การควบคุมมลภาวะทางน้ำโดยการจัดเก็บอัตราภาษีที่เหมาะสมกรณีศึกษาลุ่มแม่น้ำท่าจีน

นายราชศักดิ์ คล้ายคลึง

# สถาบนวิทยบริการ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรคุษฎีบัณฑิต สาขาวิชาการจัดการสิ่งแวดล้อม (สหสาขาวิชา) บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย ปีการศึกษา 2549 ลิขสิทธิ์ของจุฬาลงกรณ์มหาวิทยาลัย

# SURFACE WATER POLLUTION CONTROL BY APPROPRIATE EFFLUENT TAXATION: THE THACHIN RIVER BASIN STUDY, THAILAND

Mr. Rachasak Klayklung

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy Program in Environmental Management (Interdisciplinary Program) Graduate School Chulalongkorn University Academic Year 2006 Copyright of Chulalongkorn University

Thesis Title	SURFACE WATER POLLUTION CONTROL BY APPROPRIATE EFFLUENT TAXATION: THE THACHIN RIVER BASIN STUDY, THAILAND
By	Mr. Rachasak Klayklung
Field of Study	Environmental Management
Thesis Advisor	Assistant Professor Charit Tingsabadh, Ph.D.
Thesis Co-advisor	Associate Professor Nantana Gajaseni, Ph.D.

Accepted by the Graduate School, Chulalongkorn University in Partial Fulfillment of the Requirements for the Doctoral Degree

(Assistant Professor M.R. Kalaya Tingsabadh, Ph.D.)

#### THESIS COMMITTEE

8 a ..... Chairman (Associate Professor Sutha Khaodhiar, Ph.D.) ...... Thesis Advisor (Assistant Professor Charit Tingsabadh, Ph.D.) Contraction Thesis Co-advisor (Associate Professor Nantana Gajaseni, Ph.D.) Member (Manaskorn Rachakornkij, Ph.D.) K Outo (Assistant Professor Khemarath Osathaphan, Ph.D.) Sutat Weischol Member

(Assistant Professor Sutat Weesakul, Ph.D.)

ราชศักดิ์ คล้ายคลึง : การควบคุมมลภาวะทางน้ำโดยการจัดเก็บอัตราภาษีที่เหมาะสม กรณีศึกษาลุ่มแม่น้ำท่าจีน (SURFACE WATER POLLUTION CONTROL BY APPROPRIATE EFFLUENT TAXATION: THE THA-CHIN RIVER BASIN STUDY, THAILAND) อ. ที่ปรึกษา : ผศ. คร. จาริต ดิงศภัทิย์, อ. ที่ปรึกษาร่วม: รศ. คร. นันทนา คชเสนี, 229 หน้า.

แม่น้ำทำจีนถูกจัดอันดับว่ามีการปล่อยมลภาวะลงสู่แม่น้ำมากที่สุดในประเทศไทย ซึ่งแหล่งมลภาวะที่สำคัญที่เป็น ดัวกำเนิดมลภาวะหลักประกอบไปด้วย การทำฟาร์มหมู ชุมชน ฟาร์มเพาะเลี้ยงสัตว์น้ำ และโรงงานอุตสาหกรรม ซึ่งผลที่ เกิดขึ้นตามมาก็คือแม่น้ำท่าจีนประสบปัญหาอย่างหนักกับคุณภาพน้ำผิวดิน โดยเฉพาะอย่างยิ่งเมื่อควบรวมกับการสะสม มลภาวะที่มาจากแม่น้ำที่อยู่เหนือแม่น้ำท่าจีนขึ้นไป และจะเป็นการเหมาะสมอย่างยิ่งถ้าสามารถนำแบบจำลองระบบการเก็บ ภามีมาประยุกด์ใช้และทำให้ปริมาณมลภาวะที่แหล่งกำเนิดน้ำเสียและปริมาณของน้ำเสียที่สะสมในแม่น้ำท่าจีนไม่เกิน ความสามารถในการรองรับมลภาวะของระบบนิเวศน์ในแม่น้ำได้

งคม่งหมายของงานวิจัยนี้เพื่อค้นหาระบบการเก็บภาบีที่เหมาะสมสำหรับมลภาวะที่เกิดขึ้นและทำการสร้าง แบบจำลองทางคณิตศาสตร์สำหรับประกอบการตัดสินใจในการคำนวณหาสภาวะกำไรที่สูงที่สุดและสภาวะนั้นไม่เกิน ข้อจำกัดทางนี้เวศวิทยาและข้อจำกัดทางเศรษฐศาสตร์ และปริมาณมลภาวะที่เกิดขึ้นจะค้องไม่เกินความสามารถในการรองรับ บถูกาวะสูงสุดรายวันของแม่น้ำทำจีนด้วย ขั้นดอนหลักในการทำงานมีทั้งหมดสามช่วง โดยช่วงที่หนึ่งจะเป็นการรวบรวม จานข้อมูลทั้งหมด ซึ่งกุณลักษณะของข้อมูลจะประกอบไปด้วยข้อมูลเชิงสิ่งแวคล้อมและข้อมูลเชิงเศรษฐศาสตร์ ข้อมูลเชิง ้สิ่งแวคล้อมนั้นจะเป็นการเก็บข้อมูลที่เกิดขึ้นจริงในแม่น้ำทำจืนซึ่งเกี่ยวกับคุณลักษณะของมลพิษ ศักยภาพการรองรับมลพิษ และเป้าหมายของการลคมลภาวะของแม่น้ำท่าจีน และข้อมลเชิง ความสามารถในการรองรับมลภาวะสูงสุดรายวัน เสรมจุศาสตร์จะเป็นการเก็บข้อมูลเกี่ยวกับค้นทุนการผลิต ค้นทุนการบำบัคมลพิษ และกำไรจากผลประกอบการของทุกแหล่ง มถภาวะหลักในลุ่มแม่น้ำท่าจีน ช่วงที่สองจะเป็นการคำนวณเพื่อหาสมการค้นทุนหน่วยสุดท้ายในการบำบัคมลพิบ (Marginal Abatement Cost) ของแต่ละแหล่งมลภาวะหลัก และอัตราภาษีมลภาวะที่อยู่ภายใต้การควบคุม ช่วงที่สามจะเป็นการสร้าง แบบขำลองทางคณิตศาสตร์สำหรับประกอบการตัดสินใจและกระทำการจำลองสถานการณ์เพื่อหารูปแบบการเก็บภามีที่ เหมาะสม จากผลการศึกษาพบว่าด้นทุนในการบำบัดมลพิษของการเก็บภาษีแบบอัตราเดียว (Uniform tax) จะมีดันทุนน้อย กว่าการเก็บภาษีแบบไม่ใช่อัตราเดียว (Non-uniform tax) ประมาณ 3,480,944,681.53 บาทต่อปี และค่าใช้จ่ายรวมของการ เก็บภาบีและค้นทุนในการบำบัคมลพิมของการเก็บภาบีแบบอัตราเดียวค่ำกว่าประมาณ 3,517,515,764.60 บาทค่อปี ซึ่งเป็น ผลทำให้กำไรสุทธิของผู้ประกอบการจากการเก็บภาษีแบบอัตราเดียวมีค่าสูงกว่าการเก็บภาพีแบบไม่ใช่อัตราเดียวประมาณ 3.518.058.488.41 บาทต่อปี และการเก็บภาษีทั้งสองรูปแบบนั้นทำให้มลภาวะอยู่ในระดับที่กำหนด แต่อย่างไรก็ตามเมื่อ พิจารณาตามหลักเสรมจุศาสตร์การเก็บภาษีแบบอัตราเดียวมีประสิทธิภาพมากกว่าเพราะปริมาณรายจ่ายโดยรวมในการบำบัด มลพิษต่อรายได้ของผู้ประกอบการของการเก็บภาษีแบบอัตราเดียวมีค่าต่ำกว่าการเก็บภาษีแบบไม่ใช่อัตราเดียวประมาณ 0.552% อนึ่งแบบจำลองนี้สามารถนำไปปรับใช้สำหรับการควบคุมมลภาวะในแม่น้ำอื่นได้

สาขาวิชา การจัดการสิ่งแวดล้อม ปีการศึกษา 2549

#### # # 4589673720: MAJOR ENVIRONMENTAL MANAGEMENT KEY WORD: MARGINAL ABATEMENT COST/ NON-UNIFORM TAX/ UNIFORM TAX/ MATHEMATICAL DECISION MAKING MODEL

RACHASAK KLAYKLUNG: SURFACE WATER POLLUTION CONTROL BY APPROPRIATE EFFLUENT TAXATION: THE THACHIN RIVER BASIN STUDY, THAILAND. THESIS ADVISOR: ASST. PROF. CHARIT TINGSABADH, Ph.D., THESIS CO-ADVISOR: ASSOC. PROF. NANTANA GAJASENI, Ph.D., 229 pp.

The Thachin River was ranked as the most polluted river in Thailand. Pig farms, Urban communities, Aqua cultures, and Industries were significant contributors to deteriorating water quality in Thachin River basin. Consequently, it is facing a serious problem of surface water quality especially when dealing with an accumulation of upstream wastewater discharges. It would be more appropriate, if the taxation model would take into account both the amount of pollution emission at the 'end-of-pipe' and the amount of wastewater contaminant in the surface water which should not exceed the environmental loading or overload the carrying capacity of the river ecosystem.

This research purposed to seek the appropriated effluent tax system and constructed the optimization mathematical decision making model in order to make the maximization profit that met the environmental constraint and economic constraint from Thachin River. Moreover the amount of pollution discharges would not excess Total Maximum Daily Loading of Thachin River. The steps in estimating of appropriated effluent taxation were divided into 3 phases, Phase I, The data collection was divided into 2 aspects which were Environmental aspect and Economic aspect. First Environmental aspect was the actual information which concerned on pollution characteristic, carrying capacity, Total Maximum Daily BOD Loading, and Target of emission reduction of Thachin River. Second Economic aspect concerned on the production cost, abatement cost and the revenue of every activity in Thachin sub-basin. Phase II was the calculation of marginal abatement cost (MAC) of each main point source and the emission tax rate under Command and Control (CAC). Phase III was the construction of Mathematical Decision-making model and simulated by using optimization model for arriving the appropriate tax charge. The result showed that abatement cost of Uniform tax was lower than Non-uniform tax approximately of 3,480,944,681.53 Baht/year. Moreover the total expenses of Uniform tax was lower than Non-uniform tax approximately of 3,517,515,764.60 Baht/year which lead to the higher of net profit of Uniform tax approximately of 3,518,058,488.41 Baht. Both of Non-uniform and Uniform tax reduced efficiently the wastewater emission in Thachin River which met the standard requirement however, in term of economic, the Uniform tax was more efficient than Non-uniform tax because the total expense per revenue of entire river was lower than Non-uniform tax approximately of 0.552 %. The processes in this study are practical in applying of water pollution control in other rivers.

 Field of study Environmental Management
 Student's signature

 Academic year 2006
 Advisor's signature

Advisor's signature Co-advisor's signature

#### ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my thesis advisors, Asst. Prof. Dr. Charit Tingsabadh and Assoc. Prof. Dr. Nantana Gajaseni, for their encouragement, incomparable support, and guidance. Their comments and suggestions not merely provide valuable knowledge but broaden perspective in practical applications as well. Special gratitude goes to the chairman of the committee, Assoc. Prof. Dr. Sutha Khaodhiar for providing valuable advice. I would also like to thank other committee members, Dr. Manaskorn Rachakornkij, Asst. Prof. Dr. Khemrath Osathaphan, and Asst. Prof. Dr. Sutat Weesakul for many valuable comments and their insightful suggestions.

Special respect and thanks are also given to Mr. Chucheep Wongsupap for uncountable assistances throughout my research time. The sincere appreciation was also passed to Mr. Nithikorn Phiama, Mr. Barclay Nettlefold, Mr. Nigel Van Cuylenburg, and Mr. David Edmon for their support.

I would like extend my sincere appreciation to all staffs and students, especially generation 3 at the National Research Center for Environmental and Hazardous Waste Management (NRC-EHWM) Program. Special thanks should go to School of Civil Engineering, Asian Institute of Technology and Faculty of Science, Chulalongkorn University for their support.

This research was granted by the National Research Center for Environmental and Hazardous Waste Management (NRC-EHWM) Program, Thailand. Without these financial supports, my achievement should not become true.

Special thanks were also passed to all friends, especially Mr. Worawit Gumpusirikul and Mr. Sirichai Ittichaicharn for their assistances and encouragement

Finally, if this dissertation possesses any few advantages, they will be dedicated to my beloved parents and sisters for their unconditional love, wholehearted understanding, never-ending encouragement, and patient support for this long journey.

# CONTENTS

	Page
ABSTRACT IN THAI.	iv
ABSTRACT IN ENGLISH	V
ACKNOWLEDGEMENTS	vi
CONTENTS	vii
LIST OF TABLES	xi
LIST OF FIGURES	XV
NOMENCLATURES	xvii
CHAPTER I INTRODUCTION	1
1.1 Description of Problems	1
1.1.1 Conflict Management	3
1.1.2 Current situation of BOD loading in Thachin River	5
1.2 Objectives of study	7
1.3 Hypothesis	8
1.4 Scopes of the study	8
1.5 Conceptual Framework	13
CHAPTER II LITERATURE REVIEW	15
2.1 Thachin River	15
2.1.1 Total Maximum Daily Loading and Target of emission	18
2.1.2 Economic of significant pollution activities	19
2.2 Existing Regulation in Thailand	22
2.2.1 Regulation to control sources of pollution water	23
2.2.2 Regulation to preserve the quality and utilize the water resource	e.25
2.2.2.1 Directed regulation to preserve the water resources	26
2.2.2.2 Regulation from local authorities to preserved	
the local water resources	30

	٠	٠	٠	
V	1	1	1	

## Page

2.3 Case study of other countries controlled the effluent from the water resources	32
2.3.1 Control the effluent sources by control the concentration-based	
effluent standard	33
2.3.1.1 Singapore	33
2.3.1.2 Malaysia	34
2.3.2 Load Effluent Standard	35
2.3.2.1 Water quality-based effluent limited for each type of	
polluted sources	35
2.3.2.2 Water quality-based effluent limits	37
2.4 The effluent tax charge applied in Foreign countries	44
2.4.1 Charges Support River Basin Agencies in France	. 44
2.4.2 Dutch Experience with How charges Influence Firms	46
2.4.3 German Experience with Charges	. 47
2.4.4 Discharge Fees and Subsidies in China	50
2.4.5 Philippine	51
2.4.6 India	52
CHAPTER III CONCEPTUAL FRAMEWORK	55
CHAPTER III CONCEPTUAL FRAMEWORK	55 55
3.1 Study site	55
3.1 Study site	55
<ul><li>3.1 Study site</li><li>3.1.1 Land use in the Thachin River</li><li>3.1.2 Significant pollution-generating sources</li></ul>	55 55
<ul> <li>3.1 Study site</li> <li>3.1.1 Land use in the Thachin River</li> <li>3.1.2 Significant pollution-generating sources</li> <li>in Thachin River Basin</li></ul>	55 55 56
<ul> <li>3.1 Study site</li> <li>3.1.1 Land use in the Thachin River</li> <li>3.1.2 Significant pollution-generating sources</li> <li>in Thachin River Basin</li> </ul>	55 55 56 56
<ul> <li>3.1 Study site</li> <li>3.1.1 Land use in the Thachin River</li> <li>3.1.2 Significant pollution-generating sources</li> <li>in Thachin River Basin</li></ul>	55 55 56 56 58
<ul> <li>3.1 Study site</li></ul>	55 55 56 56 58 60
3.1 Study site	55 55 56 56 58 60 62
<ul> <li>3.1 Study site.</li> <li>3.1.1 Land use in the Thachin River.</li> <li>3.1.2 Significant pollution-generating sources in Thachin River Basin.</li> <li>4.1.2.1 Pig farm.</li> <li>4.1.2 Urban communities.</li> <li>4.1.2.2 Aqua culture.</li> <li>4.1.2.3 Industry.</li> </ul>	55 55 56 56 58 60 62 68

#### Page

92
92
92
95
95
95
103
.116
.116
.116
.118
119
120
ain
122
.122
.127
.133
.141
.146
.151

ix

Pag	ge
5.3.4 The method of reducing BOD peak in sub basin from	
Km70 to Km80 (Peak6)15	56
5.3.4 The method of reducing BOD peak in sub basin from	
river mouth to Km50 (Peak7)15	58
CHAPTER VI CONCLUSIONS AND RECOMMENDATION17	77
6.1 Comparison of Non-Uniform tax and Uniform tax17	77
6.2 Applied the Mathematical decision-making model with other rivers17	78
6.3 Emission tax charge apply for main point sources	80
6.4 Wastewater from Non-point sources	84
DEEEDEN/OEG	~

REFERENCES	186
APPENDICES	196
BIOGRAPHY	229

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

### LIST OF TABLES

Table	Page
2-1	Percentage and ratio of each province in each sub basin of Thachin River15
2-2	Regulation and Constraint of each polluted water resource23
2-3	Regulation to preserve the quality and utilize the water resource
2-4	Directed regulation to preserve the water resources
2-5	Regulation from local authorities to preserved the local water resources
	which concern with authorized to the local authorities
2-6	Regulation from local authorities to preserved the local water resources
	which concern with water resources
2-7	The standard drainage in commercial zone of Singapore
2-8	The standard industrial effluent in Malaysia
2-9a	Load-based standards in India
2-9b	Quantity of pollution water from certain industries in India
2-10	Comparable table of controlling source pollution emission between
	Japan and United States of America43
3-1	Number of large communities situated in Thachin River Basin
3-2	Number and type of factories generating water pollution in
	Thachin River Basin
3-3	Number of factories generating water pollution for each province
	in the area of Thachin River Basin65
3-4	Percentage of pollution from any sources in any sub basin and target of
	emission reduction
3-5	Results of daily BOD loading estimation of effluent discharged
	from 33 sub basin to Thachin River73
3-6	High BOD value in all 9 point of Thachin River
3-7	BOD load from 18 sub-basins which generate BOD peak
	in Thachin River.6078
3-8	Allowable BOD discharging load from each sub-basin that keep water
	quality in Thachin River to meet standard criteria

.

Table	Page
3-9	Transaction cost of pig farm waste water treatment in each size81
3-10	Cost and revenue of pig farm product
3-11	Evaluated operating cost of stabilization pond in each local government83
3-12	Evaluated operating cost of aerated lagoon in each local government84
3-13	Evaluated operating cost of activated sludge in each local government84
3-14	Total provincial budget of public service and social development and
	budget per capita of each province
3-15	Abatement cost of each type of aqua culture
3-16	Operation cost of each type of aqua culture
3-17	Revenue of each type of aqua culture
3-18	Revenue and Cost of Abatement of each Industry activities
3-19	The necessary parameters of database collection90
5-1	Data set for marginal abatement cost function of pig farm117
5-2	Dataset of marginal abatement cost function of urban community118
5-3	Dataset of marginal abatement cost function of Aqua culture119
5-4	Dataset of marginal abatement cost function of industry121
5-5	The effluent charge of pig farm in each sub-basin122
5-6	The effluent charge of urban community in each sub-basin
5-7	The effluent charge of aquaculture in each sub-basin
5-8	The effluent charge of industry in each sub-basin
5-9	The main sources effluent discharge in 18 sub-basin127
5-10	Non-uniform tax of each main point source at sub-basin LI
5-11	Uniform Tax of entire main point source at sub-basin LI129
5-12	Comparable between Non-uniform tax and Uniform tax in sub-basin LI129
5-13	Non-uniform tax of each main point source at sub-basin RF131
5-14	Uniform Tax of entire main point source at sub-basin RF132
5-15	Comparable between Non-uniform tax and Uniform tax in sub-basin RF.132
5-16	Non-uniform tax of each main point source at sub-basin LJ
5-17	Uniform Tax of entire main point source at sub-basin LJ135
5-18	Comparable between Non-uniform tax and Uniform tax in sub-basin LJ135

.

•

Table	Page
5-45 Comparable between Non-uniform tax and Uniform tax in sub-basin F	RI158
5-46 Non-uniform tax of each main point source at sub-basin LS	159
5-47 Uniform Tax of entire main point source at sub-basin LS	160
5-48 Comparable between Non-uniform tax and Uniform tax in sub-basin I	LS161
5-49 Non-uniform tax of each main point source at sub-basin RJ	162
5-50 Uniform Tax of entire main point source at sub-basin RJ	163
5-51 Comparable between Non-uniform tax and Uniform tax in sub-basin F	XJ163
5-52 Non-uniform tax of each main point source at sub-basin RK	164
5-53 Uniform Tax of entire main point source at sub-basin RK	165
5-54 Comparable between Non-uniform tax and Uniform tax in sub-basin F	RK165
5-55 Non-uniform tax of each main point source at sub-basin LT	167
5-56 Uniform Tax of entire main point source at sub-basin LT	167
5-57 Comparable between Non-uniform tax and Uniform tax in sub-basin I	.T168
5-58 Non-uniform tax of each main point source at sub-basin LU	169
5-59 Uniform Tax of entire main point source at sub-basin LU	170
5-60 Comparable between Non-uniform tax and Uniform tax in sub-basin I	LU170
5-61 Non-uniform tax of each main point source at sub-basin RL	172
5-62 Uniform Tax of entire main point source at sub-basin RL	172
5-63 Comparable between Non-uniform tax and Uniform tax in sub-basin F	RL173
6-1 Comparison effect of Non-Uniform tax	
and Uniform tax to Thachin River	156

# สถาบนวทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

•

# LIST OF FIGURES

Figu	re Page
1-1	Appropriate variation charges at any reduction case
1-2	BOD value 1995 to 2004
1-3	The boundary of Thachin River Basin10
2-1	The regulation structure to control the polluted water in Thailand22
3-1	Proportion of Land use in Thachin River Basin
3-2	Location of pig farms in Thachin River Basin
3-3	Location of large communities in Thachin River Basin
3-4	Locations of Aqua culture in Thachin River Basin
3-5	Locations of factories generating water pollution in Thachin River Basin66
3-6	Work diagram of Determination of Industrial effluent standard research70
3-7	Sub-basins which has potential to cause water quality deterioration72
3-8	Proportion of Point sources and Non-point sources effluent discharged from
	33 sub-basins to Thachin River
3-9	Prediction of current water quality in Thachin River using
	BOD loading from each sub-basin in 200475
3-10	Calculating results of BOD value of Thachin River after reducing
	BOD loading at particular area that led to BOD peak80
	Non-uniform tax equivalent to CAC
3-12	Uniform tax
3-13	The optimal case of tax charge at total cost curve and marginal abatement
	cost curve101
5-1	Estimation Command, Estimation Equation, and Substituted Coefficients116
5-2	Estimation Command, Estimation Equation, and Substituted Coefficients118
5-3	Estimation Command, Estimation Equation, and Substituted Coefficients119
5-4	Estimation Command, Estimation Equation, and Substituted Coefficients120

5-5	Comparable of cost of abatement between Non-uniform and			
	Uniform tax in each sub-basin	174		
5-6	Comparable of Tax expense between Non-uniform and			
	Uniform tax in each sub-basin	174		
5-7	Comparable of Total expense between Non-uniform and			
	Uniform tax in each sub-basin	175		
5-8	Comparable of Net profit between Non-uniform and			
	Uniform tax in each sub-basin	175		



สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# NOMENCLATURES

Alpha	An ability of pollution release in each point source
a,b,c, and d	Coefficient set
BAT	Best Available Technology
Beta	BOD loading when produce at q unit of each main point source
B.E.	Buddhist era
BMPs	Best Management Practices
BOD	Bio-chemical Oxygen Demand
С	Cost of Abatement
CAC	Command And Control
CGWB	The Central Ground Water Board
COD	Chemical Oxygen Demand
СРСВ	The Central Pollution Control Board
CSO	The Central Statistical Organization
CWA	Clean Water Act
DENR	Department of Environment Studies and Natural Resources
DIW	Department of Industrial Work
DO	Dissolved Oxygen
E	Pollution Concentration in Effluent stream
e จุฬา	Natural logarithm
EEFD	European Environmental Framework Directive
EPBs	Environment Protection Bureaus
EPA	Environment Protection Agency
EU	European Union
F	Total amount of wastewater treatment

FRG	Federal Republic of Germany
FWPCA	Federal Water Pollution Control Agency
Ι	Pollution Concentration in influent stream
MAC	Marginal Abatement Cost
NPDES	National Pollutant Discharge Elimination System
NSW	New South Wales
PCD	Pollution Control Department
POEO	Protection of the Environment Operation Act
Q	Type of each production in each sub-basin
RMB	Chinese currency "Yuan"
SS	Suspended Solids
TMDL	Total Maximum Daily Loading
TOC	Total Organic Chloride

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

### **CHAPTER I**

#### **INTRODUCTION**

#### **1.1 Description of problem**

According to a worldwide Environmental Sustainability Index in December 2002, to show the state of the environment and how it is affected by human activities, Thailand ranked 46th out of 56 countries. This was conducted by the World Economic Forum 2000. Many observers in and outside of Thailand believe that this poor environmental performance is due to the government's lack of will in enforcing existing laws and regulation. They maintain that the Natural Resources and Environment Ministry does not have any real power and authority and that the government needs to take a tougher position to regulate and monitor all developments which impact the environment.

Thailand, considered as one of the "East Asian tigers," was praised for its strong economic growth during the expansion years up to the financial crash of 1997, for example it had more than quadrupled the amount of energy consumed per person, from 11 million Btu per person in 1980 to 46.2 million Btu per person in 2001. However, at the same time the country also suffered from increased levels of industrial wastewater, a dramatic rise in domestic sewage and hazardous wastes, and severe degradation of its water and coastal resources. After 1997 there was an increased awareness that Thailand's economic development must take into greater account the environment in order to be sustainable in the longer-term. Furthermore, based on the Environmental Protection Act (1992), Thailand's 1997 constitution requires the government to conduct public hearings and seek the views of local communities before it embarks on development projects that will have an effect on the environment.

In spite of this legislation, increasingly water reservoirs, rivers, canals and swamps have become severely polluted due to wastewater discharged from many activities such as pig farms, urban communities, aquaculture and industries. Especially, industrial activities generate a lot of wastewater resulting from its high water consumption. Often the wastewater being generated is highly contaminated with both organic and inorganic substances. Legal requirements for factories and industrial parks to treat their wastewater in order to meet the industrial effluent standard could be considered as just an 'end-of-pipe' control. Moreover, as the standard only specifies the concentration of contaminants without taking into consideration the contaminant loading, the amount of wastewater being discharged does not correspond with the carrying capacity of the receiving aquatic ecosystem which is attained by the pollution. Each water basin has its own respective temporal and spatial carrying capacity in absorbing pollution, i.e., different carrying capacities. The deterioration in reservoir water quality has resulted from factory permits which are issued for a specific area but do not conform with the land use, the environment and the carrying capacity of that particular aquatic ecosystem.

In theory, government policy should provide measures to alleviate poverty and promote the development of a sustainable environment. There has been some interesting relevant research and development which has emerged which could be applied in order to promote the standard of living and at the same time improve environmental protection. Naturally, such R&D would be highly appreciated as a possible 'win-win' solution to certain environmental problems. Several projects have been launched to control and minimize pollution and to improve industrial technology. For example, the Thachin River Basin partnership is to establish the "Thachin River Business Coalition" and also enhance the partnership between Thailand-Phillipines and the EPA in USA.

From 2000 to 2002, the Thachin River was ranked as the most polluted river in Thailand. Urban communities and effluent from pig farms in Nakhon Chaisri District, Nakhon Pathom Province were significant contributors to deteriorating water quality in the lower part of the basin

In Thailand, there are twenty-five river basins that increasingly have to deal with pollution loadings which exceeds their carrying capacity.

Thachin River, located in the central region is the main river passing through nine provinces and serves approximately eight million people for domestic, agricultural and industrial uses. Currently, it is being overloaded with wastewater from various industrial, agricultural and urban activities. Consequently, it is facing a serious problem of surface water quality especially when dealing with an accumulation of upstream wastewater discharges.

From a technological point of view, there are evidently many ways to minimize and to mitigate wastewater loading before discharging into a natural aquatic ecosystem especially a river.

However, in Thailand, many researchers have proposed non-technological methods by applying a taxation method to control wastewater effluent not only from industries but also from agriculture and domestic use. Based on this method, a Uniform or Non-uniform Tax has been proposed and applied to deal with pollution emission permits. At present, the Pollution Control Act is used as a uniform tax, which is a single tax rate charge, to control pollution emissions nationwide. This method is not an optimization tax. Although the unit charge is concerned with the amount of pollution emission at the 'end-of-pipe', it does not take the water quality of river after the wastewater has been actually discharged into consideration.

It would be more appropriate, if the taxation model would take into account both the amount of pollution emission at the 'end-of-pipe' and the amount of wastewater contaminant in the surface water which should not exceed the environmental loading or overload the carrying capacity of the river ecosystem. To solve these problems based on a non-technological method, the incentive based method together with a taxation system could be effectively introduced to control pollution discharge levels in order to reduce the pollution loading into the river.

# <u>1.1.1 Conflict Management.</u>

At present Thailand has only implemented the 'end-of-pipe' wastewater regulation, which specifies that the Biochemical Oxygen Demand (BOD) at the end-ofpipe shall not exceed 20-60 mg/l, in order to control the quality of wastewater being discharged into a public water source or natural water system. However, this still poses various questions about how to conserve the water quality without serious pollution. A hypothetical situation would be, if thousands of wastewater discharges from individual sources comply to the national effluent standard, then would the river basin be able to absorb them all?

Therefore, in order to further clarify the issue of accumulated loadings, the Total Maximum Daily Loading (TMDL) for each sub-basin is needed in order to better understand and recognize the limits of loading. Theoretically, when a TMDL is set for a sub-basin, the Maximum Load for each pollution activity could be traced back to it's source. This means that the intensity of BOD in each sub-basin would not be identical which would depend upon the specific environmental conditions of both each sub-basin as well as the whole river basin.

Regarding the industrial effluent standards of Thailand, which indicates parameters, standard values and recommended methods for observation and analysis as shown in Table A-1.

In the past, there was an attempt to use taxation to control water pollution. However, this was not successful since each sub-basin has its own specific TMDL, the tax used should therefore vary for each sub-basin depending on the carrying capacity.

For the environmental conditions of the Thachin River in this study, the author used water classification standard class 2, 3, and 4 to determine the TMDL of each subbasin along the river in Table A-4.

Based on the abatement cost which defines the cost for the treatment of effluent discharges and the marginal abatement cost (MAC) defined as the cost which is sufficient for treatment up to the last unit of effluent. The MAC curve in Figure 1-1 shows that the more polluting substances are released into the environment, the less the abatement spending to be paid by the factories.

Theoretically, effective taxation could be used as a measure for controlling the amount of pollution emissions that could be indicated by the tax line ( $P_1$ ,  $P_2$ , and  $P_3$ ).

This shows where polluters would have to pay a variable tax at each P line if they were to produce any unit of pollution. This could induce them to produce less pollution which would be an amount lower than the appropriate level at the tax line intersection. This point would then provide the MAC that the polluter would benefit from in paying lower taxes.

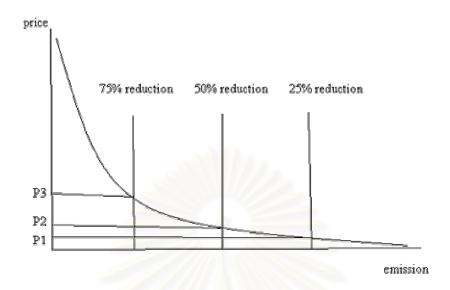


Figure 1-1: Appropriate variation charges at any reduction case

There is a further important reason why non-uniform and uniform taxes should be used. Due to the controlling of ambient water quality in each sub-basin under the water classification standard, we have to consider several factors some of which are the following:-

1) the cost of treatment of each activity; and

2) the pollution carrying capacity ability of each sub-basin.

#### 1.1.2 Current situation of BOD loading in Thachin River

The monitoring of water quality in the Thachin River from the Pollution Control Department (PCD) found that Thachin River has continuously deteriorating BOD values and dissolved oxygen as pollution indictors. The Thachin River catchment has a BOD higher than the surface water standard which should not exceed 4.0 mg/l for downstream, 2.0 mg/l for midstream and 1.5 mg/l for upstream sections. At the same time, the dissolved oxygen is lower than the standard limit 2.0 mg/l for downstream, 4.0 mg/l for midstream and 6.0 mg/l for upstream sections.

Moreover the rapid deterioration rate of Thachin River also has to face severely polluted water in some segments, especially from the end of the dry season through to the rainy season. As can be seen in the pollution water crisis of Thachin River in A.D.2000, which started at the end of April to the beginning of May, coincides with rice harvesting. During that period, the rainfall was more than usual and it covered an area of more than 21,120 ha, resulting in extensive flooding and water pollution in rice fields covered the area of Toon Soangpinong and Suphanburi Province. As a result, in order to resolve the water pollution problem, farmers discharged polluted water into the Thachin River at the middle segment. Consequently, masses of polluted water passed through Banglane District, Nakornchaisri District, and Sampran District of Nakornpathom Province, and continued onto Kratumban and Muang district, Samutsakorn Province. A total distance of 150 kilometers became a dark color and had extremely low Dissolved Oxygen (DO), even reaching 'Zero' at some points, PCD (2005a).

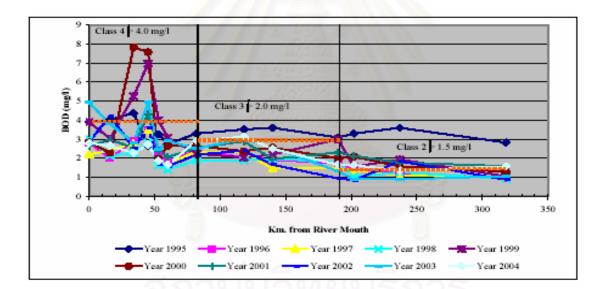


Figure 1-2 BOD value 1995 to 2004

Source: PCD, (2005a)

#### **1.2 Objectives of the study**

This research, aims to explore the possible maximum volume of BOD effluent in each sub-basin without causing a deterioration in the river ecosystem. Therefore, the approach taken in this study is to optimize the effluent taxation model in order to control the surface water quality of the Thachin River. There are two specific objectives which are as follows:

- 1. To find the appropriated effluent tax system to control the pollution loading of the Thachin River.
- 2. To construct the optimization mathematical decision making model: in order to make the maximization profit to system, that meet the environmental constraint and economic constraint from Thachin River, and the amount of pollution discharges will not exceed Total Maximum Daily Loading of Thachin River.

The results of the database collection (PCD, 2005a) show permitted pollution loading and the targets of emission reduction for the Thachin River. These results will be converted to the abatement costs and tax rates. The wastewater abatement cost, the appropriated variation tax and reduction rate from each sub-basin will be shown in this study. Then these results will be processed by mathematical programming, to give the effects of the taxation system.

The results of study should provide useful information about the optimal taxation level for controlling pollution emissions in each sub-basin of the Thachin River by using the incentive based method. The polluter would pay taxes which are less than the full abatement cost. Furthermore, the environment around Thachin River would be improved because the wastewater discharge level would be controlled by taxation.

This study would also provide valuable information to policy makers to assist them in implementing plans which could be integrated to complete the projected database. This project is a basic database to provide the foundation for an effective quality control policy for the Thachin River. Moreover, this policy could be extended with other methods such as transferable trade permits for future pollution.

Finally, the efforts to support a sustainable environment is at the core of the project, which should lead to an improvement of the Thachin River basin. Thus, the communities in the Thachin river area should also have a the better quality of life. Furthermore, the results of the study could possibly be applied to many of the major rivers in Thailand.

#### 1.3 Hypothesis of the study

The 'Emission Taxation system' could control the pollution discharges of a subbasin which would then reduce the amount of effluent loading to meet the 'Total Maximum Daily Loading' requirements of Thachin River and also satisfy certain economic constraints.

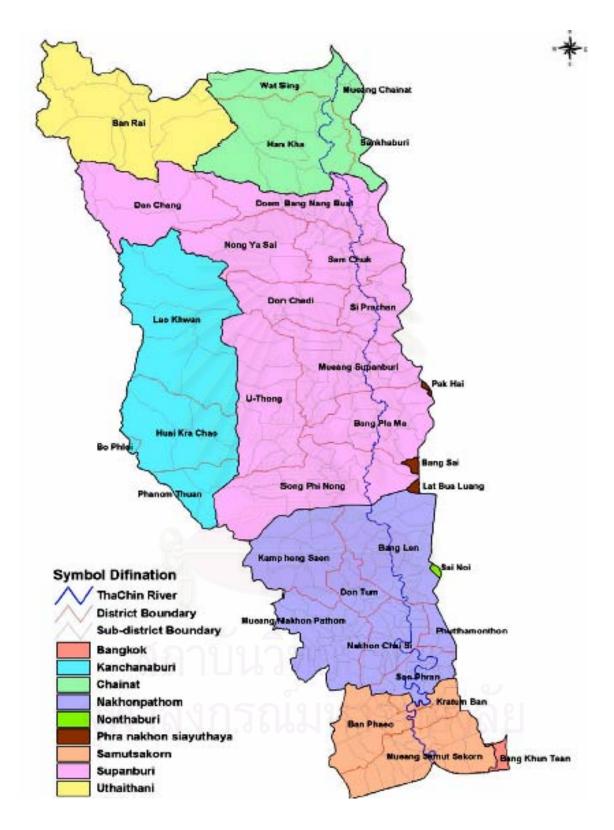
#### 1.4 Scope of the study

#### 1.4.1 Thachin River

Thachin River is the only major river in the Thachin water basin and is known under several different names depending on the location it passes through, such as the Makhamtao Canal, Supanburi River and the Nakornchaisri River. However, it is commonly known as the Thachin River. It originates from a stream that separates from the right bank of the Chaopraya River at Ban Paakklongmakhamtao, Makhamtao subdistrict, Watsing district, Chainat Province. This then passes through Hanka district, Chainat Province, going to Supanburi Province through the districts of Dermbangnangbuat, Samchuk, Sriprachan, Muang, Bangplama, and Songpinong. It passes through Nakornpathom Province at the districts of Banglane, Nakornchaisri, and Sampran, and flows into the gulf of Thailand at Samutsakorn Province by passing through Banprao, Kratumban, and Muang districts. The total length of the river is 325 kilometers, PCD (2005a). The Thachin River Basin has a total area of 11,763 square kilometers or 7.35 million rais covering nine provinces, consisting of Bangkok, Ayuthaya, Nontaburi, Chainat, Utaithani, Supanburi, Kanjanaburi, Nakornpathom, and Samutsakorn. A majority of the area, about 99.5 %, is situated in six provinces, excluding Ayuthaya, Nontaburi, and Bangkok. The boundary of Thachin River Basin is shown in Figure 1.3.



# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย



**Figure 1-3** The boundary of Thachin River Basin Source: PCD (2005a)

#### 1.4.2 Using tax system for controlling water pollution in Thachin River sub-basin

In Thailand environmental management is largely carried out at the state level. This is true for natural resources such as forests, land as well as for air, water quality and solid waste pollution. Therefore, the focus of efforts to improve environmental stewardship has to be at the state level. This paper proposes and implements a methodology to evaluate the cost-effectiveness of market-based approaches to environmental management. In particular, using data from the PCD, we quantify potential water pollution control in Thachin River that would result from using a market-based instrument (MBI) such as an emissions tax compared to command and control (CAC) regulations focus on all 4 main polluting sectors.

While there is an existing alternative approach for pollution abatement in Thailand, the policy response to regulate pollution has been through command and control (CAC) strategies. Without going into the compulsions for adopting a Tax Emission approach, there are a number of problems with the current regulatory regime from an economic point of view.

#### 1.4.3 Using BOD represented all types of water polluter

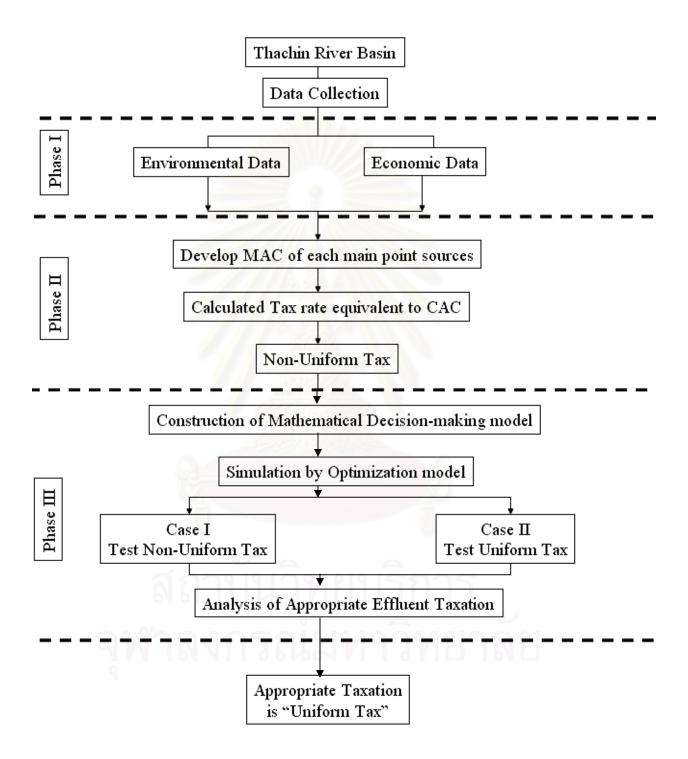
Industrial, agricultural chemicals and organic pollutants from agro-based industries are a significant source of surface and ground water pollution. Understanding the impact of water quality on human health and aquatic life has improved greatly in recent years. Consequently, two broad measures of water quality have come to be widely accepted and used as measures of oxygen levels or oxygen demands in water.

The use of BOD indicators provides an approximate but useful overview of the overall health of a water body and/or the threats confronting it. The procedures required for the measurement of water quality indicators are problem-specific and are generally well understood.

Biochemical Oxygen Demand (BOD) is one of the important parameters used for water quality evaluation including domestic and industrial wastewater, waste treatment monitoring and design. The BOD standard method is measured following the Standard Method for the Examination of Water and Wastewater (Clescerl et al., 1999). BOD waste is one of the most hazardous wastes that contain high amounts of heavy metals substances and toxic substances. These hazardous wastes generate from BOD are a major cause of serious problems threatening public health and the environment.



# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย



**Figure 1-4: Conceptual Framework** 

The steps in estimating the Appropriate effluent taxation are briefly described:

The first phase is to collect the data which divided into 2 aspects which are Environmental aspect and Economic aspect. First aspect is the actual information of Environmental aspect which is concerned with pollution characteristic, carrying capacity, Total Maximum Daily BOD Loading, and Target of emission reduction of Thachin subbasin. Second aspect is concerned with the production cost, abatement cost and the revenue of every activities in Thachin sub-basin. From these information are using continuously in Phase II and III.

Second phase is the calculation of the marginal abatement cost (MAC) of each main point source and calculate the emission tax rate under Command and Control (CAC).

Third phase is the construction of the Mathematical Decision-making model and simulated by using optimization model for arriving appropriate emission tax charge.



# **CHAPTER II**

#### LITERATURE REVIEW

#### 2.1 Thachin River

The Thachin river basin covers a total area of 11,763 sq. km. or 7.35 million rai, consisting of 9 provinces, i.e., Chai Nat, Uthai Thani, Suphanburi, Kanchanaburi, Nakhon Pathom and Samut Sakorn covering approximately 11,706 sq. km. or 99.5% while 57 sq. km is located in the remaining three provinces, i.e., Ayutthaya, Nonthaburi and Bangkok.

The details are shown in the table below:-

	Province	Area of Province		Ratio	Ratio	District Name
Sub-basin		Total area	Basin area	Province in Basin (%)	Area in Basin (%)	in Province
Upper	1. Chainat	1,541,681	736,356	47.7	10	Muang, Sankhaburi, Han Kha, Wat sing,
	2. Uthaithani	4,161,896	671,368	16.1	9.1	Ban Rai
	3. Suphanburi	3,378,300	1,678,875	49.7	22.8	Don Jadi, Sam Chuk, Dan Chang, Nong Yasai, Sri prajan
	4. Kanchanaburi	12,116,415	471,237	3.89	6.4	Lao khwan
Middle	5. Suphanburi	3,378,300	1,246,337	36.9	16.9	Muang, Song Pri Nong, Bang Pra Ma, U thong
	6. Kanchanaburi	12,116,415	638,562	5.3	8.7	Panomthom, Huai kra Chao, Bo Phloi
	7. Ayutthaya	1,591,470	14,662	0.92	0.2	Lat Bua Luang, BangSai, Pakhai
	8. Nonthaburi	404,858	3,600	0.9	0.05	Sainoi
	9. Nakhon Pathom	1,317,218	1,004,287	76.2	13.6	Kamphaeng Saen, Don Tum, BangLen, Muang, Buddha Monthon, Nakorn Chai Sri
Lower	10. Nakhon Pathom	1,317,218	312,931	23.7	4.3	SamPhran
	11. Samut Sakorn	556,718	556,718	100	7.57	Ban Phaeo, Krathum Ban
	12. Bangkok	984,822	177,162	1.7	0.23	Bang Khun Thain

Table 2-1: Percentage and	ratio of each	province in eac	ch sub basin	of Thachin River
Tuble 2 11 I el centage and	i i atto oi cacii	province in ca	chi buo buoin	or r machini ruver

Source: PCD, (2005a)

Thachin River is a major river known under many different names depending upon the location through which it passes, such as KlongMakham, Suphan River, and Nakornchaisri River. However it is commonly known as the Thachin river. The origin of the Thachin River is a tributary of the Chaopraya River which separates at Khong Makham, Makhamtao Subdistrict, WatSign District, Chainat Province and passes through many provinces including Chainat Province, Suphanburi Province, Nakon Pathom Province and downstream in Samut Sakorn Province before flowing into the Gulf of Thailand. This gives a total length of approximately 325 km.

The average depth of Thachin River is approximately 5.30 to 11.50 m. Upstream in the area of Khong Makham up to Khong Phayabunlo the average depth is 6.00-6.50 m. and downstream from Bann Banghuang to Samut Sakorn Province the average depth is 7.50 – 11.50m. The average width of Thachin River is approximately of 46-500m., the narrowest part of the river being less than 100 m. between Wat Bang Mae Mae, Bang Pra Ma District, Suphanburi Province and upstream to the origin of Thachin River located at Mak Hamtao sub district, Wat Sing District, Chainat Province. The Thachin River is wider than 200m. downstream between Mahasawat Watergate to river mouth, PCD (2005a).

Evidently, the hydrology of the Thachin is no longer characteristic of streams in tropical regions as the inflow is controlled by the regulatory structure on the Chao Phraya River just downstream of the diffluence junction. Consequently, the average monthly discharge throughout the year varies from about 50  $m^3$ /s to 290  $m^3$ /s with the average annual flow being about 75  $m^3$ /s.

There are several water gates regulating the flow throughout the river's course. As the catchment is mostly on a flat plain, the stream gradient is minimal and the water level in most of the lower half of the watercourse is affected by tidal fluctuations. As stated earlier the Thachin River has the dubious distinction of having the worst water quality in Thailand. This situation is mostly due to the excessive discharge of waste and pollution into the river, resulting in water quality being far below the standard level set for inland water quality, especially along the lower and middle reaches of the catchment. The capacity of the stream to absorb these pollutants is also constrained by flow regulation which limits the natural flushing of the stream. Another important factor is the ponds and local water storage on the flood plain which are prone to overflow or washout during heavy rainfall periods causing a crisis scenario as experienced in 2001.

#### <u>The Sub-basin of Thachin River</u>

The sub-basins of the Thachin river are either natural creations or man-made to be used for irrigation and/or flood prevention systems. There are 36 major canals along the Thachin River:

- 2 canals connecting between the Thachin river and Mae Khong River are the Damnoen Saduak Canal and the Bang Kaew Canal
- 21 canals connect between the Thachin River and ChaoPhaya River such as the Bang Pra Ma Cannel, the Chaojed Cannel, the Prayabunloe Cannel, the Prapimon Cannel, Mahasawad Cannel, the Prasricharoen Cannel, etc.

The Thachin river can be divided into three segments according to the water quality classification as follows:-

Segment 1: Thachin River from the river mouth at Muang District, Samutsakorn Province (Zero Kilometer), going up north to the front of City Hall of Nakornchaisri District, Nakornpathom Province (82<sup>nd</sup> Kilometer). This segment is classified as class 4

Segment 2: from the front of City Hall of Nakornchaisri District, Nakornpathom Province (82<sup>nd</sup> Kilometer), going up north until reaching Prothipraya watergate at Muang District, Suphanburi Province (202<sup>nd</sup> Kilometer). This segment is classified as class 3

Segment 3: from Prothipraya watergate at Muang District, Suphanburi Province (202<sup>nd</sup> Kilometer), going up north until reaching the origin of Thachin river at Ban Pakklongmakamtao, Makamtao Subdistrict, Chainat Province (325<sup>th</sup> Kilometer). This segment is classified as class 2.

The report of Pollution Control Department (2005a) shows that the water quality in Thachin River has continuously deteriorated using the BOD and Dissolved Oxygen as indicators. The data indicates that the BOD exceeds the standard limit, which is :-

not exceeding 4.0 mg/liter for the lower segment, not exceeding 2.0 mg/liter for the middle segment, not exceeding 1.5 mg/liter upper segment.

#### 2.1.1 Total Maximum Daily Loading and Target of emission reduction

PCD (2005a) found that the problems of water resources have been continuously deteriorated due to the carrying capacity are incapable to receive the load of activities such as agriculture and especially industry. The activities of industry need a load of water which generates the wastewater as well. The wastewater from industry has highly contaminated with organic matter and non-organic matter; however, the control pollution act has been compelled the manufactures treat their waste in the standard compulsory. The controlling emission standard has been considered only the effluent loaded-concentration but unaware of effluent loading lead to the volume of effluent excess than the carrying capacity. The solution of this problem is to control the pollutant sources by limiting the effluent volume to match the carrying capacity. Each of basins has different capacity to receiving the pollutant. From Ministry of Science, Technology and Environment Issue 3 (B.E 2539) appointed to define the effluent standard for the pollutant generators in industrial park.

At present, there is no control for the volume of pollutant emission into the receiving water resources. Thus Pollution Control Department urgently studied the way to control the effluent volume and process to effluent from the industrial pollutant generators. It used for improving the effluent standard of industrial and the water surface quality standard which include the processing of permit system for pollution emission. The purposed of their project fined the suitable effluent volume and implemented the procedure for industrial pollutant generators which emitted the suitable volume of pollutant for the water resources and increased the effluent standard and surface water standard. The expected result of their project was to know the volume of the effluent and the procedure for controlling the effluent from the industrial generators sources and other pollutant sources.

### 2.1.2.1 Pig Farm

Nowadays, the numbers of pig farms are increasing which some manage to treat their waste before discharge into the environment but many of them have not. Therefore, the government agencies were gathering data, analyze and manage the wastewater from pig farm in order to control the effluent load into the water resources. However, the government would like to study the affect of farmers and entrepreneurs after applying the regulation.

The government assigned the CMS Engineering and Management to study the development and methodology for controlling the pollutant water in order to purpose to the PCD, (2003a). The purposes of their project were as follows:

1. Making database of pig farm in Thailand by searching and listing all pig farms in details such as name of the pig farm and their located.

2. Planning for managing the pig farm wastewater by concerned in legal matter, regulation which related to the economic and social aspects.

3. Providing the instruction of technology to manage pig farm.

The scopes of work of the project were to gather, analyze and study about its information. They studied the methods and procedure to eliminate the wastewater from pig farm and provided the instruction manual to manage the pig farm.

### 2.1.2.2 Urban community

Two decade, Thai government spent 67,290 million Bath for treatment facilities; however, the expenses of running treatment system are high and most local governments have inadequate budget to run fully capacity of treatment.

PCD (2003b) assumed that if local government could collect the effluent tax charge, it would be used and covered all the expense for managing the treatment system and investing in expanding facilities.

### 2.1.2.3 Aqua culture

PCD (2005b) main target was to manage and prevent the effluent of Aqua culture the details as follow:

- 1. Demonstrated farm which manage and treat the effluent pollutant to satisfy the effluent standard.
- 2. Provide manual and implement the methods to eliminate the polluted water from aqua culture.

The scopes aimed, firstly, to reduce the effluent pollutant and introduce the proper management scheme and technology in order to eliminate the polluted water and the effluent pollutant.

