROGRAMMING	74
3.1	Fuzzy Linear Programming Models	75
3.1.1	Linear Programming Problem with Fuzzy Resources	75
3.1.1.1	Verdegay's Approach	79
3.1.1.1a	Example 1: The Knox Production-Mix Selection Problem	80
3.1.1.1b	Example 2: A Transportation Problem	85

3.1.1.2	Werners's Approach	87
3.1.1.2a	Example 1: The Knox Production-Mix Selection Problem	89
3.1.1.2b	Example 2: An Air Pollution Regulation Problem	90
3.1.2	Linear Programming Problem with Fuzzy Resources and Objective	95
3.1.2.1	Zimmermann's Approach	95
3.1.2.1a	Example 1: The Knox Production-Mix Selection Problem	97
3.1.2.1b	Example 2: A Regional Resource Allocation Problem	98
3.1.2.1c	Example 3: A Fuzzy Resource Allocation Problem	101
3.1.2.2	Chanas's Approach	104
3.1.2.2a	Example 1: An Optimal System Design Problem	107
3.1.2.2b	Example 2: An Aggregate Production Planning Problem	110
3.1.3	Linear Programming Problem with Fuzzy Parameters in the Objective Function	119
3.1.4	Linear Programming with All Fuzzy Coefficients	121
3.1.4.1	Example: A Production Scheduling Problem	123
3.2	Interactive Fuzzy Linear Programming	127
3.2.1	Introduction	127
3.2.2	Discussion of Zimmermann's, Werners's Chanas's and Verdegay's Approaches	128
3.2.3	Interactive Fuzzy Linear Programming - I	130
3.2.3.1	Problem Setting	130
3.2.3.2	The Algorithm of IFLP-I	136
3.2.3.3	Example: The Knox Production-Mix	

Selection Problem	139
3.2.4 Interactive Fuzzy Linear Programming - II	146
3.2.4.1 The Algorithm of IFLP-II	151
3.3 Some Extensions of Fuzzy Linear Programming Problems	155
3.3.1 Membership Functions	155
3.3.1.1 Example: A Truck Fleet Problem	161
3.3.2 Operators	168
3.3.3 Sensitivity Analysis and Dual Theory	170
3.3.4 Fuzzy Non-Linear Programming	170
3.3.4.1 Example: A Fuzzy Machining Economics Problem	171
3.3.5 Fuzzy Integer Programming	174
3.3.5.1 Fuzzy 0-1 Linear Programming	176
3.3.5.1a Example: A Fuzzy Location Problem	180
4 POSSIBILISTIC PROGRAMMING	187
4.1 Possibilistic Linear Programming Models	189
4.1.1 Linear Programming with Imprecise Resources and Technological Coefficients	189
4.1.1.1 Ramik and Rimanek's Approach	189
4.1.1.1a Example: A Profit Apportionment Problem	191
4.1.1.2 Tanaka, Ichihashi and Asai's Approach	196
4.1.1.3 Dubois's Approach	198
4.1.2 Linear Programming with Imprecise Objective Coefficients	203
4.1.2.1 Lai and Hwang's Approach	203
4.1.2.1a Example: A Winston-Salem Development Management Problem	208
4.1.2.2 Rommelfanger, Hanuscheck and Wolf's Approach	213
4.1.2.3 Delgado, Verdegay and Vila's Approach	217
4.1.3 Linear Programming with Imprecise Objective and	

Technological Coefficients	223
4.1.4 Linear Programming with Imprecise Coefficients	225
4.1.4.1 Lai and Hwang's Approach	225
4.1.4.2 Buckley's Approach	227
4.1.4.2a Example: A Feed Mix (Diet) Problem	230
4.1.4.3 Negi's Approach	232
4.1.4.4 Fuller's Approach	236
4.1.5 Other Problems	237
4.2 Some Extensions of Possibilistic Linear Programming	238
4.2.1 Linear Programming with Imprecise Coefficients and Fuzzy Inequalities	238
4.2.1a Example: A Fuzzy Matrix Game Problem	241
4.2.2 Linear Programming with Imprecise Objective Coefficients and Fuzzy Resources	243
4.2.2a Example: A Bank Hedging Decision Problem	247
4.2.3 Stochastic Possibilistic Linear Programming	256
4.2.3a Example: A Bank Hedging Decision Problem	260
5 CONCLUDING REMARKS	268
5.1 Probability Theory versus Fuzzy Set Theory	268
5.2 Stochastic versus Possibilistic Programming	270
5.3 Future Research	275
5.4 Introduction of the Following Volume	276
5.5 Fuzzy Multiple Attribute Decision Making	277
BIBLIOGRAPHY	279
Books, Monographs and Conference Proceedings	279
Journal Articles, Technical Reports and Theses	283