Secondly, the study provided and tested the prototype treatment system in the laboratory. Thirdly, it also designed and tested the treatment system in the aqua cultural area by evaluating its efficiency, farm management, treatment system and the cost of operation.

The expected results from the study are to reduce the effect to water resources from the effluent and its sediment from the aqua culture and implement the methodology for farmer and local office to follow in order to get rid of the waste water of aqua culture.

> สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

### 2.1.2.4 Industry

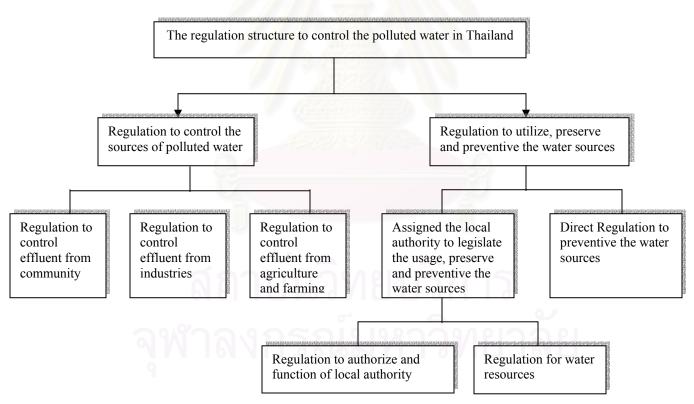
The purposed of PCD (2003c) aim to draw the tools for pollution control officer to indict the pollutant generators who smuggle to drain the waste water or do not use treatment system. The target of this research is defined the charging rate in order to use its against the pollutant generators. The expected results of their project are to control and monitor the pollutant generators to emit the pollutant water not over the standard limits. The scopes of their work are firstly, gathering data and analysis. Secondly, to study, analyses and finding the cost of operation. Thirdly, to provide software which use for calculating the daily charge rate for treatment system. Fourthly, to arrange the implement meeting one time that needs the participants at least 80 persons to attended the meeting. Fifthly, to use the results of (1) and (2) in order to provide the manual for officers who control the pollution.

> สถาบันวิทยบริการ เพาลงกรณ์มหาวิทยาลัย

### 2.2 Existing Regulation in Thailand

The effective regulations to control water pollution in Thailand can be divided into 2 categories:-

- 1. Regulations to control the source of polluted water by defining the polluted water which discharges effluent.
- 2. Regulations to preserve the quality and utilize the water resources which can be subdivided into regulations to preserve the water resources and assigned to the local authorities responsible for their own regulations in order to preserve their local water resources.



**Figure 2-1: The regulation structure to control the polluted water in Thailand** Source: PCD, (2005a).

### 2.2.1 Regulation to control sources of polluted water

At present, Thailand has regulations which are to be applied in the control of effluent sources consisting of 3 categories including :-

(1) urban communities/built up areas

(2)agriculture and

(3) industry.

The details are shown in the table below:

### Table 2-2: Regulation and Constraint of each polluted water resource

Type of polluted water	Regulation and Constraint		
Urban area	Building		
	1. Regulations from Ministry of Sciences, Technology and		
	Environment designated to the type of building in order to		
	control the effluent of polluted water into public water		
	resources and the environment.		
	<ul> <li>2. Regulations from Ministry of Sciences, Technology and Environment designated to the type of building to control sources of polluted water into public water resources and/or environmental concerns 2 (B.E 2538).</li> <li>3. Regulations from Ministry of Sciences, Technology and Environment designated to the standard of effluent depending on the type and size of buildings.</li> </ul>		
10			
	Allocated land		
	4. Regulations from Ministry of Sciences, Technology and		
	Environment designated to allocated land that are potential		
	pollution generators and the effluent into public water		
600	<ul> <li>resources and the environment have to be controlled.</li> <li>5. Regulations from Ministry of Sciences, Technology and Environment Issue 5 (B.E 2539) designating the standard of</li> </ul>		
6 6			
	effluent for allocated land.		

### Table 2-2: (continued)

Type of polluted water	Regulation and Constraint	
Industrial	1. Regulations from Ministry of Industry Issue 2 (B.E2539)	
	designated to the effluent standard for industries.	
	2. Regulations from Department of Industrial designated to the	
	specification of effluent emissions which are different from the	
	those from the Industrial Department.	
	3. Regulations from Ministry of Industry issue 13 (B.E 2525)	
	act B.E 2512 designated to the function of industrial licensees.	
	4. Regulations from Ministry of Industry issue 22 (B.E 2528)	
	act B.E2512 appointed to the function of industrial licensees	
_	5. Regulations from Ministry of Sciences, Technology and	
	Environment Issue 3 (B.E 2539) designated to the standard for	
	controlling manufacturing emissions and industrial park	
	emissions to water resources.	
	6. Regulations from Ministry of Sciences, Technology and	
	Environment Issue 4 (B.E 2539) designated to the control of	
	manufacturing and industrial park effluent into public water	
	sources and environment.	
	ANG LONG LON	
	7. Ministerial regulation, issue 2 (B.E 2535) prohibits the	
	manufacturers to emit emissions, except those which satisfy	
	standard limits.	
	8. Ministerial regulation issue 3 (B.E 2535) designating	
	harmful manufactures of the environment, in order to provide	
	reports of pollutant loading	
	9. Ministerial regulation issue 5 (B.E 2535) appointing details	
~	and procedures for factory licenses.	
	10. Ministerial regulation issue 11 (B.E 2535) appointing to	
	manufactures equipped with wastewater treatment systems,	
	who have to install measuring equipment in order to report the	
211/222	volume of effluent.	
	11. Regulations from Department of Industrial Work appointed	
9	to provided effluent reports.	
Agriculture	1. Regulations from Ministry of Sciences, Technology and	
Sources BCD (2005a)	Environment appointed to the effluent standards for pig farms.	

Source: PCD, (2005a).

### 2.2.2 Regulations to preserve the quality and utilization of water resources

The regulations to preserve the quality and utilization of water resources can be divided into 2 categories which are (1) direct regulations to preserve water sources and (2) the local regulations which are designated by responsible local authorities.

Table 2-3: Regulations to preserve the quality and utilization of water resources

Directed regulation to preserve the water resources	<b>Regulation for decentralize to local</b> authorities to issue their own regulation
Support and preserve the national environment Act (B.E 2535)	Regulations for responsibilities and authority of local authorities
Preservation Canal Act	- Constitution of Kingdom of Thailand B.E 2540
Royal Irrigation Act (B.E 2485) and order from	- Municipality B.E 2496 (corrected issue 11 BE 2543)
Royal Irrigation department 883/2543	- Local council and Local administrative B.E 2537
Protect water supplies/ Canal Act (B.E 2526)	-Provincial Administration Act B.E 2540
Fishery Act (B.E 2490)	Regulations for water resources
Underground Water Act (B.E 2520)	- Promotion and Environmental Quality Control Act B.E 2535
Navigation in Thai Territorial Waters (B.E 2456) and	- Public Health Act B.E 2535
Harbor Department 67/2534	9 9
Public Health Act (B.E 2535)	
Criminal Code Source: PCD, (2005a).	ายบริการ

### 2.2.2.1 Directed regulation to preserve the water resources

Regulation	Detail	Constrain to control waste	
		water	
Supported and	This act gives authorization	Although this act have been	
preserved	to the Minister in order to	defined the	
Environment B.E	appoint the control of	legal punishment for the waste	
2535	effluent sources type which	water generators who spread	
	are not to exceed the	harmful polluted	
	standard limit, Act 56, for	to the public health or damage to	
	water resources or other	the private or states properties or	
	regulations which are	damaged to the environment.	
	specially issued by governors	From Act 96 and 97 the fine will	
	to control polluted water Act	be charged for waste water	
	69 to whom pollutant	generators but there is no clear	
	generators have to install	procedures and conditions.	
	waste water treatment		
	systems Act 70.		
	The penalties to those who		
	have omitted to treat the		
	waste water or illegally		
	discharged effluent into		
	public water resources. Act		
	92 in case of pollutant		
	generators omitted or		
	illegally discharged effluent		
	into public water resources		
	have to be fined on a daily		
5	basis at 4 times the rate of	2005	
6	the expenses to run the waste		
	water treatment system. Act	0/	
	96 the pollutant generators		
	have to be responsible for all		
0	expenses for the government		
	to clean up the waste water		
	from the public water		
	resources and responsible for		
	the cost of environmental		
	damage.		

### Table 2-4: Directed regulation to preserve the water resources

### Table 2-4: (Continued)

Regulation	Detail	Constrain to control waste water	
Canal Act B.E. 2536	This act defines the legal punishment to those who dispose garbage or trash into the canal and are to be fined not over 20 Bath or imprisoned not more than a month or both penalties.	Not a severe punishment.	
Royal Irrigation Act BE 2485	This act is issued in order to support and control the Royal Irrigation and heavily punish those violating the law by poisoning or contaminating the Royal irrigation rather than dumping garbage. Thus, prohibition to contaminate or poison the Royal Irrigation. Act 35 Punishment for violations gives up to 3 months prison sentence or a maximum 2,000 Baht fine or both.	Punishment of chemical effluent into water resources harmful to agriculture and consumers.	
Order from the	To prevent and improve the	Appointed to control the effluent	
Royal Irrigation	poor quality effluent to	in irrigation and other water	
Department 883/2532 at 19 Dec	irrigation and other water resources which are	resources which are concerned by irrigation in irrigation areas.	
2532 at 17 Dec	concerned by irrigation in irrigation areas.		

# จุฬาลงกรณ์มหาวิทยาลัย

### Table 2-4: (Continued)

Regulation	Detail	Constrain to control waste water	
Navigation in Thai water Territory B.E 2546	The purpose of this Act to protect the people along water routes and prohibit obstruct of the same route. Acts were added and corrected in BE 2535 in order to preserve the water environment. Consequently, Act 119 Prohibits dumping rock, sand, dirt, mud, oils and other chemicals into the river, canal, reservoirs and lakes which are the route for traveling by boat to the sea in Thai territory leading to sea shallows except those permitted by the Harbor Department. The punishment for violations are 6 months imprisonment or fines not more than 10,000 bath or both and payment of clean- up operations.	Not a severe punishment	
Announcements from Harbor Department 67/2534 at Feb 20, 2534	Appointed to allow all types of effluent into the river.	ริการ	
Public Health Act BE. 2484	This Act gives authorization to the local officer who is responsible for removing, prohibiting or stopping	The local officers able to follow the process of laws are stated in the Act	

Table 2-4: (Continued)

Regulation Detail		Constrain to control waste	
		water	
Criminal Code	Act 237 To whom poisoning or deposing any harmful chemical to contaminate water resources, wells, ponds which are provided for publics consumption. The punishments are 6 months to 10 years imprisonment or both. Act 380 To those generating the waste water drainage into the water supply will be	waterThis Law stresses the contamination of water resources harmful to the public and specifically provides water resources for public consumption such as ponds and reservoirs.	
	fined and imprisoned for not more than 1 month.		
Cleaning and Ordering of Nation BE. 2535	This issue prohibits anyone deposing dirt, garbage or anything on the road, water which issue in Act 33 and authorized the local authorities to give a warning to the guilty person to get rid of the waste Or arrest and fine the person who violates the law from Act 44 to 46 and 48.	Not severely punished.	
Preservation Water supply canal Act B.E 2535	Purpose of this law is to preserve natural water resources for the water supply by prohibiting the extraction of water from canals or canals expanding or canals with leaks.	Concerned about special protection for raw water resources which are used for the water supply only and severely punishment.	
Fishery Act B.E 2490	Purpose of this law is to protect aquatic animals and water resources for fisheries by prohibiting drainage or any activities harmful to aquatic animals or harvesting of aquatic animals	Not severely punished in proportion to the extent of damage.	

Table 2-4: (Continued)

Regulation	Detail	Constrain to control waste	
		water	
Underground Water	Act 6 gives authorization to	Only concerned with the	
Act	the Ministry	protection of underground water.	
B.E 2520			
Industrial Ministry	Specifies regulations and	-	
Issue 5 (B.E 2521)	conditions for draining water		
follow from	into underground water	-	
Underground water	wells.		
Act B.E 2520			

Source: PCD, (2005a).

### 2.2.2.2 Regulations from local authorities to preserve local water

### resources

A) Regulations concerned with authorization to the local authorities

## Table 2-5: Regulation from local authorities to preserve local water resources under local authority jurisdiction

Principle	Act	
- The constitution of	Act 78 government has to decentralize to local	
Kingdom of Thailand	authorities decisions for their own activities.	
	Act 79 government permits and support the people to	
	preserve and eliminate pollution which is harmful to	
	health, safety and quality of life.	
	Act 290 Local organizations have authority to follow the	
สภา	regulation as follows	
6 6 6	(1) Management Maintenance and utilize the natural	
	resources and environment in the surrounding area.	
- Municipality Act B.E 2496	Act 60 Municipal government has the power to legislate	
(corrected and added issue	but not to be in conflict with the law in the following	
11 B.E 2543)	cases	
	(1) To operate on the duty of municipality	
	(2) The Municipal responsibility is not to cover the	
	preservation and prevention natural resources and	
	environment, however, duty of municipality which states	
	in regulations and other duties in the regulation are the	
	duty of the municipality	

Source: PCD, (2005a).

### B) Regulations concern with water resources

### Table 2-6: Regulation from local authorities to preserve local water resources concerned with water resources

Principle	Act			
- Act of Provincial	Act 45 Provincial management organizations have a duty			
management organization	as follows:-			
B.E 2540	(1) Legislation of laws but not against the law			
	(2) Prevention and preservation of natural resources and			
	environment Act 51 legislate in the case of			
	(1) Operated on the duty of Provincial management organizations			
	(2) Allows the Provincial management organization to			
	legislate fines and imprisonment of offenders but not			
	fines over 500 Baht.			
Support and Preservation	Act 60 the local official in the polluted control area			
the quality of environment	according from Act 59 to provided the operation plan in			
Act	order to reduce and get rid of the polluted in the control			
	area and purposed to provincial governor			
	(3) To study, analyze and evaluate the pollution			
	including the effect to the quality of environment in order			
	to prevent and reduce the pollution in the controlled area.			
Public Health Act	Act 26 gives authorization to the local officer to prevent			
	and preserve the water resources such as canals and other			
	places in their controlled area.			

Source: PCD, (2005a).

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

### 2.3 Case studies of other countries controlling water effluent

From the literature review, there are apparently 2 formats to control the effluent sources as follows:-

Format 1: To control the concentration-based effluent standard which Thailand is implementing at present.

Format 2: To control the load-based effluent standard, this has a case study in each format as follows



สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# 2.3.1 Control the effluent sources by controlling the concentration-based effluent standard

This format type is to control drainage of the sources by the concentration-based effluent standard which allows every type of polluted water source. The effluent discharges into the environment without considering the limited receiving capability of the river/water body which is not able to manage the pollution load. Consequently, in some areas the expansion of industrial and community areas are increasing due to development pressure, which are not confined to the central city. As a result, the water resources are highly contaminated as they receive the excess of wastewater loading. The countries have similar types of effluent control as Thailand are Singapore, Malaysia, Vietnam and Laos. However; there are differences defining the obtaining of the source standard and the concentration-based effluent standard.

### 2.3.1.1 Singapore

Singapore is the smallest country in South East Asia with high population density, the highest standard of living and education and a fully developed hi-tech. economy. The land area is 637 sq. km. and a coastline of 193 km. In 1950, a population of about a million people with a daily water demand of 142,000 m<sup>3</sup> grew to 4 million by 2004 and its daily water consumption is 1.4 million m<sup>3</sup>. This is expected to grow by a third in 10 years. Therefore, while the population has grown by about 4 times, water demand has risen more than 9 times. Households account for 55 percent of Singapore's water consumption. Singapore now gets nearly half its drinking water from rainfall in well designed catchment's areas, with the plan that all feasible land would have to be used. Rainfall supplies approximately 50% of Singapore's water; the remainder is mainly imported from Malaysia. Presently, most catchment's areas have facilities to recycle water or desalination plants are being built.

Pollution was recognized as a problem since the 1960s, and significant steps have been taken since to alleviate industrial and urban pollution. The Ministry of Environment (ENV) was first established in the 1970s as a department within the Prime Minister's Office before eventually becoming a full-fledged Ministry. It is responsible for providing the infrastructure for waste management, as well as enforcing and administering legislation relating to pollution control and public health. The Pollution Control Department (PCD) within the ENV is in charge of environmental planning and building development control, air and water pollution control and the regulation of hazardous substances and wastes. Due to the government's strong commitment to pollution control and also to Singapore's small size, the ENV has been largely successful in implementing its pollution control programs throughout Singapore.

However, the Singapore Constitution does not contain any provisions on the environment. Neither does Singapore have a framework law on environmental protection and management. There is no mandatory environmental impact assessment (EIA) system laid out in legislation. The present scheme of environmental management in Singapore is scattered throughout numerous Acts and Regulations. EIAs are required on an ad hoc basis at the discretion of the ENV. There have not been many judicial pronouncements in fact, environmental litigation/court cases are almost unknown. The environmental protection effort in Singapore is almost exclusively administrative in nature - the relative success of environmental management in Singapore is primarily due to the administrative efficiency of the ENV and other government agencies operating within a relatively tiny country.

The receivable wastewater sources are defined into 3 categories such as sewage, general water resources and raw water sources use for treating for the water supply. The standard effluents of commercial types are shown in table 2-7. Based on the standard effluent of the industrial type which are effected at present, the standard of concentrated-based of effluents in Thailand is the same as the standard of effluent into the raw water resources for making water supply such as BOD, oils/fats and others harmful chemical compounds.

Parameter	Drain	General water resources	Raw water for water supply
1. pH Value	6-9	6-9	6-9
2. BOD (5days at 20 C	400	50	20
3. COD	600	100	60
4. Total Suspended Solids	400	50	30
5. Total Dissolved Solids	3000	2000	1000
6. Grease and Oil	60	10	5
	(Hydrocarbon)		
	100		
	(Glycerides of		
	fatty acid)		
7. Metals in Total	10	1	0.5
8. Phosphate (as PO <sub>4</sub> )	-	5	2
9. Nitrate (as NO <sub>3</sub> )	-		20

Table 2-7: The standard drainage in commercial zone of Singapore

Source: PCD, (2005a).

.

### 2.3.1.2 Malaysia

In Malaysia the receiving pollutant water resources can be divided into 2 groups. Table 2-14 indicates the standards for effluent. The standard of group A for effluent to the water basins. Group B for effluent into the surface water. A comparison for industrial effluent in Thailand are categories in group A. The standard of others concentrate-based effluents are more strictly than the standard in Thailand such as BOD, oil/fats/grease etc.

Table 2-8: The standard industrial effluent in Malaysia

Parameter	Maximum Effluent	
(mg/l)	Standard A	Standard B
pH (units)	6.0-9.0	5.5-9.0
BOD5 at 20 C	-20	50
COD	50	100
Suspended Solids	50	100
Oil and Grease	Not detectable	10.0

Source: PCD, (2005a)referred to Environmental Quality (Sewage and Industrial Effluents) Regulations 1979.

The standard pattern to control effluent sources is defined by the maximum concentration pollution which are allowed for draining, are divided into 2 formats which are concerned by the strict level of standard depending upon the receiving pollutant water resources and type of industry which are the same format in Thailand. However, the drainage standards of industry in Thailand are affected at present, especially for BOD by the highest level of quality of water resources use for consumption. Recently, Thailand is facing to the continuous decline in quality of water resources. Consequently, the polluted sources are controlled by concerning on the concentrate-based effluent only without considering the maximum carrying capacity of water system due to pollution loading. The water system or river could have limited capacity to receive pollution loading without effect to water quality which would protect the declining quality of water resources especially the development of river basin is rapidly expanded and discharges wastewater sources in Thachin basin, PCD (2005a).

### 2.3.2 Load-based effluent standard

The load-based effluent standards to control the polluted sources have water quality-based effluent limits for each type of polluted source which takes into consideration the water treatment technology. The water quality-based effluent limits depend upon the capacity of water resources to adsorb the polluted water. Examples of the controlling water quality-based effluent limits for each type are as follows.

### 2.3.2.1 Water quality-based effluent limit for each type of pollution source

The water quality-based effluent limits for each pollution source, without concern for the capacity of water resources to receive polluted water, are not equal. Each locality is concern by the Best Available Technology (BAT) to treat the load-based effluent per unit of each polluted source which leads to the specific standards of water quality-based effluent for each type of pollution source. For example, the control of water quality-based effluent implemented in India which has a load-based effluent standard from the industrial sources, is classified into 2 formats:

- Concentration-based effluent standard and load-based effluent standard for certain industries, however the quantities of polluted waters are limited for some industries.
- Load-based effluent standard are using for 3 types of industry such as Oil refinery industries, large pulp and paper industries and newspaper printing industries shown in table 2-9

The limited quantity of polluted water from industries can be divided into 9 types such as integrated iron & steel, sugar industries, pulp & paper industries, fermentation industries, caustic soda, textile industries, starch, glucose, dairy, natural rubber processing industries and fertilizer shown in table 2-9

### Table 2-9(a): Load-based standards in India

Parameter	Oil Refinery (unit : kg/1000) Tones of crude Oil processed	Paper Pulp and Printing Industrial
Oil & grease	10.0	_
Phenol	0.7	
BOD	10.5	-
Suspended Solids	14.0	-
Sulphide	0.35	-
Total Organic Chloride	<u> </u>	2.0
(TOC)	0.7	

Source: PCD, (2005a).

ลถาบนวทยบรการ จุฬาลงกรณ์มหาวิทยาลัย

Seq.	Industrial Type	Standard
1	Integrated Iron & Steel	16 m <sup>3</sup> /tons of finished steel
2	Sugar	$0.4 \text{ m}^3$ /tons of cane crushed
3	Pulp & Paper Industries	
	(i) Pulp & paper	175 m <sup>3</sup> /tons of paper produced
	(ii) Rayon grade pulp	150 m <sup>3</sup> /tons of paper produced
4	Textile Industries: Man-made fiber	
	(i) Nylon & Polyester	$120 \text{ m}^3$ /tons of fiber produced
	(ii) Viscose Staple Fiber	150 m <sup>3</sup> /tons of product
	(iii) Viscose filament Yarn	500 m <sup>3</sup> /tons of product
5	Starch Glucose and related products	8 m <sup>3</sup> /tons of maize crushed
6	Dairy	3 m <sup>3</sup> /kl of Milk

Table 2-9(b): Quantity of pollution water from certain industries in India

Source: PCD, (2005a).

### 2.3.2.2 Water quality-based effluent limits

Case studies of foreign countries such as the United States of America, the European Union (EU) and Australia are given below :-

### USA.

In USA, since the declaration of water qualities act in 1965 the Federal Water pollution Control Agency (FWPCA) was established which had authorization to control the standard of polluted water. From 1971 this organization has been changed to Environment Protection Agency (EPA) and has more responsibility to study and do research on national environment policy. However, preventing water pollution and protecting water resources are major concerns. Until 1977, this act has been called Clean Water Act or CWA which has 4 major concerns as follows:

- The polluted water draining into water resources have no privacy right as drainage into public water resources needs permission.
- The permission for draining has to be defined based on the control of the quantity of polluted water.
- The polluted water has to treat with the best treatment technology which is suitable for the economy and receiving pollutant water resources.

 The quantity of pollution that has been allowed to drain might be more strictly controlled than the standard limits to preserve and satisfy the standard of quality of water resources.

In order to achieve the target of this Act, the procedure for permission to drain out the pollution has been implemented which is called National Pollutant Discharge Elimination System (NPDES). It is a tool for local government to control the drainage polluted water into water resources. However, the NPDES system does not cover nonpoint sources.

### National Pollutant Discharge Elimination System (NPDES)

NPDES controlling system, enables the local authorities to arrange the plan and a procedure which leads to the implementation for preserving the standard quality of water called "Total Maximum Daily Loading", (U.S.EPA.). The proposals has to be sent to Environment Protection Agency for approval and permission to implement the plan.

The regulations to set up TMDL are as follows:

- The water resources having pollution problems are on the list of WQA 103.31 (a) and has to arrange the TMDL.
- TMDL has been arranged in order to prioritize the water resources
- TMDL has to identify the essential level in order to preserve the standard quality of water resources.
- TMDL includes the following details:-
  - 1. Name and location of the water resources having a problem of water pollution including the sub-basin and its network of the water resources which has been contaminated and the water quality affected.
  - 2. Types of pollutant load which are arranged for TMDL and the ability of receiving pollutant water resources to take the maximum pollutant load without affecting the water quality.
  - 3. Identify the quantity of pollutant load which the water resources have received.

- 4. Classify type of polluted sources which have allowed a certain amount of pollutant load to drain into the environment.
- 5. Identify the quantity of pollutant load for Point sources such as industry and urban communities which are allowed to drain under the Clean water Act and identify the quantity of pollutant load of Non-point sources such as rain water from abandoned mines, farming, which are permitted to drain. For other polluted sources, such as natural resources, it is unnecessary to identify the quantity of pollutant load. Indicate the technical analysis summary to show that if the control pollutant load has been arranged within the standard limit, the quality of water resources are within the standard limit.
- 6. Identify the safety value in order to calculate the maximum pollutant load without affecting the water quality.
- 7. Seasonal variations effect the ability of receiving pollutant water resources to take the maximum pollutant load without affecting the standard water quality limit.
- 8. Predict the change of pollutant sources which increase or decrease of pollutant in the future.
- 9. Implement TMDL

Taking the TMDL which has been approved by the EPA in order to implement in local area, the local environmental organization has full responsibility to implement the plan by controlling the pollutant sources that have been identified by TMDL. These organizations are capable to drain out the pollutant load into the environment by using a permit system which is covered by the WCA Act.

Wastewater Discharge Permits are legal documents using for the organization that has a duty to permit someone to drain wastewater into the environment. The organization chart is shown in Figure 2-20. Beginning with the concerned organization receiving the application. The officer reviews the application for completeness and accuracy. The calculation has to be made in order to find the quantity of pollutant load to be allowed to drain off by considering the technology-based effluent limits. Considering the water quality-based limits; however, the quantity of pollutant load in licenses is the highest strict level under monitoring requirements and other special conditions. After conducting review processes, it finally becomes a draft or proposed permit and lastly final permit can be issued.

### European Union (EU) - Europe

(Kampus et al., 2002)In the European Union (EU), water quality is a major concern for environmental policies as can be seen by the numerous Directives that, either directly or indirectly, deal with water policies. The `first series' of EU water legislation began in 1975 with the Surface Water for Drinking Directive (75/440) which coincided with the First Action Programme on the Environment. Then followed, water quality standards which were set through various Directives, such as: bathing waters (76/160); fresh waters (78/659); shellfish waters (79/869); and drinking water (80/778). The `second series' of water legislation includes the Nitrate Directive (91/676) and the Directive for Integrated Pollution and Prevention Control (96/61).

However, in the 1990s the increased awareness of European citizens and other concerned parties for water quality obliged them to push for the recent policy reform under the Water Framework Directive (WFD), which aims to unify, bring together and co-ordinate the rather fragmented structure of water policies in the EU. The WFD increases the range of water protection to all waters, surface waters and groundwater and will try to address water policy and water management in a more effective and consistent manner.

The main innovations of the WFD are at two levels. First, the emphasis is placed on river basin (catchment) as the appropriate unit of management, which is very different from the approach on administrative or political boundaries. Second, the `combined approach' of reaching `good status' for waters by setting emission limits and ambient quality. Reaction to the WFD from the different member states (15 countries in 2000 and 25 in 2006) is of course, very different. However, these directives do not necessarily mean than the various European governments will carry out and implement effective measures.

As a result, in Denmark, the new WFD is considered as inadequate as member states are not OBLIGED to implement the recommended measures – therefore, the Danish government prefers to maintain it's own standards for water quality, while respecting WFD recommendations.

On the other hand, Poland, a new member state (post-communist state, relatively low standard of living and a large population, 45 million) which has inadequate water treatment facilities combined with 'old technology' dirty-polluting industries and low societal environmental awareness (Polish people are more interested in making money and having a higher standard of living equal to Germany and France) is asking for considerable financial and 'know-how' assistance in beginning to implement some of the more basic recommendations of the WFD.

Therefore, in the Europe (EU), the control of drainage has been set up by maximum emission standards and the water quality standards. The member states of the union have in theory to follow the standards strictly. Moreover, water quality is to be managed on a catchment/basin approach to the issue of permits.

The European Union are also highly concerned by the receiving pollutant water resources which the quantity of pollutant load discharges into the water resources and does not affect the ecosystem (Ecosystem-based permitting system).

The details and procedures for controlling the emission of the members of European Union are indicated as follows:

Implementation	European	USA
Policy and target of	Central Government	US.EPA
demanding pollution		
deduction		
Government agency target	Central Government	Environmental States
to reduce quantity of	A CONTRACT OF	Agency
pollution from each		
pollution sources		
Pollution generating sources	Factory	Type of Point source
	(Waste water 50 cu.m/day)	- Industrial
_		- Urban Community
		- Farming
Reduced the pollution from	Promote and Support small	Local government control
the non-point sources	factories and households to	pollution from the non-
	reduce the pollution in locally	point sources by Best
		Management Practices
		(BMPs) propose to the EPA
		and Budget

### Table 2-10: Comparable table of controlling source pollution emission between European and United States of America

Source: PCD, (2005a).

The EU has arranged for member states to reduce water pollution problems which cause hazardous substances by following the agreement:

- 1) Maximum emission standards for hazardous substances
- 2) Water quality goals

In order to control the problem of polluted water, the EU has arranged the procedures as follows:

- 1) The permission of effluent pollutant water into water resources have to cover the pollutant sources in direct or indirect water discharges.
- 2) Permission to drain into water resources has to respect all the emission standards.
- 3) Permission has a period of time for 4 years or 5 years.
- 4) Evaluation has to be made every 4 years
- 5) Evaluation has to report the pollutant quantity which allowed to is drain off

However, the emission pollutant standard is based on the water quality standard. In 1996, the EU has used the integrated pollution prevention and controlled directive for industry and processing of permission has to concern the IPPC.

In 2000, the EU admitted to the pollution prevention to the water resources which is called European Environmental Framework Directive (EEFD). To specify the production type and management in order to satisfy the EU standard, which controls the polluted sources in types of point source and non-point source.

- 1. The EU prohibits the use the harmful chemicals.
- 2. Permission to ask before draining into water resources.
- 3. Draining the harmful chemicals is in the groups of general binding rules which have a special drainage permit, must be registered.

In order to ensure the emissions satisfy the water quality standard which the members of EU have to follow the standards are 1) Using best available technology and 2) the emission pollutant water. It has to satisfy the emission standard: however, the non-point sources have to use the best practice.

### 2.4 The effluent tax charge applied in Foreign countries

### 2.4.1 Charges Support River Basin Agencies in France

The effluent charge system in France generates revenues that support six French river basin agencies created in the 1960s. These agencies carry out planning and research and provide loans and grants for water and wastewater management projects, but they do not construct facilities or issue regulations.

Effluent charges are set through a complex negotiation process involving a river basin agency's staff, the agency's "basin committee," and a host of government officials. The basin committee includes representatives from various French ministries and from municipalities and other water users. Negotiations in setting the charges account for how much money will be needed to achieve different cleanup targets, since a portion of the charges collected are used by the river basin agency to subsidize wastewater treatment by firms and municipalities. Although the diversity of interests represented in establishing

45

charge levels sometimes slows the decision-making process, it increases the chance of developing a program of action that is fair, implementable and not challenged in court.

The French effluent charge system includes the following parameters: oxidizable material assured by a combination of chemical oxygen demand (BOD), suspended solids (SS), phosphates and toxic materials. For any one year, a base effluent charge for a river is set to yield the total revenues needed by the river basin agency to meet water quality goals for the year. Suppose, for example, the base effluent charge for suspended solids for one year is the equivalent of about \$10 per year per kg/day of SS discharged. This charge is multiplied by the pollutant discharge (fee for suspended solids). The pollutant discharge used in calculating the annual fee is based either on periodic measurements (for large/sources) or standard tabulated values per unit of output (for example, 10 gms of SS per kg of finished kraft paper). When tabulated values are used, it is necessary to know the quantity of finished product produced per unit time.

Effluent charges can be raised or lowered, depending on charges in the scope of the action program for a particular river basin. In addition, charges can vary from one zone to another. Thus waste sources in zones with major water quality problems and costly cleanup programs may have to pay relatively high charges. However, those waste dischargers may be eligible for subsidies, grants, and loans that the river basin agency provides using revenues from charges it collects. (Ortolano, 1997).

During the 1970s, the effluent charges used by the basin agencies were much lower than required to motivate dischargers to treat their wastewaters. Why, then did so many polluters implement high levels of treatment during that period? The answer is found by considering a complementary part of French water quality management strategy: effluent standards. French water quality management strategy: effluent standards. Since 1917, the prefects of French "departments" (similar to provinces) have issued permits controlling the discharge of wastewaters. Penalties for the permit system was not implemented effectively. Even through basin agencies do not issue permits, their programs of charges and subsidies have motivated polluters to reduce their wastes in compliance with permit conditions. The use of a two-part strategy economic incentive administered by prefects has led to substantial water quality improvements (Ortolano, 1997). In France, using many substances as a parameter for calculating the effluent charge such as SS, BOD, COD,  $N_{tot}$ ,  $P_{tot}$ , inhibiting substances, organic matter, soluble salts, fish toxicity, oxidized N, reduced, N, AOX, heavy metals. Effluent charges are calculated according to the following basic equation.

 $EC = f(a_i, p.u_i); 1 \le i \le n$ 

where

EC: Effluent charge for one year.

a: charge rate.

p.u.: pollution units discharged in one year.

n: number of pollutants entering the calculation; all ECS consider more than one pollution parameter.

However, the rate in France differs among the six regional water agencies and also according to the size of the urban area, (Buckland, J. and Zabel, T., 1998).

### 2.4.2 Netherlands: Experience with how charges Influence Firms

Netherlands in the 1960s. During that period, a law requiring adaptation of a nationwide system of effluent charges was adopted. In the Dutch system, effluent charges are levied on oxidizable materials (as measured, for example, using chemical oxygen demand) and heavy metals, such as mercury and zinc. The Dutch effluent charge scheme was initiated primarily to generate government revenues to subsidize waste management efforts. However, the charge itself has proven to be effective in motivating firms to abate pollution. One reason the Dutch charge scheme has affected behavior is that effluent charges are comparable to the incremental costs of waste reduction for some dischargers.

Soon after the introduction of effluent charges, wastewater releases decreased dramatically in the Netherlands. For example, between 1970 and 1980, the discharge of oxygen-consuming wastes by industry dropped by more than half, even though industrial output expanded significantly over the same period.

Could the falloff in pollution be attributed to the use of effluent charges? Or were there alternative explanations for the cutback?

Several research studies were conducted to determine the influence on polluters of the Dutch effluent charge system. Some studies used statistical methods to identify factors which correlated with sharp decreases in water pollution in Holland during the 1970s. Other investigations relied on survey questionnaires and interviews with government officials and corporate decision makers. While the research studies yielded some differences in details, they were consistent in pointing to effluent charges as a key factor affecting the behavior of polluters. For example, statistical analyses and surveybased research showed effluent charges as being much more significant that the Dutch permit requirements in causing industry to reduce organic pollution. Moreover, subsidies for pollution control, the original motivation for developing the charge system, seemed less important than either discharge permits or effluent charges in encouraging firms to abates pollution.

Results indicate that the Dutch charge system has provided regulators with an influential addition to the previous regulations with an influential addition to the command and control scheme that had been in place, (Ortolano, 1997).

Netherlands, direct and indirect sources have to pay for the effluent charge. The charge rate is determined by the quantity and nature of the waste water and is calculated by the multiplication of the pollution load by the unit tariff, for instance HFL 59 to 138;  $\in 26.8$  to 63 in 1995 (average tariff was HFL 82;  $\in 37.2$  in 1995). Households and small firms (pollution load below five pollution equivalents) are charged by a fixed amount: average charge for household was HFL 204;  $\in 92.6$  (discharging to non-state waters or sewerage) and HFL 127.5;  $\in 57.9$  in 1992. The waste water charges are not related to water consumption. Companies of intermediate size are normally charged based on a scheme considering the number of employees, the type of activity, and consumption of water and raw materials; enterprises with emissions above 1000 p.e. are charged according to actual measurements of the quantity and concentration of emissions.

### 2.4.3 German Experience with Charges

The earliest applications of effluent charges were by river basin agencies in the Ruhr Valley of Germany in the 1920s. During the 1970s, the application of effluent charges was extended to all of what was then the Federal Republic of Germany (FRG or West Germany). An effluent charge law passed in 1976 required the Lander (which corresponded to states in the FRG) to levy charges on effluents released into public waterways. Uniform charge rates were set for the nation as a whole, but implementation was carried out by individual Lander.

Administration of the charge scheme was tied to a discharge permit system. The Lander issued permits to sources of wastewater discharge. Based on the permit system, a polluter is given a right to release specified quantities of wastewater discharge. Based on the permit system, a polluter is given a right to release specified quantities of wastewater, but the concentration of pollutant must be below. Those specified by uniform national discharge standards, or by local discharge standards. (The latter may be set more rigorously than national discharge standards, or by local discharge standards.) A second component of a permit details the data needed to calculate a polluter's waste discharge bill. Using a rate schedule set a t the federal level, effluent charges are levied on the following parameters: settle able solids, chemical oxygen demand, cadmium, mercury, and toxicity for fish. Details of the computation of total charges are complex, because the basic charge is in units of deutsche marks per "damage unit." The effluent charge law spells out how to convert from quantities of pollutant to damage units (for example, 45.45 kg of chemical oxygen demand corresponds to one damage unit). The same charge per damage unit is applicable to all polluters in all regions of the country.

Based on their analysis of the FRG effluent charge system, Brown and Johnson (1984) argue that to be politically viable and administratively attractive, an effluent charge system should have the following characteristics:

- (1) It covers a small number of pollutants.
- (2) It is combined with permit system.
- (3) The charges begin at some specified level and escalate during a transition period.

- (4) The charge levels result from a process involving the participation of interested parties including those benefited and harmed by waste discharges.
- (5) Measures and levels of volumes and pollution concentrations are simplified.
- (6) Effluent charge revenues are made available for abatement related expenditures.
- (7) Hardship clauses are provided to protect discharges or industrial sectors under exceptional circumstance.
- (8) Care is taken to demonstrate how the effluent charge program actually can be implemented.

The charge system used in the FRG had features encouraging firms to meet effluent standards. Under the FRG scheme, if applicable wastewater discharge standards were met, a polluter's effluent charge bill would be cut in half. If standards were violated, a polluter lost the opportunity to save 50% of total charges and faced fines and other penalties for violating standards. In addition, revenue from charges were used to subsidize waste reduction activities by both firms and municipalities, and subsidies to offset the cost of waste-reducing changes in production processes. As a result of actions at least partially motivated by the effluent charge program, more than half the waste dischargers in the FRG met effluent standards in 1981, and it one Lander the figure was 90%.

In appraising the influence of the charge scheme on pollution abatement by firm, Brown and Johnson (1984) cited the experience of BASF, a large chemical company in the FRG. The firm made numerous innovative efforts to reduce wastes, even though effluent being much lower than required to induce firms to achieve the nation's water quality goals. Of special note was BASF's development of an intra-firm effluent charge scheme for reducing chemical oxygen demand. The firm computed an internal effluent charge counting price per unit of waste and multiplying it by the total effluent generated b the branch. Brown and Johnson (1984) summarized the results from applying the internal charge scheme over a seven-year period:

The response to the introduction of an internal liability system as internal liability system has been a 20 percent decrease in discharge. Rather than mandate physical decreases the intra-firm charge elicited a "voluntary" decrease in effluent discharge achieved through process change, recycling of solvents, improved pretreatment facilities and replacement of old facilities, (Ortolano, 1997).

Brown and Johnson (1984) went on to argue that "Even if the effluent charge is modest, it induces cost saving."

In German, direct discharges into surface waters (rivers, lakes, the sea and groundwater) by industrial and municipal sources are a payer for effluent charge. The charge is calculated by multiplying the number of pollution units by the tariff: DM 60;  $\in$  30.5 per pollution unit (1993) DM 70;  $\in$  35.5 per pollution unit since 1997. However, the government has another motivate program for polluter to reduce their emission by using tax reducing scheme. Tax reducing is possible under the following conditions:

discharge can get a 75 percent tax relief if they achieve the Technology-based standard (Best available technology - BAT) which is formulated in the law (NRA 1995; Smith 1995:27)

### 2.4.4 Discharge Fees and Subsidies in China

Using of pollutant discharge fees in China during the early 1980s, a time when China started modifying its economic system to rely more on markets.

The impetus for introducing fees on pollutant discharges came from Chinese environmental man-discharges came from Chinese environmental management experts familiar with effluent charges in Europe. During the late 1970s, these experts argued that China could benefit from a discharge fee program because the fees would enhance productive efficiency and give enterprises incentives to abate pollution. China's 1979 Environmental Protection Law included a system of pollutant discharges fees. Subsequent policy guidance and additional legislation provided details that local environmental protection bureaus (EPBs) needed to implement the system. Although the guidance is for a national charge scheme, EPBs can modify the national system to accommodate local conditions, provided the local system is at least as demanding as the national scheme.

In a typical application of the national pollutant discharge fee system, an enterprise pays fees only if applicable discharge standards are violated. The amount owned by an enterprise violating standards is based on the extent of violation. For example, consider the fee schedule for chemical oxygen demand used in Guangdong Province in southern China. if a firm's wastewater discharge has a COD concentration between one and two times the applicable COD effluent standard, 110 mg/l, the enterprise pays 0.04 Yuan (RMB) per cubic meter ( $\frac{1}{2}$ /m<sup>3</sup>) of discharge. However, if the enterprise's COD exceeds the standard by a factor of ten, the applicable fee is 0.06  $\frac{1}{2}$ /m<sup>3</sup>. Guangdong Province uses formulas to calculate unit fees (in  $\frac{1}{2}$ /m<sup>3</sup>) based on the extent of violation of the standard.

The influence of the Chinese discharge fee system on the behaviors of polluters differs depending on whether the discharges consist of non-hazardous organic wastes or hazardous materials such as heavy metals. First, consider fees on organic wastes (measured using COD). During the 1980s, pollutant discharge fees on organic wastes in China were generally too low to affect polluters. Although many factories cut back their waste discharges, they did so because of pressures unrelated to the fee system. Fees were not influential because operation and maintenance costs for treating organic wastes were often much greater than applicable fees. In such cases, even if the costs of constructing treatment plants at factories had been fully subsidized, fees would still have been ineffective as an incentive to clean up. It was much cheaper for the factories to simply pay fees.

Discharge fees for hazardous material were often relatively high (compared to fees on COD), and they had a greater influence on polluters. For example, consider the release of cadmium, chromium, and other dangerous metals from local EPBs and residents downstream of cleanup from local EPBs and residents downstream of wastewater discharges. In this context, factory managers viewed pollutant discharge fees as one more reason to abate pollution. This outcome is consistent with some experiences in Europe: discharge fees can motivate cleanup even when fees are lower than incremental costs of waste reduction (Ortolano, 1997).

### 2.4.5 Phillippine

From the research of Indab et al. (2003) the study in terms of cost savings and pollution discharge reductions, the use of effluent charge scheme as a management tool

for protecting and maintaining good water quality in Sarangani Bay. The ambient standard set by the Department of Environmental Studies and Natural Resources (DENR) served as a basis for assessing water quality of the Bay. The study assumed that compliance with the ambient standard (Class SB) would bring the level of pollution discharge to Sarangani Bay at a non-damaging level. This standard of maintaining a maximum BOD<sub>5</sub> ambient level of 5 mg/L was then used as the basis for setting the effluent charge level. The ambient requirement was converted in terms of mass through a deterministic water quality assessment model, to determine the allowable pollution discharge to the Bay. Results showed that Sarangani Bay could assimilate as much as 19,134 metric tonnes (t) of  $BOD_5$  annually without exceeding the ambient standard for Class SB. Given the existing annual discharge (6,114 t BOD<sub>5</sub>) of the industrial sector, requiring the necessary reduction from this sector alone would mean bringing the level of abatement to 92%. Based on the econometric simulations conducted, Pesos 6 (USD 0.11)/kg BOD<sub>5</sub> effluent charge level is sufficient to realize the needed industrial pollution reduction (i.e. 92%). Achieving the same level of reduction under a pure Command and Control (CAC) scheme, total abatement cost would amount to approximately Pesos 685 million (USD13 million). This implies that achieving the same level of pollution reduction target is approximately Pesos 14 million (USD 264,150) more expensive under the existing CAC scheme than one that complements CAC with effluent charge. The considerations associated with direct regulation also apply to economic instruments. There is still a need to know what the harmful level is; the need for monitoring and enforcement remains and these factors also serve as the main argument that favors economic instruments over a pure CAC scheme. Economic instruments or other instruments will not deliver economic efficiency and achievement of environmental goal if the instruments are not enforced effectively. It is far from attainable under a pure CAC scheme to allocate sufficient manpower and technical resources to enhance enforcement and monitoring to ensure that a 92% industrial pollution reduction will be achieved. If CAC could be complemented with effluent charge scheme, a certain proportion of revenue from pollution charges could be used to cover the implementation cost and/or used for self-construction of environmental protection agencies. In achieving economic efficiency and in effective environmental management, a Pesos 14 million (USD

264,150) abatement cost saving may not be significant compared to the experiences of other countries, but its value is appreciated.

### <u>2.4.6 India</u>

The report of Maria (2003) the report tries to summarize the information available about the different costs of water pollution in India. The variety of these costs comes not only from the variety of pollution dealt with (domestic, industrial, agricultural) but also from the method used to calculate these costs. However, the notion of cost is quite complex. Formally, it implies the comparison between two scenarios, and the assessment of the welfare of a group of economic agent in both scenarios. In the case of water pollution, the problem can be represented by a resource which provides environmental services, and economic agents that benefit from these services. Calculating a formal cost of water pollution would imply to model the different equilibrium at stake, and to deduct from these different equilibrium the effect of a difference in the ambient pollution on the aggregated welfare.

To determine these equilibriums, one would need hydrological as well as agronomic, medical and behavioral models that are not available as for now in India.

In practice, many different techniques are applied in order to provide estimates of the economic burden due to water pollution, that only provide partial estimates of a certain kind of cost, that is the cost of a particular aspect of pollution on a certain category of agents.

The goal of a pollution control policy is to get as close as possible to the state that maximizes the aggregated social welfare. Considering the level of pollution, the highest social welfare should be obtained by pollution abatement until the point at which the marginal abatement cost and the marginal environmental damage avoided through this abatement have the same value. Identifying such a point would imply to know precisely the aggregated abatement cost function of the national industry. Therefore, studying the cost of industrial pollution abatement is a critical element in defining an economically and ecologically sound policy for pollution control. There have been several studies carried out by Indian academics during the 90's in order to provide information about the cost of compliance with environmental standards for the Indian Industry.

In a brief paper prepared by IGIDR for the UNDP, general estimates of the cost of pollution abatement the Indian Industry may have to bear are provided. Nevertheless the signification of these figures is difficult to understand since the specification of the hypothetical scenario, especially in terms of ambient pollution standard, are not detailed in the paper. We therefore assume that those figures are referring to a scenario where all polluting industries were complying with the existing pollution standards. It is estimated that Indian industry may have to spend around 2 to 5 % of its capital investment on pollution control. The annual operating costs are expected to be between 15 to 30 per cent of the investment made on the treatment facilities. According to these estimates, the total annual investment needed for water pollution abatement across all the water polluting industries is estimated at R. 1400 crores, which is about 1.17M of the annual turnover of these industries.

This document does not provide any original figure or data. It is a preliminary literature survey of the Indian context regarding water pollution. Although it aims at being as comprehensive and exhaustive as possible, many important elements might be missing, but we hope that reactions from the different partners will enable us to provide a reliable basis for common understanding and fruitful collaboration.

Political will, or financial resources are often quoted as critical element for a sound environmental policy, but information is surely at least as important as the other elements. Information on the status of environmental quality, on the sources of pollution, and the way it affects the different actors. This is the availability of such information, and the way it is being analysed and used in India that they tried to assess.

It appears that the availability of this kind of information has been enhanced by the effort of various institutions during the last fifteen years. The Central Pollution Control Board (CPCB), the Central Ground Water Board (CGWB), the Central Statistical Organization (CSO) and several other institutions now provide nation wide data about water quality, industrial activity, etc.

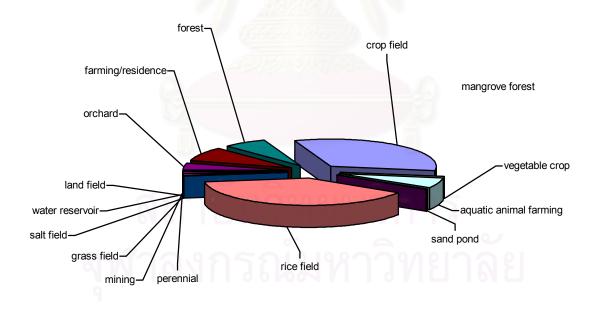
## CHAPTER III METHODOLOGY

### 3.1 Study site

As shown in the figure 3-1, the entire study covers 11,763 sq. km. or 7.35 million Rai in 9 provinces which are Bangkok, Ayuthaya, Nonthaburi, Chainart, Uthaithani, Suphanburi, Nakornphathom, and Samutsakorn.

3.1.1 Land use in the Thachin River

From the data collection of the Ministry of Agricultural and Co-operation Thailand, the percentage of land use are (a) rice fields 39.1%, (b) other crops 32.96%, (c) residential/urban areas 8.14%, (d) forest 6.96%, (e) aquaculture 6.09%, (f)orchards 4.31%, (g) water reservoirs 1.1%



**Figure 3-1: Proportion of Land use in Thachin River Basin** Source: PCD (2005a)

### 3.1.2 Significant pollution-generating sources in Thachin River Basin

### 3.1.2.1 Pig farm

Agricultural activities such as pig farming are point sources in Thachin River basin. There are 1,065 pig farms which are mostly located between the middle and the lower parts of the Thachin river basin in Nakornpathom and Supanburi provinces.





**Figure 3-2: Location of pig farms in Thachin River Basin** Source: PCD, (2005a)

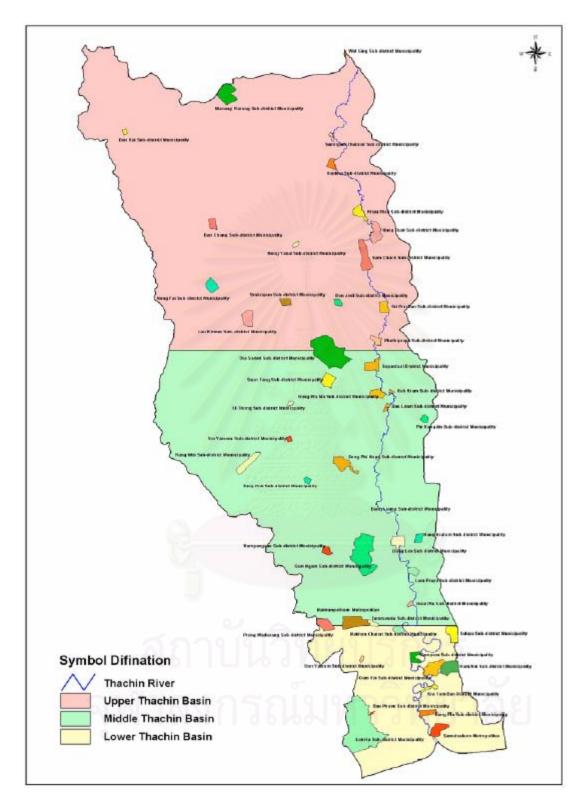
### 3.1.2.2 Urban communities

In the Thachin River basin, there are communities spread along the river especially the lower basin which are densely populated communities and become main point pollution sources. These densely populated communities located in the centre of provinces and districts, create many commercial and services activities which generate large wastewater amounts similar to a city municipality. Moreover, the scattered small communities along Thachin River are often tourist attractions with associated business and services activities to server visitors. The wastewater of these activities are released directly into the river. Thus, small communities along Thachin River have also become main point sources in the area. The large communities situated in the basin are shown in Table 3-1

		Num	ber of commu	nities	
Sub- Basin	Province	Metropolitan	District municipality	Sub-district municipality	Total number of
					communities
Upper-	1. Chainat		VASIA-1-	3	3
Basin	2. Utaithani	-	-	2	2
	3.1 Supanburi	-	-	10	10
	4.1 Kanjanaburi	-	-	2	2
Middle-	3.2 Supanburi	_	1	9	10
Basin	4.2Kanjanaburi	-	-	1	1
	5. Ayuthaya	2- a		1	1
	6.1		1001315	9	10
	Nakornpathom				
Lower-	6.2			5 0	5
Basin	Nakornpathom	ohoi	0 10 2	0 0 0 4 0 0	0 7
	7. Samutsakorn	N [ ] - ] 6 L	LIA .		- 13
	8. Bangkok	-	-	-	-
	9. Nontaburi				

Table 3-1: Number of large communities situated in Thachin River Basin

Source: PCD, (2005a) refers to Department of Public Works and Town & Country Planning

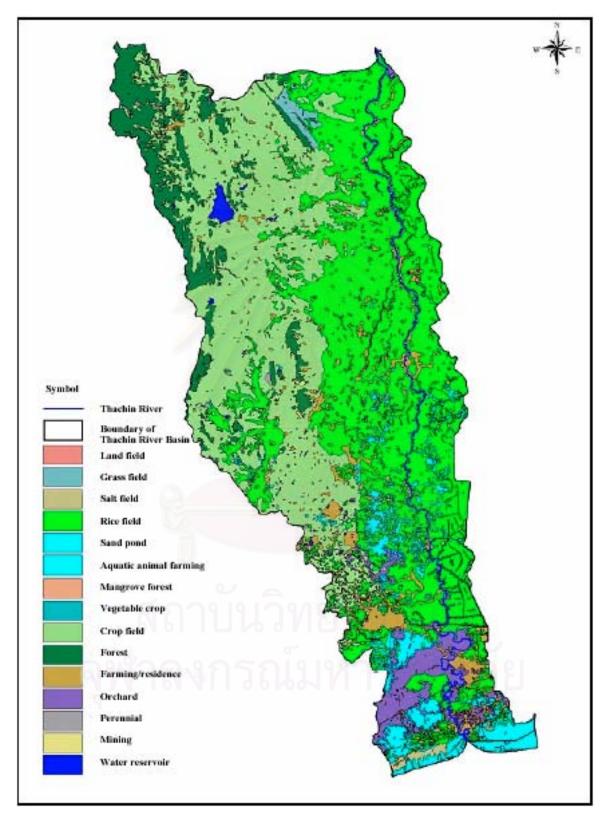


**Figure 3-3: Location of large communities in Thachin River Basin** Source: PCD, (2005a)

### 3.1.2.3 Aqua culture

Aquaculture/fish farming producing prawns and fish and are dispersed in the middle and lower parts of Thachin River basin, especially in Samutsakorn, Supanburi, and Nakornpathom provinces. 75% of the land use of Thachin river basin is for agricultural purposes such as raising livestock, fish farming which have become important pollution sources. From phase I, the total area of aquaculture covers 440,901 Rai and the average BOD loading is 0.23-0.26 kg-BOD/Rai-day. Hence, the Total BOD daily loadings are around 80,362 kg/day.





**Figure 3-4: Location of Aqua culture in Thachin River Basin** Source: PCD, (2005a)

### 3.1.2.4 Industry

Factories are the main pollution generators due to the release of polluted water directly into the river. The quantity and types of wastewater from each factory differs depending upon the raw material, products, processing and machinery. However, some factories have no polluted water as no water is involved in the production process. The National Environmental Committee and Industrial Work Department has divided factory types generating pollution water into 34 categories such as daily manufacturing, abattoirs and animal food products, vegetables, processed bakeries, bleaching and dyeing fibers etc., Factories are potential wastewater sources as shown in Table 3-2. However, these factories have wastewater treatment systems which meet the standard requirements before being released into the river.

Along the Thachin river there are many factory types scattered along the river and these establishments are shown in the table below:

 Table 3-2: Number and type of factories generating water pollution in Thachin

 River Basin

			Number of factories	Level of
No	Types of	Industrial activity	generating	water
110	industry	industrial activity	water	pollution
	maastry		pollution	severity
1	4(1)	Slaughtering	6	2
1	4(1)	The preservation of meat by toast, smoke-dried,	5	$\frac{2}{2}$
	(2)	pickled, sun-dried and sharply freezing method	5	2
	4(3)	Processed food products from animal meat, fat,		
	+(3)	hide and grease or born extract		
2	5(5)	Processed cheese and butter	1	2
2	5(6)	Processed yogurt	2	2
3	6(1)	Processed aquatic animal food and canning	19	2
5	6(2)	The preservation of aquatic animal by toast,	56	2
	0(2)	smoke-dried, pickled, sun-dried and sharply	50	2
		freezing method		
	6(3)	Processed food product from aquatic animal and	31	2
	0(5)	hide or fat of aquatic animal	51	2
	6(5)	Sliced, boiled, steamed, fired, and grinded (fish)	30	2
	0(5)	aquatic animal	50	2
4	7(1)	The extraction of vegetable and animal oils and	14	2
•	7(4)	fats	2	1
	,(.)	Processed pure vegetable and animals oils and	-	
		fats		
5	8(1)	Canning of fruit and vegetables	42	2
-	8(2)	Preserving of fruit and vegetables	34	2
6	9(2)	Processed starch	10	2
-	9(4)	Grain mill products manufacturing	17	1
7	10(1)	Processed bakeries	33	1
	10(2)	Processed biscuits	26	1
	10(3)	Baked and steamed products manufacturing	51	2
8	11(2)	Processed sugar refineries	3	2
	11(6)	Processed glucose, dextrose, fructose and	1	1
		similarly other products		
9	12(9)	Processed chewing gum	4	1
	12(11)	Processed ice-cream	13	1
10	13(2)	Processed additive	44	2
	13(3)	Processed powder-yeast	3	1
11	15(1)	Prepared animal feeds	64	1
	15(2)	Grinded vegetable, grain, meat, bone and	46	1
		shellfish for animal feeds	-	
12	16	Manufacture of distrilling rectifying and	8	2
_		blending spirits	-	
13	20(1)	Processed drinking water	16	1
-	20(2)	Processed non-alcoholic drinks	14	2

# Table 3-2: (continued)

			Number of	
			factories	Level of
No	Types of	Industrial activity	generating	water
110	industry		water	pollution
	maastry		pollution	severity
14	22(1)	Carbonize incubation, bleaching and dyeing	72	1
	22(2)	fibers	160	2
	22(3)	Spinning of cotton	103	2 2
	22(4)	Textile finishing	71	2
		Textile printing		
15	24	Knitting mills	185	2
16	30	Manufacture of fur dressing and dyeing	2	2
17	38(2)	Processed paper or fiberboard	17	2
18	42(1)	Processed chemicals	64	2
19	43(1)	Processed fertilizer and pesticides	15	2
20	44	Synthetic resin rubber, plastic or synthetic fiber	2	1
		manufacturing	_	_
21	45(1)	Processed paints	35	2
	45(2)	Processed varnish	16	
	45(3)	Processed lacquer	10	2 2
22	46(1)	Objects which are accepted in medicine text book	8	1
		manufacturing		
	46(2)	Objects which cure, relieve and protect disease	4	1
		for		
	46(3)	human or animal manufacturing	1	1
		Objects which follow 46(1) and 46(2) except		
		foods,		
		sport equipment, cosmetics and curing instrument		
		manufacturing		
23	47(1)	Processed soap and cleaning preparations	3	1
	47(3)	Processed cosmetics	8	1
24	48(1)	Processed bees wax	3	1
	48(3)	Processed water proof products, emulsifier,	19	1
		wetting		
	48(6)	agents, sizes, cements, (not dental cements)	9	1
	48(9)	Ink or carbon black manufacturing	<b>d</b> 2	1
	48(10)	Processed essential oil	1	1
	004	Processed indigo and bleaching powder	10001	
25	50(4)	Processed miscellaneous petroleum	10	1
26	52(2)	Sliced cutting and mixed rubber sheets	14	2
	52(3)	Smoked rubber, crepe rubber, sticky rubber and	1	2
		liquid rubber manufacturing		
	52(4)	Processed natural rubber product or synthetic	71	2
		rubber		

### Table 3-2: (continued)

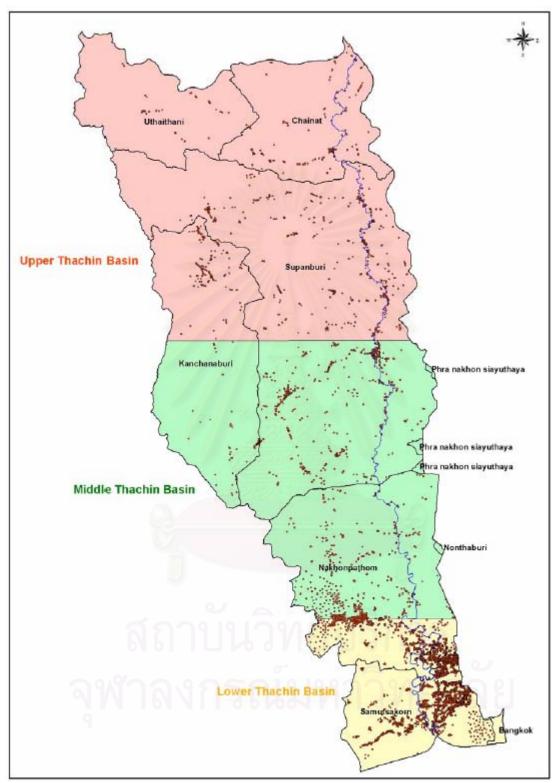
No	Types of industry	Industrial activity	Number of factories generating water pollution	Level of water pollution severity
27	54	Grass and fiberglass manufacturing	12	1
28	55	Manufacture of tile, pottery or ceramic	63	1
29	59	Smelt, melt, mold, press out, haul or produce iron	109	2
		or primary steel (Iron and steel basic)		
30	60	Smelt, mix, purify, melt and mold (Non-ferrous metal basic)	35	2
31	71	Manufacture of electrical industrial machinery and apparatus	28	2
32	92	Manufacture of frozen	96	2
33	98	Laundries, laundry services and cleaning and dyeing plant	20	1
34	101	Central waste treatment plant	18	1
		Total number of factories	1,906	-

Source: PCD, (2005a) refers to Classification of industry which generate environmental problem, office of National Environment Board and Department of Industrial Works

# Table 3-3: Number of factories generating water pollution for each province in the area of Thachin River Basin

Province	Factories (unit)	Percentage
Bangkok	125	6.56
Kanjanaburi	8	0.42
Chainat		0.16
Nakornpathom	578	30.32
Nontaburi		0.16
Samutsakorn	<b>1,087</b>	57.03
Supanburi	99	5.19
Utaithani	1 0 0 100 3 1 0 1 1	0.16
Total	1,906	100

Source: PCD, (2005a) refers to Database of factories, Department of Industrial works (DIW)



**Figure 3-5: Locations of factories generating water pollution in Thachin River Basin** Source: PCD, (2005a)

In the entire Thachin river basin, there are many activities situated along the river, however these actual wastewater discharge activities are monitored and data collected by PCD. The other activities are ignored. Due to the inefficiency in maintaining databases and their randomly distributed nature, the researcher used principally the database from PCD and as a source of information in this research.

			Pig		Urban	
No	Sub basin	Reduction	Farm	Aquaculture	Community	Industry
1	LI	50.00%	12.49%	42.43%	43.83%	1.25%
2	RF	85.00%	67.27%	17.73%	14.38%	0.62%
3	LJ	55.0 <mark>0%</mark>	0.00%	97.30%	2.69%	0.01%
4	LK	55.00%	0.00%	99.00%	1.00%	0.00%
5	LL	55.00%	0.00%	99.49%	0.51%	0.00%
6	LM	70.00%	0.00%	100.00%	0.00%	0.00%
7	RFm	70.00%	14.11%	81.08%	3.21%	1.60%
8	LP	60.00%	11.20%	75.15%	7.50%	6.15%
9	RG	60.00%	37.63%	58.16%	0.64%	3.57%
10	LQ	95.00%	40.19%	34.72%	24.82%	0.27%
11	RH	95.00%	53.59%	3.96%	13.92%	28.53%
12	RI	30.00%	13.34%	67.99%	5.16%	13.52%
13	LS	25.00%	16.16%	18.13%	21.38%	44.32%
14	RJ	25.00%	3.85%	74.51%	3.90%	17.74%
15	RK	25.00%	0.25%	96.57%	2.87%	0.32%
16	LT	25.00%	0.00%	0.73%	10.00%	89.27%
17	LU	25.00%	0.00%	43.81%	22.67%	33.52%
18	RL	25.00%	0.03%	77.59%	2.13%	20.26%

 Table 3-4: Percentage of pollution from any sources in any sub basin and target of emission reduction

Source: PCD, (2005a)

As the tables 3-4 show each sub basin has its own reduction target in order to meet the water quality standards. Each sub-basin has many activities which can be divided into 4 groups. Each group indicates the percentage of water pollution emissions.

### 3.2 Methodology

### 3.2.1 Phase I: Database collection

The Thachin river basin covers an extensive area passing through 9 provinces. Therefore to complete the data collection for each parameter, the researcher sought data from various sources such as Pollution Control Department (Ministry of Natural Resources and Environment), Department of Industrial Works and Office of Industrial Economic (Ministry of Industry), Office of the National Economic and Social Development Board, The Department of Local Administration (Ministry of Interior), Asian Institute of Technology, CMS engineering company. Gathering and adjusting of data needed 2 years.

In the first phase, a detailed explanation on how to gather the data is given below:-The data can be divided into 2 groups, (a) the Environmental Aspects and (b) the Economic Aspects.

### 3.2.1.1 Environmental Data

Most of this environmental data came from PCD reports which also incorporated AIT and CMS engineering data. The primary data need for the study is processed with the 3 following steps:-

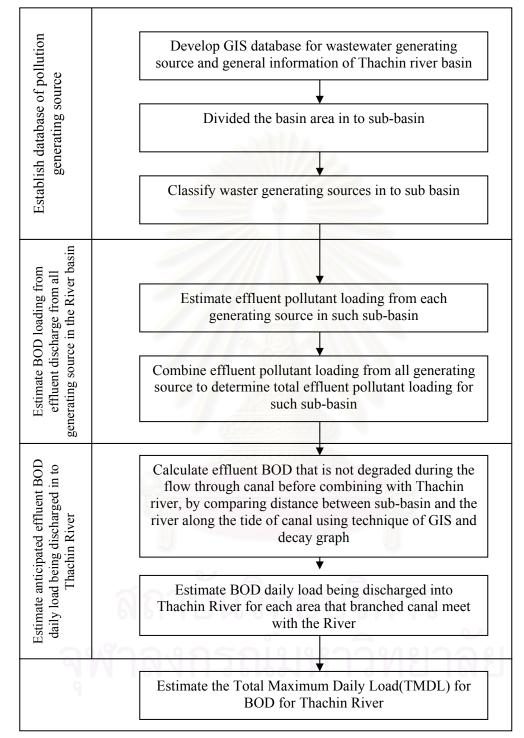
- a) Current situation of BOD loading in Thachin River,
- b) Total Maximum Daily Loading by using BOD peak reduction base
- c) Emission reduction targets.

# จุฬาลงกรณ์มหาวิทยาลย

Methodology used in these steps consists of the following :

- 1. Establish a GIS database of primary water-pollution-generating sources in Thachin river basin and basin data.
- 2. Estimate the BOD daily loading from effluent discharges from each source and source type in each sub-basin area.
- 3. Estimate the current carrying capacity of Thachin river for BOD in effluent discharge, by assuming that some BOD degradation has occurred while the water flows through canals before reaching Thachin river.
- 4. Estimate the Total Maximum Daily Loading (TMDL) for BOD without exceeding the water classification standard.





The implementing procedure in each step is briefly described as follows,

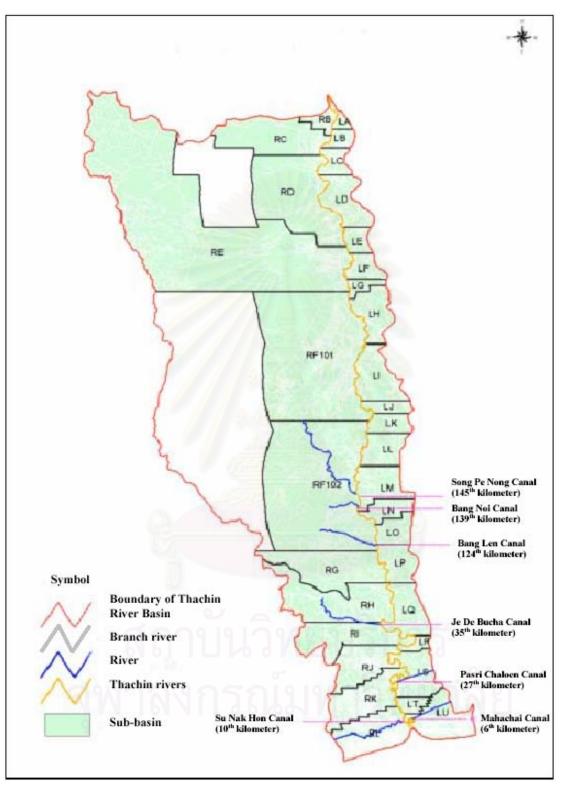
**Figure 3-6: Work diagram of Determination of Industrial effluent standard research** Source: PCD (2005a).

From the report of determination of industrial effluent standards: Revision of Industrial effluent standards of PCD, the Thachin river basin into 33 sub-basins as show in the figure 3-7.

a) Current situation of BOD loading in Thachin River.

The result of the current BOD loading and the calculated results of significant main points and non-point sources in each sub-basin are shown in the table 3-5. After obtaining BOD results from each pollution source, the simulated computer river models are shown in figure 3-9.





**Figure 3-7: Sub-basins which has potential to cause water quality deterioration** Source: PCD (2005a).

basis         bit         bit<			c(u). Itesuits of any DOD for any contractor of on							Point Source							
Code         GRID         Fam         Aquaculur         Commany         Industry         Tod         Fam         Aquaculur         Commany         Industry         Tod           No         669         421         644         1656         1523         6486         1011         22         2200         1854         907         1428         22         2040           LG         11         0.0         <	Sub-			Dry Se	eason without R	ain			Dry	Season with Ra	iin			]	Rainy Season		
h8         167         866.9         421.5         64         14.4         1368.8         132.3         648.6         101.1         22.9         2104.9         1854.4         910.7         142.8         32.1         29400           LA         7         0.0 <td></td>																	
LA         7         0.0				1						5				1	5	,	
I.B.         7         1.7         0.0         0.0         1.7         1.8         0.0         0.0         1.8         1.8         0.0		-															
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $																	
ID         35         21.1         16.9         0.0         22.6         54.0         30         50.7         32.2         27.8         64.8         25.1         20.1         0.0         24.5         66.3           LF         15         15.0         82.4         53.0         6.6         157.0         16.1         88.5         56.9         71.1         168.6         17.0         93.3         64.0         7.5         177.7           LG         9         37.9         0.0         28.7         0.4         66.9         41.3         0.0         31.2         0.4         72.9         44.0         0.0         33.3         0.5         77.7           LH         40         83.6         284.0         293.4         8.3         669.3         95.0         322.9         33.5         9.5         76.0         10.45         355.1         36.6         10.4         818.9           LK         14         0.0         68.6         10.0         11.25.7         0.0         123.9         0.0         123.6         0.0         123.5         1.0         0.0         208.9         10.6         0.0         209.7           LK         4         0.0	-	7															
LE         14         2.7         45.9         2.9         2.5         54.0         3.0         59.7         3.2         2.7         59.7         3.3         54.6         3.4         3.0         64.3           LF         15         15.0         82.4         53.0         66.6         157.0         16.1         88.5         53.9         7.1         168.6         17.0         93.3         60.0         7.5         177.7           LB         32.7         0.0         28.7         0.4         66.9         34.7         15.6         2.6         132.6         85.7         37.4         16.8         2.9         142.7           LI         40         83.6         28.40         293.4         83.6         6693         95.0         32.2         9.5         76.0         1045         355.1         36.69         10.4         83.6         10.0         10.4         83.6         0.0         112.7         0.0         121.39         10.2         0.0         1226.2         0.0         120.5         13.1         0.0         130.6         0.0         101.5         10.0         10.2         10.0         130.5         10.0         130.6         10.1         150.5         10		11	0.6		0.0							0.6			0.0	0.0	
LF         15         15.0         82.4         53.0         6.6         157.0         16.1         88.5         56.9         7.1         16.8         17.0         93.3         60.0         7.5         177.7           LG         9         37.9         0.0         28.7         0.4         66.9         41.3         0.0         31.2         0.4         72.0         43.0         0.0         33.3         0.5         77.7           LH         32         72.0         31.4         1.41         2.4         120.0         79.6         34.7         15.6         2.6         15.2         85.7         37.4         16.8         2.9         14.2           LI         40         83.6         284.0         293.4         83         669.3         95.0         322.9         333.5         9.5         70.0         101.5         355.1         366.9         10.4         836.9           LK         14         0.0         1,114.4         11.3         0.0         1125.7         0.0         121.9         10.2         0.0         289.0         10.6         10.6         10.6         121.4         13.1         0.0         132.7         0.0         121.4         183.9 <td>LD</td> <td>35</td> <td>21.1</td> <td>16.9</td> <td></td> <td>20.6</td> <td>58.6</td> <td>23.3</td> <td>18.7</td> <td>0.0</td> <td>22.8</td> <td>64.8</td> <td>25.1</td> <td>20.1</td> <td>0.0</td> <td>24.5</td> <td>69.8</td>	LD	35	21.1	16.9		20.6	58.6	23.3	18.7	0.0	22.8	64.8	25.1	20.1	0.0	24.5	69.8
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	LE	14	2.7	45.9		2.5	54.0	3.0	50.7	3.2		59.7	3.3	54.6	3.4	3.0	
LH         32         72.0         31.4         14.1         2.4         1200         79.6         34.7         15.6         2.6         132.6         85.7         37.4         16.8         2.9         142.7           LI         40         83.6         284.0         293.4         8.3         6693         95.0         322.9         333.5         9.5         760.9         104.5         355.1         366.9         10.4         836.9           LJ         8         0.0         686.6         19.0         0.1         775.6         0.0         779.9         20.6         0.1         776.6         0.0         1293.5         13.1         0.0         1306.6           LL         27         0.0         1,799.9         9.2         0.0         1809.0         0.0         1492         0.0         226         0.0         1372.1         0.0         2372.1         0.0         2372.1         0.0         2372.1         0.0         1667.7         0.0         1.1         1668.7           LD         20         0.0         928.4         37.9         0.0         1651.1         0.0         100         1561.1         0.0         1077.2         483.9         48.3	LF	15	15.0	82.4	53.0			16.1	88.5	56.9	7.1	168.6	17.0	93.3	60.0		177.7
LI         40         83.6         284.0         293.4         8.3         669.3         95.0         322.9         333.5         9.5         760.9         104.5         355.1         366.9         10.4         836.9           LI         8         0.0         686.6         19.0         0.1         705.6         0.0         747.9         20.6         0.1         766.8         0.0         796.9         22.0         0.1         819.0           LK         14         0.0         1,114.4         11.3         0.0         1125.7         0.0         1226.2         0.0         1285.1         1.0         0.10         209.7           LM         33         0.0         3,050.8         0.0         0.1         3050.9         0.0         3419.2         0.0         1286.1         0.0         1056.1         0.0         1667.7         0.0         1.1         1668.7           LO         0.0         928.4         37.9         0.0         9664         0.0         1011.3         41.3         0.0         162.7         140.5         100.5         1.1         404.8           LR         22         0.0         0.0         1.1.9         822.6         834.5	LG	9	37.9	0.0	28.7	0.4	66.9	41.3	0.0	31.2	0.4	72.9	44.0	0.0	33.3	0.5	
LJ         8         0.0         686.6         19.0         0.1         705.6         0.0         747.9         20.6         0.1         768.6         0.0         796.9         22.0         0.1         819.0           LK         14         0.0         1,114.4         11.3         0.0         1125.7         0.0         1213.9         12.3         0.0         1226.2         0.0         1293.5         13.1         0.0         1306.6           LL         27         0.0         1,799.9         9.2         0.0         1809.0         0.0         1960.6         10.0         0.0         1970.5         0.0         2089.0         10.6         0.0         2972.1           LN         13         0.0         1,436.8         0.0         0.9         1437.8         0.0         1565.1         0.0         1.0         1566.1         0.0         1667.7         0.0         1.1         1668.7           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LR         22         0.0	LH	32	72.0	31.4	14.1	2.4	120.0	79.6		15.6	2.6	132.6	85.7	37.4	16.8	2.9	142.7
LK         14         0.0         1,14.4         11.3         0.0         11257         0.0         12139         12.3         0.0         12262         0.0         1293.5         13.1         0.0         13066           LL         27         0.0         1,799.9         9.2         0.0         1809.0         0.0         1906.6         10.0         0.0         1707.5         0.0         2089.0         10.6         0.0         2099.7           LM         13         0.0         1,436.8         0.0         0.9         1437.8         0.0         1565.1         0.0         10.1         1566.1         0.0         1667.7         0.0         1.1         1668.7           LO         20         0.0         928.4         37.9         0.0         966.4         0.0         10113         41.3         0.0         1052.6         0.0         1077.6         44.0         0.0         1121.6           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         953         1.0         384.0         106.7         12.5         845.5         876.9           LK         22         0.0         0.17	LI	40	83.6	284.0	293.4	8.3	669.3	95.0	322.9	333.5	9.5	760.9	104.5	355.1	366.9	10.4	836.9
LL         27         0.0         1,799.9         9.2         0.0         1809.0         0.0         1960.6         10.0         0.0         1970.5         0.0         2089.0         10.6         0.0         2099.7           LM         33         0.0         3,050.8         0.0         0.1         3050.9         0.0         3419.2         0.0         0.2         3419.4         0.0         3721.2         0.0         0.2         3721.4           LN         13         0.0         1,436.8         0.0         0.9         1437.8         0.0         156.1         0.0         1667.7         0.0         1.1         1668.7           LO         20         0.0         928.4         37.9         0.0         966.4         0.0         1011.3         41.3         0.0         1052.6         0.0         1077.6         44.0         0.0         112.1         48.3         39.6         643.9           LQ         51         143.7         124         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LR         225         0.0	LJ	8	0.0	686.6	19.0	0.1	705.6	0.0	747.9	20.6	0.1	768.6	0.0	796.9	22.0	0.1	819.0
LM         33         0.0         3,950.8         0.0         0.1         3050.9         0.0         3419.2         0.0         0.2         3419.4         0.0         3721.2         0.0         0.2         3721.4           LN         13         0.0         1,436.8         0.0         0.9         1437.8         0.0         1565.1         0.0         1.0         1566.1         0.0         1667.7         0.0         1.1         1668.7           LO         20         0.0         928.4         37.9         0.0         966.4         0.0         1011.3         41.3         0.0         1052.6         0.0         1077.6         444.0         0.0         1121.6           LP         28         63.7         427.4         42.7         35.0         568.7         68.4         458.9         45.8         37.6         610.7         72.1         483.9         48.3         39.6         643.9           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LS         125         1.777	LK	14	0.0	1,114.4	11.3	0.0	112 <mark>5.</mark> 7	0.0	1213.9	12.3	0.0	1226.2	0.0	1293.5	13.1	0.0	1306.6
LN         13         0.0         1,436.8         0.0         0.9         1437.8         0.0         1565.1         0.0         1.0         1566.1         0.0         1667.7         0.0         1.1         1668.7           LO         20         0.0         928.4         37.9         0.0         966.4         0.0         1011.3         41.3         0.0         1052.6         0.0         1077.6         440.0         0.0         1121.6           LP         28         63.7         427.4         42.7         35.0         568.7         68.4         458.9         45.8         37.6         610.7         72.1         483.9         48.3         39.6         643.9           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LR         22         0.0         0.0         11.9         822.6         834.5         0.0         0.0         12.2         846.4         858.6         0.0         0.0         12.5         864.5         876.9           LV         188         0.0	LL	27	0.0	1,799.9	9.2	0.0	1809.0	0.0	1960.6	10.0	0.0	1970.5	0.0	2089.0	10.6	0.0	2099.7
LO         20         0.0         928.4         37.9         0.0         966.4         0.0         1011.3         41.3         0.0         1052.6         0.0         1077.6         44.0         0.0         1121.6           LP         28         63.7         427.4         42.7         35.0         568.7         68.4         458.9         45.8         37.6         610.7         72.1         483.9         48.3         39.6         643.9           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LS         125         1,579.7         1,772.8         2,000.4         4332.8         9775.8         1721.5         2071.9         2318.9         476.7         10880.3         1835.0         230.7         250.7         322.6         328.7           LU         188         0.0         2,544.6         1,316.50         1946.8         5807.9         0.0         2765.6         1374.0         2051.4         6191.1         0.0         240.3         328.8         2935.2         3287.9           LU	LM	33	0.0	3,050.8	0.0	0.1	3050.9	0.0	3419.2	0.0	0.2	3419.4	0.0	3721.2	0.0	0.2	3721.4
LP         28         63.7         427.4         42.7         35.0         568.7         68.4         458.9         45.8         37.6         610.7         72.1         483.9         48.3         39.6         643.9           LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LR         22         0.0         0.0         11.9         822.6         834.5         0.0         0.0         12.2         846.4         858.6         0.0         0.0         12.5         864.5         876.9           LT         28         0.0         21.7         297.7         2,657.6         297.0         0.0         23.0         315.1         281.5         315.1         0.0         24.0         328.8         935.2         328.7.9           LU         188         0.0         2,544.6         1,316.50         1,946.8         5807.9         0.0         2765.6         1374.0         2051.4         6191.1         0.0         2043.3         1418.3         2133.3         6494.9           RA         0	LN	13	0.0	1,436.8	0.0	0.9	143 <mark>7.</mark> 8	0.0	1565.1	0.0	1.0	1566.1	0.0	1667.7	0.0	1.1	1668.7
LQ         51         143.7         124.1         88.8         1.0         357.6         154.3         133.3         95.3         1.0         384.0         162.7         140.5         100.5         1.1         404.8           LR         22         0.0         0.0         11.9         822.6         834.5         0.0         0.0         12.2         846.4         858.6         0.0         0.0         12.5         864.5         876.9           LS         125         1,579.7         1,772.8         2,090.4         4,332.8         977.8         1721.5         2071.9         2318.9         476.9         10880.3         1835.0         2330.7         2507.4         512.6         11795.7           LU         188         0.0         2,544.6         1,316.50         1,946.8         5807.9         0.0         230.6         301.4         6191.1         0.0         240.0         328.8         2935.2         3287.9           LU         188         0.0         2,544.6         1,316.50         1,946.8         5807.9         0.0         2051.4         6191.1         0.0         240.0         328.8         2032.2         3287.9           LU         188         0.0         2	LO	20	0.0	928.4	37.9	0.0	966.4	0.0	1011.3	41.3	0.0	1052.6	0.0	1077.6	44.0	0.0	1121.6
LR         22         0.0         0.0         11.9         82.6         834.5         0.0         0.0         12.2         846.4         858.6         0.0         0.0         12.5         864.5         876.9           LS         125         1,579.7         1,772.8         2,090.4         4,332.8         9775.8         1721.5         2071.9         2318.9         4767.9         10880.3         1835.0         2330.7         2507.4         5122.6         11795.7           LT         28         0.0         21.7         297.7         2,657.6         2977.0         0.0         23.0         315.1         2813.5         3151.7         0.0         24.0         328.8         2935.2         3287.9           LU         188         0.0         2,544.6         1,316.50         1,946.8         5807.9         0.0         2765.6         1374.0         2051.4         6191.1         0.0         240.3         1418.3         2133.3         6494.9           RA         0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         362         38.6         0.0         10.6         14.3	LP	28	63.7	427.4	42.7	35.0	568.7	68.4	458.9	45.8	37.6	610.7	72.1	483.9	48.3	39.6	643.9
LS       125       1,579.7       1,772.8       2,090.4       4,332.8       977.8       1721.5       2071.9       2318.9       4767.9       10880.3       1835.0       230.7       2507.4       5122.6       11795.7         LT       28       0.0       21.7       297.7       2,657.6       297.0       0.0       23.0       315.1       2813.5       3151.7       0.0       24.0       328.8       2935.2       3287.9         LU       188       0.0       2,544.6       1,316.50       1.946.8       5807.9       0.0       2765.6       1374.0       2051.4       6191.1       0.0       2943.3       1418.3       2133.3       6494.9         RA       0       0.0       33.2       36.2       0.0       0.0       36.2       38.6       0.0       1148.3       0.0       1148.3       203.1         RD       124       102.3       0.0       167.1       1.4       270.8	LQ	51	143.7	124.1	88.8	1.0	357.6	154.3	133.3	95.3	1.0	384.0	162.7	140.5	100.5	1.1	404.8
LT       28       0.0       21.7       297.7       2,657.6       2977.0       0.0       23.0       315.1       2813.5       3151.7       0.0       24.0       328.8       2935.2       3287.9         LU       188       0.0       2,544.6       1,316.50       1,946.8       5807.9       0.0       2765.6       1374.0       2051.4       6191.1       0.0       2943.3       1418.3       2133.3       6494.9         RA       0       0.0	LR	22	0.0	0.0	11.9	822.6	834.5	0.0	0.0	12.2	846.4	858.6	0.0	0.0	12.5	864.5	876.9
LU         188         0.0         2,544.6         1,316.50         1,946.8         5807.9         0.0         2765.6         1374.0         2051.4         6191.1         0.0         2943.3         1418.3         2133.3         6494.9           RA         0         0.0	LS	125	1,579.7	1,772.8	2,090.4	4,332.8	9775.8	1721.5	2071.9	2318.9	4767.9	10880.3	1835.0	2330.7	2507.4	5122.6	11795.7
RA         0         0.0	LT	28	0.0	21.7	297.7	2,657.6	2977.0	0.0	23.0	315.1	2813.5	3151.7	0.0	24.0	328.8	2935.2	3287.9
RB         10         33.2         0.0         0.0         33.2         36.2         0.0         0.0         36.2         38.6         0.0         0.0         0.0         38.6           RC         57         148.2         0.0         11.9         0.0         160.1         197.1         0.0         15.8         0.0         212.9         243.5         0.0         19.6         0.0         263.1           RD         124         102.3         0.0         167.1         1.4         270.8         125.0         0.0         173.5         1.4         299.9         145.3         0.0         178.5         1.4         325.3           RE         195         229.4         6.4         104.1         101.0         440.8         338.6         12.1         151.9         162.7         665.2         482.4         19.4         218.7         233.2         953.7           RF         216         4,592.2         1,210.4         981.7         42.2         682.6         5400.6         1321.7         1074.6         55.4         7852.4         6106.5         1413.4         1157.1         68.4         8745.3           RFm         210         1,639.5         9,421.1	LU	188	0.0	2,544.6	1,316.50	1,946.8	5807.9	0.0	2765.6	1374.0	2051.4	6191.1	0.0	2943.3	1418.3	2133.3	6494.9
RC57148.20.011.90.0160.1197.10.015.80.0212.9243.50.019.60.0263.1RD124102.30.0167.11.4270.8125.00.0173.51.4299.9145.30.0178.51.4325.3RE195229.46.4104.1101.0440.8338.612.1151.9162.7665.2482.419.4218.7233.2953.7RF2164,592.21,210.4981.742.26826.65400.61321.71074.655.47852.46106.51413.41157.168.48745.3RFm2101,639.59,421.1372.7186.511619.82050.610523.7422.2216.81321.32512.411443.5464.6244.214664.6RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.11232.62091.39243.3749.31734.513818.4RJ177222.44,304.1225	RA	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RD124102.30.0167.11.4270.8125.00.0173.51.4299.9145.30.0178.51.4325.3RE195229.46.4104.1101.0440.8338.612.1151.9162.7665.2482.419.4218.7233.2953.7RF2164,592.21,210.4981.742.26826.65400.61321.71074.655.47852.46106.51413.41157.168.48745.3RFm2101,639.59,421.1372.7186.511619.82050.610523.7422.2216.813213.32512.411443.5464.6244.214664.6RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.11158.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.4<	RB	10	33.2	0.0	0.0	0.0	33.2	36.2	0.0	0.0	0.0	36.2	38.6	0.0	0.0	0.0	38.6
RE195229.46.4104.1101.0440.8338.612.1151.9162.7665.2482.419.4218.7233.2953.7RF2164,592.21,210.4981.742.26826.65400.61321.71074.655.47852.46106.51413.41157.168.48745.3RFm2101,639.59,421.1372.7186.511619.82050.610523.7422.2216.813213.32512.411443.5464.6244.214664.6RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.47,886.4234.026.08166.726.58868.3292.227.99214.832.19713.0344.829.510119.5RL21	RC	57	148.2	0.0	11.9	0.0	160.1	197.1	0.0	15.8	0.0	212.9	243.5	0.0	19.6	0.0	263.1
RF2164,592.21,210.4981.742.26826.65400.61321.71074.655.47852.46106.51413.41157.168.48745.3RFm2101,639.59,421.1372.7186.511619.82050.610523.7422.2216.813213.32512.411443.5464.6244.214664.6RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.47,886.4234.026.08166.726.58868.3292.227.99214.832.19713.0344.829.510119.5RL2133.711,132.8305.32,906.214347.94.113156.4330.93165.416656.84.414949.8353.63380.918688.6 <td>RD</td> <td>124</td> <td>102.3</td> <td>0.0</td> <td>167.1</td> <td>1.4</td> <td>270.8</td> <td>125.0</td> <td>0.0</td> <td>173.5</td> <td>1.4</td> <td>299.9</td> <td>145.3</td> <td>0.0</td> <td>178.5</td> <td>1.4</td> <td>325.3</td>	RD	124	102.3	0.0	167.1	1.4	270.8	125.0	0.0	173.5	1.4	299.9	145.3	0.0	178.5	1.4	325.3
RFm2101,639.59,421.1372.7186.511619.82050.610523.7422.2216.813213.32512.411443.5464.6244.214664.6RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.47,886.4234.026.08166.726.58868.3292.227.99214.832.19713.0344.829.510119.5RL2133.711,132.8305.32,906.214347.94.113156.4330.93165.416656.84.414949.8353.63380.918688.6	RE	195	229.4	6.4	104.1	101.0	440.8	338.6	12.1	151.9	162.7	665.2	482.4	19.4	218.7	233.2	953.7
RG613,147.64,865.753.7298.68365.64075.75498.967.9349.99992.44985.06043.081.2394.211503.4RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.47,886.4234.026.08166.726.58868.3292.227.99214.832.19713.0344.829.510119.5RL2133.711,132.8305.32,906.214347.94.113156.4330.93165.416656.84.414949.8353.63380.918688.6	RF	216	4,592.2	1,210.4	981.7	42.2	6826.6	5400.6	1321.7	1074.6	55.4	7852.4	6106.5	1413.4	1157.1	68.4	8745.3
RH3696,210.5459.01,613.303,307.111589.97735.3579.22019.13818.414152.09163.0694.02388.34277.716523.0RI2311,416.97,223.2548.11,436.010624.21768.98307.4654.31592.112322.62091.39243.3749.31734.513818.4RJ177222.44,304.1225.41,024.95776.8225.75091.6243.81094.16655.2228.25772.5259.81151.77412.3RK21020.47,886.4234.026.08166.726.58868.3292.227.99214.832.19713.0344.829.510119.5RL2133.711,132.8305.32,906.214347.94.113156.4330.93165.416656.84.414949.8353.63380.918688.6	RFm	210	1,639.5	9,421.1	372.7	186.5	11619.8	2050.6	10523.7	422.2	216.8	13213.3	2512.4	11443.5	464.6	244.2	14664.6
RI         231         1,416.9         7,223.2         548.1         1,436.0         10624.2         1768.9         8307.4         654.3         1592.1         12322.6         2091.3         9243.3         749.3         1734.5         13818.4           RJ         177         222.4         4,304.1         225.4         1,024.9         5776.8         225.7         5091.6         243.8         1094.1         6655.2         228.2         5772.5         259.8         1151.7         7412.3           RK         210         20.4         7,886.4         234.0         26.0         8166.7         26.5         8868.3         292.2         27.9         9214.8         32.1         9713.0         344.8         29.5         10119.5           RL         213         3.7         11,132.8         305.3         2,906.2         14347.9         4.1         13156.4         330.9         3165.4         16656.8         4.4         14949.8         353.6         3380.9         18688.6	RG	61	3,147.6	4,865.7	53.7	298.6	8365.6	4075.7	5498.9	67.9	349.9	9992.4	4985.0	6043.0	81.2	394.2	11503.4
RI         231         1,416.9         7,223.2         548.1         1,436.0         10624.2         1768.9         8307.4         654.3         1592.1         12322.6         2091.3         9243.3         749.3         1734.5         13818.4           RJ         177         222.4         4,304.1         225.4         1,024.9         5776.8         225.7         5091.6         243.8         1094.1         6655.2         228.2         5772.5         259.8         1151.7         7412.3           RK         210         20.4         7,886.4         234.0         26.0         8166.7         26.5         8868.3         292.2         27.9         9214.8         32.1         9713.0         344.8         29.5         10119.5           RL         213         3.7         11,132.8         305.3         2,906.2         14347.9         4.1         13156.4         330.9         3165.4         16656.8         4.4         14949.8         353.6         3380.9         18688.6	RH	369	6,210.5	459.0	1,613.30	3,307.1	11589.9	7735.3	579.2	2019.1	3818.4	14152.0	9163.0	694.0	2388.3	4277.7	16523.0
RJ         177         222.4         4,304.1         225.4         1,024.9         5776.8         225.7         5091.6         243.8         1094.1         6655.2         228.2         5772.5         259.8         1151.7         7412.3           RK         210         20.4         7,886.4         234.0         26.0         8166.7         26.5         8868.3         292.2         27.9         9214.8         32.1         9713.0         344.8         29.5         10119.5           RL         213         3.7         11,132.8         305.3         2,906.2         14347.9         4.1         13156.4         330.9         3165.4         16656.8         4.4         14949.8         353.6         3380.9         18688.6	RI	231	1,416.9	7,223.2	548.1	1,436.0	10624.2	1768.9	8307.4	654.3	1592.1	12322.6	2091.3	9243.3	749.3	1734.5	13818.4
RK         210         20.4         7,886.4         234.0         26.0         8166.7         26.5         8868.3         292.2         27.9         9214.8         32.1         9713.0         344.8         29.5         10119.5           RL         213         3.7         11,132.8         305.3         2,906.2         14347.9         4.1         13156.4         330.9         3165.4         16656.8         4.4         14949.8         353.6         3380.9         18688.6	RJ	177	222.4	4,304.1	225.4	1,024.9	5776.8	225.7	5091.6	243.8	1094.1	6655.2	228.2		259.8	1151.7	7412.3
RL         213         3.7         11,132.8         305.3         2,906.2         14347.9         4.1         13156.4         330.9         3165.4         16656.8         4.4         14949.8         353.6         3380.9         18688.6	RK	210	20.4	7,886.4		26.0	8166.7	26.5		292.2	27.9	9214.8	32.1	9713.0	344.8	29.5	10119.5
		213	3.7	11,132.8	305.3	2,906.2	14347.9	4.1	13156.4	330.9	3165.4	16656.8	4.4	14949.8	353.6	3380.9	18688.6
	Total	2,967					110,134		69,894		21,071			77,331		22,694	141,608

Source: PCD (2005a).

# Table 3-5(b): Results of daily BOD loading estimation of effluent discharged from 33 sub-basins to Thachin River (non-point sources)

		Non-Point Source									
Sub-			Dry Seas	on with Rain	Rainy Season						
Basin	No of	Rice	Rural		Sub-	Rice	Rural		Sub-		
Code	GRID	Field	Community	Vegetable/Fruit	Total	Field	Community	Vegetable/Fruit	Total		
n/a	167	463.0	134.8	1214.5	1812.2	684.0	533.6	4431.0	5648.7		
LA	7	7.2	3.3	1.7	12.2	66.6	32.5	16.3	115.5		
LB	7	7.8	4.2	0.0	12.0	85.7	45.5	0.0	131.2		
LC	11	19.8	5.5	0.0	25.3	189.3	50.2	0.0	239.5		
LD	35	65.0	15.3	0.0	80.3	585.4	134.3	0.0	719.6		
LE	14	38.2	3.6	0.0	41.8	246.9	23.3	0.0	270.2		
LF	15	40.1	9.9	0.0	50.0	247.1	60.8	0.0	307.8		
LG	9	23.6	13.0	0.0	36.6	143.4	79.1	0.0	222.5		
LH	32	47.3	13.9	0.0	61.2	339.6	99.4	0.0	439.1		
LI	40	354.0	106.8	0.1	460.9	738.7	303.0	0.1	1041.8		
LJ	8	24.3	5.7	0.0	30.0	133.5	31.4	0.0	165.0		
LK	14	35.4	5.7	0.0	41.0	194.4	31.3	0.0	225.7		
LL	27	76.0	5.8	0.2	82.0	429.8	32.8	1.2	463.8		
LM	33	109.3	11.0	0.0	120.3	651.1	62.9	0.0	714.0		
LN	13	67.5	6.2	0.2	73.9	353.4	31.8	1.0	386.1		
LO	20	75.8	1 <mark>6.5</mark>	0.0	92.2	387.8	84.3	0.0	472.0		
LP	28	112.7	15.8	8.9	137.3	570.9	79.9	44.8	695.6		
LQ	51	119.4	19.2	22.5	161.0	731.7	158.6	161.2	1051.5		
LR	22	11.3	11.9	1.2	24.3	114.9	121.5	12.2	248.6		
LS	125	44.2	84.0	16.9	145.0	311.2	658.9	127.3	1097.4		
LT	28	6.8	30.9	17.1	54.8	44.0	201.3	111.4	356.7		
LU	188	17.2	65.6	8.2	90.9	118.8	442.6	56.1	617.5		
RA	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
RB	10	41.7	6.6	0.0	48.3	225.1	35.7	0.0	260.8		
RC	57	104.1	6.5	43.6	154.3	809.4	50.5	300.3	1160.2		
RD	124	193.6	29.2	38.1	260.9	1561.6	224.7	360.9	2147.2		
RE	195	209.7	70.7	390.4	670.8	1610.8	580.5	3427.8	5619.2		
RF	216	1352.5	308.7	67.5	1728.7	4566.0	1032.7	473.1	6071.8		
RFm	210	539.5	167.4	114.0	820.9	3106.6	1065.6	379.9	4552.1		
RG	61	106.6	34.2	58.9	199.7	681.4	251.5	476.4	1409.2		
RH	369	112.7	98.9	37.2	248.8	1075.0	1023.8	419.5	2518.3		
RI	231	70.0	51.6	29.5	151.1	641.5	444.4	252.7	1338.6		
RJ	177	9.2	9.9	51.4	70.5	117.5	101.4	516.7	735.6		
RK	210	17.2	4.9	23.8	45.9	155.8	59.6	369.5	584.9		
RL	213	47.2	60.1	9.0	116.3	318.5	416.6	71.5	806.6		
Total	2,967	4,570	1,437	2,155	8,162	22,238	8,586	12,011	42,834		

Source: PCD (2005a).

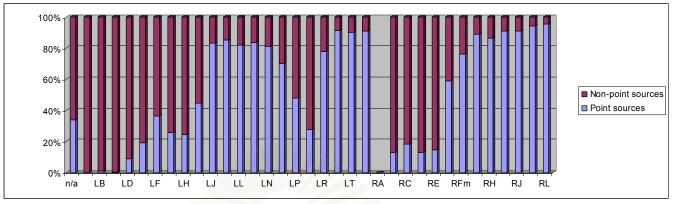
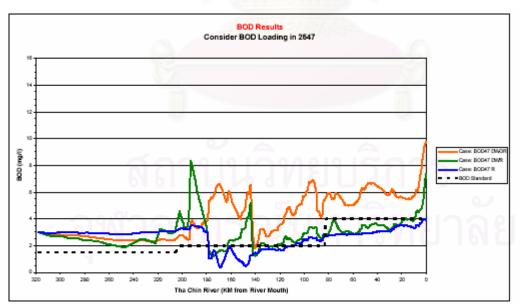


Figure 3-8: Proportion of Point sources and Non-point sources effluent discharged from 33 sub-basins to Thachin River Source: Modified from PCD (2005a).

In Thachin River, there are Point sources and Non-point sources. The tables of effluent loading are shown in the table 3-5(a) and 3-5(b) and the proportion of point sources and non-point sources are shown in the figure 3-8. Within the scope of study, effluent tax charges can only be applied from point sources. Thus, non-point sources described in the recommendation topic clarifies this further.



**Figure 3-9: Prediction of current water quality in Thachin River using BOD loading from each sub-basin in 2004.** Source: PCD (2005a).

After gathering the PCD data we could identify the types of main point sources which needed to be controlled. The parameters are:-

- point sources distances to the river,
- BOD loading at each source in each sub-basin,
- the volume of waste water treatment (F),
- Concentration in influent stream (I),
- the volume of waste water generated when produced at 'q' units at each main point source (Alpha),
- BOD loading when produced at 'q' units of each main point source (Beta)

### b) Total Maximum Daily Loading by using BOD peak reduction basis

The TMDL or Total Maximum Daily Load is a calculation of the maximum amount of pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's sources.

Water quality standards are set by states, territories, and tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use.

A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account seasonal variation in water quality (U.S.EPA., 2007).

The BOD reduction basis is used to consider a specific point or distance at the range of high BOD value. By considering a BOD peak together with BOD details at each point for the main activity producing BOD, the criteria will be set up in order to reduce the BOD until it meets the standard (PCD, 2005a).

After finishing topic a) we can use the data from a) and continue on to part b) and c). In arriving at TMDLs by reducing the pollutants at the particular area that caused BOD peaks.

The BOD peak reduction basis is concerned only by the peak of BOD in the current situation of Thachin river. All BOD peaks in Thachin River basin have 9 points and are shown in tables 3-6.

No	Km.	BOD value of Thachin River in present (mg/l)	Water Pollution- generated sub-basin	BOD loading form pollution- generating sources that flowed to Thachin River (kg/day)
1	180 - 200	8.0	LI	1,200
			RF	9,600
			LJ	700
2	160 - 180	6.5	LK	7,100
1			LL	1,800
			LM	3,000
3	140-160	6.5	RFm	12,000
		59/29/2	LP	570
4	110 – 120	4.8	RG	8,400
5	90 - 100	6.7	LQ	360
5	90 - 100	0.7	RH	12,000
6	70 - 90	6.0	RI	11,000
7	40 - 50	6.5	LS	9,800
			RJ	5,800
8	20-40	6.2	RK	8,200
			LT	3,000
9	0 - 20	7.0	LU	5,800
			RL	14,500

 Table 3-6: High BOD value in all 9 point of Thachin River

 BOD loading

The reason for the increasing BOD is the affect of 18 sub-basins from 33 sub-basins as show in Table 3-6. These sub-basins have high BODs especially between the central and lower sections of the river. 18 out of 33 sub-basins discharged a large volume of BOD which was 90% of BOD from the whole sub-basin. The details are shown in Table 3-7.

Season	BOD loading flowed to Thachin River								
	18 sub-basins	which generate BOD	15 sub-basins wh	ich not generate BOD					
		peak		peak					
	BOD loading	Percentage of total	BOD loading	Percentage of total					
	(kg/day)	BOD loading in	(kg/day)	BOD loading in					
		Thachin		Thachin					
Dry Season	104,165	96	4,602	4					
without Rain									
Dry Season	124,130	95	6,847	5					
with Rain									
Rainy Season	157,338	89	18,625	11					

### Table 3-7: BOD load from 18 sub-basins which generate BOD peak in Thachin River

Source: PCD (2005a).

In arriving at the TMDL, the BOD has to be reduced from the starting point through to the end of the river. Starting at areas LI and RF basins, the water quality improved in the range of 180-200 km until it satisfied the water quality standard. Then the reduction of the BOD process would continue to the second group (LJ, LK and LL) at the range of 160-180 km through to the end of the river (LT, LU and RL) that has a higher BOD.

### c) Target of emission reduction

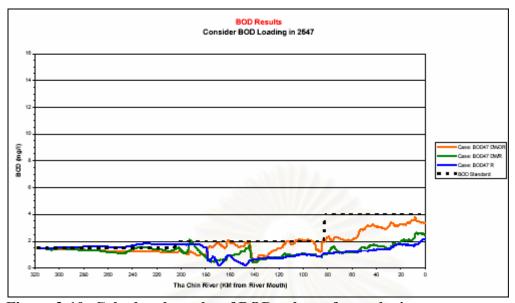
Target of emission reduction could be found by using the volume of BOD loading of the current situation in each sub-basin and deducting the Total Maximum Daily BOD loading (TMDL), where the results of reduction emissions are shown in Table 3-8 and the water quality are shown in Figure 3-10.

No	Km.	Sub-basins	BOD loading from	Allowable BOD	Target of emission
		have pollution-	pollution-generating	discharging load to	reduction
		generating	sources that flowed	Thachin River from	
		sources	to Thachin River	each sub-basin (% of	
				BOD load at present)	
1	180 - 200	LI	1,200	50%	50%
		RF	9,600	15%	85%
		LJ	700		
2	160 - 180			45%	55%
		LK	7,100		
		LL	1,800		
3	140-160	LM	3,000	30%	70%
		RFm	12,000		
4	110 - 120	LP	570	40%	60%
		RG	8,400	40%	60%
5	90 - 100	LQ	360	5%	95%
		RH	12,000	5%	95%
6	70 - 90	RI	11,000	70%	30%
7	40 - 50	LS	9,800	75%	25%
		RJ	5,800	75%	25%
8	20 - 40	RK	8,200	75%	25%
		LT	3,000		
9	0 - 20			75%	75%
			BODAY INVILL		
		LU	5,800		
		RL	14,500		

 Table 3-8: Allowable BOD discharging load from each sub-basin maintaining water

 quality in Thachin River to meet standard criteria

Source: PCD (2005a).



**Figure 3-10: Calculated results of BOD values after reducing BOD loading at particular areas that led to a BOD peak** Source: PCD (2005a).

Controlling BOD that does not exceed the PCD standard is shown in Table 3-8 and Figure 3-10. After defining the allowable BOD loading and the reduction percentage, use continues with the information for phase II and phase III.

### 3.2.1.2 Economic data of significant pollution

There are four significant point sources in this paper. This section explains how to gather the data relating to costs and estimating economics.

First, obtain the current BOD results, and compare the total maximum daily loading with the water classification standard. Then the BOD has to be reduced to meet TMDLs., this reduction of volume is called the 'emission reduction target'.

The emission reduction target will be used with the marginal abatement cost curve in order to find the tax variation in any sub-basin.

The data in 3.2.1.1 and 3.2.1.2 are needed to calculate MAC function coefficients, based on :

- the Cost of Abatement (C),
- volume of waste water (F)
- pollution concentration in influent (I)
- effluent (E). More details are explained in data analysis of Phase II.

### a) Pig farm

Data from the PCD report "Development and Technology of Wastewater Management where parameters comprise the cost of abatement in any type of pig farm i.e., price of 100 kg of pig unit and variable costs.

Detail	Small	Medium	Large
	Biogas	Biogas	Biogas
	(Digester+FP <sup>b</sup> +MP <sup>c</sup> )	(Carmatec digester+FP <sup>b</sup> +MP <sup>c</sup> )	(UASB <sup>a</sup> +FP <sup>a</sup> +MP <sup>c</sup> )
Volume of wastewater (cubic-meter/day)	10.00	30.00	50.00
Area of wastewater treatment system (square			
meter)	100.00	1,750.00	2,000.00
Land price (Baht)	3 65 -		-
Construction cost (Baht)			
Civil structure (a)	54,000.00	367,000.00	760,000.00
Machinery equipment (b)	and the state of t	-	-
Electricity system and piping (c)	2,000.00	10,000.00	60,000.00
Preliminary cost	56,000.00	377,000.00	820,000.00
Safety factor 20%	11,200.00	75,400.00	164,000.00
Transaction cost 10%	6,720.00	45,240.00	98,400.00
Total construction cost	73,920.00	497,640.00	1,082,400.00
Construction cost (Baht/cubic-meter)	2.03	4.54	5.93
Construction cost (Baht/unit)	5.23	8.79	7.65
Operating and Maintenance cost(Baht/year)			
Maintenance	2,500.00	5,705.00	12,600.00
Electricity system and piping (c)	-	<u> </u>	-
Chemical (lime)		-	-
Officer	1,200.00	2,500.00	40,000.00
Total operating and maintenance	3,700.00	8,205.00	52,600.00
Operating and Maintenance cost(Baht/cubic-			ŕ
meter)	<b>1.01</b>	0.75	2.88
Operating and Maintenance cost(Baht/unit)	2.62	1.45	3.72
Total cost (Baht/unit)	7.84	10.24	11.37

Table 3-9: Transaction	cost of pig	g farm wast	e water	treatment in	each size

<sup>a</sup> Upflow Anaerobic Sludge Blanket, <sup>b</sup> Facultative Pond, <sup>c</sup> Maturation Pond Source: PCD (2003a).

	Variable	Fixed	Total	cost	Price	Revenue
B.E.	cost	cost	Baht/unit	Baht/Kg	Baht/Kg	Baht/Kg
2527	2,242.63	52.81	2,295.44	22.95	21.74	(1.21)
2528	1,707.58	81.86	1,789.44	17.89	17.00	(0.89)
2529	1,575.63	56.51	1,632.14	16.32	19.15	2.83
2530	1,927.56	57.28	1,984.84	19.85	22.11	2.26
2531	2,246.60	70.67	2,317.27	23.17	25.96	2.79
2532	2,367.41	79.08	2,446.49	24.46	28.17	3.71
2533	2,261.67	83.84	2,345.51	23.46	24.92	1.46
2534	2,238.12	74.34	2,312.46	23.12	30.00	6.88
2535	2,658.15	73.34	2,731.49	27.31	31.31	4.00
2536	2,301.19	62.69	2,363.88	23.64	23.75	0.11
2537	2,202.44	64.68	2,267.12	22.67	26.70	4.03
2538	2,849.18	67.12	2,916.30	29.16	35.21	6.05
2539	3,237.73	70.17	3,307.90	33.08	40.57	7.49
2540	3,529.66	78.28	3,607.94	36.08	39.07	2.99
2541	3,497.55	80.74	3,577.62	35.78	41.65	5.87

Table 3-10: Cost and revenue of pig farm production

Source: PCD (2003a).

b) Urban communities

The Ministry of Natural Resources and Environmental declaration issued in 2/2546 has stipulates that every household in each community have to pay a wastewater treatment charge. Thus, treatment charge rates from the Ministry of Natural Resources and Environment are used The table 3-11 is shown below.

1 401			t volume	Operating and Maintenance	Current operating	Evaluated operating	
No.	Municipality	of wastewater treatment (cubic (cubic- meter/day) meter/year)		cost (Million Baht/year)	cost (Baht/cubic- meter)	cost (Baht/cubic- meter)	
	District U-thong,	<b>.</b>				í í	
1	Suphanburi province	3,500	1.28	0.39	0.31	0.40	
2	Mueng Rajburi	17,000	6.21	2.19	0.35	0.46	
3	Varin-chumrab, ubomratchathani province	2,896	1.06	0.40	0.38	0.49	
		,					
<u>4</u> 5	Mueng Chanthaburi City municipal of Nakorn prathom province	5,000	1.83 5.48	0.86	0.47	0.61	
6	City municipal of Nakornratchasrima province	50,884	18.57	9.79	0.53	0.69	
7	Mueng Kumpaeng-phet	2,500	0.91	0.60	0.66	0.85	
8	Mueng Baan-mee	600	0.22	0.15	0.68	0.89	
9	Mueng Chainat	2,500	0.91	0.70	0.77	1.00	
10	Mueng Tak	2,903	1.06	0.83	0.78	1.02	
11	Mueng Panus-nikom	2,000	0.73	0.65	0.89	1.16	
12	Mueng Hat yai	50,000	18.25	17.52	0.96	1.25	
13	District Tha-Raae, Sakolnakorn province	958	0.35	0.34	0.97	1.26	
14	Mueng Suphanburi	2,000	0.73	0.80	1.10	1.42	
15	Mueng Payao	3,598	1.31	1.86	1.42	1.84	
16	Mueng Sakolnakorn	7,295	2.66	3.84	1.44	1.87	
17	Mueng Nan	1,400	0.51	0.81	1.59	2.06	
18	District Pakchong	2,000	0.73	1.25	1.71	2.23	
19	District Huakwang, Mahasarakham province	600	0.22	0.51	2.33	3.03	
20	Mueng Phetburi	3,500	1.28	3.55	2.78	3.61	

Table 3-11: Evaluated operating cost of stabilization pond in each local government

Remark: Other municipals in each province referred to the regulation of Municipality of Amphoe Mueng

	•	Current	volume	Operating	Current	
No.	Municipality			and Maintenance	operating	Evaluated
		of wastewat	of wastewater treatment			operating
				cost	cost	cost
		(cubic	(cubic-	(Million	(Baht/cubic-	(Baht/cubic-
		meter/day)	meter/year)	Baht/year)	meter)	meter)
1	Mueng Nondhaburi	20,000	7.3	7.93	1.09	1.41
2	Mueng Pattaya(wat bun)	5,500	2.01	2.57	1.28	1.66
3	Mueng Pa-tong	6,500	2.37	3.15	1.33	1.73
	District pra-in racha,					
4	Ayuthaya province	1,900	0.69	0.96	1.38	1.8
5	Mueng Laem chabang	1,450	0.53	0.78	1.47	1.92
6	Mueng Pattaya(Na kluea)	50,000	18.25	28.44	1.56	2.03
7	Mueng Phuket	20,443	7.46	12	1.61	2.09
8	Meung Kanchanaburi	12000	4.38	8.2	1.87	2.43
9	Mueng Chacheungsao	3,000	1.1	2.11	1.93	2.51
10	Provincial local government, Chonburi	10,315	3.76	7.69	2.04	2.66
11	District Baan paae	941	0.34	0.72	2.1	2.73
12	Mueng Saensuk north- west	17,131	6.25	16	2.56	3.33
13	Mueng Potharam	2500	0.23	2.6	5.85	3.7
15	City Pranakorn	2300	0.91	2.0	0.00	5.1
14	Sriayuthaya	1,500	0.55	2	3.65	4.75

Table 3-12: Evaluated operating cost of aerated lagoon in each local government

Source: PCD (2003b).

<u>Remark</u>: Other municipals in each province referred to the regulation of Municipality of Amphoe Mueng

Table 3-13: Evaluated operating cost of activated sludge in each local government

					Current	
		Current volume		Operating and	operating	Evaluated
				Maintenance		operating
No.	Municipality	of wastewat	er treatment	cost	cost	cost
		(cubic	(cubic-	(Million	(Baht/cubic-	(Baht/cubic-
		meter/day)	meter/year)	Baht/year)	meter)	meter)
1	City Trang	6,500	2.37	1.63	0.69	89.00
2	Mueng Burirum	6,500	2.37	2.02	0.85	1.11
3	City Ubon				d	
	Ratchathani	5,500	2.01	2.92	1.45	1.89
4	District Cha-am,	0000		0000		
	Phetburi province	2,306	0.84	1.54	1.83	2.38
5	City Songkha	5,000	1.83	3.60	1.97	2.56
6	Mueng					
	Prachuabkhirikhun	2,480	0.91	1.91	2.11	2.74
7	City Chieng mai	15,000	5.48	14.37	2.62	3.41

Source: PCD (2003b).

Remark: Other municipals in each province referred to the regulation of Municipality of Amphoe Mueng

The urban community revenue comes from profit per capita. Parameter (P) is derived from public service budget. Social development is supported by the provincial government and can be divided by the provincial population. The quantity (Q) is derived from the population in each sub-district. The revenue of urban community in each sub-basin is derived from (P) multiply by (Q). (P)and (Q) of each province are shown in the table below.

	Provincia	l budget for				Current operating cost
	_	Social			Budget per	
	Public service	development	Total	No. of	capita	(Baht/cubic-
Province	(Baht)	(Baht)	(Baht)	people	(Baht)	metre)
Samuth sakorn	73,453,068.00	18,029,153.00	91,482,221.00	449,090.00	203.71	1.09
Suphunburi	190,698,415.00	8,683,323.00	199,381,738.00	868,681.00	229.52	1.10
Chai nat	75,415,999.00	3,596,661.00	79,012,660.00	339,032.00	233.05	0.77
Kanchanaburi	194,293,494.00	1,337,492.00	195,630,986.00	826,169.00	236.79	1.87
Uthaithani	92,063,538.00	270,831.00	92,334,369.00	326,882.00	282.47	0.77
Nakornprathom	169,141,324.00	11,062,003.00	180,203,327.00	798,016.00	225.81	0.51

 Table 3-14: Total provincial budget of public service, social development and budget per capita, and Current operating abatement cost of each province

Source: Bureau of the Budget (2004) and PCD (2003b).

### c) Aqua culture

Most of the economic data are from the Development of Effluent Treatment Management for Aquaculture projects, PCD (2005a). The abatement cost for aquaculture can be divided into 2 groups. All fish farms treatment methods refer to the use Aerated Lagoons with Constructed wetlands. All prawn farms treatment methods refer constructed wetlands. The detail of expenses are shown in the table below:

Fish	Prawn
16,432.00	3,307.20
72,210.00	-
4.39	-
-	16,000.00
-	4.84
	16,432.00 72,210.00

Table 3-15: Abatement cost of each type of aqua culture

Source: PCD (2005b).

## Table 3-16: Operation cost of each type of aquaculture

Detail	Cost (Baht/rai/year)			
Operation cost				
Snake-head fish feeding cost	989,250			
Nile tilapia feeding cost	5,500			
Cat fish feeding cost	116,792			
Giant freshwater prawn	38,500			
1	a var a sin a			

Source: PCD (2005b).

## Table 3-17: Revenue of each type of aqua culture

Detail	Price (Baht/kg)	Quantity (kg/rai)	Revenue (Baht/rai-yr)
Benefit			d
Sales of Snake-head fish	60.00	21,150.00	1,269,000.00
Sales of Nile tilapia fish	20.00	800.00	16,000.00
Sales of Cat fish	25.00	6,742.00	168,550.00
Sales of Giant freshwater prawn	250.00		51,708.00

Source: PCD (2005b).

### d) Industry

There are 44 types of factory along the Thachin river giving a total of 8,160 factories. In arriving at the abatement cost, we investigated the wastewater treatment processing systems of each factory from the Department of Industry. The expense for each processing referred to the average expense was obtained from the research of "The Standard of Wastewater Treatment Charge, (2003c)"

Revenue section, the net profit per ton of whole industrial type, referred to table 202 of I/O model (Office of the National Economic and Social Development Board), divided by the Quantity of National Production (tons) (information comes from the Ministry of Industry). The profits per production (ton) of each manufacturing type multiplied by Q (number of manufacturers of each type in each sub-basin). Finally, the revenue per unit of each type in each sub-basin are shown in the table below:

No	Types of	Industrial activity	Revenue per ton	Wastewater Technology	Cost of Abatement
	industry		thousand Baht		Baht/cubic meter-day
1	4(1)	Slaughtering	44.86	Sump Area	0.29
	4(2) 4(3)	The preservation of meat by toast, smoke-dried, pickled, sun-dried and sharply freezing method Processed food products from animal meat, fat, hide and grease	44.86	Activated Sludge	3.1
		or born extract	44.86	Septic Tank	0
2	5(5)	Processed cheese and butter	23.33	RBC <sup>a</sup>	1.62
	5(6)	Processed yogurt	23.33	Activated Sludge	3.1
3	6(1)	Processed aquatic animal food and canning	62.56	Aerated Lagoon	1.49
	6(2)	The preservation of aquatic animal by toast, smoke-dried, pickled, sun-dried and sharply freezing method	62.56	Aerated Lagoon	1.49
	6(3)	Processed food product from aquatic animal and hide or fat of aquatic animal	62.56	Activated Sludge	3.1
	6(5)	Sliced, boiled, steamed, fired, and grinded (fish) aquatic animal	62.56	Activated Sludge	3.1
4	7(1)	The extraction of vegetable and animal oils and fats	7.70	Sump Area	0.29
	7(4)	Processed pure vegetable and animals oils and fats	7.70	Activated Sludge	3.1
5	8(1)	Canning of fruit and vegetables	21.45	Sump Area	0.29
6	8(2)	Preserving of fruit and vegetables Processed starch	21.45	Sump Area	0.29
0	9(2) 9(4)	Grain mill products manufacturing	3.74 3.74	Stabilization pond	0 0.29
7	10(1)	Processed bakeries	48.94	Sump Area Septic Tank	0.29
,	10(1) 10(2)	Processed biscuits	48.94	Septic Tank	0
	10(3)	Baked and steamed products manufacturing	48.94	Sump Area	0.29
8	11(2) 11(6)	Processed sugar refineries Processed glucose, dextrose, fructose and similarly other	5.21	Sump Area	0.29
9	12(0)	products	5.21	Activated Sludge	3.1
9	12(9)	Processed chewing gum	23.33	Activated Sludge	3.1
	12(11)	Processed ice-cream	23.33	Septic Tank	0

Table 3-18: Revenue and Cost of Abatement for each Industrial activity

# Table 3-18: (Continued)

No	Types of	Industrial activity	Revenue per ton	Wastewater Technology	Cost of Abatement
	industry		thousand Baht		Baht/cubic meter-day
10	13(2)	Processed additive	-	Sump Area	0.29
	13(3)	Processed powder-yeast	-	Sump Area	0.29
11	15(1)	Prepared animal feeds	1.58	Sump Area	0.29
	15(2)	Grinded vegetable, grain, meat, bone and shellfish for animal feeds	1.58	Stabilization pond	0
12	16	Manufacture of distilling rectifying and blending spirits	1.20	UASB <sup>b</sup>	32.95
13	20(1)	Processed drinking water	8.40	Septic Tank	0
	20(2)	Processed non-alcoholic drinks	8.40	Activated Sludge	3.1
14	22(1)	Carbonize incubation, bleaching and dyeing fibers	135.00	Activated Sludge	3.1
	22(2)	Spinning of cotton	135.00	Activated Sludge	3.1
	22(3)	Textile finishing	135.00	Activated Sludge	3.1
1.5	22(4)	Textile printing	135.00	Sump Area	0.29
15	24	Knitting mills	135.00	Activated Sludge	3.1
16	30	Manufacture of fur dressing and dyeing	12.07	Activated Sludge	3.1
17	38(2)	Processed paper or fiberboard	9.71	Activated Sludge	3.1
18	42(1)	Processed chemicals	17.16	Sump Area	0.29
19	43(1)	Processed fertilizer and pesticides	-	Septic Tank	0
20	44	Synthetic resin rubber, plastic or synthetic fiber manufacturing	5.99	Activated Sludge	3.1
21	45(1)	Processed paints	-	Activated Sludge	3.1
22	46(1)	Objects which are accepted in medicine text book manufacturing	398.43	Septic Tank	0
	46(2)	Objects which cure, relieve and protect disease for human or animal manufacturing	398.43	Septic Tank	0
23	47(1)	Processed soap and cleaning preparations	14.39	Septic Tank	0
	47(3)	Processed cosmetics	14.39	Septic Tank	0
24	48(6)	Ink or carbon black manufacturing		Sump Area	0.29
25	50(4)	Processed miscellaneous petroleum	0.13	Sump Area	0.29
26	52(3) 52(4)	Smoked rubber, crepe rubber, sticky rubber and liquid rubber manufacturing Processed natural rubber product	5.99	Stabilization pond	0
	52(4)	or synthetic rubber	5.99	Sump Area	0.29

## Table 3-18: (Continued)

No	Types of industry	Industrial activity	Revenue per ton	Wastewater Technology	Cost of Abatement
			thousand Baht		Baht/cubic meter-day
27	54	Grass and fiberglass manufacturing	1.69	Sump Area	0.29
28	55	Manufacture of tile, pottery or ceramic	27.90	Sump Area	0.29
29	59	Smelt, melt, mold, press out, haul or produce iron or primary steel (Iron and steel basic)	7.57	Sump Area	0.29
30	60	Smelt, mix, purify, melt and mold (Non-ferrous metal basic)	50.23	Sump Area	0.29
31	92	Manufacture of frozen	-	Activated Sludge	3.1
32	98	Laundries, laundry services and cleaning and dyeing plant	-	Activated Sludge	3.1
33	101	Central waste treatment plant	-	Activated Sludge	3.1

<sup>a</sup> Rotating Biological Contactor, <sup>b</sup>Upflow Anaerobic Sludge Blanket Source: Database of Department of Industrial Work (2006), Office of Industrial Economics (2006), National Economics and Social Development Board (2006), PCD (2003c).

Table 3-19: The necessary	parameters of database collection
---------------------------	-----------------------------------

Details	Unit	
Current situation of BOD loading in Thachin river		
- Volume of wastewater treatment(F)	Cubic-metre	
- Pollution concentration in infuent stream(I)	Kg-BOD/Cubic-metre	
- An ability of pollution release in any point source(alpha)		
Total Maximum Daily Loading, target of emission reduction		
- Total Maximum Daily Loading	Kg-BOD/day	
- % Reduction in any subbasin	Percentage	
Pig farm		
- Cost of abatment of any wastewater treatment technology	Bant/Cubic-metre	
- Profit per pig unit (100 kg)	Baht	
- Quantity of number of pig unit in any subbasin	Unit	
- Pollution concentration in effluent stream(E)	Kg-BOD/Cubic metre	
(depend on treatment technology)		

# Table 3-19: (continued)

Details	Unit	
Urban community		
- Cost of abatment of any local government	Bant/Cubic-metre	
- Received budget per capita	Baht	
- Number of people in each subbasin	Unit	
- Pollution concentration in effluent stream(E)	Kg-BOD/Cubic metre	
(depend on expected treatment technology)		
Aqua culture		
- Cost of abatment of any wastewater treatment technology	Bant/Cubic-metre	
- Profit per unit of aqua culture area	Baht	
- Quantity of aqua culture area in any subbasin	Unit	
- Pollution concentration in effluent stream(E)	Kg-BOD/Cubic metre	
(depend on expected treatment technology)		
Industry		
- Cost of abatment of any wastewater treatment technology	Bant/Cubic-metre	
- Profit per unit of industrial type	Baht	
- Quantity of any industrial type in any subbasin	Unit	
- Total revenue from industrial production in any subbasin	Baht	
- Pollution concentration in effluent stream(E)	Kg-BOD/Cubic metre	
(depend on expected treatment technology)		



# 3.2.2 Phase II: Development of MAC for each main point source and Calculated Tax rate equivalent to CAC

In this phase, the data collection can be divided into 2 groups which are (a) marginal abatement cost function and (b) Non-Uniform tax from any main point sources of 18 sub-basins. More details are shown below:

#### 3.2.2.1 Data collection

- 1. Finding volume of wastewater treatment (F), pollution concentration in the influent stream (I), pollution concentration in the effluent stream (E) of whole river for each activity.
- 2. Synthesis co-efficient of abatement cost, function equation (3-1)
- 3. Separated F, I, E of each sub-basins. Each sub-basin is separated for each activity. Finally, arriving at the total value of F, I, E for each sub-basin and related activities
- 4. Emission reduction targets
- 5. Abatement costs
- 3.2.2.2 Data analysis

The marginal Abatement Cost function is a non-linear regression program which is selected to input the economic data set from the required economic criteria. The idea of a marginal abatement cost curve (MAC) comes from company or plant level models of reducing pollution. In production theory, the interpretation is straightforward. Given that certain activities in the production process lead to pollutions of undesired substances and considering certain abatement technologies. The marginal abatement costs represents either the marginal loss in profits from avoiding the last unit of emissions or the marginal cost of achieving a certain pollution target from a certain level of output. Whereas the latter focuses on abatement technologies such as air or water filters, the former concept is more interesting in the overall adjustment of a company to an emission constraint including adjustments in the output levels (McKitrick, 1999).

The results of phase II and phase III are divided into 2 scenarios. First, is the emission tax rate for each main point sources of each sub basin (Non-uniform tax), and secondly is a single emission tax rate for each sub basin (Uniform tax). The procedures to calculate effluent variation taxes are as follows:

 Using F, I, E and C for each main point source of the entire Thachin river from phase I in order to run the regression in E-view program. Finding the coefficient set of abatement cost equation of each main point source.

Cost of abatement equation:

$$C = e^{a} F^{b} I^{c} E^{d}$$
(3-1)

Where C is the cost of abatement,

'e' is natural logarithm,

'F' is volume of waster water treatment,

' I' is pollution concentration in influent stream,

'E' is pollution concentration in effluent stream.

and 'a', 'b', 'c', and 'd' are coefficient sets (Mehta, S., 1997)

2. Creating the marginal abatement cost function. By a partial derivative cost of abatement equation by 'E'

$$C = e^a F^b I^c E^d \tag{3-2}$$

take log

$$LnC = a + bLnF + cLnI + dLnE$$
(3-3)

$$\frac{d}{dE}C = e^{a}F^{b}I^{c}(-d)E^{d-1}$$
(3-4)

$$Tax = MC = e^{a}F^{b}I^{c}(-d)E^{d-1}$$
(3-5)

3. Creating a calculation sheet to find the tax variation of each main activity in each sub basin. By including the data of each parameter into the equation 3-5. Derivative of abatement cost equal to marginal abatement costs and equal to tax rates as shown in the figure above.

Where;

- F = Total volume of wastewater treatment of each main point source at each sub basin in scenario one and equal to total volume of wastewater treatment of each sub basin in scenario two,
- I = Total pollution concentration in influent stream of each main point source at each sub basin in scenario one and equal to total pollution concentration in influent stream of each sub basin in scenario two,

E = I - (I \* % target of emission reduction),

Percentage of target of emission reduction = ((I - TMDL)\*100)/Iand 'a', 'b', 'c', are co-efficient sets.



#### 3.2.3 Phase III. Mathematical decision-making model

#### 3.2.3.1 Data collection

- a) Allowable pollution loading in each sub-basin (at source) is the sum of the maximum pollution loading without deteriorating the river. This value comes from the database collection in phase I which was explained previously.
- b) Revenue per product unit of each main point source is the difference for the section on economics of significant pollution.
- c) Product quantity of each significant production in every sub-basin.
- d) Effluent Variation tax for each product in each sub-basin. This value came from the phase II results
- e) Emitted Emissions after tax charges has been added for every product in each sub-basin
- f) Emission sources in each product have been emitted into each sub-basin before passing treatment system.
- g) The effluent volume emitted from each product in each sub-basin
- h) An ability of pollution emission in each production type
- i) An ability of wastewater per each production unit
- j) Co-efficient set of each main point source.

## 3.2.3.2 Data analysis

#### a) Econometric

Literally interpreted, econometrics means "economic measurement ." Although measurement is an important part of econometrics, the scope of econometrics is much broader, as can be seen from the following quotations (Gujarati, 2003):

Econometrics, the result of a certain outlook on the role of economics, consists of the application of mathematical statistics to economic data to lend empirical support to the models constructed by mathematical economics and to obtain numerical results (Tintner, 1968)

...econometrics may be defined as the quantitative analysis of actual economic phenomena based on the concurrent development theory and observation, related by appropriate methods of inference (Samuelson et al., 1954)

Econometricians...are a positive help in trying to dispel the poor public image of economics (quantitative or otherwise) as a subject in which empty boxes are opened by assuming the existence of can-openers to reveal contents which any ten economists will interpret in 11 ways (Darnell, 1990)

This model is created on the basis that the government has to set up taxes for each sub-basin. The models response to the limiting conditions or constants in the environment. The environmental constants meet the standard requirements and the expected profit of the main point sources activities are not zero.

In this research, econometrics are used for converting the qualitative data into quantitative data and to describe the relation of all attributes in mathematic equations in order to develop a mathematical decision making model. The details are shown in section 4.4

#### b) Excel Solver

#### What is optimization?

When we want to know how much maximized benefit is produced when these companies are limited by certain constraints (environmental and economic constraints as show in section 4.4: Mathematical Decision Making model)

In this situation, we want to find the values of certain cells in a spreadsheet that optimizes certain objectives which the Excel Solver tool assists in solving optimization problems.

Defining an optimization model.

An optimization model has three parts : i. the target cell, ii. the changing cells, and iii.the constraints.

#### i. Target cell

The target cell represents the objective or goal which on needs to either minimize or maximize, thus measuring profitability.

## ii. Changing cells

Changing cells are those that are changed or adjusted to optimize the target cells. In this model these cells are the yearly volumes of each pollution unit produced from each main point source.

## iii. Constraints

Constraints are restrictions place on the changing cells. In this model, the pollution is released within allowable loadings that meet water classification standards. In most Solver models, there is the implicit constraint that all changing cells must be non-negative.

In this mathematical decision making model, 'Target' is set at maximization value of system profit of each sub basin. By changing the emission release cells, to study the effect of tax charges on how much volume of emission is polluted by each main point source. While as any result of target and changing cells is limited by the constraints which are set in the model.

The mathematical decision making model's results as show;

- Gross profit of each sub basin
- Total effluent pollution of each sub basin
- Allowable pollution loading in each subbasin
- Revenue of each main point source
- Cost of abatement of each main point source at each sub basin
- Tax expense of each main point source at each sub basin
- Effluent pollution of each main point source at each sub basin
- Total expense of each main point source at each sub basin
- Profit of each main point source at each sub basin

#### The description of Non-uniform and Uniform tax

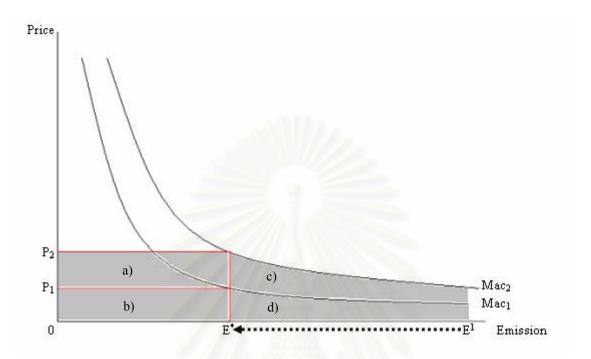


Figure 3-11: Non-uniform tax equivalent to CAC

In this research, If Non-uniform tax is adopted, Non-uniform tax would require from Thailand government to control of pollution discharge of all activities.

The cost of each main point source is not equal. The government, thus, need each main point source to reduce their effluent from  $E^1$  to  $E^*$  by appointed point source 1 has marginal abatement cost function at mac1 and main point source 2 has marginal abatement cost function at mac2. The government, then, should collect tax of main point source 1 at P1 and collect tax of main point source 2 at P2. The cost of abatement of main point source 1 is equal to the area of *d* and tax expense of main point source 1 is equal to the area of *b*. And the cost of abatement of main point source 2 is equal to the area of c + d and tax expense is equal to the area of a + b

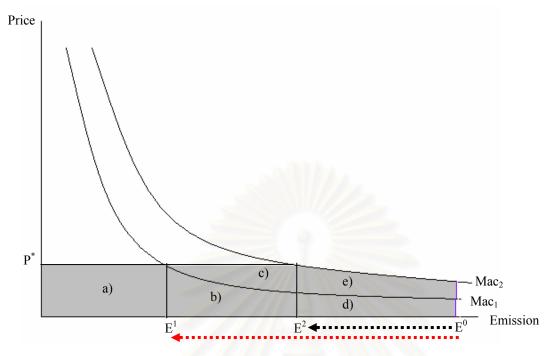


Figure 3-12: Uniform tax

In this research, If uniform tax is adopted, the government requirement to allowable the effluent discharge is to set up the total amount of pollution loading of all activities which should not excess than ambient of water quality. Thus, Tax rate is equal to  $MAC_1 = MAC_2$ . The result is that main point source1 has the cost of abatement equal to the area of b + d and tax expense is equal to a, main point source2 has the cost of abatement equal to the area e + d and tax expense is equal to a + b + c.

Thus, applied the uniform tax follow the theorem. The ambient water quality reduce equally each sub-basin, however, each activities reduce unequally pollution depend upon the economic efficient of each sub-basin which sub-basin has higher economic efficient the more reduced pollution have to be done.

The point where  $MAC_1 = MAC_2 = Emission$  Charge indicated the least-cost allocation of abatement responsibilities across the two polluters and satisfied the requirement for equi-marginal principle of optimality (Callan and Thomas, 1996).

## Applied Mathematical Decision-making model into 2 Scenario

The results are divided into two scenarios: (1) first scenario is using Non-Uniform Tax (variation tax) for each main point source in each sub basin and (2) second scenario is using Uniform tax for entire main point source in each sub basin. The scope of the problem for each scenario is presented below.

# Case 1: Non-Uniform Tax

- The government forces the polluter to reduce their effluent by imposing Non-Uniform tax rates to charge each main point source in each sub basin (Profit maximization).
  - o Using Excel Solver to investigate
    - Main point sources pollution at each sub basin
    - Profit of each main point source
    - Abatement cost and tax expenses

# Case 2: Uniform Tax

- Government sets the minimum effluent tax which brings sub-basin emissions lower than the sub-basin effluent standard levels. (Profit maximization)
  - Using Excel Solver to investigate
    - Uniform Tax
    - Main point sources pollution at each sub basin
    - Profit of each main point source
    - Abatement cost and tax expenses

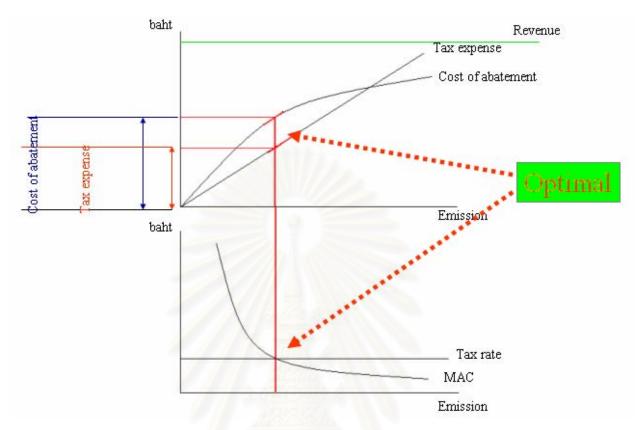


Figure 3-13: The optimal case of tax charge at total cost curve and marginal abatement cost curve

#### How optimization Mathematical Decision-making model work with excel solver

Case 1: Non-Uniform Tax

1. 
$$\prod_{i} = \sum_{k=1}^{N} P Q_{k} - \sum_{k=1}^{N} ABC_{k} - T \sum_{k=1}^{N} E_{k}$$

Finding the Maximized benefits which are involved in 'E' for Abatement cost (Cost = $e^{a}F^{b}$  I<sup>c</sup> E<sup>d</sup>) and Tax expense (TE)

2. When reducing 'E' for one unit. Tax expenses decrease for 'T' Baht, while cost abatement increases MAC Baht.

3. Whenever reducing 'E' and 'T' Baht is greater than MAC Baht, the model will continue decreasing 'E' until the last unit of 'E' makes value of MAC Baht > T Baht. The model will stop decreasing 'E'. At that point T = MAC then profit is maximized.

# Case 2: Uniform Tax

- 1. Uniform Tax is a single tax rate where MAC values in every activity are equal and profits maximized, where T = MAC
- 2. Uniform Tax =  $MAC_1 = MAC_2 = MAC_3 = MAC_4$ and pollutant loading must not exceed the standard.
- 3. We have to find the least uniform tax rate =  $MAC_1 = MAC_2 = MAC_3 = MAC_4$ and pollution must not exceed the standard (Callan and Thomas, 1996).



สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# **CHAPTER IV**

# MATHEMATICAL DECISION-MAKING MODEL

#### 4.1 Surface water quality control: Mathematical Decision-Making model

#### **Objective functions:**

The objective function is considered for the problem which is the maximization of system profits.

Maximize 
$$\prod_{j=1}^{N} = \prod_{pj} + \prod_{uj} + \prod_{aj} + \prod_{ij}$$
(4-5)

Where  $\prod_{j=1}^{N}$  is the system profit in sub-basin.  $\prod_{pj}$  is the system profit of an entire pig farm that already includes social costs in sub-basin 'j'. This social cost is represented by abatement costs added to a function. In the same way,  $\prod_{uj}$  is system profit of the entire urban communities in sub-basin 'j'.  $\prod_{aj}$  is the system profit of an entire aqua culture.  $\prod_{ij}$  is the system profit of an entire industry.

Subject to:

Sub basin pollution:

$$E_{j} = \sum_{k=1}^{N} E_{pjk} + \sum_{k=1}^{N} E_{ujk} + \sum_{k=1}^{N} E_{ajk} + \sum_{k=1}^{N} E_{ijk}$$
(4-6)

Where ' $E_j$ ' is the pollution concentration of the entire effluent in sub-basin 'j'.  $\sum_{i=1}^{N} E_{pik}$  is

the summation of pollution concentration of an entire pig farm effluent in sub-basin 'j'.  $\sum_{k=1}^{N} E_{ujk}$  is the summation of pollution concentration of an entire urban communities effluent in sub-basin 'j'.  $\sum_{k=1}^{N} E_{ajk}$  is the summation of pollution concentration of an entire aquaculture effluent in

sub-basin 'j'.  $\sum_{k=1}^{N} E_{ijk}$  is the summation of pollution concentration of an entire industrial effluent in sub-basin 'j'.

#### Sub-basin pollution constraint:

The most common requirement of pollution control is assuring the pollution loading throughout the river system in an attempt to satisfy and maintain the water classification standard. Specifically, pollution concentrations must be less than the standard limit. Each control point and discharge location becomes a constraint in a mathematical programming model. In a general framework, a typical water quality constraint would be as follows:

$$A_j = E_j + \gamma A_{j-1} \tag{4-7}$$

and 
$$A_j^* \ge A_j$$
 (4-8)

Sources: Modified from Handley et al., (1997).

Where ' $A_j$ ' is the total pollution concentration of an entire effluent in sub-basin 'j', ' $E_j$ ' is the pollution concentration of an entire effluent in sub-basin 'j', ' $\gamma$ ' (transfer coefficient) is the pollution concentration effective of sub-basin 'j-1' affected by pollution concentrations of sub-basin j, ' $A_{j-1}$ ' is the total pollution concentration of an entire effluent in sub-basin 'j-1', and ' $A_j^*$  ' is the required water classification standard or allowable pollution daily loading at sub-basin 'j'.

#### **Production** benefit constraint:

These constraints are defining the acceptable profit level of a production type. The capital cost, variable costs, and abatement costs exist in the production process. When the taxation system is added to the costs, this financial burden is not the cause of a business going bankrupt. At least, the minimum profit level must be more than the break-even point of production. Thus, the profit level of each industry can be formulated as

$$\pi > 0 \tag{4-9}$$

Where  $\pi$  is a benefit in this model.

#### 4.4.1 Pig farm

**Pig farm production:** 

$$\prod_{pj} = \sum_{k=1}^{N} P_p Q_{pjk} - \sum_{k=1}^{N} ABC_{pjk} - T_{pjk} \sum_{k=1}^{N} E_{pjk}$$
(4-10)

Where  $\prod_{pj}$  is the system profit of the entire pig farm production in sub-basin 'j',  $\sum_{k=1}^{N} P_p Q_{pjk}$  is the summation of pig farm production prices per unit multiplied with the quantity of pig farm production unit at farm 'k' in sub-basin 'j'.  $\sum_{k=1}^{N} ABC_{pjk}$  is the summation of abatement cost functions of pig farms at farm 'k' in sub-basin 'j'.  $T_{pjk} \sum_{k=1}^{N} E_{pjk}$  the charges system of pig farm at farm 'k' in sub-basin 'j' multiplied by the effluent pollution of pig farms at farm 'k' in sub-basin 'j'.

#### Abatement cost function:

$$ABC_{pjk} = e^a W^{bp}_{pjk} I^{cp}_{pjk} E^{dp}_{pjk}$$

$$\tag{4-11}$$

Source: Modified from Metha et al., (1997)

Where ' $ABC_{pjk}$ ' is the abatement cost function of pig farm at farm 'k' in sub-basin 'j'. 'e' = natural logarithm, ' $W_{pjk}$ ' is the quantity of treated water of pig farm at farm 'k' in sub-basin 'j'. ' $I_{pjk}$ ' is the pollution concentration in the influent treated water of pig farm at farm 'k' in sub-basin 'j'. ' $E_{pjk}$ ' is the pollution concentration in the effluent treated water of pig farm at farm 'k' in sub-basin 'j'. 'a',' bp', 'cp', and 'dp' are coefficient parameters of pig farms. Volume of wastewater per production unit:

$$F_{pjk} = \alpha_p Q_{pjk} \tag{4-12}$$

Where ' $F_{pjk}$ ' is the volume of wastewater of pig farm at farm 'k' in sub-basin 'j'. ' $\alpha_p$ ' is the ability of wastewater production per pig farm unit. ' $Q_{pjk}$ ' is the quantity of pig farm production units at farm 'k' and sub-basin 'j'.

#### Influent pollution concentration:

$$I_{pjk} = \beta_p Q_{pjk} \tag{4-13}$$

Where ' $I_{pjk}$ ' is the pollution concentration in the influent treated water of pig farm at farm 'k' in sub-basin 'j'. ' $\beta_p$ ' is the capacity of pollution released at pig farm. ' $Q_{pjk}$ ' is the quantity of pig farm production unit at farm 'k' in sub-basin 'j'.

# Pig farm pollution constraint:

$$E_{pjk} \le \bar{E}_{pj} \tag{4-14}$$

Where ' $E_{pjk}$ ' the pollution concentration in the effluent treated water of pig farm at farm 'k' in sub-basin 'j'. ' $\bar{E}_{pj}$ ' is the required water classification standard of pig farm in sub-basin 'j' or permitted pollution loading of pig farm in sub-basin 'j'.

#### 4.4.2 Urban community

#### Urban community production:

$$\prod_{uj} = \sum_{k=1}^{N} P_{u} Q_{ujk} - \sum_{k=1}^{N} ABC_{ujk} - T_{ujk} \sum_{k=1}^{N} E_{ujk}$$
(4-15)

Where  $\prod_{uj}$  is the system profit of the entire urban community production in sub-basin 'j'.  $\sum_{k=1}^{N} P_{u}Q_{ujk}$  is the summation of urban community prices per production unit multiplied by the quantity of urban community production unit at community 'k' in sub-basin 'j',  $\sum_{k=1}^{N} ABC_{ujk}$  is a summation of the abatement cost function of urban community at community 'k' and sub-basin 'j'.  $T_{ujk}\sum_{k=1}^{N} E_{ujk}$  is the charges system of urban community at community 'k' and sub-basin 'j' multiplied by the effluent pollution of urban community at community 'k' and sub-basin 'j'.

#### Abatement cost function:

$$ABC_{ujk} = e^a W^{bu}_{ujk} I^{cu}_{ujk} E^{du}_{ujk}$$

$$\tag{4-16}$$

Source: Modified from Metha et al., (1997)

Where ' $ABC_{ujk}$ ' is the abatement cost function of the urban community at community 'k' and sub-basin 'j'. 'e' = natural logarithm, ' $W_{ujk}$ ' is the quantity of treated water of urban community at community 'k' and sub-basin 'j'. ' $I_{ujk}$ ' is the pollution concentration in the influent treated water of urban community at community 'k' and sub-basin 'j'. ' $E_{ujk}$ ' is the pollution concentration in the effluent treated water of urban community 'k' and sub-basin 'j'. ' $E_{ujk}$ ' is the pollution concentration in the effluent treated water of urban community at community 'k' and sub-basin 'j'. ' $E_{ujk}$ ' is the pollution concentration in the effluent treated water of urban community at community 'k' and sub-basin 'j'. ' $E_{ujk}$ ' is the pollution concentration in the effluent treated water of urban community at community is community.

Amount of wastewater per production unit :

$$F_{ujk} = \alpha_u Q_{ujk} \tag{4-17}$$

Where ' $F_{ujk}$ ' is the amount of urban community wastewater at community 'k' in subbasin 'j'. ' $\alpha_u$ ' is the wastewater production capacity per urban community unit. ' $Q_{ujk}$ ' is the quantity of urban community production unit at community 'k' in sub-basin 'j'.

Influent pollution concentration:

$$I_{ujk} = \beta_u Q_{ujk} \tag{4-18}$$

Where ' $I_{ujk}$ ' is the pollution concentration in the influent treated water of urban community at community 'k' in sub-basin j, ' $\beta_u$ ' is the pollution release capacity of the urban community. ' $Q_{ujk}$ ' is the urban community production unit at community 'k' in sub-basin 'j'.

# Urban community pollution constraint:

$$E_{ujk} \le \bar{E}_{uj} \tag{4-19}$$

Where ' $E_{ujk}$ ' is the pollution concentration in the effluent treated water of urban community at community 'k' and sub-basin 'j'. ' $\bar{E}_{uj}$ ' is the required water classification standard of urban community in sub-basin 'j' or the permitted pollution loading of urban community at sub-basin 'j'.

#### 4.4.3 Aquaculture

Aquaculture production:

$$\prod_{aj} = \sum_{k=1}^{N} P_a Q_{ajk} - \sum_{k=1}^{N} ABC_{ajk} - T_{ajk} \sum_{k=1}^{N} E_{ajk}$$
(4-20)

Where  $\prod_{aj}$  is the system profit of the entire aquaculture production at sub-basin 'j'.  $\sum_{k=1}^{N} P_a Q_{ajk}$  is the summation of aquaculture production prices per unit multiplied by the quantity aquaculture production unit at source 'k' in sub-basin 'j'.  $\sum_{k=1}^{N} ABC_{ajk}$  is the summation of abatement cost functions of aquaculture at source 'k' in sub-basin 'j'.  $T_{ajk} \sum_{k=1}^{N} E_{ajk}$  are the charges system of aquaculture at source 'k' in sub-basin 'j' multiplied by the effluent pollution of aquaculture at source 'k' in sub-basin 'j'.

#### Abatement cost function:

$$ABC_{ajk} = e^a W^{ba}_{ajk} I^{ca}_{ajk} E^{da}_{ajk}$$
(4-21)

Source: Modified from Metha et al., (1997)

Where ' $ABC_{ajk}$ ' is the abatement cost function of aquaculture at source 'k' in sub-basin 'j'. 'e' = natural logarithm. ' $W_{ajk}$ ' is the quantity of treated water of aquaculture at source 'k' in sub-basin 'j'. ' $I_{ajk}$ ' is the pollution concentration in the influent treated water of aquaculture at source 'k' in sub-basin 'j'. ' $E_{ajk}$ ' is the pollution concentration in the effluent treated water of aquaculture at source 'k' in sub-basin 'j'. ' $E_{ajk}$ ' is the pollution concentration in the effluent treated water of aquaculture at source 'k' in sub-basin 'j'. 'a', 'ba', 'ca', and 'da' are coefficient parameters of aquaculture. Amount of wastewater per production unit :

$$F_{ajk} = \alpha_a Q_{ajk} \tag{4-22}$$

Where ' $F_{ajk}$ ' is the volume of wastewater of aquaculture at source 'k' in sub-basin j, ' $\alpha_a$ ' is the wastewater production capacity per aquaculture unit and ' $Q_{ajk}$ ' is the quantity of aquaculture production unit at source 'k' in sub-basin 'j'.

#### Influent pollution concentration:

$$I_{ajk} = \beta_a Q_{ajk} \tag{4-23}$$

Where ' $I_{ajk}$ ' is the pollution concentration in the influent treated water of aquaculture at source 'k' in sub-basin 'j'. ' $\beta_a$ ' is the pollution release capacity of aquaculture. ' $Q_{ajk}$ ' is the quantity of aquaculture production unit at source 'k' in sub-basin 'j'.

#### Aquaculture pollution constraint:

$$E_{ajk} \le \bar{E}_{aj} \tag{4-24}$$

Where ' $E_{ajk}$ ' is the pollution concentration in the effluent treated water of aquaculture at source 'k' in sub-basin 'j'. ' $\bar{E}_{aj}$ ' is the required water classification standard of aquaculture at sub-basin 'j' or permitted pollution loading of aquaculture at sub-basin 'j'.

#### 4.4.4 Industry

Industry production:

$$\prod_{ij} = \sum_{k=1}^{N} P_i Q_{ijk} - \sum_{k=1}^{N} ABC_{ijk} - T_{ijk} \sum_{k=1}^{N} E_{ijk}$$
(4-25)

Where  $\prod_{ij}$  is the system profit of the entire industry production at sub-basin 'j',  $\sum_{k=1}^{N} P_i Q_{ijk}$  is the summation of industrial production price per unit multiplied by the quantity of industrial production unit at factory 'k' and sub-basin 'j',  $\sum_{k=1}^{N} ABC_{ijk}$  is the summation of abatement cost functions of industry at factory 'k' in sub-basin 'j',  $T_{ijk} \sum_{k=1}^{N} E_{ijk}$  the charges system of industry at factory 'k' and sub-basin 'j' multiplied by the effluent pollution of industry at factory 'k' in sub-basin 'j'.

#### Abatement cost function:

$$ABC_{ijk} = e^a W^{bi}_{ijk} I^{ci}_{ijk} E^{di}_{ijk}$$
(4-26)

Source: Modified from Metha et al., (1997)

Where ' $ABC_{ijk}$ ' is the abatement cost function of industry at factory 'k' in sub-basin 'j'. 'e' = natural logarithm, ' $W_{ijk}$ ' is the quantity of treated water of industry at factory 'k' in subbasin 'j'. ' $I_{ijk}$ ' is the pollution concentration in the influent treated water of industry at factory 'k' in sub-basin 'j'. ' $E_{ijk}$ ' is the pollution concentration in the effluent treated water of industry at factory 'k' in sub-basin 'j'. 'a',' bp', 'cp', and 'dp' are coefficient parameters of industry. Amount of wastewater per production unit :

$$F_{ijk} = \alpha_i Q_{ijk} \tag{4-27}$$

Where ' $F_{ijk}$ ' is the volume of wastewater of industry at factory 'k' in sub-basin 'j'. ' $\alpha_i$ ' is wastewater production capacity per industry unit. ' $Q_{ijk}$ ' is the quantity of industry production unit at factory 'k' in sub-basin 'j'.

#### Influent pollution concentration:

$$I_{ijk} = \beta_i Q_{ijk} \tag{4-28}$$

Where  $I_{ijk}$  is the pollution concentration in the influent treated water of industry at factory 'k' in sub-basin 'j'. ' $\alpha_i$ ' is the ability of pollution release of industry. ' $Q_{ijk}$ ' is the quantity of industry production unit at factory 'k' in sub-basin 'j'.

#### Industry pollution constraint:

$$E_{ijk} \le \bar{E}_{ij} \tag{4-29}$$

Where ' $E_{ijk}$ ' is the pollution concentration in the effluent treated water of industry at factory 'k' in sub-basin j, ' $\bar{E}_{ij}$ ' is the required water classification standard of industry in sub-basin 'j' or the permitted pollution loading of industry in sub-basin 'j'.

In summary, the model can be expressed as follows:

# Regulatory objective:

Maximize 
$$\prod_{j=1}^{N} = \prod_{pj} + \prod_{uj} + \prod_{aj} + \prod_{ij}$$
 (4-30)

Subject to:

Sub-basin pollution:

$$E_{j} = \sum_{k=1}^{N} E_{pjk} + \sum_{k=1}^{N} E_{ujk} + \sum_{k=1}^{N} E_{ajk} + \sum_{k=1}^{N} E_{ijk}$$
(4-31)

Sub-basin pollution constraint:

$$A_j = E_j + \gamma A_{j-1} \tag{4-32}$$

$$A_j^* \ge A_j \tag{4-33}$$

Production benefit constraint:

$$\pi > 0 \tag{4-34}$$

Pig farm production:

$$\prod_{pj} = \sum_{k=1}^{N} P_p Q_{pjk} - \sum_{k=1}^{N} ABC_{pjk} - T_{pjk} \sum_{k=1}^{N} E_{pjk}$$
(4-35)

Pig farm abatement cost function:

$$ABC_{pjk} = e^a W^{bp}_{pjk} I^{cp}_{pjk} E^{dp}_{pjk}$$
(4-36)

Amount of wastewater per production unit :

and

$$F_{pjk} = \alpha_p Q_{pjk} \tag{4-37}$$

Pig farm influent pollution concentration:

$$I_{pjk} = \beta_p Q_{pjk} \tag{4-38}$$

*Pig farm pollution constraint:* 

$$E_{pjk} \le \bar{E}_{pj} \tag{4-39}$$

Urban community production:

$$\prod_{uj} = \sum_{k=1}^{N} P_u Q_{ujk} - \sum_{k=1}^{N} ABC_{ujk} - T_{ujk} \sum_{k=1}^{N} E_{ujk}$$
(4-40)

Urban community abatement cost function:

$$ABC_{ujk} = e^a W^{bu}_{ujk} I^{cu}_{ujk} E^{du}_{ujk}$$
(4-41)

Amount of wastewater per production unit :

$$F_{ujk} = \alpha_u Q_{ujk} \tag{4-42}$$

Urban community influent pollution concentration:

$$I_{ujk} = \beta_u Q_{ujk} \tag{4-43}$$

Urban community pollution constraint:

$$E_{ujk} \le \bar{E}_{uj} \tag{4-44}$$

Aquaculture production:

$$\prod_{aj} = \sum_{k=1}^{N} P_a Q_{ajk} - \sum_{k=1}^{N} ABC_{ajk} - T_{ajk} \sum_{k=1}^{N} E_{ajk}$$
(4-45)

Aqua culture abatement cost function:

$$ABC_{ajk} = e^a W^{ba}_{ajk} I^{ca}_{ajk} E^{da}_{ajk}$$
(4-46)

Amount of wastewater per production unit :

$$F_{ajk} = \alpha_a Q_{ajk} \tag{4-47}$$

Aquaculture influent pollution concentration:

$$I_{ajk} = \beta_a Q_{ajk} \tag{4-48}$$

Aquaculture pollution constraint:

$$E_{ajk} \le E_{aj} \tag{4-49}$$

Industry production:

$$\prod_{ij} = \sum_{k=1}^{N} P_i Q_{ijk} - \sum_{k=1}^{N} ABC_{ijk} - T_{ijk} \sum_{k=1}^{N} E_{ijk}$$
(4-50)

Industry Abatement cost function:

$$ABC_{ijk} = e^a W^{bi}_{ijk} I^{ci}_{ijk} E^{di}_{ijk}$$
(4-51)

Amount of wastewater per production unit :

$$F_{ijk} = \alpha_i Q_{ijk} \tag{4-52}$$

Industry influent pollution concentration:

$$I_{ijk} = \beta_i Q_{ijk} \tag{4-53}$$

Industry pollution constraint:

$$E_{ijk} \leq E_{ij}$$

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# **CHAPTER V**

# **RESULTS AND DISCUSSIONS**

5.1 Marginal Abatement Cost function and its properties of each source type in each sub basin area.

#### <u>5.1.1Pig farm</u>

Equation 3-1 is developed with a parameter from data collection, the results show that the estimation function as equation 5-1 and its characteristic at table 5-1.

Estimation Command:

LS(H) LOG (COST) C LOG(F) LOG(I) LOG(E) AR(1)

Estimation Equation:

LOG(COST) = C(1) + C(2)\*LOG(F) + C(3)\*LOG(I) + C(4)\*LOG(E) + [AR(1)=C(5)]

Substituted Coefficients:

LOG(COST) = -1.184940371 + 0.7196545134\*LOG(F) + 0.5233609931\*LOG(I) - 0.1365064184\*LOG(E) + [AR(1)=0.2012589663] (5-1)

Figure 5-1: Estimation Command, Estimation Equation, and Substituted Coefficients

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Dependent Variable: LOG(COST)						
Sample(ad	justed): 1065					
Variable	Coefficient	Std. Error	t-Sta	tistic		
С	-1.18494	0.07391	-16.0	3272		
LOG(F)	0.719 <mark>6</mark> 55	0.17215	4.180	0373		
LOG(I)	0.523361	0.13938	3.755	5045		
LOG(E)	-0.136506	0.02185	-6.24	6217		
AR(1)	0.201259	0.03314	6.073	3994		
R-squared	0.99442	Mean dep	endent var	8.208		
Adjusted R-squared	0.994398	S.D. depe	ndent var	1.6717		

Table 5-1: Data set for marginal abatement cost function of pig farm

Arriving in Table 5-1, using the total data collection from 1,065 samples of the volume of wastewater treatment (F), Concentration influent stream (I) and Concentration effluent stream (E) use for finding the relationship between F, I, E with Cost of Abatement (C) in the form of linear program technique.

The output found that the co-efficient of volume of wastewater treatment (F) was 0.719655 which, mean if the volume of wastewater treatment changed 1 %, the cost of abatement changed in 0.719655, and t-statistic was 4.180373 indicated that they were positive significant. The coefficient of concentration influent stream (I) was 0.523361 which, mean if the concentration in influent stream changed 1 %, the cost of abatement changed in 0.523361 and t-statistic was 3.755045 indicated that they were positive significant. The coefficient of concentration in effluent steam (E) was -0.136506 which mean if amount of concentration in effluent stream (E) was -0.136506 which mean if the concentration in effluent stream (E) was -0.136506 which mean if the concentration in effluent stream (Langed 1 unit, the cost of abatement changed in -0.136506 and t-statistic was -6.246217. The result indicated that they were negative significant. The R-squared and adjusted R-squared of pig farm were 0.994420 and 0.994398 respectively.

#### 5.1.2 Urban Community

Equation 3-1 is developed with a parameter from data collection, the results show that the estimation function as equation 5-2 and its characteristic at table 5-2.

Estimation Command:

LS(H) LOG(COST) C LOG(F) LOG(I) LOG(E) AR(1)

Estimation Equation:

LOG(COST) = C(1) + C(2)\*LOG(F) + C(3)\*LOG(I) + C(4)\*LOG(E) + [AR(1)=C(5)]

Substituted Coefficients:

```
LOG(COST) = -0.2211052255 + 0.8080639203*LOG(F) + 0.472856765*LOG(I) - 0.279286674*LOG(E) +
[AR(1)=0.9574446249] (5-2)
Figure 5-2: Estimation Command, Estimation Equation, and Substituted Coefficients
```

Sample(adjusted): 525							
Variable	Coefficient	Std. Error	t-Stat	istic			
С	-0.221105	0.35932	-0.61	5349			
LOG(F)	0.808064	0.16629	4.859	434			
LOG(I)	0.472857	0.16642	2.841	336			
LOG(E)	-0.279287	0.01359	-20.54	4528			
<b>AR</b> (1)	0.957445	0.01394	68.70	269			
R-squared	0.997401	Mean depe	endent var	9.9076			
Adjusted R-squared	0.997379	S.D. depe	ndent var	1.8224			

Table 5-2: Data set of marginal abatement cost function of urban community

Arriving in Table 5-2, using the total data collection from 525 samples of the volume of wastewater treatment (F), Concentration influent stream (I) and Concentration effluent stream (E) use for finding the relationship between F, I, E with Cost of Abatement (C) in form of linear program technique.

The output found that the co-efficient of the volume of wastewater treatment (F) was 0.808064 which, mean if volume of wastewater treatment changed 1 %, the cost of abatement changed in 0.808064, and t-statistic was 4.859434 indicated that they were positive significant.

The coefficient of concentration influent stream (I) was 0.472857 which, mean if the concentration in influent stream changed 1 %. The cost of abatement changed in 0.472857 and t-statistic was 2.841336 indicated that they were positive significant. The coefficient of concentration in effluent steam (E) was -0.279287 which mean if amount of concentration in effluent changed 1 %, the cost abatement changed in -0.279287 and t-statistic was -20.54528. The result indicated that they were negative significant. The R-squared and adjusted R-squared of urban community were 0.997401 and 0.997379 respectively.

#### 5.1.3 Aqua culture

Equation 3-1 is developed by using a parameter from data collection. The results show that the estimation function as equation 5-3 and its characteristic at table 5-3. Estimation Command:

LS(H) LOG(COST) C LOG(F) LOG(I) LOG(E) AR(1)

Estimation Equation:

LOG(COST) = C(1) + C(2)\*LOG(F) + C(3)\*LOG(I) + C(4)\*LOG(E) + [AR(1)=C(5)]

Substituted Coefficients:

LOG(COST) = 3.679472766 + 0.4665055163\*LOG(F) + 0.5449644505\*LOG(I) - 0.01146996687\*LOG(E) + [AR(1)=1.00000001] (5-3) Figure 5-3: Estimation Command, Estimation Equation, and Substituted Coefficients

Table 5-3: Data set of marginal	abatement cos	st function of A	qua culture

Dependent Variable: LOG(COST)							
Sample(adjusted): 3075							
Variable	Coefficient	Std. Error	t-Sta	tistic			
С	3.679473	0.00399	921.	2608			
LOG(F)	0.466506	1.2E-08	3768	66663			
LOG(I)	0.544964	1.5E-08	3712	6864			
LOG(E)	-0.01147	2.3E-09	-497	5406			
AR(1)	1	1E-07					
R-squared	1	Mean dep	bendent var	15.5531			
Adjusted R- squared	1	S.D. depe	endent var	1.40396			

Arriving in Table 5-3, using the total data collection from 3,075 samples of the volume of wastewater treatment (F), Concentration influent stream (I) and Concentration effluent stream (E) use for finding the relationship between F, I, E with Cost of Abatement (C) in form of linear program technique.

The output found that the co-efficient of the volume of wastewater treatment (F) was 0.466506 which, mean if volume of wastewater treatment changed 1 %, the cost of abatement changed in 0.466506, and t-statistic was 37686663 indicated that they were significant. The coefficient of concentration influent stream (I) was 0.544964 which, mean if the concentration in influent stream changed 1 %, the cost of abatement changed in 0.544964 and t-statistic was 37126864. The result indicated that they were positive significant. The coefficient of concentration in effluent steam (E) was -0.01147 which mean if amount of concentration in effluent changed 1 %. The cost abatement changed in -0.01147 and t-statistic was -4975406. The result indicated that they were significant. The R-squared and Adjusted R-squared of aquaculture were 1 and 1 respectively.

#### 5.1.4 Industry

Equation 3-1 is developed with a parameter from collection, the results show that the estimation function as equation 5-4 and its characteristic at table 5-4.

Estimation Command:

LS(H) LOG(COST) C LOG(F) LOG(I) LOG(E)

Estimation Equation:

LOG(COST) = C(1) + C(2)\*LOG(F) + C(3)\*LOG(I) + C(4)\*LOG(E)

Substituted Coefficients:

LOG(COST) = -2.706498807 + 1.3810916\*LOG(F) + 0.1691965884\*LOG(I) - 0.4072167085\*LOG(E)

(5-4)

Figure 5-4 : Estimation Command, Estimation Equation, and Substituted Coefficients

Dependent	Dependent Variable: LOG(COST)						
Sample(adjusted): 8100							
Variable	Coefficient	Std. Error	t-Sta	ntistic			
С	-2.706499	0.12081	-22.4	40325			
LOG(F)	1.381092	0.03513	39.31115				
LOG(I)	0.169197	0.02677	6.319535				
LOG(E)	-0.407217	0.0221	-18.	4225			
R-squared	0.913056	Mean dep	9.55385				
Adjusted R-squared	0.912868	S.D. dependent var 3.37141					

Table 5-4: Data set of marginal abatement cost function of industry

Arriving in Table 5-4, using the total data collection from 8,100 samples of the volume of wastewater treatment (F), Concentration influent stream (I) and Concentration effluent stream (E) use for finding the relationship between F, I, E with Cost of Abatement (C) in form of linear program technique.

The output found that the co-efficient of the volume of wastewater treatment (F) was 1.381092 which, mean if volume of wastewater treatment changed 1 %, the cost of abatement changed in 1.381092, and t-statistic was 39.31115 indicated that they were significant. The coefficient of concentration influent stream (I) was 0.169197 which, mean if the concentration in influent stream changed 1 %, the cost of abatement changed in 0.169197 and t-statistic was 6.319535 indicated that they were not significant. The coefficient of concentration in effluent stream (E) was -0.407217 which mean if amount of concentration in effluent changed 1 %, the cost abatement changed in -0.407217 and t-statistic was -18.4225. The result indicated that they were significant. The R-squared and Adjusted R-squared of industry were 0.913056 and 0.912868 respectively.

# 5.2 The effluent charge of each significant main point source and entire main point source in each sub-basin

The study found that in each district to use the effluent charge in different rate for the pollution generators are very confuses and hardly to implement. Thus, the Tax charge of every main-point source should be the same in the district.

5.2.1The effluent t charge of each significant main point sources in each sub-basin

5.2.1.1 Pig farm

To control and preserve the water quality standard of Thachin River, the effluent charge of pig farm in each sub-basin has to apply as the table below:

	Charge	BOD(Kg/year)		% reduction	Cost of abatement	Tax expense
Sub basin	(Bath/Kg- BOD)	Influent	Effluent		(Bath/year)	(Bath/year)
LI	0.15	40,870.88	20,435.44	50.00%	22,154.11	3,024.17
RF	0.91	2,084,110.76	312,616.61	85.00%	2,077,580.41	283,602.19
RFm	0.37	988,853.44	296,656.03	70.00%	811,684.66	110,799.83
LP	0.18	31,481.25	12,592.50	60.00%	17,000.76	2,320.71
RG	0.29	1,985,859.15	794,343.66	60.00%	1,693,611.34	231,188.11
LQ	2.16	73,682.55	3,684.13	95.00%	58,290.46	7,957.00
RH	3.33	3,458,866.84	172,943.34	95.00%	4,223,481.10	576,530.51
RI	0.14	823,831.46	576,682.02	30.00%	601,506.25	82,109.21
LS	0.14	685,541.18	514,155.88	25.00%	509,815.52	69,592.88
RJ	0.10	83,636.10	62,727.08	25.00%	47,912.82	6,540.39
RK	0.09	12,592.50	9,444.38	25.00%	6,239.89	851.78
RL	0.10	1,642.50	1,231.88	25.00%	858.43	117.18

Table 5-5: The effluent charge of pig farm in each sub-basin

Table of 5-5 show that sub-basin LI need to reduce 50% of pollution water. The effluent should be charged at 0.15 Baht / Kg of BOD. The effluent added with cost of abatement was 22,154.11 Baht/year.

To control and preserve the water quality standard of Thachin River, the effluent charge of urban community in each sub-basin has to apply as the table below:

	Charge	BOD(K	(g/year)	% reduction	Cost of abatement	Tax expense
Sub basin	(Bath/Kg- BOD)	Influent	Effluent		(Bath/year)	(Bath/year)
LI	3.09	138,631.98	69,315.99	50.00%	766,413.59	214,049.35
RF	14.96	434,537.87	65,180.68	85.00%	3,490,437.18	974,833.73
LJ	3.80	8,218.34	3,698.25	55.00%	50,348.14	14,061.58
LK	3.80	4,900.89	2,205.40	55.00%	29,999.05	8,378.34
LL	3.80	5,244.30	2,359.93	55.00%	32,104.63	8,966.41
RFm	6.42	146,743.26	44,022.98	70.00%	1,011,539.56	282,509.85
LP	4.43	17,969.04	7,187.61	60.00%	113,910.95	31,813.85
RG	4.43	31,648.20	12,659.28	60.00%	200,812.82	56,084.41
LQ	63.37	37,395.92	1,869.80	95.00%	424,234.83	118,483.27
RH	43.99	2,981,167.04	149,058.35	95.00%	23,477,416.59	6,556,937.25
RI	2.12	716,956.59	501,869.62	30.00%	3,813,489.90	1,065,058.15
LS	1.91	594,845.01	446,133.76	25.00%	3,057,571.42	853,939.95
RJ	1.86	196,757.15	147,567.86	25.00%	984,669.23	275,005.31
RK	1.99	133,711.88	100,283.91	25.00%	713,492.18	199,269.09
LT	1.88	55,468.22	41,601.16	25.00%	279,543.15	78,072.77
LU	1.83	588,827.67	441,620.75	25.00%	2,899,785.93	809,872.51
RL	1.89	132,415.02	99,311.27	25.00%	672,919.87	187,937.77

Table 5-6: The effluent charge of urban community in each sub-basin

Table 5-6 indicated that sub-basin LI need to reduce 50% of pollution water. The effluent should be charged at 3.09 Baht / Kg of BOD. The effluent added with cost of abatement was 766,413.59 Baht/year.

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# 5.2.1.3 Aquaculture

To control and preserve the water quality standard of Thachin River, the effluent charge of aquaculture in each sub-basin has to apply as the table below:

	Charge	BOD(K	g/year)	% reduction	Cost of abatement	Tax expense
Sub basin	(Bath/Kg- BOD)	Influent	Effluent		(Bath/year)	(Bath/year)
LI	6.11	134,192.25	67,096.13	50.00%	35,725,921.78	409,776.32
RF	20.65	526,476.00	78,971.40	85.00%	142,149,911.09	1,630,459.48
LJ	6.79	297,675.75	133,954.09	55.00%	79,342,651.37	910,060.21
LK	6.79	483,168.75	217,425.94	55.00%	128,784,053.40	1,477,153.09
LL	6.79	780,351.75	351,158.29	55.00%	207,995,366.93	2,385,706.86
LM	10.20	1,400,803.84	420,241.15	70.00%	373,723,821.49	4,286,612.23
RFm	10.11	4,541,916.28	1,362,574.88	70.00%	1,200,452,084.16	13,769,185.41
LP	7.51	180,047.66	72,019.06	60.00%	47,148,390.10	540,792.03
RG	7.51	2,284,614.84	913,845.94	60.00%	598,263,338.34	6,862,080.49
LQ	61.52	52,297.66	2,614.88	95.00%	14,025,555.28	160,873.12
RH	61.52	271,069.53	13,553.48	95.00%	72,697,343.76	833,838.53
RI	4.26	3,509,936.95	2,456,955.87	30.00%	913,252,910.54	10,475,010.88
LS	3.90	888,382.63	666,286.97	25.00%	226,778,549.04	2,601,149.96
RJ	3.96	2,206,034.91	1,654,526.18	25.00%	570,641,848.39	6,545,262.00
RK	3.90	3,667,944.31	2,750,958.23	25.00%	936,320,753.84	10,739,599.05
LT	3.90	8,896.88	6,672.66	25.00%	2,271,116.46	26,049.71
LU	3.90	1,099,060.63	824,295.47	25.00%	280,558,586.84	3,218,006.99
RL	3.90	5,721,461.69	4,291,096.27	25.00%	1,460,524,714.63	16,752,218.48

 Table 5-7: The effluent charge of aqua culture in each sub-basin

Table 5-7 indicated that sub-basin LI need to reduce 50% of pollution water. The effluent should be charged at 26.51 Baht / Kg of BOD. The effluent added with cost of abatement was 905,082.31 Baht/year.

#### 5.2.1.4 Industrial

To control and preserve the water quality standard of Thachin River, the effluent charge of industry in each sub-basin has to apply as the table below:

	Charge	BOD(K	(g/year)	% reduction	Cost of abatement Tax expen	
Sub basin	(Bath/Kg- BOD)	Influent	Effluent		(Bath/year)	(Bath/year)
LI	0.42	26,497.78	13,248.89	50.00%	13,810.31	5,623.79
RF	2.25	130,195.50	19,529.33	85.00%	107,699.72	43,857.16
LJ	10.74	1,803.10	811.40	55.00%	21,409.36	8,718.25
RFm	1.04	3,613,003.38	1,083,901.01	70.00%	2,778,086.17	1,131,283.92
LP	2.43	157,577.80	63,031.12	60.00%	375,705.61	152,993.71
RG	1.35	1,821,384.75	728,553.90	60.00%	2,411,758.62	982,109.11
LQ	24.56	11,544.07	577.20	95.00%	34,806.81	14,173.93
RH	30.02	23,111,693.56	1,155,584.68	95.00%	85,199,692.65	34,694,763.24
RI	0.11	47,383,228.62	33,168,260.03	30.00%	8,979,717.40	3,656,693.58
LS	0.73	44,065,531.29	33,049,148.47	25.00%	59,149,200.43	24,086,559.95
RJ	0.56	4,266,169.36	3,199,627.02	25.00%	4,434,068.85	1,805,628.22
RK	1.19	1,056,674.61	792,505.96	25.00%	2,324,454.20	946,557.27
LT	0.39	47,963,547.13	35,972,660.35	25.00%	34,702,684.12	14,131,522.92
LU	0.42	21,198,491.80	15,898,868.85	25.00%	16,468,108.39	6,706,093.69
RL	0.26	38,401,885.51	28,801,414.13	25.00%	18,679,146.03	7,606,465.81

Table 5-8: The effluent charge of industry in each sub-basin

Table 5-8 indicated that sub-basin LI need to reduce 50% of pollution water. The effluent should be charged at 0.63 Baht / Kg of BOD. The effluent added with cost of abatement was 48,696.58 Baht/year.

ิลถาบนวทยบรการ จุฬาลงกรณ์มหาวิทยาลัย

#### 5.3 Optimization results of Mathematical decision making model

The result of Mathematical decision-making model applied with optimization technique are shown in the table and charts below. The explanation from the table is if we want to reduce the emission (I) lower than effluent standard (reduction %) and satisfy to all constraint in model. The result from optimizing model is shown that the tax charge should be charge at rate (Baht / Unit) which lead to reduce all activities production emission (referred the Economic theory from figure 3-11). The table below show the suitable of paying tax charge and the abatement cost for all the activities however, each activity still have profit remain which is shown in the figure II. For instance, in sub-basin LI to control pollution, the production in every activities should be reduced to 50% or not excess than 170,033.80 Kg-BOD/year for whole sub-basin.

Tax charge should be applied in every activities such as pig farm, urban community, aquaculture and factory, at 0.15, 3.09, 6.11 and 0.42 Baht/Kg BOD respectively. The total expenses of all activities are the addition of Tax charge and abatement cost which are 25,167.75, 980,599.96, 36,135,879.06, and 19,374.84 Baht, respectively. From the result, the net profit of all activities in sub-basin LI are 1,733,484.25, 6,166,497.70, 99,900,748.44, and 280,376,341.99 Baht respectively which shown in the figure below. From the result of scenario 1, we have studied the pollution generating source in each sub-basin have a different tax charge. The scenario 2 show the result of applying uniform tax in each sub-basin which affect to the emission and its profit of each pollution generating sources.

#### The method of reducing BOD peak in each sub basin of Thachin River.

BOD emission reduction in 18 sub-basin cause the critical of water quality in middle and lower part of Thachin River Basin. By controlling the volume of effluent discharge and BOD without effect the surface water quality of Thachin River. The volume of effluent discharge is a TMDL of 7 parts in Thachin River. The information effluent discharge in sub basin is shown in table below.

Sub basin has BOD higher than TMDL	Sub basin has high B	OD effluent emission	BOD, TMDL has target control. (% Effluen discharge, at present)	
	Left Bank	Right Bank	Left Bank	Right Bank
Km. 190-200	LI	RF	50%	15%
Km. 160-180	LJ, LK, LL	- Andre -	45%	-
Km. 140-150	LM	RFm	30%	30%
Km. 110-120	LP	RG	100%	40%
Km. 90-100	LQ	RH	100%	5%
Km. 70-80	-	RI	-	70%
Km. 50	LS, LT, LU	RJ, RK, RL	75%	75%

Table 5-9: The main sources effluent discharge in 18 sub-basin

Sources : PCD (2005a)

### 5.3.1 The method of reducing BOD peak in sub basin from Km190 to Km200 (Peak1)

Peak 1 at Km 190-200 are included Sub-basin LI and RF. In this sub basin, at present, during the dry season with rain has BOD peak which are equal to 1,222 and 9,581 kg/day respectively. Sub basin LI, the main effluent discharge has the highest ratio of BOD discharge are communities and aquatic animal farms which have a percentage of 27% and 26% respectively. Sub basin RF, the main effluent discharge has the highest ratio of BOD discharge at 14.1%, 13% and 11.2% respectively.

### • <u>Sub-basin LI</u>

This sub-basin is located at KM no.180-200 from river mouth. BOD value is shown at 8.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 1,200 Kg-BOD/day. Urban community and aquaculture pollution sources about 42 and 44 percentage of pollution, respectively. Allowable BOD discharging load at this sub-basin is about 50 percent and target of emission reduction is 50 percent.

The table below shown that in this sub-basin, each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the non uniform tax of pig farm should be 0.15 Baht/Kg-BOD. The effluent charge of urban community should be 3.09 Baht/Kg-BOD. The effluent charge of aqua culture should be 6.11 Baht/Kg-BOD and the effluent charge of industry should be 0.42 Bath/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin Regardless of main-point sources in this sub-basin. For instance, in this sub-basin, the effluent charge is 3.80 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin
					Approve
Tax rate(Baht/Kg-BOD)	0.15	3.09	6.11	0.42	
Influent (Kg-BOD/yr)	40,745.60	138,631.98	134,192.25	26,497.78	340,067.61
Effluent (Kg-BOD/yr)	20,152.66	69,281.29	67,066.83	13,248.89	169,749.67
Effluent Std.(Kg-BOD/yr)	20,372.80	69,315.99	67,096.13	13,248.89	170,033.80
%Reduction (Gov.)	50.00 <mark>%</mark>	50.00%	50.00%	50.00%	50.00%
%Reduction (Active)	50.54%	50.03%	50.02%	50.00%	50.08%
Revenue (Baht/yr)	1,758,652.00	7,147,097.66	136,036,627.50	280,395,716.84	425,338,093.99
Cost of abatement(Baht/yr)	22,144.85	766,520.77	35,726,100.76	13,810.31	36,528,576.68
Tax expense(Baht/yr)	3,022.90	214,079.19	409,778.31	5,564.53	632,444.93
Total expense(Baht/yr)	25,167.75	980,599.96	36,135,879.06	19,374.84	37,161,021.62
Net profit(Baht/yr)	1,733,484.25	6,166,497.70	99,900,748.44	280,376,341.99	388,177,072.38
Total expense/ Revenue	1.43%	13.72%	26.56%	0.01%	8.74%

Table 5-10: Non-uniform tax of each main point source at sub-basin LI

From the table above in Sub-basin LI shown that after applying tax charge for each activities which are not the same rate. Thus, the emission reduce to 50% which meet the standard limits and abatement cost is lower than the profit in pig farm, Urban community and Industry except the Aqua culture. This means the aqua culture have to pay high tax rate which can effort to run the business in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin
					Approve
Tax rate(Baht/Kg-BOD)	3.90	3.90	3.90	3.90	3.90
Influent (Kg-BOD/yr)	40,745.60	138,631.98	134,192.25	26,497.78	340,067.61
Effluent (Kg-BOD/yr)	1,146.34	57,754.09	104,537.75	2,739.66	166,177.83
Effluent Std.(Kg-BOD/yr)	20,372.80	69,315.99	67,096.13	13,248.89	170,033.80
%Reduction (Gov.)	50.00%	50.00%	50.00%	50.00%	50.00%
%Reduction (Active)	97.19%	58.34%	22.10%	89.66%	51.13%
Revenue (Baht/yr)	1,758,652.00	7,147,097.66	136,036,627.50	280,395,716.84	425,338,093.99
Cost of abatement(Baht/yr)	32,751.07	806,486.10	35,544,679.26	26,238.36	36,410,154.80
Tax expense(Baht/yr)	4,470.71	225,240.93	407,697.22	10,684.66	648,093.52
Total expense(Baht/yr)	37,221.78	1,031,727.04	35,952,376.48	36,923.02	37,058,248.32
Net profit(Baht/yr)	1,721,430.22	6,115,370.62	100,084,251.02	280,358,793.82	388,279,845.67
Total expense/ Revenue	2.12%	14.44%	26.43%	0.01%	8.71%

Table 5-11: Uniform Tax of entire main point source at sub-basin LI

From the table above in Sub-basin LI shown that after applying uniform tax charge for each activities. Thus, the emission reduce to 50% which meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LI		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)	
Tax rate	(Baht/KgBOD)		3.90		
Influent	(Kg-BOD/yr)	340,067.61	340,067.61		
Effluent	(Kg-BOD/yr)	169,749.67	166,177.83	-3,571.85	
Effluent Std.	(Kg-BOD/yr)	170,033.80	170,033.80		
%Reduction	(Government)	50.00%	50.00%		
%Reduction	(Active)	50.08%	51.13%	0.01	
Revenue	(Baht/yr)	425,338,093.99	425,338,093.99		
Cost of abatement	(Baht/yr)	36,528,576.68	36,410,154.80	-118,421.88	
Tax expense	(Baht/yr)	632,444.93	648,093.52	15,648.59	
Total expense	(Baht/yr)	37,161,021.62	37,058,248.32	-102,773.29	
Net profit	(Baht/yr)	388,177,072.38	388,279,845.67	102,773.29	
Totalexpense/Revenu	e	8.74%	8.71%	-0.02%	

Table 5-12: Comparable between Non-uniform tax and Uniform tax in sub-basin LI

The main point sources in sub basin LI are Pig farm, Urban community, Aqua culture and industry.

There are 3 pig farms situated in sub basin LI, comprise of 2 middle size pig farms and 1 small size pig farm. The effluent discharge of BOD is 180 kg/day (The volume of effluent emission of pig farm is 10-20 liters/unit-day and BOD value is in between 1,500 - 3,000 mg/liter).

Urban community in sub basin LI are Phoa-Phaya District and Muang Subanburi District which have a population 3,252 and 27,887 people respectively. Urban community in LI sub basin generate BOD wastewater in the volume of 380 kg/day and none of them has been passed through the wastewater treatment system.

Aqua culture in sub-basin LI there are aqua culture cover an area approximately of 1,533 Rai. The effluent discharge of BOD is 386 kg/day or average of 0.24 kg/Rai-day (especially fish feeding with vegetable farm has the ratio of wastewater discharge approximately of 11.4 cu.m/Rai-day. The average of BOD pollutant loading is 20 mg/liter. King fresh water shrimp farm has the ratio of wastewater discharge approximately of 25.6 cu.m/Rai-day.)

Industry in sub-basin LI, there are 22 industries which generate the BOD pollutant loading approximately of 20.4 kg/day. 59% of all BOD pollutant loading come from the meat ball manufacturing. 22% and 18% of all BOD pollutant loading come from the ice cream plants and meat ball plant, respectively. The cause of these 3 type of manufactures has released high BOD pollutant loading. Due to the BOD effluent at end-of-pipe of are higher than the standard.

The method of reducing BOD peak in sub basin LI, at present, all pollutant generators which located in this sub-basin has released the wastewater. The wastewater contained total BOD pollutant loading approximately of 1,400 kg/day. After flowing and decomposing along the cannel before meet the Thachin river, the remaining BOD pollutant loading has an average of 1,222 kg/day. While Thachin river has a ability of carrying capacity at 50% of the currently situation has occurred. Hence, the target emission in this sub-basin has been set at least 50% of the capability of carrying capacity nowadays which means that BOD pollutant loading in effluent discharge might not higher than 700 kg/day.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LI are using Uniform tax has less cost of abatement about 118,421.88 Baht, more tax expense about 15,648.59 Baht, less total expense about 102,773.29, and gain more net profit about 102,773.29 Baht.

### • <u>Sub-basin RF</u>

This sub-basin is located at KM no.180-200 from river mouth. BOD value is shown at 8.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 9,600 Kg-BOD/day. Pig farm pollution sources about 56 percentage of the total pollution. Allowable BOD discharging load at this sub-basin is about 15 percent and target of emission reduction is 85 percent.

The table below shown that in this sub-basin, each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of pig farm should be 0.91 Baht/Kg-BOD. The effluent charge of urban community should be 14.96 Baht/Kg-BOD. The effluent charge of aqua culture should be 20.65 Baht/Kg-BOD and the effluent charge of industry should be 2.25 Bath/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 5.92 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.91	14.96	20.65	2.25	
Influent (Kg-BOD/yr)	2,084,110.76	434,537.87	526,476.00	130,195.50	3,175,320.13
Effluent (Kg-BOD/yr)	311,767.19	65,166.59	78,957.02	19,502.87	475,393.67
Effluent Std.(Kg-BOD/yr)	312,616.61	65,180.68	78,971.40	19,529.33	476,298.02
%Reduction (Gov.)	85.00%	85.00%	85.00%	85.00%	85.00%
%Reduction (Active)	85.04%	85.00%	85.00%	85.02%	85.03%
Revenue (Baht/yr)	17,527,820.00	17,594,497.74	1,018,692,885.00	195,685,864.92	1,249,501,067.66
Cost of abatement(Baht/yr)	2,078,352.19	3,490,648.00	142,150,208.02	107,759.18	147,826,967.39
Tax expense(Baht/yr)	283,708.14	974,892.14	1,630,462.46	43,881.46	2,932,944.20
Total expense(Baht/yr)	2,362,060.33	4,465,540.14	143,780,670.47	151,640.64	150,759,911.59
Net profit(Baht/yr)	15,165,759.67	13,128,957.60	874,912,214.53	195,534,224.28	1,098,741,156.07
Total expense/ Revenue	13.48%	25.38%	14.11%	0.08%	12.07%

Table 5-13: Non-uniform tax of each main point source at sub-basin RF

From the table above in Sub-basin RF shown that after applying non uniform tax charge for each activities. Thus, the emission reduce to 50% which meet the standard limits and abatement cost is lower than the profit in every activities.

Table 5-14: Uniform Tax of entire main point source at sub-basin RF

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	5.92	5.92	5.92	5.92	
Influent (Kg-BOD/yr)	2,084,110.76	434,537.87	526,476.00	130,195.50	3,175,320.13
Effluent (Kg-BOD/yr)	60,011.22	134,505.24	271,541.37	9,807.04	475,864.86
Effluent Std.(Kg-BOD/yr)	312,616.61	65,180.68	78,971.40	19,529.33	476,298.02
%Reduction (Gov.)	85.00%	85.00%	85.00%	85.00%	85.00%
%Reduction (Active)	97.12%	69.05%	48.42%	92.47%	85.01%
Revenue (Baht/yr)	17,527,820.00	17,594,497.74	1,018,692,885.00	195,685,864.92	1,249,501,067.66
Cost of abatement(Baht/yr)	2,602,570.85	2,851,086.96	140,150,442.25	142,571.66	145,746,671.73
Tax expense(Baht/yr)	355,266.40	796,271.02	1,607,524.88	58,057.69	2,817,119.99
Total expense(Baht/yr)	2,957,837.25	3,647,357.98	141,757,967.13	200,629.35	148,563,791.71
Net profit(Baht/yr)	14,569,982.75	13,947,139.76	876,934,917.87	195,485,235.57	1,100,937,275.94
Total expense/ Revenue	16.88%	20.73%	13.92%	0.10%	11.89%

From the table above in Sub-basin RF shown that after applying uniform tax charge for each activities. Thus, the emission must reduce below 85% which meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RF	ล การ เร	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		5.92	
Influent	(Kg-BOD/yr)	3,175,320.13	3,175,320.13	
Effluent	(Kg-BOD/yr)	475,393.67	475,864.86	471.19
Effluent Std.	(Kg-BOD/yr)	476,298.02	476,298.02	
%Reduction	(Government)	85.00%	85.00%	
%Reduction	(Active)	85.03%	85.01%	0.00
Revenue	(Baht/yr)	1,249,501,067.66	1,249,501,067.66	
Cost of abatement	(Baht/yr)	147,826,967.39	145,746,671.73	-2,080,295.66
Tax expense	(Baht/yr)	2,932,944.20	2,817,119.99	-115,824.22
Total expense	(Baht/yr)	150,759,911.59	148,563,791.71	-2,196,119.87
Net profit	(Baht/yr)	1,098,741,156.07	1,100,937,275.94	2,196,119.87
Totalexpense/Revenue		12.07%	11.89%	-0.18%

Table 5-15: Comparable between Non-uniform tax and Uniform tax in sub-basin RF

The method of reducing BOD peak in sub basin RF, at present, all pollutant generators which located in this sub-basin has released the wastewater. The wastewater contained total BOD pollutant loading approximately of 11,183 kg/day. After flowing and decomposing along the cannel before meet the Thachin river, the remaining BOD pollutant loading has an average of 1,222 kg/day. While Thachin river has a ability of carrying capacity at 15% of the currently situation has occurred. Hence, the target emission in this sub-basin has been set at least 85% of the capability of carrying capacity nowadays which means that BOD pollutant loading in effluent discharge might not higher than 1,670 kg/day.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LI. Uniform tax has less cost of abatement about 2,080,295.66 Baht, less tax expense about 115,824.22 Baht, less total expense about 2,196,119.87, and gain more net profit about 2,196,119.87 Baht.

### 5.3.2 The method of reducing BOD peak in sub basin from Km160 to Km180 (Peak2)

At sub-basin Km 160-180 are included in Sub-basin LJ, LK and LL. In this sub basin, at present, during the dry season has BOD peak at 4,324 kg/day. Sub-basin LL is the main effluent discharge which has the highest BOD discharge ratio at 50 %. Sub-basin LK and LK has the BOD discharge ratio at 30.9 % and 19.4 % respectively. In this peak 2, aqua culture as a major pollutant generator has BOD pollutant loading ratio at 98.9 %. Urban community has BOD discharge ratio at 1.1%. Industry has only one factory located which generate the small volume.

The effluent pollutant loading in cannel before meet the Thachin river has BOD pollutant loading at 3,640 kg/day. The target emission in this peak is 45% of 3 sub-basin or has the volume of BOD pollutant loading not more than 1,946 kg/day.

## • <u>Sub-basin LJ</u>

This sub-basin is located at KM no.160-180 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 700 Kg-BOD/day. Aquaculture pollution sources about 97 percentage of the total pollution.

Allowable BOD discharging load at this sub-basin is about 45 percent, target of emission reduction is 55 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of urban community should be 3.81 Baht/Kg-BOD. The effluent charge of aqua culture should be 6.80 Baht/Kg-BOD and the effluent charge of industry should be 10.74 Bath/Kg-BOD.

The alternative effluent charge is to set a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 6.75 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	3.81	6.80	10.74	
Influent (Kg-BOD/yr)	8,218.34	297,675.75	1,803.10	307,697.19
Effluent (Kg-BOD/yr)	3,692.35	133,833.72	811.40	138,337.46
Effluent Std.(Kg-BOD/yr)	3,698.25	133,954.09	811.40	138,463.74
%Reduction (Gov.)	55.00%	55.00%	55.00%	55.00%
%Reduction (Active)	55.07%	55.04%	55.00%	55.04%
Revenue (Baht/yr)	397,532.78	301,767,092.50	39,866,071.18	342,030,696.46
Cost of abatement(Baht/yr)	50,370.59	79,343,469.53	21,409.36	79,415,249.48
Tax expense(Baht/yr)	14,067.87	910,069.27	8,714.38	932,851.52
Total expense(Baht/yr)	64,438.46	80,253,538.79	30,123.74	80,348,100.99
Net profit(Baht/yr)	333,094.32	221,513,553.71	39,835,947.44	261,682,595.47
Total expense/ Revenue	16.21%	26.59%	0.08%	23.49%

Table 5-16: Non-uniform tax of each main point source at sub-basin LJ

From the table above in Sub-basin LJ shown that after applying tax charge for each activities which are not equal. Thus, the emission reduce to 55% which meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Urban community	Aqua culture	Industry	Sub-basin
				Approve
Tax rate(Baht/Kg-BOD)	6.75	6.75	6.75	
Influent (Kg-BOD/yr)	8,218.34	297,675.75	1,803.10	307,697.19
Effluent (Kg-BOD/yr)	2,361.29	134,813.78	1,129.02	138,304.08
Effluent Std.(Kg-BOD/yr)	3,698.25	133,954.09	811.40	138,463.74
%Reduction (Gov.)	55.00%	55.00%	55.00%	55.00%
%Reduction (Active)	71.27%	54.71%	37.38%	55.05%
Revenue (Baht/yr)	397,532.78	301,767,092.50	39,866,071.18	342,030,696.46
Cost of abatement(Baht/yr)	57,069.20	79,336,829.68	18,714.59	79,412,613.48
Tax expense(Baht/yr)	15,938.70	909,992.98	7,620.89	933,552.57
Total expense(Baht/yr)	73,007.90	80,246,822.66	26,335.48	80,346,166.05
Net profit(Baht/yr)	324,524.88	221,520,269.84	39,839,735.70	261,684,530.41
Total expense/ Revenue	18.37%	26.59%	0.07%	23.49%

Table 5-17: Uniform Tax of entire main point source at sub-basin LJ

From the table above in Sub-basin LJ shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LJ	A	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)	12 Martin	6.75	
Influent	(Kg-BOD/yr)	307,697.19	307,697.19	
Effluent	(Kg-BOD/yr)	138,337.46	138,304.08	-33.38
Effluent Std.	(Kg-BOD/yr)	138,463.74	138,463.74	
%Reduction	(Government)	55.00%	55.00%	
%Reduction	(Active)	55.04%	55.05%	0.00
Revenue	(Baht/yr)	342,030,696.46	342,030,696.46	
Cost of abatement	(Baht/yr)	79,415,249.48	79,412,613.48	-2,636.00
Tax expense	(Baht/yr)	932,851.52	933,552.57	701.05
Total expense	(Baht/yr)	80,348,100.99	80,346,166.05	-1,934.95
Net profit	(Baht/yr)	261,682,595.47	261,684,530.41	1,934.95
Totalexpense/Revenue		23.49%	23.49%	0.00%

Table 5-18: Comparable between Non-uniform tax and Uniform tax in sub-basin LJ

The method of reducing BOD peak in sub basin LJ can be divided into 2 choice. First is reducing 45 % equally in every main point sources. Second is reducing in each main point sources in different ratio according to the effluent ratio. According to aqua culture is the major main point source in this LJ, LL and LK sub-basin, thus the effluent pollutant loading of aqua culture is the main target for reducing BOD pollutant loading.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LJ. Uniform tax has less cost of abatement about 2,636.00 Baht, higher tax expense about 701.05 Baht, less total expense about 1,934.95, and gain more net profit about 1,934.95 Baht.

### • <u>Sub-basin LK</u>

This sub-basin is located at KM no.160-180 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 7,100 Kg-BOD/day. Aquaculture pollution source about 99 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 45 percent, target of emission reduction is 55 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of urban community should be 3.80 Baht/Kg-BOD. The effluent of aqua culture should be 6.80 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 6.77 Baht/Kg-BOD to all main-point sources in this sub-basin.

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Urban community	Aqua culture	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	3.80	6.80	
Influent (Kg-BOD/yr)	4,900.89	483,168.75	488,069.64
Effluent (Kg-BOD/yr)	2,204.95	217,230.63	219,435.58
Effluent Std.(Kg-BOD/yr)	2,205.40	217,425.94	219,631.34
%Reduction (Gov.)	55.00%	55.00%	55.00%
%Reduction (Active)	55.01%	55.04%	55.04%
Revenue (Baht/yr)	428,977.34	489,809,562.50	490,238,539.84
Cost of abatement(Baht/yr)	30,000.75	128,785,380.92	128,815,381.66
Tax expense(Baht/yr)	8,378.82	1,477,168.26	1,485,547.08
Total expense(Baht/yr)	38,379.57	130,262,549.17	130,300,928.75
Net profit(Baht/yr)	390,597.77	359,547,013.33	359,937,611.10
Total expense/ Revenue	8.95%	26.59%	26.58%

Table 5-19: Non-uniform tax of each main point source at sub-basin LK

From the table above in Sub-basin LK known that after applying non uniform tax for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

 Table 5-20: Uniform Tax of entire main point source at sub-basin LK

Item	Urban community	Aqua culture	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	6.77	6.77	
Influent (Kg-BOD/yr)	4,900.89	483,168.75	488,069.64
Effluent (Kg-BOD/yr)	1,403.94	218,182.21	219,586.15
Effluent Std.(Kg-BOD/yr)	2,205.40	217,425.94	219,631.34
%Reduction (Gov.)	55.00%	55.00%	55.00%
%Reduction (Active)	71.35%	54.84%	55.01%
Revenue (Baht/yr)	428,977.34	489,809,562.50	490,238,539.84
Cost of abatement(Baht/yr)	34,031.93	128,778,924.44	128,812,956.37
Tax expense(Baht/yr)	9,504.67	1,477,093.56	1,486,598.23
Total expense(Baht/yr)	43,536.60	130,256,018.00	130,299,554.60
Net profit(Baht/yr)	385,440.74	359,553,544.50	359,938,985.24
Total expense/ Revenue	10.15%	26.59%	26.58%

From the table above in Sub-basin LK shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LK		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		6.77	
Influent	(Kg-BOD/yr)	488,069.64	488,069.64	
Effluent	(Kg-BOD/yr)	219,435.58	219,586.15	150.57
Effluent Std.	(Kg-BOD/yr)	219,631.34	219,631.34	
%Reduction	(Government)	55.00%	55.00%	
%Reduction	(Active)	55.04%	55.01%	0.00
Revenue	(Baht/yr)	490,238,539.84	490,238,539.84	
Cost of abatement	(Baht/yr)	128,815,381.66	128,812,956.37	-2,425.29
Tax expense	(Baht/yr)	1,485,547.08	1,486,598.23	1,051.15
Total expense	(Baht/yr)	130,300,928.75	130,299,554.60	-1,374.14
Net profit	(Baht/yr)	359,937,611.10	359,938,985.24	1,374.14
Totalexpense/Revenue		26.58%	26.58%	0.00%

Table 5-21: Comparable between Non-uniform tax and Uniform tax in sub-basin LK

The method of reducing BOD peak in sub basin LK can be divided into 2 choice. First is reducing 45 % equally in every main point sources. Second is reducing in each main point sources in different ratio according to the effluent ratio. According to aqua culture is the major main point source in this LJ, LL and LK sub-basin, thus the effluent pollutant loading of aqua culture is the main target for reducing BOD pollutant loading.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LK. Uniform tax has less cost of abatement about 2,425.29 Baht, higher tax expense about 1,051.15Baht, less total expense about 1,374.14 Baht, and gain more net profit about 1,374.14 Baht.

### • Sub-basin LL

This sub-basin is located at KM no.160-180 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 1,800 Kg-BOD/day. Aquaculture pollution sources about 99 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 45 percent, target of emission reduction is 55 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of urban community should be 3.80 Baht/Kg-BOD and the effluent of aqua culture should be 6.80 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 6.78 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Urban community Aqua culture		<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	3.80	6.80	
Influent (Kg-BOD/yr)	5,244.30	780,351.75	785,596.05
Effluent (Kg-BOD/yr)	2,359.66	350,842.77	353,202.43
Effluent Std.(Kg-BOD/yr)	2,359.93	351,158.29	353,518.22
%Reduction (Gov.)	55.00%	55.00%	55.00%
%Reduction (Active)	55.01%	55.04%	55.04%
Revenue (Baht/yr)	1,340,137.55	791,077,132.50	792,417,270.05
Cost of abatement(Baht/yr)	32,105.65	207,997,511.48	208,029,617.13
Tax expense(Baht/yr)	8,966.72	2,385,730.83	2,394,697.55
Total expense(Baht/yr)	41,072.37	210,383,242.31	210,424,314.68
Net profit(Baht/yr)	1,299,065.18	580,693,890.19	581,992,955.37
Total expense/ Revenue	3.06%	26.59%	26.55%

 Table 5-22: Non-uniform tax
 of each main point source at sub-basin LL

From the table above in Sub-basin LL known that after applying tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

## สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Urban community	Aqua culture	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	6.78	6.78	
Influent (Kg-BOD/yr)	5,244.30	780,351.75	785,596.05
Effluent (Kg-BOD/yr)	1,500.71	351,865.87	353,366.59
Effluent Std.(Kg-BOD/yr)	2,359.93	351,158.29	353,518.22
%Reduction (Gov.)	55.00%	55.00%	55.00%
%Reduction (Active)	71.38%	54.91%	55.02%
Revenue (Baht/yr)	1,340,137.55	791,077,132.50	792,417,270.05
Cost of abatement(Baht/yr)	36,431.42	207,990,564.60	208,026,996.02
Tax expense(Baht/yr)	10,174.83	2,385,650.63	2,395,825.45
Total expense(Baht/yr)	46,606.25	210,376,215.23	210,422,821.48
Net profit(Baht/yr)	1,293,531.30	580,700,917.27	581,994,448.57
Total expense/ Revenue	3.48%	26.59%	26.55%

 Table 5-23: Uniform Tax
 of entire main point source at sub-basin LL

From the table above in Sub-basin LL shown that after applying uniform tax for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LL		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		6.78	
Influent	(Kg-BOD/yr)	785,596.05	785,596.05	
Effluent	(Kg-BOD/yr)	353,202.43	353,366.59	164.15
Effluent Std.	(Kg-BOD/yr)	353,518.22	353,518.22	
%Reduction	(Government)	55.00%	55.00%	
%Reduction	(Active)	55.04%	55.02%	0.00
Revenue	(Baht/yr)	792,417,270.05	792,417,270.05	
Cost of abatement	(Baht/yr)	208,029,617.13	208,026,996.02	-2,621.10
Tax expense	(Baht/yr)	2,394,697.55	2,395,825.45	1,127.90
Total expense	(Baht/yr)	210,424,314.68	210,422,821.48	-1,493.20
Net profit	(Baht/yr)	581,992,955.37	581,994,448.57	1,493.20
Totalexpense/Revenue	ue	26.55%	26.55%	0.00%

Table 5-24: Comparable between Non-uniform tax and Uniform tax in sub-basin LL

The method of reducing BOD peak in sub basin LL can be divided into 2 choice. First is reducing 45 % equally in every main point sources. Second is reducing in each main point sources in different ratio according to the effluent ratio. According to aqua culture is the major main point source in this LJ, LL and LK sub-basin, thus the effluent pollutant loading of aqua culture is the main target for reducing BOD pollutant loading.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LL. Uniform tax has less cost of abatement about 2,621.10 Baht, higher tax expense about 1,127.90 Baht, less total expense about 1,493.20 Baht, and gain more net profit about 1,493.20 Baht.

### 5.3.3 The method of reducing BOD peak in sub basin from Km140 to Km150 (Peak3)

At sub-basin Km 140-150 are included in Sub-basin LM and RFm. In this sub basin, at present, during the dry season has BOD peak at 19,109 kg/day. Sub-basin RFm is the main effluent emission which has the highest BOD discharge ratio at 79 %.

The main point source in this Peak 3 are Aquatic animal farm and pig farm which has BOD pollutant loading in the ratio at 82% and 14.2 % respectively. The target emission in this peak is 30% or has the volume of BOD pollutant loading not more than 5,732 kg/day.

### • Sub-basin RFm

This sub-basin is located at KM no.140-160 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 12,000 Kg-BOD/day. Aquaculture and pig farm pollution sources about 81 and 14 percentage of pollution, respectively. Allowable BOD discharging load at this sub-basin is about 30 percent, target of emission reduction is 70 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.38 Baht/Kg-BOD, the effluent charge of urban community should be 6.42 Baht/Kg-BOD and the effluent of aqua culture should be 10.11 Baht/Kg-BOD and the effluent charge of industry should be 1.05 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 5.73 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.38	6.42	10.11	1.05	
Influent (Kg-BOD/yr)	988,869.60	146,743.26	4,541,916.28	3,613,003.38	9,290,532.52
Effluent (Kg-BOD/yr)	292,070.65	44,008.68	1,361,943.80	1,079,286.00	2,777,309.13
Effluent Std.(Kg-BOD/yr)	296,660.88	44,022.98	1,362,574.88	1,083,901.01	2,787,159.76
%Reduction (Gov.)	70.00%	70.00%	70.00%	70.00%	70.00%
%Reduction (Active)	70.46%	70.01%	70.01%	70.13%	70.11%
Revenue (Baht/yr)	42,681,357.00	11,173,465.48	7,688,317,305.00	5,798,532,010.43	13,540,704,137.91
Cost of abatement(Baht/yr)	813,051.11	1,011,631.32	1,200,458,462.98	2,782,917.41	1,205,066,062.82
Tax expense(Baht/yr)	110,986.85	282,535.73	13,769,251.77	1,133,250.30	15,296,024.65
Total expense(Baht/yr)	924,037.95	1,294,167.06	1,214,227,714.75	3,916,167.71	1,220,362,087.47
Net profit(Baht/yr)	41,757,319.05	9,879,298.42	6,474,089,590.25	5,794,615,842.72	12,320,342,050.44
Total expense/ Revenue	2.16%	11.58%	15.79%	0.07%	9.01%

Table 5-25: Non-uniform tax of each main point source at sub-basin RFm

From the Figure above in Sub-basin RFm known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to 70% which meet the standard limits and abatement cost is lower than the profit in every activities.

 Table 5-26: Uniform Tax of entire main point source at sub-basin RFm

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	5.73	5.73	5.73	5.73	
Influent (Kg-BOD/yr)	988,869.60	146,743.26	4,541,916.28	3,613,003.38	9,290,532.52
Effluent (Kg-BOD/yr)	26,831.71	48,099.20	2,387,587.86	323,171.18	2,785,689.95
Effluent Std.(Kg-BOD/yr)	296,660.88	44,022.98	1,362,574.88	1,083,901.01	2,787,159.76
%Reduction (Gov.)	70.00%	70.00%	70.00%	70.00%	70.00%
%Reduction (Active)	97.29%	67.22%	47.43%	91.06%	70.02%
Revenue (Baht/yr)	42,681,357.00	11,173,465.48	7,688,317,305.00	5,798,532,010.43	13,540,704,137.91
Cost of abatement(Baht/yr)	1,126,296.33	986,829.07	1,192,753,637.32	4,547,382.19	1,199,414,144.90
Tax expense(Baht/yr)	153,745.70	275,608.41	13,680,878.44	1,851,770.86	15,962,003.41
Total expense(Baht/yr)	1,280,042.02	1,262,437.48	1,206,434,515.76	6,399,153.05	1,215,376,148.31
Net profit(Baht/yr)	41,401,314.98	9,911,028.00	6,481,882,789.24	5,792,132,857.38	12,325,327,989.60
Total expense/ Revenue	3.00%	11.30%	15.69%	0.11%	8.98%

From the table above in Sub-basin RFm shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RFm		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		5.73	
Influent	(Kg-BOD/yr)	9,290,532.52	9,290,532.52	
Effluent	(Kg-BOD/yr)	2,777,309.13	2,785,689.95	8,380.82
Effluent Std.	(Kg-BOD/yr)	2,787,159.76	2,787,159.76	
%Reduction	(Government)	70.00%	70.00%	
%Reduction	(Active)	70.11%	70.02%	0.00
Revenue	(Baht/yr)	13,540,704,137.91	13,540,704,137.91	
Cost of abatement	(Baht/yr)	1,205,066,062.82	1,199,414,144.90	-5,651,917.92
Tax expense	(Baht/yr)	15,296,024.65	15,962,003.41	665,978.76
Total expense	(Baht/yr)	1,220,362,087.47	1,215,376,148.31	-4,985,939.16
Net profit	(Baht/yr)	12,320,342,050.44	12,325,327,989.60	4,985,939.16
Totalexpense/Revenue		9.01%	8.98%	-0.04%

Table 5-27: Comparable between Non-uniform tax and Uniform tax in sub-basin RFm

The method of reducing BOD peak in sub basin RFm can be divided into 2 choices. First is reducing 30 % equally in every main point sources. Second is reducing in each main point sources in different ratio according to the effluent ratio.

The result of comparing Non-uniform tax and Uniform tax in sub-basin RFm. Uniform tax has less cost of abatement about 5,651,917.92 Baht, higher tax expense about 665,978.76 Baht, less total expense about 4,985,939.16 Baht, and gain more net profit about 4,985,939.16 Baht.

### • <u>Sub-basin LM</u>

This sub-basin is located at KM no.140-160 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 3,000 Kg-BOD/day. Aquaculture pollution sources about 99 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 30 percent, target of emission reduction is 70 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution

water has been generated. Hence, the effluent charges for each main-point source should not the same. For example the effluent charge of aqua culture should be 10.21 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 10.21 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Aqua culture	Subbasin Approve
Tax rate(Baht/Kg-BOD)	10.21	
Influent (Kg-BOD/yr)	1,400,803.84	1,400,803.84
Effluent (Kg-BOD/yr)	419,848.99	419,848.99
Effluent Std.(Kg-BOD/yr)	420,241.15	420,241.15
%Reduction (Gov.)	70.00%	70.00%
%Reduction (Active)	70.03%	70.03%
Revenue (Baht/yr)	1,408,819,957.50	1,408,819,957.50
Cost of abatement(Baht/yr)	373,727,823.56	373,727,823.56
Tax expense(Baht/yr)	4,286,658.21	4,286,658.21
Total expense(Baht/yr)	378,014,481.78	378,014,481.78
Net profit(Baht/yr)	1,030,805,475.72	1,030,805,475.72
Total expense/ Revenue	26.83%	26.83%

 Table 5-28: Non-uniform tax of each main point source at sub-basin LM

From the table above in Sub-basin LM known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Aqua culture	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	10.21	
Influent (Kg-BOD/yr)	1,400,803.84	1,400,803.84
Effluent (Kg-BOD/yr)	419,848.94	419,848.94
Effluent Std.(Kg-BOD/yr)	420,241.15	420,241.15
%Reduction (Gov.)	70.00%	70.00%
%Reduction (Active)	70.03%	70.03%
Revenue (Baht/yr)	1,408,819,957.50	1,408,819,957.50
Cost of abatement(Baht/yr)	373,727,824.07	373,727,824.07
Tax expense(Baht/yr)	4,286,657.70	4,286,657.70
Total expense(Baht/yr)	378,014,481.78	378,014,481.78
Net profit(Baht/yr)	1,030,805,475.72	1,030,805,475.72
Total expense/ Revenue	26.83%	26.83%

Table 5-29: Uniform Tax of entire main point source at sub-basin LM

From the table above in Sub-basin LM shown that after applying uniform tax charge for each activities at the same rate. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities. The sub-basin LM profit of using Uniform tax and Non-uniform tax are the same.

Sub basin LM		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		10.21	
Influent	(Kg-BOD/yr)	1,400,803.84	1,400,803.84	
Effluent	(Kg-BOD/yr)	419,848.99	419,848.94	-0.05
Effluent Std.	(Kg-BOD/yr)	420,241.15	420,241.15	
%Reduction	(Government)	70.00%	70.00%	
%Reduction	(Active)	70.03%	70.03%	0.00
Revenue	(Baht/yr)	1,408,819,957.50	1,408,819,957.50	
Cost of abatement	(Baht/yr)	373,727,823.56	373,727,824.07	0.51
Tax expense	(Baht/yr)	4,286,658.21	4,286,657.70	-0.51
Total expense	(Baht/yr)	378,014,481.78	378,014,481.78	0.00
Net profit	(Baht/yr)	1,030,805,475.72	1,030,805,475.72	0.00
Totalexpense/Revenu	e	26.83%	26.83%	0.00%

Table 5-30: Comparable between Non-uniform tax and Uniform tax in sub-basin LM

The method of reducing BOD peak in sub basin LM can be divided into 2 choices. First is reducing 30 % equally in every main point sources. Second is reducing in each main point sources in different ratio according to the effluent ratio.

The result of comparing Non-uniform tax and Uniform tax in sub-basin LM. Uniform tax has more cost of abatement about 0.51Baht, less tax expense about 0.51 Baht, non total expense about 0.00 Baht, and no net profit about 0.00 Baht.

### 5.3.4 The method of reducing BOD peak in sub basin from Km110 to Km120 (Peak4)

At sub-basin Km 110-120 are included in Sub-basin RG and LP. In this sub basin, at present, during the dry season has BOD peak at 12,790 kg/day. Sub-basin RG is the main effluent emission which has the highest BOD discharge ratio at 95 %.

The main point source in this Peak 4 are Aquatic animal farm and pig farm which has BOD pollutant loading ratio at 52.8 % and 42.6 % respectively. The rest main point sources are urban community and industry which has BOD pollutant loading ration at 3.5 % and 1.1% respectively.

Due to the sub-basin LP has an effluent emission ration at 5 %. Thus, only sub-basin RG has to reduce the effluent emission. The target emission of sub-basin RG is 40% or has the volume of BOD pollutant loading not more than 5,116 kg/day.

### • <u>Sub-basin LP</u>

This sub-basin is located at KM no.110-120 from river mouth. BOD value is shown at 4.8 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 570 Kg-BOD/day. Aquaculture pollution sources about 75 percentage of pollution.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.19 Baht/Kg-BOD, the effluent charge of urban community should be 4.43 Baht/Kg-BOD and the effluent of aqua culture should be 7.51 Baht/Kg-BOD and the effluent charge of industry should be 2.43 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this subbasin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 4.93 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Subbasin Approve
Tax rate(Baht/Kg-BOD)	0.19	4.43	7.51	2.43	
Influent (Kg-BOD/yr)	31,481.25	17,969.04	180,047.66	157,577.80	387,075.74
Effluent (Kg-BOD/yr)	12,259.02	7,182.80	72,009.74	62,980.73	154,432.29
Effluent Std.(Kg-BOD/yr)	12,592.50	7,187.61	72,019.06	63,031.12	154,830.30
%Reduction (Gov.)	60.00%	60.00%	60.00%	60.00%	60.00%
%Reduction (Active)	61.06%	60.03%	60.01%	60.03%	60.10%
Revenue (Baht/yr)	1,350,100.00	2,643,154.95	175,221,392.50	5,798,532,010.43	5,977,746,657.88
Cost of abatement(Baht/yr)	17,063.16	113,932.29	47,148,460.07	375,828.00	47,655,283.52
Tax expense(Baht/yr)	2,329.21	31,819.79	540,793.18	153,043.17	727,985.35
Total expense(Baht/yr)	19,392.37	145,752.08	47,689,253.26	528,871.17	48,383,268.87
Net profit(Baht/yr)	1,330,707.63	2,497,402.87	127,532,139.24	5,798,003,139.26	5,929,363,389.01
Total expense/ Revenue	1.44%	5.51%	27.22%	0.01%	0.81%

Table 5-31: Non-uniform tax of each main point source at sub-basin LP

From the table above in Sub-basin LP known that after applying non-uniform tax for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	4.93	4.93	4.93	4.93	
Influent (Kg-BOD/yr)	31,481.25	17,969.04	180,047.66	157,577.80	387,075.74
Effluent (Kg-BOD/yr)	698.57	6,606.72	109,171.90	38,095.73	154,572.92
Effluent Std.(Kg-BOD/yr)	12,592.50	7,187.61	72,019.06	63,031.12	154,830.30
%Reduction (Gov.)	60.00%	60.00%	60.00%	60.00%	60.00%
%Reduction (Active)	97.78%	63.23%	39.36%	75.82%	60.07%
Revenue (Baht/yr)	1,350,100.00	2,643,154.95	175,221,392.50	5,798,532,010.43	5,977,746,657.88
Cost of abatement(Baht/yr)	25,229.37	116,623.76	46,923,960.32	461,208.58	47,527,022.03
Tax expense(Baht/yr)	3,443.95	32,571.14	538,217.48	187,811.95	762,044.52
Total expense(Baht/yr)	28,673.32	149,194.90	47,462,177.80	649,020.53	48,289,066.55
Net profit(Baht/yr)	1,321,426.68	2,493,960.05	127,759,214.70	5,797,882,989.90	5,929,457,591.33
Total expense/ Revenue	2.12%	5.64%	27.09%	0.01%	0.81%

Table 5-32: Uniform Tax of entire main point source at sub-basin LP

From the table above in Sub-basin LP shown that after applying uniform tax for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LP	and a set	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		4.93	
Influent	(Kg-BOD/yr)	387,075.74	387,075.74	
Effluent	(Kg-BOD/yr)	154,432.29	154,572.92	140.64
Effluent Std.	(Kg-BOD/yr)	154,830.30	154,830.30	
%Reduction	(Government)	60.00%	60.00%	
%Reduction	(Active)	60.10%	60.07%	0.00
Revenue	(Baht/yr)	5,977,746,657.88	5,977,746,657.88	
Cost of abatement	(Baht/yr)	47,655,283.52	47,527,022.03	-128,261.49
Tax expense	(Baht/yr)	727,985.35	762,044.52	34,059.16
Total expense	(Baht/yr)	48,383,268.87	48,289,066.55	-94,202.33
Net profit	(Baht/yr)	5,929,363,389.01	5,929,457,591.33	94,202.33
Totalexpense/Revenue	e	0.81%	0.81%	0.00%

Table 5-33: Comparable between Non-uniform tax and Uniform tax in sub-basin LP

The result of comparing Non-uniform tax and Uniform tax in sub-basin LP. Uniform tax has less cost of abatement about 128,261.49 Baht, higher tax expense about 34,059.16 Baht, less total expense about 94,202.33 Baht, and gain more net profit about 94,202.33 Baht.

### • <u>Sub-basin RG</u>

This sub-basin is located at KM no.110-120 from river mouth. BOD value is shown at 4.8 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 8,400 Kg-BOD/day. Aquaculture and pig farm pollute about 58 and 38 percentage of pollution, respectively.. Allowable BOD discharging load at this sub-basin is about 40 percent, target of emission reduction is 60 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.30 Baht/Kg-BOD, the effluent charge of urban community should be 4.44 Baht/Kg-BOD and the effluent of aqua culture should be 7.51 Baht/Kg-BOD and the effluent charge of industry should be 1.35 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this subbasin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 3.46 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.30	4.44	7.51	1.35	
Influent (Kg-BOD/yr)	1,985,859.15	31,648.20	2,284,614.84	1,821,384.75	6,123,506.95
Effluent (Kg-BOD/yr)	773,438.04	12,637.65	913,726.70	727,796.25	2,427,598.63
Effluent Std.(Kg-BOD/yr)	794,343.66	12,659.28	913,845.94	728,553.90	2,449,402.78
%Reduction (Gov.)	60.00%	60.00%	60.00%	60.00%	60.00%
%Reduction (Active)	61.05%	60.07%	60.01%	60.04%	60.36%
Revenue (Baht/yr)	85,861,664.00	3,613,478.47	2,223,374,647.50	4,837,476,701.55	7,150,326,491.52
Cost of abatement(Baht/yr)	1,699,788.51	200,908.75	598,264,233.78	2,412,780.70	602,577,711.74
Tax expense(Baht/yr)	232,031.41	56,111.17	6,862,087.49	982,524.94	8,132,755.01
Total expense(Baht/yr)	1,931,819.92	257,019.92	605,126,321.27	3,395,305.63	610,710,466.75
Net profit(Baht/yr)	83,929,844.08	3,356,458.55	1,618,248,326.23	4,834,081,395.91	6,539,616,024.77
Total expense/ Revenue	2.25%	7.11%	27.22%	0.07%	8.54%

Table 5-34: Non-uniform tax of each main point source at sub-basin RG

From the table above in Sub-basin RG known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	3.46	3.46	3.46	3.46	
Influent (Kg-BOD/yr)	1,985,859.15	31,648.20	2,284,614.84	1,821,384.75	6,123,506.95
Effluent (Kg-BOD/yr)	89,954.35	15,357.95	1,965,909.69	372,862.08	2,444,084.07
Effluent Std.(Kg-BOD/yr)	794,343.66	12,659.28	913,845.94	728,553.90	2,449,402.78
%Reduction (Gov.)	60.00%	60.00%	60.00%	60.00%	60.00%
%Reduction (Active)	95.47%	51.47%	13.95%	79.53%	60.09%
Revenue (Baht/yr)	85,861,664.00	3,613,478.47	2,223,374,647.50	4,837,476,701.55	7,150,326,491.52
Cost of abatement(Baht/yr)	2,280,061.46	190,262.18	593,029,679.45	3,168,099.04	598,668,102.13
Tax expense(Baht/yr)	311,242.05	53,138.52	6,802,047.52	1,290,102.79	8,456,530.88
Total expense(Baht/yr)	2,591,303.51	243,400.70	599,831,726.97	4,458,201.83	607,124,633.01
Net profit(Baht/yr)	83,270,360.49	3,370,077.78	1,623,542,920.53	4,833,018,499.72	6,543,201,858.51
Total expense/ Revenue	3.02%	6.74%	26.98%	0.09%	8.49%

Table 5-35: Uniform Tax of entire main point source at sub-basin RG

From the table above in Sub-basin RG shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RG	0.7	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)			
Tax rate	(Baht/KgBOD)		3.46				
Influent	(Kg-BOD/yr)	6,123,506.95	6,123,506.95				
Effluent	(Kg-BOD/yr)	2,427,598.63	2,444,084.07	16,485.44			
Effluent Std.	(Kg-BOD/yr)	2,449,402.78	2,449,402.78				
%Reduction	(Government)	60.00%	60.00%				
%Reduction	(Active)	60.36%	60.09%	0.00			
Revenue	(Baht/yr)	7,150,326,491.52	7,150,326,491.52				
Cost of abatement	(Baht/yr)	602,577,711.74	598,668,102.13	-3,909,609.62			
Tax expense	(Baht/yr)	8,132,755.01	8,456,530.88	323,775.87			
Total expense	(Baht/yr)	610,710,466.75	607,124,633.01	-3,585,833.74			
Net profit	(Baht/yr)	6,539,616,024.77	6,543,201,858.51	3,585,833.74			
Totalexpense/Revenu	e	8.54%	8.49%	-0.05%			

Table 5-36: Comparable between Non-uniform tax and Uniform tax in sub-basin RG

The method of reducing BOD peak in sub basin RG can be divided into 2 choices. First is reducing 60 % equally in every main point sources. Second is reducing in each main point sources in different ratio which can be divided into 2 sub-case. In 2.1 is appointed the deduction ratio in each main point source according to the effluent discharge ratio. In 2.2, the reduction of effluent emission ration in each main point sources according to the ease of reduction BOD pollutant loading.

The result of comparing Non-uniform tax and Uniform tax in sub-basin RG. Uniform tax has less cost of abatement about 3,909,609.62 Baht, higher tax expense about 323,775.87 Baht, less total expense about 3,585,833.74 Baht, and gain more net profit about 3,585,833.74 Baht.

### 5.3.5 The method of reducing BOD peak in sub basin from Km90 to Km100 (Peak5)

At sub-basin Km 90-100 are included in Sub-basin LQ and RH. In this sub basin, at present, during the dry season has BOD peak at 17,921 kg/day.

The main point source in this Peak 5 are Pig farm and industry which has BOD pollutant loading ratio at 55.4 % and 24.9 % respectively. The rest main point sources are urban community and aqua culture which has BOD pollutant loading ratio at 14.7 % and 4.9% respectively.

Due to the sub-basin LQ has an small volume of effluent emission at 2.3 %. Thus, only sub-basin RH has to reduce the effluent emission. The target emission of sub-basin RH is 95% or has the volume of BOD pollutant loading not more than 880 kg/day.

## • <u>Sub-basin LQ</u>

This sub-basin is located at KM no.90-100 from river mouth. BOD value is shown at 6.7 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 360 Kg-BOD/day. Aquaculture and pig farm pollution sources about 40 and 35 percentage of pollution, respectively.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution

water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 2.16 Baht/Kg-BOD, the effluent charge of urban community should be 63.37 Baht/Kg-BOD and the effluent of aqua culture should be 61.53 Baht/Kg-BOD and the effluent charge of industry should be 24.56 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax charge which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 33.06 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	2.16	63.37	61.53	24.56	
Influent (Kg-BOD/yr)	73,682.55	37,395.92	52,297.66	11,544.07	174,920.20
Effluent (Kg-BOD/yr)	3,683.84	1,869.72	2,614.55	577.14	8,745.25
Effluent Std.(Kg-BOD/yr)	3,684.13	1,869.80	2,614.88	577.20	8,746.01
%Reduction (Gov.)	95.0 <mark>0%</mark>	95.00%	95.00%	95.00%	95.00%
%Reduction (Active)	95.00%	95.00%	95.00%	95.00%	95.00%
Revenue (Baht/yr)	3,111,100.00	1,490,507.05	50,895,792.50	420,964,440.92	476,461,840.47
Cost of abatement(Baht/yr)	58,291.08	424,239.35	14,025,575.75	34,808.38	14,542,914.56
Tax expense(Baht/yr)	7,957.10	118,484.46	160,873.27	14,174.55	301,489.37
Total expense(Baht/yr)	66,248.18	542,723.81	14,186,449.01	48,982.93	14,844,403.93
Net profit(Baht/yr)	3,044,851.82	947,783.24	36,709,343.49	420,915,457.98	461,617,436.54
Total expense/ Revenue	2.13%	36.41%	27.87%	0.01%	3.12%

Table 5-37: Non-uniform tax of each main point source at sub-basin LQ

From the table above in Sub-basin LQ known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	33.05	33.05	33.05	33.05	33.05
Influent (Kg-BOD/yr)	73,682.55	37,395.92	52,297.66	11,544.07	174,920.20
Effluent (Kg-BOD/yr)	334.10	3,110.07	4,833.39	467.36	8,744.92
Effluent Std.(Kg-BOD/yr)	3,684.13	1,869.80	2,614.88	577.20	8,746.01
%Reduction (Gov.)	95.00%	95.00%	95.00%	95.00%	95.00%
%Reduction (Active)	99.55%	91.68%	90.76%	95.95%	95.00%
Revenue (Baht/yr)	3,111,100.00	2,033,230.86	50,895,792.50	420,964,440.92	477,004,564.28
Cost of abatement(Baht/yr)	80,890.76	368,036.35	13,927,073.72	37,931.23	14,413,932.06
Tax expense(Baht/yr)	11,042.08	102,787.74	159,743.48	15,446.25	289,019.54
Total expense(Baht/yr)	91,932.83	470,824.08	14,086,817.20	53,377.48	14,702,951.59
Net profit(Baht/yr)	3,019,167.17	1,562,406.77	36,808,975.30	420,911,063.44	462,301,612.68
Total expense/ Revenue	2.95%	23.16%	27.68%	0.01%	3.08%

Table 5-38: Uniform Tax of entire main point source at sub-basin LQ

From the table above in Sub-basin LQ shown that after applying uniform tax for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LQ		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		33.05	
Influent	(Kg-BOD/yr)	174,920.20	174,920.20	
Effluent	(Kg-BOD/yr)	8,745.25	8,744.92	-0.34
Effluent Std.	(Kg-BOD/yr)	8,746.01	8,746.01	
%Reduction	(Government)	95.00%	95.00%	
%Reduction	(Active)	95.00%	95.00%	0.00
Revenue	(Baht/yr)	476,461,840.47	477,004,564.28	
Cost of abatement	(Baht/yr)	14,542,914.56	14,413,932.06	-128,982.50
Tax expense	(Baht/yr)	301,489.37	289,019.54	-12,469.84
Total expense	(Baht/yr)	14,844,403.93	-14,702,951.59	-141,452.34
Net profit	(Baht/yr)	461,617,436.54	462,301,612.68	684,176.15
Totalexpense/Revenue		3.12%	3.08%	-0.03%

Table 5-39: Comparable between Non-uniform tax and Uniform tax in sub-basin LQ

The result of comparing Non-uniform tax and Uniform tax in sub-basin LQ. Uniform tax has less cost of abatement about 128,982.50 Baht, less tax expense about 12,469.84 Baht, less total expense about 141,452.34 Baht, and gain more net profit about 684,176.15 Baht.

### • <u>Sub-basin RH</u>

This sub-basin is located at KM no.90-100 from river mouth. BOD value is shown at 6.7 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 12,000 Kg-BOD/day. Pig farm pollution sources about 54 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 5 percent, target of emission reduction is 95 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 3.33 Baht/Kg-BOD, the effluent charge of urban community should be 43.99 Baht/Kg-BOD and the effluent of aqua culture should be 61.53 Baht/Kg-BOD and the effluent charge of industry should be 30.03 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 27.79 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	3.33	43.99	61.53	30.03	
Influent (Kg-BOD/yr)	3,458,866.84	2,981,167.04	271,069.53	23,111,693.56	29,822,796.97
Effluent (Kg-BOD/yr)	172,943.34	149,055.78	13,551.74	1,155,409.98	1,490,960.85
Effluent Std.(Kg-BOD/yr)	172,943.34	149,058.35	13,553.48	1,155,584.68	1,491,139.85
%Reduction (Gov.)	95.00%	95.00%	95.00%	95.00%	95.00%
%Reduction (Active)	95.00%	95.00%	95.00%	95.00%	95.00%
Revenue (Baht/yr)	160,103,663.00	38,923,016.43	263,803,382.50	29,533,795,936.75	29,996,625,998.68
Cost of abatement(Baht/yr)	4,223,481.10	23,477,529.85	72,697,450.36	85,204,938.12	185,603,399.43
Tax expense(Baht/yr)	575,901.33	6,556,963.64	833,838.81	34,696,961.85	42,663,665.62
Total expense(Baht/yr)	4,799,382.42	30,034,493.49	73,531,289.17	119,901,899.96	228,267,065.05
Net profit(Baht/yr)	155,304,280.58	8,888,522.94	190,272,093.33	29,413,894,036.79	29,768,358,933.64
Total expense/ Revenue	3.00%	77.16%	27.87%	0.41%	0.76%

Table 5-40: Non-uniform tax of each main point source at sub-basin RH

From the Figure above in Sub-basin RH known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to 95% which meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin
					Approve
Tax rate(Baht/Kg-BOD)	27.79	27.79	27.79	27.79	
Influent (Kg-BOD/yr)	3,458,866.84	2,981,167.04	271,069.53	23,111,693.56	29,822,796.97
Effluent (Kg-BOD/yr)	26,763.99	213,436.21	29,735.78	1,220,842.72	1,490,778.70
Effluent Std.(Kg-BOD/yr)	172,943.34	149,058.35	13,553.48	1,155,584.68	1,491,139.85
%Reduction (Gov.)	95.00%	95.00%	95.00%	95.00%	95.00%
%Reduction (Active)	99.23%	92.84%	89.03%	94.72%	95.00%
Revenue (Baht/yr)	160,103,663.00	38,923,016.43	263,803,382.50	29,533,795,936.75	29,996,625,998.68
Cost of abatement(Baht/yr)	5,448,645.95	21,237,635.90	72,045,133.56	83,314,898.29	182,046,313.70
Tax expense(Baht/yr)	743,771.42	5,931,392.30	826,357.27	33,927,219.13	41,428,740.11
Total expense(Baht/yr)	6,192,417.37	27,169,028.20	72,871,490.82	117,242,117.42	223,475,053.81
Net profit(Baht/yr)	153,911,245.63	11,753,988.23	190,931,891.68	29,416,553,819.33	29,773,150,944.87
Total expense/ Revenue	3.87%	69.80%	27.62%	0.40%	0.75%

Table 5-41: Uniform Tax of entire main point source at sub-basin RH

From the table above in Sub-basin RH shown that after applying uniform tax charge for each activities at the same rate. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RH	J OOLIN	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		27.79	
Influent	(Kg-BOD/yr)	29,822,796.97	29,822,796.97	
Effluent	(Kg-BOD/yr)	1,490,960.85	1,490,778.70	-182.15
Effluent Std.	(Kg-BOD/yr)	1,491,139.85	1,491,139.85	181
%Reduction	(Government)	95.00%	95.00%	
%Reduction	(Active)	95.00%	95.00%	0.00
Revenue	(Baht/yr)	29,996,625,998.68	29,996,625,998.68	
Cost of abatement	(Baht/yr)	185,603,399.43	182,046,313.70	-3,557,085.72
Tax expense	(Baht/yr)	42,663,665.62	41,428,740.11	-1,234,925.51
Total expense	(Baht/yr)	228,267,065.05	223,475,053.81	-4,792,011.24
Net profit	(Baht/yr)	29,768,358,933.64	29,773,150,944.87	4,792,011.24
Totalexpense/Revenue	1	0.76%	0.75%	-0.02%

Table 5-42: Comparable between Non-uniform tax and Uniform tax in sub-basin RH

The result of comparing Non-uniform tax and Uniform tax in sub-basin RH. Uniform tax has less cost of abatement about 3,557,085.72 Baht, less tax expense about 1,234,925.51Baht, less total expense about 4,792,011.24 Baht, and gain more net profit about 4,792,011.24 Baht.

### 5.3.6 The method of reducing BOD peak in sub basin from Km 70 to Km 80 (Peak6)

Sub-basin located at Km 70- 80 are included in Sub-basin RI. In this sub basin, at present, during the dry season has BOD peak at 14,421 kg/day.

The main point source in this Peak 6 are Aquatic animal farm, Pig farm, industry and urban community which have BOD pollutant loading ratio at 66.7 %, 15.4 %, 12.4 % and 5.5 % respectively.

The target emission in this peak6 is 30% or has the volume of BOD pollutant loading not more than 10,100 kg/day.

### Sub-basin RI

This sub-basin is located at KM no.70-90 from river mouth. BOD value is shown at 6.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 11,000 Kg-BOD/day. Aquaculture pollution sources about 68 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 70 percent, target of emission reduction is 30 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.15 Baht/Kg-BOD, the effluent charge of urban community should be 0.12 Baht/Kg-BOD and the effluent of aqua culture should be 4.27 Baht/Kg-BOD and the effluent charge of industry should be 0.10 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.12 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	0.15	2.13	4.27	0.12	
Influent (Kg-BOD/yr)	823,831.46	716,956.59	3,509,936.95	47,383,228.62	52,433,953.62
Effluent (Kg-BOD/yr)	550,828.19	500,429.00	2,453,207.25	31,229,257.71	34,733,722.14
Effluent Std.(Kg-BOD/yr)	576,682.02	501,869.62	2,456,955.87	33,168,260.03	36,703,767.54
%Reduction (Gov.)	30.00%	30.00%	30.00%	30.00%	30.00%
%Reduction (Active)	33.14%	30.20%	30.11%	34.09%	33.76%
Revenue (Baht/yr)	37,103,683.00	45,407,952.86	3,415,851,410.25	54,158,796,949.23	57,657,159,995.35
Cost of abatement(Baht/yr)	605,284.26	3,816,552.78	913,268,904.78	9,202,713.13	926,893,454.95
Tax expense(Baht/yr)	82,624.23	1,065,913.76	10,475,194.96	3,747,510.92	15,371,243.87
Total expense(Baht/yr)	687,908.49	4,882,466.54	923,744,099.74	12,950,224.06	942,264,698.83
Net profit(Baht/yr)	36,415,774.51	40,525,486.32	2,492,107,310.51	54,145,846,725.18	56,714,895,296.52
Total expense/ Revenue	1.85%	10.75%	27.04%	0.02%	1.63%

Table 5-43: Non-uniform tax of each main point source at sub-basin RI

From the Figure above in Sub-basin RI known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.12	0.12	0.12	0.12	
Influent (Kg-BOD/yr)	823,831.46	716,956.59	3,509,936.95	47,383,228.62	52,433,953.62
Effluent (Kg-BOD/yr)	670,340.00	716,956.59	3,509,936.95	31,229,194.16	36,126,427.70
Effluent Std.(Kg-BOD/yr)	576,682.02	501,869.62	2,456,955.87	33,168,260.03	36,703,767.54
%Reduction (Gov.)	30.00%	30.00%	30.00%	30.00%	30.00%
%Reduction (Active)	18.63%	0.00%	0.00%	34.09%	31.10%
Revenue (Baht/yr)	37,103,683.00	45,407,952.86	3,415,851,410.25	54,158,796,949.23	57,657,159,995.35
Cost of abatement(Baht/yr)	589,275.37	ารถายเห	224	9,202,720.76	9,791,996.13
Tax expense(Baht/yr)	80,440.80	86,034.79	421,192.43	3,747,503.30	4,335,171.32
Total expense(Baht/yr)	669,716.17	86,034.79	421,192.43	12,950,224.06	14,127,167.45
Net profit(Baht/yr)	36,433,966.83	45,321,918.07	3,415,430,217.82	54,145,846,725.18	57,643,032,827.89
Total expense/ Revenue	1.80%	0.19%	0.01%	0.02%	0.02%

Table 5-44: Uniform Tax of entire main point source at sub-basin RI

From the Figure above in Sub-basin RI shown that after applying uniform tax charge for each activities at the same rate. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities. The sub-basin RH profit of using Uniform tax is greater than using Non-uniform tax approximately of 928,137,531.37 Baht / year.

Sub basin RI		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.12	
Influent	(Kg-BOD/yr)	52,433,953.62	52,433,953.62	
Effluent	(Kg-BOD/yr)	34,733,722.14	36,126,427.70	1,392,705.56
Effluent Std.	(Kg-BOD/yr)	36,703,767.54	36,703,767.54	
%Reduction	(Government)	30.00%	30.00%	
%Reduction	(Active)	33.76%	31.10%	-0.03
Revenue	(Baht/yr)	57,657,159,995.35	57,657,159,995.35	
Cost of abatement	(Baht/yr)	926,893,454.95	9,791,996.13	-917,101,458.82
Tax expense	(Baht/yr)	15,371,243.87	4,335,171.32	-11,036,072.55
Total expense	(Baht/yr)	942,264,698.83	14,127,167.45	-928,137,531.37
Net profit	(Baht/yr)	56,714,895,296.52	57,643,032,827.89	928,137,531.37
Totalexpense/Revenue		1.63%	0.02%	-1.61%

Table 5-45: Comparable between Non-uniform tax and Uniform tax in sub-basin RI

The result of comparing Non-uniform tax and Uniform tax in sub-basin LQ. Uniform tax has less cost of abatement about 917,101,458.82 Baht, less tax expense about 11,036,072.55 Baht, less total expense about 928,137,531.37 Baht, and gain more net profit about 928,137,531.37 Baht.

### 5.3.7 The method of reducing BOD peak in sub basin from river mouth to Km 50 (Peak7)

At sub-basin Km 0 - 50 are included in Sub-basin LS, LT, LU, RJ, RK and RL. In this sub basin, at present, during the dry season has BOD peak at 56,802 kg/day.

The main sub-basins have high effluent emission are sub-basin RL, LS, RK, RJ, LU and LT which has BOD pollutant loading ratio at 32.6 %, 20.3 %, 17.5 %, 12.9 %, 11.1 % and 5.6 %

The main point source in this Peak 7 are aquatic animal farm, industry, urban community and pig farm which have BOD pollutant loading ratio at 62.3 %, 25.2 %, 8.9 % and 3.6 % respectively.

The target emission in this peak6 is 25% or has the volume of BOD pollutant loading not more than 44,870 kg/day.

### • <u>Sub-basin LS</u>

This sub-basin is located at KM no.40-50 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 9,800 Kg-BOD/day. Industry pollution sources about 44 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.13 Baht/Kg-BOD, the effluent charge of urban community should be 1.92 Baht/Kg-BOD and the effluent of aqua culture should be 3.91 Baht/Kg-BOD and the effluent charge of industry should be 0.73 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.74 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	0.13	1.92	3.91	0.73	
Influent (Kg-BOD/yr)	685,541.18	594,845.01	888,382.63	44,065,531.29	46,234,300.10
Effluent (Kg-BOD/yr)	514,155.88	445,059.71	665,268.02	33,010,848.67	34,635,332.28
Effluent Std.(Kg-BOD/yr)	514,155.88	446,133.76	666,286.97	33,049,148.47	34,675,725.07
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	25.00%	25.18%	25.11%	25.09%	25.09%
Revenue (Baht/yr)	30,656,075.00	20,862,973.86	831,316,445.00	306,197,737,724.28	307,080,573,218.14
Cost of abatement(Baht/yr)	509,815.52	3,059,630.42	226,782,530.06	59,177,136.50	289,529,112.50
Tax expense(Baht/yr)	66,840.26	854,514.64	2,601,197.94	24,097,919.53	27,620,472.37
Total expense(Baht/yr)	576,655.79	3,914,145.05	229,383,728.00	83,275,056.03	317,149,584.87
Net profit(Baht/yr)	30,079,419.21	16,948,828.81	601,932,717.00	306,114,462,668.25	306,763,423,633.27
Total expense/ Revenue	1.88%	18.76%	27.59%	0.03%	0.10%

Table 5-46: Non-uniform tax of each main point source at sub-basin LS

From the Figure above in Sub-basin LS known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to 25.09% which meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.74	0.74	0.74	0.74	
Influent (Kg-BOD/yr)	685,541.18	594,845.01	888,382.63	44,065,531.29	46,234,300.10
Effluent (Kg-BOD/yr)	115,389.36	594,845.01	888,382.63	32,692,751.25	34,291,368.25
Effluent Std.(Kg-BOD/yr)	514,155.88	446,133.76	666,286.97	33,049,148.47	34,675,725.07
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	83.17%	0.00%	0.00%	25.81%	25.83%
Revenue (Baht/yr)	30,656,075.00	20,862,973.86	831,316,445.00	306,197,737,724.28	307,080,573,218.14
Cost of abatement(Baht/yr)	625,166.59		-	59,410,934.46	60,036,101.05
Tax expense(Baht/yr)	85,388.13	440,185.31	657,403.14	24,192,635.93	25,375,612.50
Total expense(Baht/yr)	710,554.72	440,185.31	657,403.14	83,603,570.39	85,411,713.56
Net profit(Baht/yr)	29,945,520.28	20,422,788.55	830,659,041.86	306,114,134,153.89	306,995,161,504.59
Total expense/ Revenue	2.32%	2.11%	0.08%	0.03%	0.03%

Table 5-47: Uniform Tax of entire main point source at sub-basin LS

From the Figure above in Sub-basin LS shown that after applying uniform tax charge for each activities at the same rate. Thus, the emission reduce to 25.83% which meet the standard limits and abatement cost is lower than the profit in every activities. The sub-basin LS profit of using Uniform tax is greater than using Non-uniform tax approximately of 231,737,871.32 Baht / year.

ิลถาบนวทยบรการ จุฬาลงกรณ์มหาวิทยาลัย

Sub basin LS		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.74	
Influent	(Kg-BOD/yr)	46,234,300.10	46,234,300.10	
Effluent	(Kg-BOD/yr)	34,635,332.28	34,291,368.25	-343,964.03
Effluent Std.	(Kg-BOD/yr)	34,675,725.07	34,675,725.07	
%Reduction	(Government)	25.00%	25.00%	
%Reduction	(Active)	25.09%	25.83%	0.01
Revenue	(Baht/yr)	307,080,573,218.14	307,080,573,218.14	
Cost of abatement	(Baht/yr)	289,529,112.50	60,036,101.05	-229,493,011.44
Tax expense	(Baht/yr)	27,620,472.37	25,375,612.50	-2,244,859.87
Total expense	(Baht/yr)	317,149,584.87	85,411,713.56	-231,737,871.31
Net profit	(Baht/yr)	306,763,423,633.27	306,995,161,504.59	231,737,871.31
Totalexpense/Revenue		0.10%	0.03%	-0.08%

Table 5-48: Comparable between Non-uniform tax and Uniform tax in sub-basin LS

The result of comparing Non-uniform tax and Uniform tax in sub-basin LS. Uniform tax has less cost of abatement about 229,493,011.44 Baht, less tax expense about 2,244,859.87 Baht, less total expense about 231,737,871.31 Baht, and gain more net profit about 231,737,871.31 Baht.

### • <u>Sub-basin RJ</u>

This sub-basin is located at KM no.40-50 from river mouth. BOD value is shown at 6.5 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 5,800 Kg-BOD/day. Aquaculture pollution sources about 75 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.11 Baht/Kg-BOD, the effluent charge of urban community should be 1.86 Baht/Kg-BOD and the effluent of aqua culture should be 3.96 Baht/Kg-BOD and the effluent charge of industry should be 0.57 Baht/Kg-BOD.

The alternative effluent charge is to set a single effluent charge which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this

sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.74 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	0.11	1.86	3.96	0.57	
Influent (Kg-BOD/yr)	83,636.10	196,757.15	2,206,034.91	4,266,169.36	6,752,597.52
Effluent (Kg-BOD/yr)	59,843.05	147,567.86	1,652,862.84	3,176,952.42	5,037,226.18
Effluent Std.(Kg-BOD/yr)	62,727.08	147,567.86	1,654,526.18	3,199,627.02	5,064,448.14
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	28.45%	25.00%	25.08%	25.53%	25.40%
Revenue (Baht/yr)	3,665,228.00	12,961,700.77	2,123,747,660.00	23,654,889,434.85	25,795,264,023.62
Cost of abatement(Baht/yr)	48,221.65	984,669.23	570,648,431.85	4,446,928.85	576,128,251.58
Tax expense(Baht/yr)	6,582.74	274,476.22	6,545,336.86	1,810,862.88	8,637,258.70
Total expense(Baht/yr)	54,804.39	1,259,145.45	577,193,768.71	6,257,791.73	584,765,510.28
Net profit(Baht/yr)	3,610,423.61	11,702,555.32	1,546,553,891.29	23,648,631,643.12	25,210,498,513.34
Total expense/ Revenue	1.50%	9.71%	27.18%	0.03%	2.27%

Table 5-49: Non-uniform tax of each main point source at sub-basin RJ

From the table above in Sub-basin RJ known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.74	0.74	0.74	0.74	
Influent (Kg-BOD/yr)	83,636.10	196,757.15	2,206,034.91	4,266,169.36	6,752,597.52
Effluent (Kg-BOD/yr)	11,184.43	196,757.15	2,206,034.91	2,639,125.11	5,053,101.60
Effluent Std.(Kg-BOD/yr)	62,727.08	147,567.86	1,654,526.18	3,199,627.02	5,064,448.14
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	86.63%	0.00%	0.00%	38.14%	25.17%
Revenue (Baht/yr)	3,665,228.00	12,961,700.77	2,123,747,660.00	23,654,889,434.85	25,795,264,023.62
Cost of abatement(Baht/yr)	60,627.97		_	4,795,808.23	4,856,436.20
Tax expense(Baht/yr)	8,276.48	145,600.29	1,632,465.83	1,952,952.58	3,739,295.18
Total expense(Baht/yr)	68,904.45	145,600.29	1,632,465.83	6,748,760.81	8,595,731.38
Net profit(Baht/yr)	3,596,323.55	12,816,100.48	2,122,115,194.17	23,648,140,674.04	25,786,668,292.24
Total expense/ Revenue	1.88%	1.12%	0.08%	0.03%	0.03%

Table 5-50: Uniform Tax of entire main point source at sub-basin RJ

From the Figure above in Sub-basin RJ shown that after applying uniform tax charge for each activities. Thus, the emission reduce which meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RJ	and the	Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.74	
Influent	(Kg-BOD/yr)	6,752,597.52	6,752,597.52	
Effluent	(Kg-BOD/yr)	5,037,226.18	5,053,101.60	15,875.42
Effluent Std.	(Kg-BOD/yr)	5,064,448.14	5,064,448.14	
%Reduction	(Government)	25.00%	25.00%	
%Reduction	(Active)	25.40%	25.17%	0.00
Revenue	(Baht/yr)	25,795,264,023.62	25,795,264,023.62	
Cost of abatement	(Baht/yr)	576,128,251.58	4,856,436.20	-571,271,815.38
Tax expense	(Baht/yr)	8,637,258.70	3,739,295.18	-4,897,963.51
Total expense	(Baht/yr)	584,765,510.28	8,595,731.38	-576,169,778.90
Net profit	(Baht/yr)	25,210,498,513.34	25,786,668,292.24	576,169,778.90
Totalexpense/Revenue		2.27%	0.03%	-2.23%

Table 5-51: Comparable between Non-uniform tax and Uniform tax in sub-basin RJ

The result of comparing Non-uniform tax and Uniform tax in sub-basin RJ. Uniform tax has less cost of abatement about 571,271,815.38 Baht, less tax expense about 4,897,963.51 Baht, less total expense about 576,169,778.90 Baht, and gain more net profit about 576,169,778.90 Baht.

#### • <u>Sub-basin RK</u>

This sub-basin is located at KM no.20-40 from river mouth. BOD value is shown at 6.2 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 8,200 Kg-BOD/day. Aquaculture pollution sources about 97 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.09 Baht/Kg-BOD, the effluent charge of urban community should be 1.99 Baht/Kg-BOD and the effluent of aqua culture should be 3.91 Baht/Kg-BOD and the effluent charge of industry should be 1.20 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.74 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.09	1.99	3.91	1.20	
Influent (Kg-BOD/yr)	12,590.60	133,711.88	3,667,944.31	1,056,674.61	4,870,921.40
Effluent (Kg-BOD/yr)	9,442.95	100,173.19	2,746,875.51	789,987.84	3,646,479.49
Effluent Std.(Kg-BOD/yr)	9,442.95	100,283.91	2,750,958.23	792,505.96	3,653,191.05
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	25.00%	25.08%	25.11%	25.24%	25.14%
Revenue (Baht/yr)	569,390.00	8,427,918.52	3,432,330,102.50	2,400,331,773.75	5,841,659,184.77
Cost of abatement(Baht/yr)	6,235.48	713,712.34	936,336,704.56	2,327,468.54	939,384,120.92
Tax expense(Baht/yr)	849.87	199,344.65	10,740,283.24	947,985.41	11,888,463.16
Total expense(Baht/yr)	7,085.35	913,056.99	947,076,987.80	3,275,453.95	951,272,584.09
Net profit(Baht/yr)	562,304.65	7,514,861.54	2,485,253,114.70	2,397,056,319.79	4,890,386,600.68
Total expense/ Revenue	1.24%	10.83%	27.59%	0.14%	16.28%

Table 5-52: Non-uniform tax of each main point source at sub-basin RK

From the table above in Sub-basin RK known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	3.35	3.35	3.35	3.35	3.35
Influent (Kg-BOD/yr)	12,590.60	133,711.88	3,667,944.31	1,056,674.61	4,870,921.40
Effluent (Kg-BOD/yr)	392.31	66,667.89	3,200,290.68	380,815.00	3,648,165.89
Effluent Std.(Kg-BOD/yr)	9,442.95	100,283.91	2,750,958.23	792,505.96	3,653,191.05
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	96.88%	50.14%	12.75%	63.96%	25.10%
Revenue (Baht/yr)	569,390.00	8,427,918.52	3,432,330,102.50	2,400,331,773.75	5,841,659,184.77
Cost of abatement(Baht/yr)	9,626.09	799,670.10	934,697,343.71	3,132,805.82	938,639,445.71
Tax expense(Baht/yr)	1,314.24	223,337.45	10,720,973.78	1,275,730.26	12,221,355.72
Total expense(Baht/yr)	10,940.33	1,023,007.54	945,418,317.49	4,408,536.07	950,860,801.43
Net profit(Baht/yr)	558,449.67	7,404,910.98	2,486,911,785.01	2,395,923,237.67	4,890,798,383.33
Total expense/ Revenue	1.92%	12.14%	27.54%	0.18%	16.28%

 Table 5-53: Uniform Tax of entire main point source at sub-basin RK

From the table above in Sub-basin RK shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RK		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)		
Tax rate	(Baht/KgBOD)	9	3.35			
Influent	(Kg-BOD/yr)	4,870,921.40	4,870,921.40			
Effluent	(Kg-BOD/yr)	3,646,479.49	3,648,165.89	1,686.40		
Effluent Std.	(Kg-BOD/yr)	3,653,191.05	→ 3,653,191.05			
%Reduction	(Government)	25.00%	25.00%	6		
%Reduction	(Active)	25.14%	25.10%	0.00		
Revenue	(Baht/yr)	5,841,659,184.77	5,841,659,184.77			
Cost of abatement	(Baht/yr)	939,384,120.92	938,639,445.71	-744,675.21		
Tax expense	(Baht/yr)	11,888,463.16	12,221,355.72	332,892.56		
Total expense	(Baht/yr)	951,272,584.09	950,860,801.43	-411,782.65		
Net profit	(Baht/yr)	4,890,386,600.68	4,890,798,383.33	411,782.65		
Totalexpense/Revenue		16.28%	16.28%	-0.01%		

Table 5-54: Comparable between Non-uniform tax and Uniform tax in sub-basin RK

The result of comparing Non-uniform tax and Uniform tax in sub-basin RK. Uniform tax has less cost of abatement about 744,675.21 Baht, more tax expense about 332,892.56 Baht, less total expense about 411,782.65 Baht, and gain more net profit about 411,782.65 Baht.

# • <u>Sub-basin LT</u>

This sub-basin is located at KM no.0-20 from river mouth. BOD value is shown at 7.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 3,000 Kg-BOD/day. Industry pollution sources about 89 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of urban community should be 1.88 Baht/Kg-BOD and the effluent of aqua culture should be 3.91 Baht/Kg-BOD and the effluent charge of industry should be 0.40 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.40 Baht/Kg-BOD to all main-point sources in this sub-basin.

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	1.88	3.91	0.40	
Influent (Kg-BOD/yr)	55,468.22	8,896.88	47,963,547.13	48,027,912.22
Effluent (Kg-BOD/yr)	41,543.98	6,662.47	35,513,930.23	35,562,136.68
Effluent Std.(Kg-BOD/yr)	41,601.16	6,672.66	35,972,660.35	36,020,934.17
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	25.10%	25.11%	25.96%	25.96%
Revenue (Baht/yr)	13,227,414.33	8,325,375.00	69,844,138,681.56	69,865,691,470.89
Cost of abatement(Baht/yr)	279,650.55	2,271,156.26	34,884,525.61	37,435,332.42
Tax expense(Baht/yr)	78,102.69	26,050.26	14,205,572.09	14,309,725.04
Total expense(Baht/yr)	357,753.24	2,297,206.52	49,090,097.70	51,745,057.46
Net profit(Baht/yr)	12,869,661.09	6,028,168.48	69,795,048,583.86	69,813,946,413.43
Total expense/ Revenue	2.70%	27.59%	0.07%	0.07%

Table 5-55: Non-uniform tax of each main point source at sub-basin LT

From the table above in Sub-basin LT known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Table 5-56: Uniform Tax of entire main point source at sub-basin LT

Item	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.40	0.40	0.40	
Influent (Kg-BOD/yr)	55,468.22	8,896.88	47,963,547.13	48,027,912.22
Effluent (Kg-BOD/yr)	55,468.22	8,896.88	35,513,932.09	35,578,297.18
Effluent Std.(Kg-BOD/yr)	41,601.16	6,672.66	35,972,660.35	36,020,934.17
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	0.00%	0.00%	25.96%	25.92%
Revenue (Baht/yr)	13,227,414.33	8,325,375.00	69,844,138,681.56	69,865,691,470.89
Cost of abatement(Baht/yr)			34,884,524.86	34,884,524.86
Tax expense(Baht/yr)	22,187.29	3,558.75	14,205,572.83	14,231,318.87
Total expense(Baht/yr)	22,187.29	3,558.75	49,090,097.70	49,115,843.74
Net profit(Baht/yr)	13,205,227.04	8,321,816.25	69,795,048,583.86	69,816,575,627.16
Total expense/ Revenue	0.17%	0.04%	0.07%	0.07%

From the table above in Sub-basin LT shown that after applying uniform tax charge for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LT		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.40	
Influent	(Kg-BOD/yr)	48,027,912.22	48,027,912.22	
Effluent	(Kg-BOD/yr)	35,562,136.68	35,578,297.18	16,160.50
Effluent Std.	(Kg-BOD/yr)	36,020,934.17	36,020,934.17	
%Reduction	(Government)	25.00%	25.00%	
%Reduction	(Active)	25.96%	25.92%	0.00
Revenue	(Baht/yr)	69,865,691,470.89	69,865,691,470.89	
Cost of abatement	(Baht/yr)	37,435,332.42	34,884,524.86	-2,550,807.55
Tax expense	(Baht/yr)	14,309,725.04	14,231,318.87	-78,406.17
Total expense	(Baht/yr)	51,745,057.46	49,115,843.74	-2,629,213.72
Net profit	(Baht/yr)	69,813,946,413.43	69,816,575,627.16	2,629,213.72
Totalexpense/Revenue		0.07%	0.07%	0.00%

Table 5-57: Comparable between Non-uniform tax and Uniform tax in sub-basin LT

The result of comparing Non-uniform tax and Uniform tax in sub-basin LT. Uniform tax has less cost of abatement about 2,550,807.55 Baht, less tax expense about 78,406.17 Baht, less total expense about 2,629,213.72 Baht, and gain more net profit about 2,629,213.72 Baht.

### • Sub-basin LU

This sub-basin is located at KM no.0-20 from river mouth. BOD value of is shown at 7.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 5,800 Kg-BOD/day. Aquaculture and industry pollute about 99 and 34 percentage of pollution, respectively. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of urban community should be 1.84 Baht/Kg-BOD and the effluent of aqua culture should be 3.91 Baht/Kg-BOD and the effluent charge of industry should be 0.43 Baht/Kg-BOD.

The alternative effluent charge is a uniform tax which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.44 Baht/Kg-BOD to all main-point sources in this sub-basin.

Item	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	1.84	3.91	0.43	
Influent (Kg-BOD/yr)	588,827.67	1,099,060.63	21,198,491.80	22,886,380.09
Effluent (Kg-BOD/yr)	440,469.09	823,034.03	15,682,731.26	16,946,234.38
Effluent Std.(Kg-BOD/yr)	441,620.75	824,295.47	15,898,868.85	17,164,785.07
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	25.20%	25.11%	26.02%	25.95%
Revenue (Baht/yr)	12,316,254.12	7,020,455,722.50	31,575,430,891.57	38,608,202,868.19
Cost of abatement(Baht/yr)	2,901,901.44	280,563,515.23	16,560,156.21	300,025,572.87
Tax expense(Baht/yr)	810,463.13	3,218,063.07	6,743,574.44	10,772,100.65
Total expense(Baht/yr)	3,712,364.57	283,781,578.30	23,303,730.65	310,797,673.52
Net profit(Baht/yr)	8,603,889.55	6,736,674,144.20	31,552,127,160.92	38,297,405,194.67
Total expense/ Revenue	30.14%	4.04%	0.07%	0.81%

 Table 5-58: Non-uniform tax
 of each main point source at sub-basin LU

From the table above in Sub-basin LU known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Item	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	0.44	0.44	0.44	
Influent (Kg-BOD/yr)	588,827.67	1,099,060.63	21,198,491.80	22,886,380.09
Effluent (Kg-BOD/yr)	588,827.67	1,099,060.63	15,428,611.24	17,116,499.53
Effluent Std.(Kg-BOD/yr)	441,620.75	824,295.47	15,898,868.85	17,164,785.07
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	0.00%	0.00%	27.22%	25.21%
Revenue (Baht/yr)	12,316,254.12	7,020,455,722.50	31,575,430,891.57	38,608,202,868.19
Cost of abatement(Baht/yr)	-		16,670,690.11	16,670,690.11
Tax expense(Baht/yr)	259,084.17	483,586.68	6,788,588.94	7,531,259.79
Total expense(Baht/yr)	259,084.17	483,586.68	23,459,279.05	24,201,949.90
Net profit(Baht/yr)	12,057,169.95	7,019,972,135.83	31,551,971,612.52	38,584,000,918.29
Total expense/ Revenue	2.10%	0.01%	0.07%	0.06%

Table 5-59: Uniform Tax of entire main point source at sub-basin LU

From the table above in Sub-basin LU shown that after applying uniform tax charge for each activities at the same rate. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin LU		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.44	
Influent	(Kg-BOD/yr)	22,886,380.09	22,886,380.09	
Effluent	(Kg-BOD/yr)	16,946,234.38	17,116,499.53	170,265.14
Effluent Std.	(Kg-BOD/yr)	17,164,785.07	17,164,785.07	
%Reduction	(Government)	25.00%	25.00%	
%Reduction	(Active)	25.95%	25.21%	-0.01
Revenue	(Baht/yr)	38,608,202,868.19	38,608,202,868.19	
Cost of abatement	(Baht/yr)	300,025,572.87	16,670,690.11	-283,354,882.77
Tax expense	(Baht/yr)	10,772,100.65	7,531,259.79	-3,240,840.85
Total expense	(Baht/yr)	310,797,673.52	24,201,949.90	-286,595,723.62
Net profit	(Baht/yr)	38,297,405,194.67	38,584,000,918.29	286,595,723.62
Totalexpense/Revenue		0.81%	0.06%	-0.74%

Table 5-60: Comparable between Non-uniform tax and Uniform tax in sub-basin LU

The result of comparing Non-uniform tax and Uniform tax in sub-basin LU. Uniform tax has less cost of abatement about 283,354,882.77 Baht, less tax expense about 3,240,840.85 Baht, less total expense about 286,595,723.62 Baht, and gain more net profit about 286,595,723.62 Baht.

### • <u>Sub-basin RL</u>

This sub-basin is located at KM no.0-20 from river mouth. BOD value of is shown at 7.0 mg/l and BOD loading from pollution generating sources that flowed to Thachin River is about 14,500 Kg-BOD/day. Aquaculture pollution sources about 78 percentage of pollution. Allowable BOD discharging load at this sub-basin is about 75 percent, target of emission reduction is 25 percent.

The table below shown that in this sub-basin, In each main-point sources has a different effluent charge according to the number of each main-point sources and the quantity of pollution water has been generated. Hence, the effluent charges for each main-point source should not the same. For example, the effluent charge of Pig farm should be 0.10 Baht/Kg-BOD, the effluent charge of urban community should be 1.90 Baht/Kg-BOD and the effluent of aqua culture should be 3.91 Baht/Kg-BOD and the effluent charge of industry should be 0.27 Baht/Kg-BOD.

The alternative effluent charge is to set a single effluent charge which is a single effluent charge for all main-point sources in this sub-basin. Thus, regardless of main-point sources in this sub-basin will be charged at the same rate. For instance, in this sub-basin, the effluent charge is 0.29 Baht/Kg-BOD to all main-point sources in this sub-basin.



Item	Pig farm	Urban community	Aqua culture	Industry	<b>Sub-basin</b> Approve
Tax rate(Baht/Kg-BOD)	0.10	1.90	3.91	0.27	
Influent (Kg-BOD/yr)	1,642.50	132,415.02	5,721,461.69	38,401,885.51	44,257,404.72
Effluent (Kg-BOD/yr)	1,180.72	99,001.05	4,284,528.24	28,352,790.12	32,737,500.14
Effluent Std.(Kg-BOD/yr)	1,231.88	99,311.27	4,291,096.27	28,801,414.13	33,193,053.54
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	28.11%	25.23%	25.11%	26.17%	26.03%
Revenue (Baht/yr)	88,050.00	20,179,296.57	6,049,383,982.50	64,926,053,871.63	70,995,705,200.70
Cost of abatement(Baht/yr)	863.42	673,508.10	1,460,550,375.71	18,798,942.80	1,480,023,690.04
Tax expense(Baht/yr)	118.07	188,102.00	16,752,505.44	7,655,253.33	24,595,978.84
Total expense(Baht/yr)	981.49	861,610.10	1,477,302,881.15	26,454,196.14	1,504,619,668.88
Net profit(Baht/yr)	87,068.51	19,317,686.46	4,572,081,101.35	64,899,599,675.49	69,491,085,531.82
Total expense/ Revenue	1.11%	4.27%	24.42%	0.04%	2.12%

Table 5-61: Non-uniform tax of each main point source at sub-basin RL

From the table above in Sub-basin RL known that after applying tax charge for each activities which are not equal. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Table 5-62: Uniform Tax of entire main point source at sub-basin RL					<b></b>
Item	Pig farm	Urban community	Aqua culture	Industry	Sub-basin Approve
Tax rate(Baht/Kg-BOD)	0.29	0.29	0.29	0.29	
Influent (Kg-BOD/yr)	1,642.50	132,415.02	5,721,461.69	38,401,885.51	44,257,404.72
Effluent (Kg-BOD/yr)	475.33	132,415.02	5,721,461.69	26,948,962.02	32,803,314.06
Effluent Std.(Kg-BOD/yr)	1,231.88	99,311.27	4,291,096.27	28,801,414.13	33,193,053.54
%Reduction (Gov.)	25.00%	25.00%	25.00%	25.00%	25.00%
%Reduction (Active)	71.06%	0.00%	0.00%	29.82%	25.88%
Revenue (Baht/yr)	88,050.00	20,179,296.57	6,049,383,982.50	64,926,053,871.63	70,995,705,200.70
Cost of abatement(Baht/yr)	977.60	0 0 1001	I I <u>o</u> FIC	19,191,728.57	19,192,706.17
Tax expense(Baht/yr)	137.85	38,400.36	1,659,223.89	7,815,198.99	9,512,961.08
Total expense(Baht/yr)	1,115.44	38,400.36	1,659,223.89	27,006,927.56	28,705,667.25
Net profit(Baht/yr)	86,934.56	20,140,896.21	6,047,724,758.61	64,899,046,944.07	70,966,999,533.45
Total expense/ Revenue	1.27%	0.19%	0.03%	0.04%	0.04%

From the table above in Sub-basin RL shown that after applying uniform tax for each activities. Thus, the emission reduce to meet the standard limits and abatement cost is lower than the profit in every activities.

Sub basin RL		Non-uniform(X)	Uniform(X-alpha)	Different(alpha)
Tax rate	(Baht/KgBOD)		0.29	
Influent	(Kg-BOD/yr)	44,257,404.72	44,257,404.72	
Effluent	(Kg-BOD/yr)	32,737,500.14	32,803,314.06	65,813.92
Effluent Std.	(Kg-BOD/yr)	33,193,053.54	33,193,053.54	
%Reduction	(Government)	25.00%	25.00%	
%Reduction	(Active)	26.03%	25.88%	0.00
Revenue	(Baht/yr)	70,995,705,200.70	70,995,705,200.70	
Cost of abatement	(Baht/yr)	1,480,023,690.04	19,192,706.17	-1,460,830,983.86
Tax expense	(Baht/yr)	24,595,978.84	9,512,961.08	-15,083,017.76
Total expense	(Baht/yr)	1,504,619,668.88	28,705,667.25	-1,475,914,001.63
Net profit	(Baht/yr)	69,491,085,531.82	70,966,999,533.45	1,475,914,001.63
Totalexpense/Revenue		2.12%	0.04%	-2.08%

Table 5-63: Comparable between Non-uniform tax and Uniform tax in sub-basin RL

The result of comparing Non-uniform tax and Uniform tax in sub-basin RL. Uniform tax has less cost of abatement about 1,460,830,983.86 Baht, less tax expense about 15,083,017.76 Baht, less total expense about 1,475,914,001.63 Baht, and gain more net profit about 1,475,914,001.63 Baht.



# The effect of the effluent charge

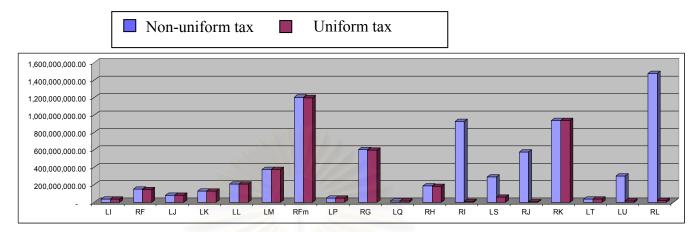


Figure 5-5: Comparable of cost of abatement between Non-uniform and Uniform tax in each sub-basin

Form the figure above show that in sub-basin RI, LS, RJ, LU and RL the abatement cost of Non-uniform tax is vastly different from uniform tax. Because the marginal abatement cost curve of some activities has steep slope until first abatement unit is higher than the last abatement unit of others. Thus, these main point sources has fully spend tax expenses.

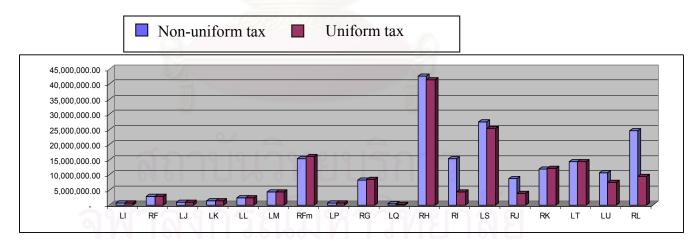
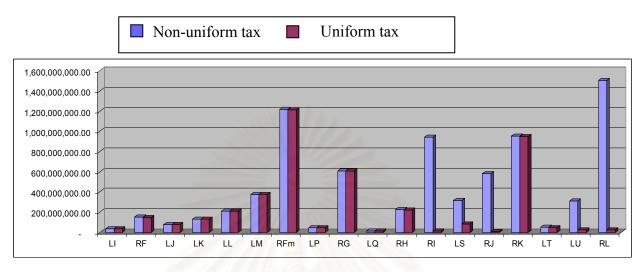


Figure 5-6: Comparable of Tax expense between Non-uniform and Uniform tax in each sub-basin

From the Figure above, although sub-basin RI, LS, RJ, LU and RL have fully spend tax expense, the tax expense of Uniform tax in sub-basin RI and RJ which have tax expense great lower than Non-Uniform tax. Because the marginal abatement cost curve in that sub-basin has a

great different. Due to the activity has lower marginal abatement cost and has reduced the marginal abatement cost until the ambient water quality passed the standard.



# Figure 5-7: Comparable of Total expense between Non-uniform and Uniform tax in each sub-basin

From the Figure above, The total expense of Uniform tax in every sub-basins are lower than Non-Uniform tax. Vastly different in Sub-basin RI, LS, RJ, LU and RL due to the efficiency of uniform tax theory which has been explained previously.

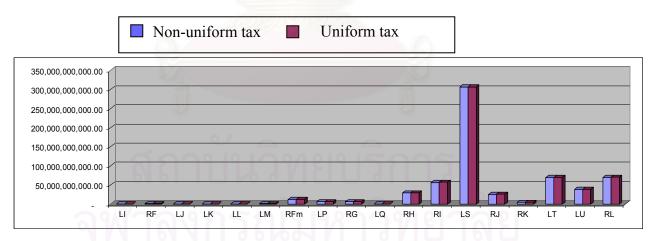


Figure 5-8: Comparable of Net profit between Non-uniform and Uniform tax in each sub-basin

Form the tax expense and cost of abatement figure above show that some sub-basins are vastly different., when compare with net profit. Thus, Non-uniform and Uniform tax has slightly different for the net profit. Due to the total expense or total pollution control cost is very cheap when comparing to the revenue. This mean that if Non-uniform or Uniform tax has been applied, the activities will not face any trouble.

There is an abundance of literature on the effect of effluent charge which has been widely introduced in many countries. One study which has looked at the issue by Indab et al. (2003) who studied effluent charge for Sarangani Bay in Philippines. However, the existing effluent charge scheme is under CAC scheme does not help to reduce the water pollution, they recommended newly effluent charge scheme to increase the pollution reduction which generated a 92% increase in pollution reduction. However, 23% increase in total abatement cost. Our study uses the uniform tax scheme as a management for protecting and maintaining good water quality. Moreover uniform tax cause total abatement cost decreased comparing to Non-uniform tax.

Another study in China by Dasgupta (1996) which of water pollution abatement by Chinese industry determined that the current regulatory system provides an economic incentive to abate by charging a levy on pollution in excess of the standard. However, the study results suggest that changing to a full emissions charge system would greatly reduce overall abatement costs. Uniform pollution charges could produce much higher environmental quality. If China emissions charge system is adopted, it would seem appropriate to give local regulators the authority to adapt charges to local circumstances. Our study compares Non-uniform tax and Uniform tax is suitable to adapt charges system. However, the conclusion of this study is similarity to our research which say that the uniform tax is the suitable effluent charge scheme to apply.

Nevertheless, there is some article point the disadvantage of applied effluent charge scheme cause. The study Peretto (2007) in the effects of effluent taxes on firms' allocation of resources to cost-reducing and emission-reducing. In terms of environmental benefits, the tax induces a positive rate of pollution abatement that offsets the "dirty" side of economic growth. A tax set at an endogenous rate that holds constant the tax burden per unit of output, consequently, an impact of increased cost unit of output bring down the marginal revenue of factory or an increased price of products.

# **CHAPTER VI**

# **CONCLUSION & RECOMMENDATION**

#### 6.1 Comparison of Non-Uniform tax and Uniform tax

	Command & Control	Market Daged Incenting	Different
	Command&Control Non-Uniform Tax (X)	Market Based Incentive Uniform Tax (X-alpha)	(alpha)
Effluent			(aipiia)
(Kg-Bod/yr)	171,933,645.26	173,274,193.21	1,340,547.95
%Reduction (Active)	38.100%	37.617%	-0.483%
Cost of abatement (Baht/yr)	7,579,208,523.25	4,098,278,631.53	-3,480,929,891.71
Tax expense (Baht/yr)	192,982,306.15	156,413,160.39	-36,569,145.76
Total expense (Baht/yr)	7,772,190,829.39	4,254,691,791.92	-3,517,499,037.47
Net profit (Baht/yr)	629,922,275,884.23	633,440,317,645.51	3,518,041,761.28
Total expense	e v		
/ Revenue	1.219%	0.667%	-0.552%

Table 6-1: Comparison effect of Non-Uniform tax and Uniform tax to Thachin river

In this model, E is consisting in 2 parts which are Tax and Cost of abatement. When the effluents (E) decrease 1 unit, it generates the tax expense t Baht and the cost abatement increase MAC Baht. Thus, reduction of t Baht which greater than MAC Baht. Polluter continuous reduce effluent (E) unit MAC greater than t Baht. The firm polluter will stop emission. In contrast, Non-uniform tax use price as a tool to reduce the emissions. Thus, there is no competition in sub-basin.

For instance, Tax 1 = MC 1, Tax 2 = MC2 etc, however uniform tax perform as t = MC1, MC2, MC3m MC4 hence the result of this tax is the optimal. The principle of Uniform tax is reducing the first effluent (E) unit, the model will fine to whom has the minimum of MAC , who has the minimum of MAC will the first to reduce effluent (E) and continue reducing until MAC of that polluter higher than other. The model will find the next

polluter and repeat the process again however this will be under the standard tax rate which called "Uniform Tax" for any sub-basin.

From the table above, using the uniform tax can effluent more than using Nonuniform, which meet the effluent standard, approximately of 1,344,399.32 Kg-BOD/yr. The cost of abatement of uniform tax is lower than non-uniform tax approximately of 3,480,944,681.53 Baht/year. Moreover the total expenses of uniform tax is lower than non-uniform tax approximately of 3,517,515,764.60 Baht/year which lead to the net profit of Uniform tax is higher than Non-uniform tax approximately of 3,518,058,488.41 Baht.

In conclusion, both of Non-uniform and Uniform tax are reducing efficiently the wastewater emission in Thachin River to meet the standard requirement however, in term of economic, the uniform tax is more efficient than Non-uniform tax as the total expense per revenue of entire river is higher than using Non-uniform tax approximately of 0.552 %.

# 6.2 Applied the Mathematical decision-making model with other rivers.

In case of using this model apply for other rivers. The procedures are as follows

- a) Collected an information is shown in table 3-19
  - Finding current situation of BOD loading
  - Finding Total Maximum Daily Loading and target of emission reduction
  - Specific characteristic of main point sources in the river
  - Economic composite of main point sources in the river

b) Followed the procedure from conceptual framework is shown in the figure 3-1

- Developed MAC of each main point sources
- Calculated Tax rate equivalent to CAC
- Simulation by optimization model

# Advantage and Disadvantage of Mathematical decision-making model.

The advantages of this model are

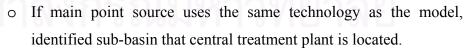
- Flexible, this model can be applied with other river by collecting new set of data.
- This model is friendly used with non-technical economist because the mathematical model has already been transformed into excel solver.

# The disadvantages of this model are

- Data collection is complicated and time consuming.
- This model can be used with only point sources
- Excel solver use significant parameters which are co-efficient set of each main point source. Arrived of MAC by running the statistical program is complicated for non technical economist.

# <u>Remark</u>

- In case of central treatment plant has been established, this model can be used. It can be used however, the first step is finding the following:-
  - Distinguishable types of main point source are covered by Central treatment plant.
  - Identified the number of main point sources is using the central treatment plant.
  - Identified the location of main point sources and located in which sub-basin.
  - Considered the wastewater treatment technology is using the same technology.



• If the treatment technology changed, MAC would re-run the program which assumed that central treatment plant is other point sources.

- Distance of point source is effected to emission tax charge
  - Emission tax charge is collected as the same rate as shown in the report. Due to the data collection from PCD were considered the self purification rate, in form of distance of the river, distance of river network e.g. the polluter is located 1 km. away from the river. 1 km. distance of self purification is equal to 20%. If this polluter is located in sub-basin LI, emission tax rate is the same rate as in the report. Because emission tax rate has been set as same as target of mission reduction 50%. Thus, when upstream is reduced pollution loading at 50%, downstream is also reduced at same rate.
- If the concentration based effluent is concentrated, is this model working?
  - Yes, it is, however, the polluter has to pay more tax expense.
     Due to the polluter release more amount of pollution loading which show that the polluter is interested to pay less abatement cost. Therefore tax expense is increased by the volume of pollutant loading multiply by tax rate.

# 6.3 Emission tax charge apply for main point sources

- a) First, is measuring BOD at end-of-pipe, where C is the average wastewater BOD or effluent BOD from generating-source of interest (g-BOD /cu.m.)
- b) Second, BOD is brought to calculate by using the equation in the table below. By Q is equal to P where P is numbers of wastewater generating unit for source of interest (unit/day). And V is quantity of wastewater or effluent per wastewater generating unit of the source of interest (cu.m./unit).
- c) Third, finding L by using the equation below. Then multiply L by emission tax charge which is shown in the table.

In production line, that will be released discharges into a river, this discharge may direct from production line or come from treatment plant, which discharges level will be related with

$$L = \overline{C}VP \tag{1}$$

When L = wastewater BOD load or effluent BOD load from generatingsource of interest (g BOD/day)

> C = average wastewater BOD or effluent BOD from generatingsource of interest  $(g/m^3)$

> V = quantity of wastewater or effluent per wastewater generating unit of the source of interest (m<sup>3</sup>/unit)

> P = numbers of wastewater generating unit for the source of interest (unit/day)

The selected values for three variables in the above equation for each type of generating source are as follows.

1) Pig farms

P = Using numbers of pigs in the farm

V and C depends on the size of pig farms, as follows

Farm size	$\mathbf{N} = \mathbf{V}$	1915CIDS
	(L/pig-day)	(mg/l)
<500 pigs	20	1,500
500-5,000 pigs		2,500
>5,000 pigs	10	3,000
Source: $PCD$ (2005a)		

Source: PCD, (2005a)

# 2) Aquatic animal farms

P = Use the area of cultivating pond (rai)

2.1) Use V and C from 2 types of aquatic animal farm: prawn farming and fish farming. According to the registration data, there is only 1.5 % of total aquatic animal framing area in Thachin River Basin that is used for cultivation of other aquatic animals (Fishery Department, B.E. 2548). Since effluent from meateating fish pond will go to plant-eating fish farm before being discharged. Therefore, the selected values of V and c used as representative of effluent form fish farm are the value from effluent of the plant-eating fish pond only PCD.

2.2) The values of V for effluent from two types of aquatic animal farms are the yearly average values. The C values are the average values of effluent being discharged for each cultivating period as follows

Type of aquatic	V	С	
animal	(m <sup>3</sup> /rai-day)	(mg/l)	
Plant-eating fish	11.4	20.0	
prawn	25.6	10.25	

Source: PCD, (2005a)

2.3) Effluent BOD load from aquatic animal farm in each province is areaweighted average, according to the ratio of area used for farming of these 2 types of aquatic animal in each province. (The type of aquatic animal can not be differentiating based on the satellite photo).

V			С
	Ratio of area		Effluent BOD load from
Province	as aquatic animal		aquatic animal farm
	farming <sup>1</sup>		(kg/rai-day)
	prawn	fish	
Samutsakorn	0.84:	0.16	0.26
Nakornpathom	0.64:	0.36	0.25
Supanburi	0.44:	0.56	0.24
Kanjanaburi	0.06:	0.94	0.23
Chainatr	0.04:	0.96	0.23
Utaitani	0.02:	0.98	0.23

Source: PCD, (2005a)

3) Community

P = Use number of people in the community

V and C = Use the average values from the survey for flow and characteristics of wastewater of sub-district municipality and municipality in Thachin River Basin under this project as follows

Community size	V	С
-	(L/person-day)	(mg/l)
Sub-district municipality	120	105
Municipality, metropolitan	300	120
Source: PCD, (2005a)		

4) Factory generating wastewater from production process

P = Use daily quantity of raw material used or products produced

V and C = Use the average volume of wastewater from the factory (PCD, 2005a).

### 6.4 Wastewater from Non-point sources

In generally, any types of polluter such as point sources and non-point sources, which discharge wastewater into the river, are followed the same regulation, however, non-point sources have an uncertain form of emission. Therefore, monitoring and reducing the volume of wastewater is complicated for an implementation. Hence, the permit system of non-point sources, which has the volume of BOD higher than TMDL in Thachin River, is an improper system (PCD, 2005a)

The suitable procedure for reducing the emission discharge of Non-point sources are as follows:

6.4.1 Developed good agriculture practice in order to improve the production efficient. The procedures are as follows,

- 1) Given environmental agriculture handbook to the farmers
- 2) Farmers have a financial privilege supported by government financial institute.
- 3) Created market based instrument such as certify product or certify farm

6.4.2 Created management scheme reduce water pollution from Non-point sources. The procedures are as follows,

- 1) Encouraged the local government by providing an information of pollution generator.
- 2) Given a financial support to the farmers.
- 3) Given directly extra financial supports to any projects are concerned to pollution system.
- 4) Publish announcement or given information of agriculture water pollution.
- 5) Encouraged communities participate in monitoring the quality of water sources.

Nevertheless, from the polluter-pay –principle said that all pollution sources are responsible for preserving the water quality. Thus, for long term periods the government has to develop system which can control the pollution from Non-point sources. However, at present, there is non mechanism for controlling the wastewater from Non-point sources.



# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

### REFERENCES

- Baumol, W., and Oates, W. 1988. <u>The Theory of Environmental Policy</u>. Cambridge University Press.
- Boyd, C. E. 2003. Guidelines for aquaculture effluent management at the farm-level. Aquaculture 226: 101-112.
- Brown, M. T., and McClanahan, T. R. 1996. EMergy analysis perspectives of Thailand and Mekong River dam proposals. <u>Ecological Modelling</u> 91: 105-130.
- Buchholz, R. A., and Butt, J. A. 1998. <u>Principles of Environmental Management</u>. Prentice-Hall, Inc.
- Buckland, J., and Zabel, T. 1998. Economic and financial aspects of water management policies. <u>Water Resources Management in Europe</u> 261-318.
- Bureau of the budget. 2004. Accessed in June 2006. Budget expenditures fiscal year 2004. Available online at

[http://www.bb.go.th/bb/project/changwad47/TreeView/demolarge.html]

- Burtraw, D., Party, I., and Goulder, L. 1998. <u>Effective Environmental Policy in the</u> <u>Presence of Distorting Taxes</u>. In 1998 Decision-making and valuation for environmental policy workshop, Washington, DC.
- Cai, X., McKinney, D. C., and Lasdon, L. S. 2003. Integrated Hydrologic-Agronomic-Economic Model for River Basin Management. <u>Water resources planning and</u> management
- Callan and Thomas. 1996. <u>Environmental Economics and Management: Theory, Policy</u> <u>and Applications.</u> Times Mirror Higher Education Group, Inc.

Chapra, S. C. 1997. Surface Water-Quality Modeling. The McGraw-Hill company.

- Cheevaporn, V., and Menasveta, P. 2003. Water pollution and habitat degradation in the Gulf of Thailand. <u>Marine Pollution Bulletin</u> 47: 43-51.
- Clescerl, L. S., Greenberg, A. E., and Eaton, A. D. 1999. <u>Standard Methods for</u> <u>Examination of Water and Wastewater</u>. American Public Health Association.
- Collentine, D. 2003. <u>Including Non-Point Sources in a Water Quality Trading Permit</u> <u>Program</u>, Department of Economics, Swedish University of Agricultural Sciences.
- Conrad, J. M. 1999. <u>Resource Economics</u>. Cambridge University Press.
- Darnell, A. C., and Evans, J. L. 1990. <u>The Limits of Econometrics</u>. Edward Elgar Publishing.
- Dasgupta, S., Huq, M., Wheeler, D., and Zhang, C. 1996. <u>Water Pollution Abatement by</u> <u>Chinese Industry: Cost Estimates and Policy Implication</u>. Infrastructure and Agriculture Division of the World Bank's Policy Research Department.

Department of Industrial Works. Accessed in June 2006. Factory Data.

Available online at

[http://reg.diw.go.th/water/util/login.asp]

Department of Industrial Works. Accessed in June 2006. <u>Pollution Loading Data</u>. Available online at

[http://reg.diw.go.th/water/menu.asp]

Erickson, S. L., and King, B. J. 1999. <u>Fundamental of Environmental Management</u>. John Wiley & Sons, Inc. Field, B. C. 2006. Environmental Economics. Mc Graw Hill.

- Finkelshtain, I., and Kislev, Y. 2004. Taxes and subsidies in a polluting and politically powerful industry. <u>Asian Economics</u> 15: 481-492.
- Geoghegan, J. 1998. Policy Applications for the Patuxent Watershed Ecological-Economic Model. In. <u>The 1998 Decision-making and valuation for environmental</u> <u>policy workshop</u>. Washington, DC.
- Giupponi, C., Mysiak, J., and Crimi, J. 2004. <u>Participatory Approach in Decision Making</u>
   <u>Processes for Water Resources Management in the Mediterranean Basin</u>.
   Dipartimento di Produzione Vegetale, Universit degli Studi di Milano.
- Glazyrina, I., Glazyrin, V., and Vinnichenko, S. 2006. The polluter pays principle and potential conflicts in society. <u>Ecological Economics</u> 59: 324-330.
- Gomann, H., Kreins, P., Kunkel, R., and Wendland, F. 2005. Model based impact analysis of policy options aiming at reducing diffuse pollution by agriculture-- a case study for the river Ems and a sub-catchment of the Rhine. <u>Environmental</u> <u>Modelling</u> 20: 261-271.
- Grimaud, A., and Tournemaine, F. 2007. Why can an environmental policy tax promote growth through the channel of education? <u>Ecological Economics</u> 62: 27-36.
- Gujarati, D. N. 2003. Basic Econometrics. McGraw-Hill.
- Gunatilaka, A., Dreher, J., and Pitono, D. <u>River Basin Management Strategies for</u> <u>Indonesia – Extension of the Brantas Model to Central Java. Jakarta</u>. Indonesian Institute of Sciences.
- Gupta, S. 2002. <u>Environmental Benefits and Cost Savings Through Market-Based</u> <u>Instruments: An Application Using State-Level Data From India</u>. A Joint Center

of the Department of Economics, Laboratory for Energy and the Environment, and Sloan School of Management.

- Hair, J. F., Anderson, R. E., Tatham, R. L., and Black, W. C. 1998. <u>Multivariate Data</u> Analysis. Prentice-Hall International, Inc.
- Handley, N., Shorgren, J. F., and White, B. 1997. <u>Environmental Economics in Theory</u> <u>and Practice</u>. London, Macmillan Press LTD.
- Harrington, W., and Morgenstern, R. D. 2004. <u>Economic Incentives versus Command</u> and Control.
- Hungspreugs, M., Utoomprurkporn, W., Dharmvanij, S., and Sompongchaiyakul, P.
   1989. The Present Status of the Aquatic Environment of Thailand. <u>Marine</u>
   <u>Pollution Bulletin</u> 20: 327-332.
- Indab, A. L., Guzman, A. I., and Bagarinao, R. T. 2003. <u>An Effluent Charge for</u> <u>Sarangani Bay, Philippines: An Ex-ante Assessment</u>. Economy and Environment Program for Southeast Asia.
- Itsawilanond, S., and Tokrisana, R. 1994. <u>Environmental and Natural resources in</u> <u>Economics</u>. Bangkok: Kasetsart University Press.
- Kampas, A., Edwards, A. C., and Ferrier, R. C. 2002. Joint pollution control at a catchment scale: compliance costs and policy implications. <u>Environmental</u> <u>Management</u> 66: 281-291.
- Khan, M. H. 2000. <u>Reading Material: Collective Action Lectures</u>. Cambridge University Press.
- Koenig, E. F. 1984. Uncertainty and Pollution: The Role of Indirect Taxation. <u>Public</u> <u>Economics</u> 24: 111-122.

- Kruawal, K., Sacher, F., Werner, A., Muller, J., and Knepper, T. P. 2005. Chemical water quality in Thailand and its impacts on the drinking water production in Thailand. <u>Science of the Total Environment</u> 340: 57-70.
- LaGrega, M. D., Buckingham, P. L., and Evan, J. C. 2001. <u>Hazardous Waste</u> <u>Management and Environmental Resources Management</u>. McGraw-Hill International edition.
- Mahujchariyawong, J., and Ikeda, S. 2001. Modelling of environmental phytoremediation in eutrophic river — the case of water hyacinth harvest in Tha-chin River, Thailand. <u>Ecological Modelling</u> 142: 121-134.
- Maria, A. 2003. <u>The Costs of Water Pollution in India</u>. CERNA, Ecole Nationale Suprieure des Mines de Paris, Paris, France.
- McKitrick, R. 1999. A Derivation of the Marginal Abatement Cost Curve. Journal of Environmental Economics and Management 37: 306-314.
- Mehta, S., Mundle, S., and Shankar, U. 1997. <u>Controlling Pollution: Incentives and Regulations</u>. New Delhi, Sage Publications.
- Murty, M. N., Kumar, S., and Paul, M. 2006. Environmental regulation, productive efficiency and cost of pollution abatement: a case study of the sugar industry in India. <u>Environmental Management</u> 79: 1-9.

Nicholson, W. 2000. Intermediate Microeconomics. Harcourt, Inc.

Nugent, C. J. 1998. <u>Moreton Bay Catchment Water Quality Management Strategy</u>. Department of Environment and Heritage. Office of Industrial Economics. Accessed in June 2006. Industrial Statistics data.

Available online at

[http://www.oie.go.th/industrystat\_th.asp]

Office of the National Economic and Social Development Board. Accessed in June 2006. <u>Input-Output Tables of Thailand</u>. Available online at [http://www.nesdb.go.th/Default.aspx?tabid=97]

- Ortolano, L. 1977. Environmental Regulation and Impact Assessment. John Wiley & Sons, Inc.
- Pearce, D. W., and Turner, R. K. 1990. <u>Economics of Natural Resources and the</u> <u>Environment</u>. Harvester Wheatsheaf.
- Peretto, P. F. 2007. Effluent taxes, market structure, and the rate and direction of endogenous technological change. <u>Environmental Resource Economic</u>.
- Perez, R., and Ruiz, J. 2007. Global and local indeterminacy and optimal environmental public policies in an economy with public abatement activities. <u>Economic</u> <u>Modelling</u> 24: 431–452.
- Pollution Control Department. 1997. <u>Development of an Action Plan to Improve Water</u> <u>Quality in the Central River Basin, Thailand</u>. Bangkok: Thailand Environmental Foundation Montgomery Watson Asia Coastal Consultancy International Pty Ltd.
- Pollution Control Department. 1998. <u>Determination of Water Pollution Loading from</u> <u>Industrial in Thai.</u> Bangkok: Pollution Control Department, Ministry of Environmental and Natural resources, Thailand.
- Pollution Control Department. 2002a. <u>International Review for Environmental Strategies</u>. Institute for Global Environmental Strategies.

- Pollution Control Department. 2002b. <u>Allowable Pollution Loading of Water resources</u>: <u>Pollution Control in Water Supply resources</u>. Bangkok: Pollution Control Department, Ministry of Environmental and Natural resources, Thailand.
- Pollution Control Department. 2003a. <u>Development and technology of wastewater</u> <u>management from pig farm in Thai</u>. Bangkok: Pollution Control Department.
- Pollution Control Department. 2003b. <u>Wastewater treatment surcharge planning as</u> <u>Polluter Pay Principle in Thai</u>. Bangkok: Pollution Control Department.
- Pollution Control Department. 2003c. <u>The Standard of Wastewater Treatment Charge in</u> <u>Thai</u>. Bangkok: Pollution Control Department.
- Pollution Control Department. 2004. <u>The Statistics of Industrial</u>. Bangkok: Office of Industrial Economics.
- Pollution Control Department. 2005a. <u>Determination of Industrial Effluent Standard:</u> <u>Revision of Industrial Effluent Standard in Thai</u>. Bangkok: Pollution Control Department.
- Pollution Control Department. 2005b. <u>Development of effluent treatment management</u> <u>from aqua culture project in Thai</u>. Bangkok: Pollution Control Department.
- Pollution Control Department. 2005c. <u>Wastewater management of Aqua culture project</u> <u>in Thai</u>. Bangkok: Pollution Control Department, Ministry of Environmental and Natural resources, Thailand.
- Samuelson, P. A., Koopmans, T. C., and Stone, J. R. N. 1954. <u>Report of the Evaluative</u> <u>Committee for Econometrica</u>: pp. 141-146.

Sapsford, R., and Jupp, V. 1996. Data collection and Analysis. SAGE Publication Inc.

- Schou, J. S., Skop, E., and Jensen, J. D. 2000. Integrated agri-environmental modelling:
   A cost-effectiveness analysis of two nitrogen tax instruments in the Vejle Fjord watershed, Denmark. <u>Environmental Management</u> 58: 199-212.
- Sthiannopkao, S., Takizawa, S., Homewong, J., and Wirojanagud, W. 2007. Soil erosion and its impacts on water treatment in the northeastern provinces of Thailand. <u>Environmental International</u>: *in press*.
- Supsomboon, S. 2002. <u>Decision Support Model Course Packet</u>. Khon Kaen University Press.
- Tintner, G. 1968. <u>Methodology of Mathematical Economics and Econometrics</u>. Chicago, The University of Chicago Press.
- Tippanee, V., and Rutchaniphon, R. 1995. <u>Exercise and Technical solution in Calculus</u>. Bangkok.
- U.S. Environmental Protection Agency. Accessed in January 2007. Introduction to TMDLs. Available online at

[http://www.epa.gov/owow/tmdl/intro.html]

- Vasseur, P., Ferard, J. F., and Babut, M. 1991. The Biological aspects of the Regulatory control of Industrial effluent in France. <u>Chemosphere</u> 22: 625-633.
- Vigneswaran, S., Jegatheesan, V., and Visvanathan, C. 1999. Industrial waste minimization initiatives in Thailand: concepts, examples and pilot scale trials. <u>Cleaner Production</u> 7: 43-47.
- Wang, H. 2000. <u>Pollution Charge, Community Pressure and Abatement Cost: An</u> <u>Analysis of Chinese Industries</u>. Development Research Group, World Bank.

- Winston, W. L. 2004. <u>Microsoft Excel Data Analysis and Business Modeling</u>. Microsoft Press.
- Wu, C.-C. and Chang, N.-B. 2004. Corporate optimal production planning with varying environmental costs: A grey compromise programming approach. <u>European</u> <u>Journal of Operational Research</u> 155: 68-95.



สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย ด้นฉบับไม่มีหน้านี้ NO THIS PAGE IN ORIGINAL

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX

# **APPENDIX A**

Parameters	Standard Values	Method for Examination
1. pH value	5.5-9.0	pH Meter
2. Total Dissolved Solids (TDS)	Not more than 3,000 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 5,000 mg/l Not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea	Dry Evaporation 103-105 °C, 1 hour
3. Suspended solids (SS)	not more than 50 mg/l depending on receiving water or type of industry or wastewater treatment system under consideration of PCC but not exceed 150 mg/l	Glass Fiber Filter Disc
4. Temperature	not more than 40°C	Termometer during the sampling
5. Color and Odor	not objectionable	Not specified
6. Sulphide as H <sub>2</sub> S	not more than 1.0 mg/l	Titrate
7. Cyanide as HCN	not more than 0.2 mg/l	Distillation and Pyridine Barbituric Acid Method
8. Fat, Oil & Grease (FOG)	not more than 5.0 mg/l depending of receiving water or type of industry under consideration of PCC but not exceed 15.0 mg/l	Sovent Extraction by Weight
9. Formaldehyde	not more than 1.0 mg/l	Spectrophotometry
10.Phenols	not more than 1.0 mg/l	Distillation and 4-Aminoantipyrine Method
11.Free Chlorine	not more than 1.0 mg/l	lodometric Method
12.Pesticides	not detectable	Gas-Chromatography

# **Table A-1: Industrial Effluent Standards**

Table A-1: (continued)

Parameters	Standard Values	Method for Examination
Oxygen	not more than 20 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 60 mg/l	-Azide Modification at 20 °C , 5 days
14.Total Kjedahl Nitrogen (TKN)	not more than 100 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 200 mg/l	Kjeldahl
15.Chemical Oxygen Demand (COD)	not more than 120 mg/l depending on receiving water of type of industry under consideration of PCC but not exceed 400 mg/l	Potassium Dichromate Digestion
16.Heavy metals	3.4	Contraction of the second se
1. Zinc (Zn)	not more than 5.0 mg/l	Atomic Absorption Spectro Photometry; Direct
2. Chromium (Hexavalent)	not more than 0.25 mg/l	Aspiration or Plasma Emission Spectroscopy ; Inductively Coupled Plama : ICP
3. Chromium (Trivalent)	not more than 0.75 mg/l	
4. Copper (Cu)	not more than 2.0 mg/l	
5. Cadmium (Cd)	not more than 0.03 mg/l	
6. Barium (Ba)	not more than 1.0 mg/l	ทยบริการ
7. Lead (Pb)	not more than 0.2 mg/l	
8. Nickel (Ni)	not more than 1.0 mg/l	เขาหาวิทยาวัย
9. Manganese (Mn)	not more than 5.0 mg/l	PRI RIVE INFR
10. Arsenic (As)	not more than 0.25 mg/l	Atomic Absorption Spectrophotometry; Hydride Generation, or Plasma Emission Spectroscopy;
11. Selenium (Se)	not more than 0.02 mg/l	Inductively Coupled Plasma : ICP
12. Mercury (Hg)	not more than 0.005 mg/l	Atomic Absorption Cold Vapour Techique

#### Remarks: 1) PCC Pollution Control Committee

- 2) The standards were summerized from the Notification of the Ministry of Science, Technology and Environment, No. 3, B.E. 2539 (1996) and it specifies that pollution sources that the above standards are to be applied are factories group II and III issues under the Factory Act B.E.2535 (1992) and every kind of industrial estates.
- 3) Notification of the Pollution Control Committee, No. 3, B.E. 2539 (1996) dated August 20, B.E. 2539 (1996) has issued types of factories (category of factories issued under the Factory Act B.E.2535 (1992) that are allowed to discharge effluent having different standards from the Ministerial Notification No. 3 above as follows :
  1. BOD up to 60 mg/l
  - animal furnishing factories (category 4 (1))
  - starch factories (category 9 (2))
  - food from starch factories (category 10)
  - textile factories (category 15)
  - tanning factories (category 22)
  - pulp and paper factories (category 29)
  - chemical factories (category 42)
  - pharmaceutical factories(category 46)
  - frozen food factories (category 92)
  - 2. COD up to 400 mg/l
    - food furnishing factories (category 13 (2))
    - animal food factories (category 15 (1))
    - textile factories (category 22)
    - pulp and paper factories (category 38)
  - 3. TKN
    - 100 mg/l effective after 1 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4
    - 200 mg/l effective after 2 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4 for the following factories:
      - 1. food furnishing factories (category 13 (2))
      - 2. animal food factories (category 15 (1))
- Sources: 1. Notification the Ministry of Science, Technology and Environment, No. 3, B.E.2539 (1996) issued under the Enhancement and Conservation of the National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 113 Part 13 D, dated February 13, B.E.2539 (1996)

# จุฬาลงกรณ์มหาวิทยาลัย

Classification	Objectives/Condition and Beneficial Usage
Class 1	Extra clean fresh surface water resources used for : (1) conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction (2) ecosystem conservation where basic organisms can breed naturally
Class 2	Very clean fresh surface water resources used for : (1) consumption which requires ordinary water treatment process before use (2) aquatic organism of conservation (3) fisheries (4) recreation
Class 3	Medium clean fresh surface water resources used for : (1) consumption, but passing through an ordinary treatment process before using (2) agriculture
Class 4	Fairly clean fresh surface water resources used for : (1) consumption, but requires special water treatment process before using (2) industry
Class 5	The sources which are not classification in class 1-4 and used for navigation.

**Table A-2: Classification and Objectives** 

Source : Notification of the National Environmental Board, No. 8, B.E. 2537 (1994), issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 111, Part 16, dated February 24, B.E.2537 (1994).



Parameter <sup>1/</sup>	Units	Statistics	<u>St</u>	tandard	Value	for Clas	<u>s</u> <sup>2/</sup>	Methods for
1 al ameter	Units	Statistics	Class1	Class2	Class3	Class4	Class5	Examination
1. Colour,Odour and Taste	-	-	n	n'	n'	n'	-	-
2. Temperature	C°	-	n	n'	n'	n'	-	Thermometer
3. pH	-	-	n	5-9	5-9	5-9	-	Electrometric pH Meter
4. Dissolved Oxygen (DO) <sup>2/</sup>	mg/l	P20	n	6.0	4.0	2.0	-	Azide Modification
5. BOD (5 days, 20°C)	mg/l	P80	n	1.5	2.0	4.0	-	Azide Modification at 20°C , 5 days
6. Total Coliform Bacteria	MPN/100 ml	P80	n	5,000	20,000	-	-	Multiple Tube Fermentation Technique
7. Fecal Coliform Bateria	MPN/100 ml	P80	n	1,000	4,000	-	-	Multiple Tube Fermentation Technique
8. NO <sub>3</sub> -N	mg/l	-	n		5.0		-	Cadmium Reduction
9. NH <sub>3</sub> -N	mg/l	-	n		0.5		-	Distillation Nesslerization
10.Phenols	mg/l	- 44	n	13.21.8	0.005		-	Distillation,4- Amino antipyrene
11.Copper (Cu)	mg/l	-	n		0.1		-	Atomic Absorption -Direct Aspiration
12.Nickle (Ni )	mg/l	_	n		0.1		-	Atomic Absorption -Direct Aspiration
13.Manganese (Mn)	mg/l		n		1.0		-	Atomic Absorption -Direct Aspiration
14.Zinc (Zn)	mg/l		n	181	1.0		9-	Atomic Absorption -Direct Aspiration
15.Cadmium (Cd)	mg/l	ากร	n	19	0.005* 0.05**	118	176	Atomic Absorption -Direct Aspiration
16.Chromium Hexavalent	mg/l	-	n		0.05		-	Atomic Absorption -Direct Aspiration

 Table A-3: Surface Water Quality Standard

Table A-3: (continued)

Parameter <sup>1/</sup>	Units	Statistics	5	standard	Value for Class <sup>2/</sup>	Methods for Examination
			Class1	Class2	Class3 Class4 Class5	
17.Lead (Pb)	mg/l	-	n	0.05	-	Atomic Absorption - Direct Aspiration
18.Total Mercury (Total Hg)	mg/l		n	0.002	-	Atomic Absorption-Cold Vapour Technique
19.Arsenic (As)	mg/l	-	n	0.01	-	Atomic Absorption - Direct Aspiration
20.Cyanide (Cyanide)	mg/l	-	n	0.005	-	Pyridine- Barbituric Acid
21.Radioactivity - Alpha - Beta	Becqurel /l	-	n	0.1 1.0	-	Gas- Chromatography
22.Total Organochlorine Pesticides	mg/l		n	0.05	-	Gas- Chromatography
23.DDT	µg/l	- 45	n	1.0	6	Gas- Chromatography
24.Alpha-BHC	μg/l	-	n	0.02		Gas- Chromatography
25.Dieldrin	μg/l	-	n	0.1	_	Gas- Chromatography
26.Aldrin	µg/l		n	0.1	ริการ	Gas- Chromatography
27.Heptachlor & Heptachlorepoxi de	µg/l	งกร	n	0.2	กิ่ายาลัง	Gas- Chromatography
28.Endrin	μg/l	110	n	None	1 0 1 10 1041	

#### **Remark :**

- P Percentile value
- n naturally
- n' naturally but changing not more than  $3^{\circ}C$
- \* when water hardness not more than 100 mg/l as CaCO<sub>3</sub>
- \*\* when water hardness more than 100 mg/l as CaCO<sub>3</sub>

Based on Standard Methods for the Examination of Water and Wastewater recommended by APHA : American Public Health Association, AWWA : American Water Works Association and WPCF : Water Pollution Control Federation

Source : Notification of the National Environmental Board, No. 8, B.E. 2537 (1994), issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992), published in the Royal Government Gazette, Vol. 111, Part 16, dated February 24, B.E.2537 (1994).



# สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

River	Control Areas (km. from River Mouth)	Water Quality Standards (Same as Standards of Water Classification)	Source
<b>Central Regio</b>	n		
1. Chao Phraya River	Part 1 From Pra Samutchedi Samutprakarn Province To the Old Nontaburi City Hall (Km. 7 to	4	
	62) <u>Part 2</u> From the Old Nontaburi City Hall to Pompetch in Ayutthaya (Km. 62 to 142)	3	
	Part 3 Frorm Pompetch in Ayutthaya to the begining of Chaopraya River in Nakhornsawan Province (Km.142 to 379)	2	
2. Thachin River	<u>Part 1</u> From River Mouth Muang ,Samutrprakarn to Nakhornchaisri, Nakhornpathom (Km. 0	4	
	to 82) <u>Part 2</u> From Nakhornchaisri, Nakhornpathom	3	
	to Pho pra ya Watergate, Muang Suphanburi (Km.82 to 202) <u>Part 3</u> From Pho pra ya Watergate, Muang Suphanburi to Mouth of Makhamtao Chanel, Watsing Chainat (Km. 202 To 325)	2	Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 111, Part 62, dated August 4, B.E.2537 (1994).
3. Bang Pakong, Nakorn	<u>1. Bang Pakong River</u> from river mouth to Bansang, Prachinburi Province (122 KM. Distance)	3	
Nayok, and Prachinburi River	2. Nakorn Nayok River from Bansang, Prachinburi Province to Amphur Muang, Nakorn Nayok Province	3	
	(84 Km. Distance) <u>3. Prachinburi River</u> from Bansang, Prachinburi Province to Amphur Muang, Prachinburi Province (63 Km. Distance)	2	15
4. Maeklong River	From River Mouth (Shell Oil Terminal) Samutrsongkram to Pak preak ,Muang Kanchanaburi (Km 0 to 140)	3	ยาลัย

#### Table A-4: Classification of Water Resources for each Region

#### Table A-4: (continued)

River	Control Areas (km. from River Mouth)	Water Quality Standards (Same as Standards of Water Classification)	Source
Northeaste			
Songkram	from Ta-uten, Nakhonpanom Province(km.0) to Sohpisai , Nongkai Province(km.189)	3	
River	from Kosoompisai, Mahasarakarm Province(km.0) to Ubonrat Dam, Khonkhean Province(km.140)	3	
River	from Warinchamrab, Ubonratchatani Province(km.0) to Bankwao, Chaiyaphum Province(km.429)	3	
River	from Kongjuim, Ubonratchatani Province(km.0) to Chokchai, Nakhonratchasima Province(km.787)	3	Notification of Pollution Control Department, published in the Royal Government Gazette, Vol.
Lamtakong Water	Part 1 from the conjunction with Moon River in Amphur Muang, Nakhonratcharatsima Province (km. 0) to Khonchum Dike in Amphur Muang, Nakhonratchasima Province (km. 24) Part 2 from Khonchum Dike in Amphur Muang, Nakhonratchasima Province (km. 24) to	4 3	116, Part 53, dated July 6, B.E.2542 (1999).
	Pakchong,Nakhonratchasima Province (km. 180)		

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

Table A-4: (continued)

River	Control Areas (km. from River Mouth)	Water Quality Standards (Same as Standards of Water Classification)	Source
Southern <b>R</b>	Region		
	Part 1 From River Mouth Banleam ,Petchburi )	3	
River	to Petchaburi Dam, Bahn Kohla-om, Tayang Pecthcburi (Km.0 to 61) <u>Part 2</u> Petchaburi Dam, Bahn Kohla-om, Tayang Pecthcburi to Keangkrajarn Dam, Keangkrajarn Petchaburi Province (Km. 61 to 118)	2	Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 116, Part 72, dated September 9, B.E.2542 (1999).
2. Tapi River- Phum Duang River	<b>1. Tapi River</b> <u>Part 1</u> from River mouth in Amphur Muang,Surattani Province (km.0) to Amphur Chawang, Surattani Province	3	
	(km.184) <u>Part 2</u> from Banwungmaung in Amphur Chawang,Surattani Province (km.184) to Amphur Phipoon, Surattani Province (km.221)	2 3	Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 117, Special Part 10, dated February 2, B.E.2543 (2000).
	2. Klong Phumduang from the conjunction with Tapi River and Phumduang River in Amphur Punpin, Surattani Province (km.0) to Ratchaprapa Dam, in Bantakhun, Surattani Province (km.121)		Teoruary 2, D.D.2545 (2000).
3. Pattani River	Part 1 from river mouth (km.0) to Yarang, Pattani Province (km.19) Part 2 from Yarang, Pattani Province (km.19) to Banglang Dam in Bannang, Yala Province (km.128)	3	Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 116, Part 72, dated September 9,
4. Pak Phanang River	from river mouth(km.0) to Maisieb Dam in Cha- ued,Nakhonsrithammarat Province(km.109)		B.E.2542 (1999).

#### **APPENDIX B**

#### Table B-1: Properties of Marginal Abatement Cost function (Pig farm)

Dependent Variable: LOG(	COST)			
Method: Least Squares	,			
Date: 08/17/06 Time: 04:4	4			
Sample(adjusted): 2 1065				
Included observations: 1032	2			
Excluded observations: 32	after adjusting er	dpoints		
Convergence achieved after		1		
White Heteroskedasticity-C		rd Errors & Covar	iance	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
С	-1.184940	0.073908	-16.03272	0.0000
LOG(F)	0.719655	0.172151	4.180373	0.0000
LOG(I)	0.523361	0.139375	3.755045	0.0002
LOG(E)	-0.136506	0.021854	-6.246217	0.0000
AR(1)	0.201259	0.033135	6.073994	0.0000
R-squared	0.994420	Mean dependent	var	8.207981
Adjusted R-squared	0.994398	S.D. dependent v	ar	1.671726
S.E. of regression	0.125122	Akaike info crite	rion	-1.314229
Sum squared resid	16.07810	Schwarz criterio	n	-1.290298
Log likelihood	683.1420	F-statistic		45754.54
Durbin-Watson stat	1.830169	Prob(F-statistic)		0.000000
Inverted AR Roots	.20		25	
6161	าบนม	ายบ งก	19	

จุฬาลงกรณ์มหาวิทยาลัย

Dependent Variable: LOG	(COST)			
Method: Least Squares				
Date: 08/16/06 Time: 23:	47			
Sample(adjusted): 2 525				
Included observations: 488	3			
Excluded observations: 36	after adjusting er	ndpoints		
Convergence achieved after	er 5 iterations			
White Heteroskedasticity-	Consistent Standa	rd Errors & Covar	iance	
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.221105	0.359317	-0.615349	0.5386
LOG(F)	0.808064	0.166288	4.859434	0.0000
LOG(I)	0.472857	0.166421	2.841336	0.0047
LOG(E)	-0.279287	0.013594	-20.54528	0.0000
AR(1)	0.957445	0.013936	68.70269	0.0000
R-squared	0.997401	Mean dependent	var	9.907555
Adjusted R-squared	0.997379	S.D. dependent v	/ar	1.822383
S.E. of regression	0.093296	Akaike info crite	erion	-1.895896
Sum squared resid	4.204060	Schwarz criterio	n	-1.852962
Log likelihood	467.5986	F-statistic		46333.64
Durbin-Watson stat	1.990792	Prob(F-statistic)		0.000000
Inverted AR Roots	.96	E.		

สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

#### Table B-3: Properties of Marginal Abatement Cost function (Aqua Culture)

Dependent Variable: LOG(COST)

Method: Least Squares

Date: 03/28/07 Time: 06:24

Sample(adjusted): 60 3075

Included observations: 683

Excluded observations: 2333 after adjusting endpoints

Convergence achieved after 8 iterations

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
С	3.679473	0.003994	921.2608	0.0000
LOG(F)	0.466506	1.24E-08	37686663	0.0000
LOG(I)	0.544964	1.47E-08	37126864	0.0000
LOG(E)	-0.011470	2.31E-09	-4975406.	0.0000
AR(1)	1.000000	1.04E-07	9630947.	0.0000
R-squared	1.000000	Mean dependent	var	15.55306
Adjusted R-squared	1.000000	S.D. dependent v	ar	1.403957
S.E. of regression	2.10E-10	Akaike info crite	rion	-41.71836
Sum squared resid	3.00E-17	Schwarz criterio	n	-41.68523
Log likelihood	14251.82	F-statistic		7.59E+21
Durbin-Watson stat	3.004338	Prob(F-statistic)	าร	0.000000
Inverted AR Roots	1.00 👓	6	0	
จฬาล	Estimated AR p	process is nonstatio	nary	

#### Table B-4: Properties of Marginal Abatement Cost function (Industry)

Dependent Variable: LOG(COST)

Method: Least Squares

Date: 03/27/07 Time: 07:04

Sample(adjusted): 1 8100

Included observations: 1393

Excluded observations: 6707 after adjusting endpoints

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
С	-2.706499	0.120808	-22.40325	0.0000
LOG(F)	1.381092	0.035132	39.31115	0.0000
LOG(I)	0.169197	0.026774	6.319535	0.0000
LOG(E)	-0.407217	0.022104	-18.42250	0.0000
R-squared	0.913056	Mean dependent	var	9.553845
Adjusted R-squared	0.912868	S.D. dependent v	/ar	3.371413
S.E. of regression	0.995177	Akaike info crite	erion	2.831075
Sum squared resid	1375.634	Schwarz criterio	n	2.846119
Log likelihood	-1967.844	F-statistic		4862.265
Durbin-Watson stat	1.058904	Prob(F-statistic)		0.000000

สถาบนวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

#### **APPENDIX C**

### Table C-1: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin LI

	Subbasin I Transfer coe Subbasin En At-1	efficient 0 nission 169749.6728 475393.6692				
	A A*	169749.6728 170,033.80			Emission P	ass Approve
		Pig Farm Sector		Ur	ban Community See	
Co P Q alpha beta F	onstant 587 2996 5.5 13.6 16478	Revenue Abatement Cost T Emission Pig Farm Profit	1758652 22144.85 0.15 20152.663 1733484.3	Constant           P         0           Q         31139           alpha         37.31962           beta         4.452037           F         1162096	Revenue Abatement Cost T Emission Urban Profit	7147097.7 766520.77 3.09 69281.292 6166497.7
l Co- a b c d e^a	40745.6 •effcient -1.18494 0.719655 0.523361 -0.13651 0.305765		1	I         138632           Co-effcient         a           a         -0.22111           b         0.808064           c         0.472857           d         -0.27929           e^a         0.801633	5	
		Aquaculture Sector			Factory Sector	
Co P Q alpha beta	onstant 55502500 2.451 3194027 54750	Revenue Abatement Cost T Emission	136036628 35726101 6.11 67066.826	Constant P - Q 12055.95 alpha 2.761833 beta 2.197901	Revenue Abatement Cost T Emission	280395717 13810.31 0.42 13248.892
F I	7828561 134192.3 -effcient	Aquaculture Profit	99900748	F 33296.52 I 26497.78	Factory Profit	280376342
a	3.679473			Co-effcient a -2.7065		
	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin F		37		3.9	
a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin F Transfer coe Subbasin Em At-1 A	fficient hission 166,177.8 475,864.8 166,177.8	33 96 13	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e^a 0.06677		
a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Fr Transfer coe Subbasin Fr At-1	fficient hission 166,177,6 475,864,8 166,177,8 170,033,8	33 96 13	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e*a 0.06677 Uniform Tax	Emission F	
a b c d <u>e</u> *a Co P Q alpha	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin En Transfer coe Subbasin En At-1 A A A' Substant 587 2996 5.5	fficient hission 166,177.8 475,864.8 166,177.8	33 96 13	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e*a 0.06677 Uniform Tax Uniform Tax Constant P 00 0 31139 alpha 37.31962	Emission F rban Community Se Revenue Abatement Cost T	
a b c d e^a P Q alpha beta F I Co- a b	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin En At-1 A A' Subbasin En At-1 A' Subbasin At-1 Subbasin At-1 A' Subbasin At-1 Subbasin A	fficient ission 166,177.6 475,864.6 166,177.6 170,033.6 Pig Farm Sector Revenue Abatement Cost T	13 16 13 10 1758652 32751.075 3.9	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e*a 0.066777 Uniform Tax Uniform Tax Uniform Tax Constant P 0 0 0 31139 alpha 37.31962 beta 4.452037 F 1162006 I 138632 Co-effcient a -0.22111 b 0.808064	Emission F rban Community Se Revenue Abatement Cost T	ctor 7147097.7 806486.1 3.9
a b c d e^a e^a P Q alpha beta F I Co- a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Fr Transfer coe Subbasin Err At-1 At-1	fficient ission 166,177.6 475,864.6 166,177.6 170,033.8 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	1758652 32751.075 3.9 1146.3353	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e^a 0.06677 Uniform Tax Uniform Tax Vniform Tax P 0 Q 31139 alpha 37.31962 beta 4.452037 F 1162096 I 138632 Co-effcient a -0.22111	Emission F rban Community Se Revenue Abatement Cost T Emission Urban Profit	etor 7147097.7 806486.1 3.9 57754.086
a b c d d e^a Alpha beta F I Co-i b c d e^a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Fr Transfer coe Subbasin Err At-1 A At-1 A A A' onstant 587 2996 5.5 13.6 16478 40745.6 effcient -1.18494 0.719655 0.523361 -0.305765	fficient ission 166,177.6 475,864.6 176,077.6 176,033.8 Pig Farm Sector Revenue Abatemat Cost T Emission Pig Farm Profit Aquaculture Sector	1758652 32751.075 3.9 1146.3353 1721430.2	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e^a 0.06677 Uniform Tax Uniform Tax Uniform Tax Uniform Tax Uniform Tax Constant P 0 Q 31139 alpha 37.31962 beta 4.45203 F 1162096 I 138632 Co-effcient a -0.22111 b 0.808084 c 0.472857 d -0.27929 e^a 0.801633	Emission F rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector	etor 7147097.7 806466.1 3.9 57754.086 6115370.6
a b c d e A a p Q alpha beta F I Co a b c d e A a Co Co P Co P Co P Co P Co P Co P Co P	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin En At-1 A A A' Onstant 587 2996 5.5 13.6 16478 40745.6 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765	fficient ission 166,177.6 475,864.6 166,177.6 170,033.8 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	13 1758652 32751.075 3.9 1146.3353 1721430.2 136036628 35544679	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e*a 0.06677 Uniform Tax Uniform Tax View Constant P 0 0 31139 alpha 37.31962 beta 4.452037 F 1162096 I 138632 Co-effcient a -0.27192 beta 4.452037 F 1162096 I 138632 Co-effcient a -0.27192 e*a 0.801633	Emission F rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	etor 7147097.7 806486.1 3.9 57754.086 6115370.6 6115370.6 280395717 26238.384
a b c d e^a P Q alpha beta F I Co-i b c d e^a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin En Act A A' A' A' A' A' A' A' A' A' A' A' A' A	fficient ission 166,177.6 475,684.6 166,177.6 170,033.6 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	1758652 32751.075 3.9 1146.3353 1721430.2	a -2.7065 b 1.381092 c 0.169197 d -0.40722 e*a 0.06677 Uniform Tax Uniform Tax Uniform Tax Uniform Tax Constant P 0 0 31139 alpha 37.31962 beta 4.452037 F 116206 I 138632 Co-effcient a -0.22111 b 0.808064 c 0.472857 d -0.27929 e*a 0.801633	Emission F rban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ctor 7147097.7 806486.1 3.9 57754.086 6115370.6 6115370.6 280395717

### Table C-2: Mathematical Decision-making model of Non-uniform and Uniform tax in sub-basin RF

	Subbasin	n Profit 1098741156						
	Transfer co							
	Subbasin E							
	At-							
	A A'	475,393.67 476,298.02				Emission P	ass An	prove
		Pig Farm Sector			Urt	oan Community Sec		prove
			47507000					
р	onstant	Revenue Abatement Cost	17527820	P	onstant	Revenue	17594498 3490648	
Q	587 29860	Abatement Cost	2078352.19 0.91	Q	0 76657	Abatement Cost T	3490646 14.96	
alpha	29.20984	Emission	311767.19	alpha	49.65039	Emission	65166.587	
beta	69.79607			beta	5.6686			
F	872205.8	Pig Farm Profit	15165759.7	F	3806050	Urban Profit	13128958	
1	2084111			1	434537.9			
a CO-	effcient -1.18494			a	effcient -0.22111			
b	0.719655			b	0.808064			
c	0.523361			c	0.472857			
d	-0.13651			d	-0.27929			
e^a	0.305765			e^a	0.801633			
		Aquaculture Sector				Factory Sector		
	onstant	Revenue	1018692885		onstant	Revenue	195685865	
P Q	55502500 18.354	Abatement Cost T	142150208 20.65	PQ	- 22849	Abatement Cost T	107759.18	
Q alpha	18.354 1674357	Emission	20.65	alpha	22849 5.948243	Emission	2.25 19502.873	
beta	28684.54	LINISSION	10001.0100	beta	5.698083	Linioolon	.0002.010	
F	30731143	Aquaculture Profit	874912215	F	135911.4	Factory Profit	195534224	
	526476			1	130195.5			
	effcient			Co-	effcient -2.7065			
a b	3.679473 0.466506			ab				
a b c	0.466506			a b c	1.381092 0.169197			
b c d	0.466506			b	1.381092			
b c d	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co	efficient -		b c d e^a	1.381092 0.169197 -0.40722	5.92		
b c d	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1	efficient - mission 475,864./ -	86	b c d e^a	1.381092 0.169197 -0.40722 0.06677	5.92		
b c d	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er	efficient - mission 475,8643	86	b c d e^a	1.381092 0.169197 -0.40722 0.06677	5.92 Emission P	ass Ap	prove
b	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1 A	efficient - mission 475,8643 - 475,8643	86	b c d e^a	1.381092 0.169197 -0.40722 0.06677	嗖 V		prove
b c d e^a	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> Er At-1 A A	efficient 475,864. Mission 475,864. 475,864. 476,298. Pig Farm Sector	86 86 02	b c d e^a Un	1.381092 0.169197 -0.40722 0.06677	Emission P ban Community Se	ctor	prove
b c d e^a	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1 A	efficient mission 475,8643 475,8643 475,283	86	b c d e^a Un	1.381092 0.169197 -0.40722 0.06677	Emission P		prove
b c d e^a e^a Co P Q	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin E At-1 A A Y Subbasin E At-1 Subbasin Subbasin Subbasin A A Subbasin Sub	efficient mission 475,864 475,864 475,864 475,288 475,298 475,2975,2975,2975,2975,2975,2975,2975,29	86 02 17527620 2602570.85 5.92	b c e^a Un C P Q	1.381092 0.169197 0.040722 0.06677 iform Tax iform Tax Un Constant 0 76657	Emission P ban Community Se Revenue Abatement Cost T	ctor 17594498 2851087 5.92	prove
b c d <u>e^aa</u> Cc P Q alpha	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> Ei <b>At-1</b> A <b>A</b> <b>A</b> <b>Constant</b> 587 29860 29.20984	efficient mission 475,864. 475,875. 475,975. 475	86 02 17527820 2602570.85	b c d e^a Un P Q alpha	1.381092 0.168197 -0.40722 0.06677 wiform Tax Unconstant 0 76657 49.65039	Emission P ban Community Se Revenue Abatement Cost	ctor 17594498 2851087	prove
b c d <u>e^a</u> Cc P Q alpha beta	0.466506 0.544964 -0.01147 39.62551 Subbasin At-1 A A A Subtasin El At-1 A A A Subbasin El At-1 A A A Subbasin El At-1 A A A	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c e^a Un C P Q	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 76657 49.6503 9.5.6666	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d <u>e^aa</u> Cc P Q alpha	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> Ei <b>At-1</b> A <b>A</b> <b>A</b> <b>Constant</b> 587 29860 29.20984	efficient mission 475,864 475,864 475,864 475,288 475,298 475,2975,2975,2975,2975,2975,2975,2975,29	86 02 17527620 2602570.85 5.92	b c d e^a Un P Q alpha beta F I	1.381092 0.168197 -0.40722 0.06677 iiform Tax U Constant 0 76657 49.65039 5.6686 3806050 434537.9	Emission P ban Community Se Revenue Abatement Cost T	ctor 17594498 2851087 5.92	prove
b c d e^a P Q alpha beta F I Co-	0.466506 0.544964 -0.01147 39.62551 Subbasin At-1 A A A Subtasin E At-1 A A A Subbasin E At-1 A A A Subbasin E At-1 A A Subbasin E At-1 A A Subbasin E At-1 A A Subbasin E Subbasin E At-1 A A Subbasin E Subbasin E At-1 A A Subbasin E Subbasin E At-1 A A Subbasin E Subbasin Subbasin Subbasin Subbasin Subbasin Subbasin Subbasin Subbasin Subba	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c d e^a Un P Q alpha beta F I C	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 76657 49.65039 5.6686 3806050 434537.9 0-effcient	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d d e^a P Q alpha beta F I Co- a	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin El At-1 A A A' Subbasin El At-1 A A' Sign 29.0984 89.79607 87.2005.8 2084111 efficient -1.18494	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c d e^a Un O aipha beta F I c a	1.381092 0.169197 0.040722 0.06677 iform Tax iform Tax understand Constant 0 76657 49.6503 9.6686 3806050 434537.9 o-effcient -0.22111	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d e^a P Q alpha beta F I Co- a b	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> <b>At-1</b> <b>A</b> <b>A'</b> <b>Onstant</b> 587 29660 29.20984 69.79607 872205.8 2084111 - <b>effcient</b> -1.18494 0.719655	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c d e^a Un P Q alpha beta F I C c a b	1.381092 0.168197 0.040722 0.06677 iform Tax iform Tax U Constant 0 76657 49.65039 5.8686 3806050 434537.9 0-effcient -0.22111 0.808064	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d d e^a P Q alpha beta F I Co- a	0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin El At-1 A A A' Subbasin El At-1 A A' Sign 29.600 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 20.209844 20.20984 20.2	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c d e^a Un O aipha beta F I c a	1.381092 0.169197 0.040722 0.06677 iform Tax iform Tax understand Constant 0 76657 49.6503 9.6686 3806050 434537.9 o-effcient -0.22111	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d d e^a P Q alpha beta F I Co- a b c	0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A Sonstant 587 29860 29.20884 69.79607 872205.8 2084111 -effcient -1.18494 0.719655 0.523361	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164	b c d e^a Un P Q aipha beta F I C a b c	1.381092 0.169197 -0.40722 0.06677 afform Tax uform Tax	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d d e^a P Q alpha beta F I Co. a b c d	0.466506 0.544964 0.011147 39.62551 <b>Subbasin E</b> <b>Subbasin E</b> <b>At-1</b> A A' <b>Subbasin E</b> 587 29660 29.20984 69.79607 872205.8 2084111 -effcient -1.16494 0.719655	efficient mission 475,864 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,875 475,975 475,	86 02 17527820 2602570.85 5.92 60011.2164 14569982.7	b c d e^a Un P Q alpha beta F I C a a b c d	1.381092 0.169197 0.040722 0.06677 iform Tax uniform	Emission P iban Community Se Revenue Abatement Cost T Emission	ctor 17594498 2851087 5.92 134505.24	prove
b c d e*a Cc P Q alpha beta F I Co- a b c d e^a Co- c c Co- c c Co- c c c Co- c c c c c c c c c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.62551 Transfer co Subbasin Er At-1 A A A Onstant 567 29.600 29.20984 69.79607 872205.8 2084111 -effcient -1.18494 0.719655 0.523361 -0.13651 0.305765	efficient mission 475,864) 475,864) 475,864) 475,864) 475,288 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	86 86 02 17527820 2602570.85 5.92 60011.2164 14569982.7	b c d e^a Un P Q alpha beta F I C c a b c a b c a b c a c c c c c c c c c	1.381092 0.169197 0.040722 0.06677 iform Tax uniform	Emission P Iban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue	etor 17594498 2851087 5.92 134505.24 13947140 195685865	prove
b c d e*a Cc P Q alpha beta F I Co- a b c d e^a Co- c c Co- c c Co- c c c Co- c c c c c c c c c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin Ei</b> <b>Subbasin Ei</b> <b>SubbasinS</b>	efficient mission 475,864 475,864 475,864 475,864 475,208 475,208 475,208 475,204 475,	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442	b c d e^a Un e a ipha beta F I c a a b c d e^a	1.381092 0.168197 -0.00722 0.06677 iform Tax U Constant 0 76657 49.65039 5.6686 3806050 434537.9 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission P Iban Community Se Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	etor 17594498 2851087 5.92 134505.24 13947140 13947140	prove
b c d d e*a Co alpha beta I Co a b c c d e*a Co Q O	0.466506 0.544964 0.01147 39.62551 <b>Subbasin E</b> <b>Subbasin E</b> <b>At-1</b> A A' <b>Subbasin E</b> <b>Subbasin E</b> <b>Subbasin E</b> <b>At-1</b> A A' <b>Subbasin E</b> <b>Subbasin E</b> <b>SubbasinSubbas</b>	efficient mission 475,864 476,989 475,864 476,989 475,864 476,989 476,999 476,	17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 10118692885 140150442 5.92	b c d e^a Un e^a alpha beta F I c a a b c a b c c a c f e^a C f O O O	1.381092 0.169197 0.040722 0.06677 iform Tax iform Tax understand 0 76657 49.6503 5.6686 3806050 434537.9 0-effcient -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.872857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22111 0.808064 0.472857 -0.22124 0.808064 0.472857 -0.22124 0.808064 0.472857 -0.22124 0.808064 0.472857 -0.22124 0.808064 0.472857 0.808064 0.808064 0.808064 0.472857 0.808064	Emission P ban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 17594498 2851087 5.92 134505.24 13947140 19568858865 142571.66 5.92	pprove
b c d e*a Cc Q alpha beta F I Co- a b c d e*a	0.466506 0.544964 -0.01147 39.62551 <b>Subbasin Ei</b> <b>Subbasin Ei</b> <b>SubbasinS</b>	efficient mission 475,864) 475,864) 475,864) 475,864) 475,288 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442	b c d e^a Un P Q alpha beta F I C c a b c a b c a b c a c c c c c c c c c	1.381092 0.168197 -0.00722 0.06677 iform Tax U Constant 0 76657 49.65039 5.6686 3806050 434537.9 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission P Iban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost	etor 17594498 2851087 5.92 134505.24 13947140 13947140	prove
b c d d e*a Cc alpha beta F l Co- a b c d d e*a Cc Q alpha	0.466506 0.544964 0.011147 39.62551 <b>Subbasin Er</b> <b>Subbasin Er</b> <b>Subbasin Er</b> <b>At-1</b> <b>A</b> <b>A'</b> <b>Constant</b> 567 29600 29.20984 69.79607 872205.8 2084111 <b>-1</b> .18494 0.719655 0.523361 0.305765 <b>Constant</b> 55502500 18.354 1674357	efficient mission 475,864 476,989 475,864 476,989 475,864 476,989 476,999 476,	17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 10118692885 140150442 5.92	b c d e^a Un P Q alpha beta F I C Q alpha beta F I C Q alpha	1.381092 0.169197 0.040722 0.06677 iform Tax 0 0 Constant 0 76657 49.65039 5.6686 3806050 434537.9 0-effcient -0.22111 0.808064 0.472857 -0.27829 0.801633 Constant 22449 5.548243 5.548243 5.548243 5.548243 5.5483511.4	Emission P ban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 17594498 2851087 5.92 134505.24 13947140 19568858865 142571.66 5.92	prove
b c d d e^a P Q alpha beta F c c d e^a Co a b c c d d e^a E C Q alpha beta F I	0.466506 0.544964 0.011147 39.62551 <b>Subbasin Er</b> <b>Subbasin Er</b> <b>At-1</b> <b>A</b> <b>A'</b> <b>Constant</b> 567 29600 29.20984 69.79607 872205.8 2084111 <b>-1.18494</b> 0.719655 0.523361 -0.13651 0.305765 <b>Constant</b> 55502500 18.354 1674357 28684.54 1674357 28684.54 30731143 3526475	efficient mission 475,864, 475,864, 475,864, 475,864, 475,208, Pig Farm Sector Revenue Abatement Cost T Revenue Abatement Cost Revenue Abatement Cost T Emission	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442 5.92 271541.365	b c d e^a Un e^a C Q alpha beta F I C Q alpha beta F I Q alpha beta F I	1.381092 0.168197 0.040722 0.06677 iform Tax 0 Constant 0 76657 49.65039 5.6666 3806050 434537.9 0.6657 -0.27829 0.801633 Constant 22849 5.946243 5.946243 5.946243 5.946243 3.698083 135911.4 130195.5	Emission P iban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 17594498 2851087 5.92 134505.24 13947140 195685865 142571.66 5.92 9807.0415	pprove
b c d d e*a Cc P o alpha beta F I co c d d e*a a beta F I Co Co Co Co Co Co Co	0.466506 0.544964 0.01147 39.62551 Subbasin E At-1 A A A Constant 587 29860 29.2084 69.79807 872205.8 2084111 69.79807 872205.8 2084111 effcient -1.18494 0.719855 0.523381 -0.13651 0.305765 0.55502500 18.354 1674357 28684.54 30731143 526476 effcient	efficient mission 475,864, 475,864, 475,864, 475,864, 475,208, Pig Farm Sector Revenue Abatement Cost T Revenue Abatement Cost Revenue Abatement Cost T Emission	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442 5.92 271541.365	b c d e^a Un e^a C Q alpha beta F I C Q alpha beta F I Q alpha beta F I	1.381092 0.169137 0.040722 0.06677 iform Tax iform Tax Un Constant 0 76657 49.6503 95.6686 3806050 434537.9 0.22111 0.808064 0.472857 -0.27929 0.801633 0.80	Emission P iban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 17594498 2851087 5.92 134505.24 13947140 195685865 142571.66 5.92 9807.0415	pprove
b c d d e*a Co alpha beta beta b c c c c c c c c c c c c c c c c c c	0.466506 0.544964 0.001147 39.62551 <b>Subbasin E</b> <b>Subbasin E</b> <b>At-1</b> <b>A</b> <b>A'</b> <b>Sonstant</b> 587 29660 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 29.20984 20.2058 20.84111 -1.16494 0.719655 20.82361 -0.13651 0.305765 <b>Sonstant</b> 55502500 18.354 1674357 2864.54 30.731143 525476 -effcient 3.679473	efficient mission 475,864, 475,864, 475,864, 475,864, 475,208, Pig Farm Sector Revenue Abatement Cost T Revenue Abatement Cost Revenue Abatement Cost T Emission	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442 5.92 271541.365	b c d e^a Un e^a o alpha beta F I c a b c alpha beta F I c a a b c a b c a a b t c a a b c a a b t c a a a c a a a c a a a c a a a c a a a c a a a c a a a a c a a a a a c a a a a a b a a a a	1.381092 0.169197 0.040722 0.06677 iform Tax 0 0 Constant 0 76657 49.65039 5.6686 3806050 434537.9 0-effcient -0.22111 0.808064 0.472857 0.27529 0.801633 Constant -2249 5.948243 5.548644 5.548243 5.548444 5.548444 5.5484444444444444444	Emission P iban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 17594498 2851087 5.92 134505.24 13947140 195685865 142571.66 5.92 9807.0415	prove
b c d d e*a Cc P o alpha beta F I co c d d e*a a beta F I Co Co Co Co Co Co Co	0.466506 0.544964 0.61147 39.62551 Subbasin Transfer co Subbasin At-1 A A' Sonstant 587 29860 29.20884 69.79607 872205.8 2084111 69.79607 872205.8 2084111 -1.18494 0.719655 0.523061 -0.13651 0.305765 S55502500 18.354 1674357 28684.54 30731143 56476 effcient 3.679473 0.466506 0.544964	efficient mission 475,864, 475,864, 475,864, 475,864, 475,208, Pig Farm Sector Revenue Abatement Cost T Revenue Abatement Cost Revenue Abatement Cost T Emission	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442 5.92 271541.365	b c d e^a Un e^a C Q alpha beta F I C Q alpha beta F I Q alpha beta F I	1.381092 0.169137 0.040722 0.06677 iform Tax iform Tax Un Constant 0 76657 49.6503 95.6686 3806050 434537.9 0.22111 0.808064 0.472857 -0.27929 0.801633 0.80	Emission P iban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 17594498 2851087 5.92 134505.24 13947140 195685865 142571.66 5.92 9807.0415	prove
b c d d e*a P O alpha beta F C c d e*a Co alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha beta S Co d d c d d d d d d d d d d d d d d d d	0.466506 0.544964 0.001147 39.62551 <b>Subbasin E</b> <b>Subbasin E</b> <b>Sub</b>	efficient mission 475,864, 475,864, 475,864, 475,864, 475,208, Pig Farm Sector Revenue Abatement Cost T Revenue Abatement Cost Revenue Abatement Cost T Emission	86 86 17527820 2602570.85 5.92 60011.2164 14569982.7 1018692885 140150442 5.92 271541.365	b c d e^a Un e^a b ta F I c d e^a d e^a C Q alpha beta F I C Q alpha beta F I C Q alpha beta F I C Q alpha beta F I C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C C Q alpha beta C C Q alpha beta C C C Q alpha beta C C C Q alpha beta C C C Q alpha beta C C Q alpha beta C C Q alpha beta C C Q alpha beta C C C Q alpha beta C C C Q alpha beta C C C C C C C C C C C C C C C C C C C	1.381092 0.168197 0.040722 0.06677 iform Tax 0.06677 iform Tax 0 76657 49.65039 5.6666 3806050 434537.9 0.6657 49.65039 5.6666 3806050 434537.9 0.27112 0.808064 0.472657 -0.27829 0.801633 Constant 22849 5.946243 5.946444 5.94644444444444444444444444444444444444	Emission P iban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 17594498 2851087 5.92 134505.24 13947140 195685865 142571.66 5.92 9807.0415	prove

#### Subbasin Profit 261682595 Transfer coefficient Subbasin Emission 138337.465 At-1 169749.673 138337.465 А Emission Pass Approve Urban Community Sector Pig Farm Sector Constant Revenue 0 Constant Revenue 397532.8 0 Abatement Cost 0 Р 0 Abatement Cost 50370.59 P Q 0 Т 0 Q 1732 Т 3.81 alpha beta 0 Emission alpha 43.8 3692.354 0 Emission 4.745 0 beta Pig Farm Profit 333094.3 0 75861.6 Urban Profit 0 8218.34 Co-effcient Co-effcient -0.22111 0.808064 -1.18494 0.719655 a b b 0.523361 0.472857 c d c d -0.13651 -0.27929 e^a 0.305765 0.801633 Aquaculture Sector Factory Sector 3.02E+08 39866071 Constant Revenue Constant Revenue 55502500 Abatement Cost 79343470 Р 21409.36 Р Abatement Cost , Q alpha beta 5.437 Т 6.8 Q 803 Т 10.74 3193750 Emission 133833.7 alpha 34.74545 Emission 811.395 54750 17364419 297675.8 beta 2.245455 Factory Profit Aquaculture Profit 2.22E+08 39835947 27900.6 1803.1 Co-effcient Co-effcient 3.679473 -2.7065 1.381092 0.169197 0.466506 b b c d c d -0.01147 -0.40722

e^a

0.06677

	Subbasin P				Uni	form Tax 👘	6.75	
	Transfer coef							
	Subbasin Emi							
	At-1	166,177.83						
	A	138,304.08						
	A*	138,463.74					Emission Pa	iss Approve
		Pig Farm Sector				Ur	ban Community Sec	tor
Co	onstant	Revenue	0		С	onstant	Revenue	397532.8
Р	0	Abatement Cost	0	F	<b>,</b>	0	Abatement Cost	57069.2
Q	0	Т	0	G	2	1732	т	6.75
alpha	0	Emission	0	a	lipha	43.8	Emission	2361.288
beta	0			L.	oeta	4.745		
F	0	Pig Farm Profit	0	F		75861.6	Urban Profit	324524.9
1	0			1		8218.34		
Co	effcient		0.7		Co	-effcient		
a	-1.18494			a		-0.22111		
b	0.719655		0010	L.	)	0.808064		
c	0.523361			c	:	0.472857		
d	-0.13651			c	-	-0.27929		
e^a	0.305765	0101		e	e^a	0.801633		
		Aquaculture Sector					Factory Sector	
Co	onstant	Revenue	301767093		с	onstant	Revenue	39866071
Р	55502500	Abatement Cost	79336830	F	)		Abatement Cost	18714.59
Q	5.437	Т	6.75	0	2	803	Т	6.75
alpha	3193750	Emission	134813.78	a	lpha	34.74545	Emission	1129.021
beta	54750			L.	oeta	2.245455		
F		Aquaculture Profit	221520270	F	-	27900.6	Factory Profit	39839736
1	297675.8			1		1803.1		
Co	effcient				Co	-effcient		
a	3.679473			a	1	-2.7065		
b	0.466506			L.	)	1.381092		
c	0.544964			c	:	0.169197		
d	-0.01147			c	1	-0.40722		
e^a	39.62551				e^a	0.06677		

39.62551

e^a

#### Table C-3: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin LJ

### Table C-4: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin LK

	Subbasi	n Profit 359937611						
	Transfer c							
	Subbasin							
	At A							
	A					Emission Pa	88	Арргоvе
	~	Pig Farm Sector			Uri	oan Community Sec		491010
Co	onstant	Revenue	0	Ce	onstant	Revenue	428977.3	
	0	Abatement Cost	0	P	0	Abatement Cost	30000.75	
	Ō	Т	0	Q	1869	Т	3.8	
pha	0	Emission	0	alpha	24.20492	Emission	2204.954	
eta	0			beta	2.622199			
	0	Pig Farm Profit	0	F	45238.99	Urban Profit	390597.8	
<b>c</b> .	0			-	4900.891			
C0-	-effcient -1.18494			a co-	-effcient -0.22111			
	0.719655			b	0.808064			
	0.523361			c	0.472857			
	-0.13651			d	-0.27929			
`a	0.305765			e^a	0.801633			
		Aquaculture Sector				Factory Sector		
6	onstant	Revenue	489809563	. C.	onstant	Revenue	0	
	55502500	Abatement Cost	128785381	P	0	Abatement Cost	0	
	8.825	T	6.8	Q	0	T	0	
pha	3193750	Emission	217230.63	alpha	0	Emission	0	
eta	54750			beta	0			
	28184844	Aquaculture Profit	359547013	F	0	Factory Profit	0	
	483168.8			-	0			
	-effcient			Co-	effcient			
Co								
Co.	3.679473			a	-2.7065			
Co.	3.679473 0.466506			b	1.381092			
	3.679473							
Co. .^ .^a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co	efficient -		b c d e^a	1.381092 0.169197	6.77		
	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasir	Defficient         -           mission         219,586.           1         138,304.	15 08	b c d e^a	1.381092 0.169197 -0.40722 0.06677	6.77		
	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin E At-	Defficient         -           imission         219,586.           1         138,304.           219,586.         219,586.	15 08 15	b c d e^a	1.381092 0.169197 -0.40722 0.06677	6.77 Emission Pa	155 /	Approve
	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Fransfer cc Subbasin E At- A	Defficient         -           imission         219,586.7           1         138,304.9           219,586.7         219,586.7	15 08 15	b c d e^a	1.381092 0.169197 -0.40722 0.06677			Approve
^a	3.679473 0.46506 0.544964 -0.01147 39.62551 Subbasin Fransfer co Subbasin E At A	befficient	15 08 15 34 0	b c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax Ur Constant	Emission Pa ban Community Sec Revenue	tor 428977.3	Approve
<sup>^</sup> a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer or Subbasin E At- A A A	efficient 219,586 1 138,304 219,586 219,586 219,586 219,581 219,531 Pig Farm Sector Revenue Abatement Cost	15 08 15 34 0 0	b c d e^a Un C	1.381092 0.169197 -0.40722 0.06677 iform Tax Un constant 0	Emission Pa ban Community Sec Revenue Abatement Cost	tor 428977.3 34031.93	Approve
<mark>^a</mark> Co	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A' onstant 0 0	refficient 219,586. 1 138,304 219,586. 219,586. 219,586. 219,631. Pig Farm Sector Revenue Abatement Cost T	15 08 15 34 0 0 0	b c d e^a Un C P Q	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax Ur constant 0 1869	Emission Pa ban Community Sec Revenue Abatement Cost T	tor 428977.3 34031.93 6.77	Approve
<u>*a</u> Co	3.679473 0.465506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> <b>At</b> A <b>A</b> <b>A</b> <b>O</b> <b>O</b> 0 0	efficient 219,586 1 138,304 219,586 219,586 219,586 219,581 219,531 Pig Farm Sector Revenue Abatement Cost	15 08 15 34 0 0	b c_d de^a Un P Q alpha	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax Un constant 0 1869 24.20492	Emission Pa ban Community Sec Revenue Abatement Cost	tor 428977.3 34031.93	Approve
<u>`a</u> Co	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A' onstant 0 0	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0	b c d e^a Un C P Q	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax Ur constant 0 1869	Emission Pa ban Community Sec Revenue Abatement Cost T	tor 428977.3 34031.93 6.77	Approve
<u>`a</u> Co	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin E</b> At- A A A A Onstant 0 0 0	refficient 219,586. 1 138,304 219,586. 219,586. 219,586. 219,631. Pig Farm Sector Revenue Abatement Cost T	15 08 15 34 0 0 0 0	b c d e^a Un Un C P Q alpha beta	1.381092 0.169197 -0.40722 0.06677 iform Tax understant 0 1869 24.20492 2.622199	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
<sup>^</sup> a Co Dha zta	3.679473 0.46506 0.544964 -0.01147 39.62551 <b>Subbasin</b> At A A A A A A A A A A A A A A A A A A	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0 0	b c d e^a Un Un P Q alpha beta F I	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 1869 24.20492 2.622199 45238.99 45208.99 4590.891	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
<sup>n</sup> a Co Dha eta	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin E</b> At- A A A A A A A A A A A A A A A A A A	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0 0	b c d e^a Un Un P O alpha beta F I Co a	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 1869 24.20492 2.622199 45238.99 45238.99 45238.99 1900.851 -o.22111	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
<sup>^</sup> a Co Dha zta	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin E</b> At- A A A A A A A A A A A A A A A A A A	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0 0	b c d e^a Un Vn P Q alpha beta F I Co a b b	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax Un constant 0 1869 24.20492 24.20492 24.20492 24.20492 24.20492 24.20492 24.20492 24.20492 24.20492 0.66278 0 1869 4900.891 0-effcient -0.22111 0.808064	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
<sup>n</sup> a Co Dha eta	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Fransfer co</b> <b>Subbasin</b> At- A A <b>Subbasin</b> At- A O 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0 0	b c d e^a Un Un P Q alpha beta F I Co a b c	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 1869 24.20492 2.622199 45238.99 4900.891 0.422857 0.808064 0.472857	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
Na Co Dha ta Co-∩	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer co Subbasin E At- A A A A A A A A A A A A A A A A A A	Abatement Cost The Sign Cost Abatement Cost Emission	15 08 15 34 0 0 0 0	b c d d e^a Un Un O alpha beta F I C c a b b c c d	1.381092 0.169197 -0.40722 0.06677 iform Tax Un constant 0 1869 24.20492 2.622199 45238.99 45238.99 45238.99 45238.99 1890 -effcient -0.22111 0.0808064 0.472857 -0.27929	Emission Pa ban Community Sec Revenue Abatement Cost T Emission	tor 428977.3 34031.93 6.77 1403.94	Approve
Na Co Dha ta Co-∩	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Fransfer co</b> <b>Subbasin</b> At- A A <b>Subbasin</b> At- A O 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	pefficient 219,586 1 138,304 1 219,586 219,586 219,586 219,586 219,586 219,586 219,581 219,581 219,581 219,581 219,581 219,581 219,586 219,587 219,58	15 08 15 34 0 0 0 0	b c d e^a Un Un P Q alpha beta F I Co a b c	1.381092 0.169197 -0.40722 0.06677 iform Tax Un Constant 0 1869 24.20492 2.622199 45238.99 4900.891 0.422857 0.808064 0.472857	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit	tor 428977.3 34031.93 6.77 1403.94	Approve
^a Co pha sta Co 'a	3.679473 0.46506 0.544964 -0.01147 39.62551 <b>Subbasin</b> A A A A A A A A A A A A A A A A A A A	Aquaculture Sector		b c d e^a Un Vn Alpha beta F I Co a beta c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax Un constant 0 1869 24.20492 2.622199 45238.99 45238.99 45238.99 45238.99 45238.99 0.801663	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7	Approve
Co Dha ta Co-i	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue	4.9E+08	b c d e^a Un Vn Alpha beta F I Co a beta c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax Un constant 0 1869 24.20492 2.622199 45238.99 45238.99 45238.99 45238.99 1890 -effcient -0.22111 0.0808064 0.472857 -0.27929	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit	tor 428977.3 34031.93 6.77 1403.94	Approve
^a Co pha sta Co 'a	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin E</b> At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector		b c d e^a Un P O alpha beta F I C a b b c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax Un constant 0 1869 24.20492 2.622199 45238.99 45238.99 45238.99 45238.99 45238.99 45238.99 45238.99 0.808064 0.472857 -0.27929 0.801633	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7	Approve
Aa Co Pha Eta Co	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost Revenue Abatement Cost Revenue Abatement Cost	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d e^a Un P O alpha beta F I Co a b c d d e^a Co Q alpha C Q Q alpha D C Q Q alpha	1.381092 0.169197 -0.40722 0.06677 iform Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profession Pr	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0	Approve
Na Co Dha tta Co-i ta Co	3.679473 0.46506 0.544964 -0.01147 39.62551 <b>Subbasin E</b> At- Subbasin E At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d e^a Un P Q alpha beta F I C a b c d e^a C Q alpha beta	1.381092 0.169197 0.040722 0.06677 iform Tax iform Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve
<sup>k</sup> a Co Dha ta Co	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> At A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Adatement Cost T Emission Pig Farm Profit Adatement Cost T Emission Pig Farm Profit J Adatement Cost T Emission T Emission T T T Cost T T T T T T T T T T T T T	4.9E+08 1.29E+08 6.77	b c d e^a Un P O alpha beta F I Co a b c d d e^a Co Q alpha C Q Q alpha D C Q Q alpha	1.381092 0.169197 0.040722 0.06677 iform Tax Ur Constant 0 1869 24.20492 2.622199 45238.99 4500.891 0.472657 -0.22111 0.472657 -0.27929 0.801633 Constant 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0	Approve
Na Co Dha eta Co- Go Co Dha eta	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> A A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d e^a Un P O alpha beta F I Co a b c c d d e^a C C P O alpha beta F I C C a b b c c f I I C C	1.381092 0.169197 -0.40722 0.06677 iform Tax 0 1859 24.20492 2.622199 45238.99 45238.99 45238.99 45238.99 45238.99 0.801633 0 0.02111 0.0806064 0.472857 -0.27929 0.801633 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve
Co Dha ta a Co Dha ta	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d d e^a Un P O alpha beta F I C C a b c c c d a b b c c c f l C C Q alpha beta F I C Q alpha beta I C C C C C C C C C C C C C C C C C C	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve
Co Dha ta a Co Dha ta	3.679473 0.46506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Transfer co</b> <b>Subbasin</b> At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d e^a Un P Q alpha beta F I Co a beta F C Q alpha beta F I C Q alpha beta F I C Q alpha beta	1.381092 0.168197 0.040722 0.06677 <b>iform Tax</b> <b>iform Tax</b> <b>ur</b> <b>constant</b> 0 1869 24.20492 2.622199 45238.99 4900.891 0.808064 0.472857 -0.27929 0.801633 <b>constant</b> 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve
*a Co pha eta Co- Co-	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer cc Subbasin E At- A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d d e^a Un P O alpha beta F I C C a b c c c d a b b c c c f l C C Q alpha beta F I C Q alpha beta I C C C C C C C C C C C C C C C C C C	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve
<u>^a</u> Co Pha eta Co- Co Pha eta	3.679473 0.466506 0.544964 -0.01147 39.62551 <b>Subbasin</b> <b>Fransfer co</b> <b>Subbasin</b> A A A A A A A A A A A A A A A A A A A	Aquaculture Sector Revenue Abatement Cost T Revenue Abatement Cost T Emission Aquaculture Sector Revenue Abatement Cost T Emission	15 08 15 34 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	b c d e^a VIN P Q alpha beta F I C Q alpha beta C Q alpha beta F I C Q alpha beta I C C Q alpha beta C C	1.381092 0.163197 0.40722 0.06677 iform Tax Un 0 1869 24 20492 2.622199 45238.99 45238.99 45238.99 45238.99 45238.99 0.808064 0.472857 -0.27129 0.808064 0.472857 -0.27929 0.801633 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Profit	tor 428977.3 34031.93 6.77 1403.94 385440.7 0 0 0 0 0 0 0 0 0 0 0 0 0	Approve

### Table C-5: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin LL

	Subbasi	n Profit 581992955					
	Transfer c						
		Emission 353202.434					
	At-						
	A						
	A	353,518.22				Emission Pa	iss Approv
		Pig Farm Sector			Uri	ban Community Sec	tor
Co	onstant	Revenue	0	C	onstant	Revenue	1340138
	0	Abatement Cost	0	Р	0	Abatement Cost	32105.65
	0	Т	0	Q	5904	т	3.8
pha	0	Emission	0	alpha	8.199336	Emission	2359.664
eta	0	Dia Corpo Drofit	0	beta F	0.888261 48408.88	Urban Profit	1299065
	0	Pig Farm Profit	U		5244.295	orban Profit	1299000
Co-	effcient			Co	-effcient		
	-1.18494			а	-0.22111		
	0.719655			b	0.808064		
	0.523361			c	0.472857		
	-0.13651			d	-0.27929		
a	0.305765			e^a	0.801633		
		Aquaculture Sector				Factory Sector	
Co	Instant	Revenue	791077133	Ce	onstant	Revenue	0
	55502500	Abatement Cost	207997511	Р	0	Abatement Cost	0
	14.253	Т	6.8	Q	0	Т	0
pha	3193750	Emission	350842.77	alpha	0	Emission	0
eta	54750	A	50000000	beta F	0	Frank and Draffe	0
	45520519 780351.8	Aquaculture Profit	580693890	r -	0	Factory Profit	U
Co-	effcient			Co	effcient		
	3.679473			a	-2.7065		
	0.466506			b	1.381092		
	0.544084						
	0.544964			c	0.169197		
l ⊧^a	-0.01147 39.62551 Subbasit Transfer c			d e^a	0.169197 -0.40722 0.06677	6.78	
	-0.01147 39.62551 Subbasit Transfer c	oefficient 0 Emission 353366.586 4 219586.15		d e^a	-0.40722 0.06677	6.78	
	-0.01147 39.62551 Subbasii Transfer c Subbasin At-	oefficient         0           Emission         353366.586           1         219586.15           353,366.59         353,518.22		d e^a	-0.40722 0.06677	Emission Pa	
	-0.01147 39.62551 Transfer c Subbasin At- A A	oefficient         0           Emission         353366.586           1         219586.15           353,566.59         353,518.22           Pig Farm Sector		d e^a	-0.40722 0.06677	Emission Pa Dan Community Sec	tor
Co	-0.01147 39.62551 Transfer c Subbasin At- A A A	oefficient         0           Emission         353366,586           1         219586,15           353,366,59         353,518,22           Pig Farm Sector         Revenue	0	d e^a Unif	-0.40722 0.06677	Emission Pa Dan Community Sec Revenue	tor 1340138
Co	-0.01147 39.62551 Transfer c Subbasin I At A A A	oefficient         0           Emission         353366.586           1         219586.15           353,386.59         353,386.59           9         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         1	0	d e^a Unif	-0.40722 0.06677 orm Tax url onstant 0	Emission Pa Dan Community Sec Revenue Abatement Cost	tor 1340138 36431.42
Co	-0.01147 39.62551 Transfer c Subbasin At- A A A	oefficient         0           Emission         353366,586           1         219586,15           353,366,59         353,518,22           Pig Farm Sector         Revenue	0	d e^a Unif	-0.40722 0.06677	Emission Pa Dan Community Sec Revenue	tor 1340138 36431.42 6.78
Co	-0.01147 39.62551 Transfer c Subbasin At- A A Onstant 0 0	oefficient         0           Emission         353366.596           1         219586.15           353,366.59         353,318.22           Pig Farm         Sector           Revenue         Abatement Cost           Abatement Cost         T	0 0 0	d e^a Unif	-0.40722 0.06677 iorm Tax Url onstant 0 5904	Emission Pa Dan Community Sec Revenue Abatement Cost T	tor 1340138 36431.42
Co	-0.01147 39.62551 Subbasin Transfer c Subbasin At A A A Onstant 0 0 0 0 0	oefficient         0           Emission         353366.596           1         219586.15           353,366.59         353,318.22           Pig Farm         Sector           Revenue         Abatement Cost           Abatement Cost         T	0 0 0	d e^a Unif Cc P Q alpha	-0.40722 0.06677 orm Tax orm Tax Url onstant 0 5904 8.199336 0.888261 48408.88	Emission Pa Dan Community Sec Revenue Abatement Cost T	tor 1340138 36431.42 6.78
C d pha eta	-0.01147 39.62551 Subbasin At. At. A Dirstant 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif Q Q alpha beta F I	-0.40722 0.06677 orm Tax orm Tax Un sstant 0 5904 8.199336 0.888261 48408.88 5244.295	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
C d pha eta	0.01147 39.62551 Subbasin At. At. A Donstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif P O alpha beta F I Co-	-0.40722 0.06677 orm Tax orm Tax Url onstant 0 5904 8.199336 0.888261 48408.88 5244.295 5244.295	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
C d Ipha eta	-0.01147 39.62551 Transfer c Subbasin At A A A Donstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif P Q alpha beta F I Co- a	-0.40722 0.06677 orm Tax orm Tax Url onstant 0 5904 8.199336 0.888261 48408.88 5944.295 0.888261 49408.88 5944.295	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
Aa Co Ipha eta	0.01147 39.62551 Subbasin At. At. A Donstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif P O alpha beta F I Co-	-0.40722 0.06677 orm Tax orm Tax Url onstant 0 5904 8.199336 0.888261 48408.88 5244.295 5244.295	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
Co Ipha eta Co-	-0.01147 39.62551 Subbasin Transfer c Subbasin At. A A A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif Q alpha beta F I Co- a b	-0.40722 0.06677 form Tax Url postant 0 5904 8.199336 0.88261 48408.88 5244.295 effcient -0.22111 0.808064	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
Co Ipha Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif P O alpha beta F I Co- a b beta c	-0.40722 0.06677 orm Tax 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
Co Ipha eta Co-	-0.01147 39.62551 Subbasii Att A A A Distant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient         0           Emission         353366.598           1         219586.15           363.366.59         353,518.22           Pig Farm Sector         Revenue           Abatement Cost         T           Emission         Sission	0 0 0	d e^a Unif P Q alpha beta F I Co- a b c c d	-0.40722 0.06677 orm Tax orm T	Emission Pa Dan Community Sec Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712
Co Co- ^a	-0.01147 39.62551 Transfer c Subbasin At. A A A Onstant 0 0 0 0 0 0 0 effcient -1.18494 0.719655 0.523361 -0.13655	oefficient 0 Emission 35386,598 1 219586,15 333,366,59 333,57 33,57	0 0 0 0 0 0	d e^a Unif Q alpha beta F I Co- a b c c d d e^a	-0.40722 0.06677 orm Tax orm	Emission Pa ban Community Sec Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue	tor 1340138 36431.42 6.78 1500.712 1293531
Co- Co- *a Co-	-0.01147 39.62551 Transfer c Subbasin At. A A A A Onstant 0 0 0 0 0 0 0 0 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765	oefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0	d e^a Unif P Q alpha beta F I Co- a b b c d d e^a Co Q a P Co Q Co Q P Co Q Co Q Co Q Co Q Co Q	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit	tor 1340138 36431.42 6.78 1500.712 1293531
Co- Co- ^^a Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient 0 Emission 35366.566 1 219586.15 353,366.59 353,518.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 791077133 207990565 6.78	d e^a Unif P O alpha beta F I Co- a b c c d e^a Co Q	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0
Aa Cc Ipha eta Co- Co- Co- Co- Co- Ipha	-0.01147 39.62551 Transfer c Subbasin At. A A Donstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0	d e^a Unif Q alpha beta F I Co a b c c d e^a d e^a Co a b c c d d e^a	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit	tor 1340138 36431.42 6.78 1500.712 1293531
Co- Co- ^a Co- Co- Co- Co- Co- Co- Co- Co- Co- Co-	-0.01147 39.62551 Subbasin At. At. A Onstant 0 0 0 0 0 0 0 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 0.523361 -0.13655 0.523361 -0.13655 0.523361 -0.13655 0.523361 -0.13655 0.523361 -0.13655 0.553361 -0.13655 0.55355 0.5550 -5500 -5000	eefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d e^a Unif Q alpha beta b c c d e^a C c P C c P C c Q alpha beta	-0.40722 0.06677 Tax 0.0677 0.0677 0.007 0.007 0.007 0.007 0.008261 0.88261 0.88264 0.88264 0.472857 0.27929 0.20111 0.808064 0.472857 0.27929 0.801633 0.001 0.	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0 0 0
Aa Co Ipha eta Co- Co- Co- Co- Ipha eta	-0.01147 39.62551 Transfer c Subbasin At. A A Donstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	oefficient 0 Emission 35366.566 1 219586.15 353,366.59 353,518.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 791077133 207990565 6.78	d e^a Unif Q alpha beta F I Co a b c c d e^a d e^a Co a b c c d d e^a	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0
Co- Dipha Co- Co- Co- Co- Co- Co- Co- Co- Co- Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	eefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d e^a Unif P O alpha beta F I Co- a c c d e^a Cc P O alpha beta F I Co- a b b t c c d e^a	-0.40722 0.06677 orm Tax orm Tax 0 5904 8.199336 0.888261 48406.88 5244.295 effcient -0.22111 0.808064 0.472857 -0.2213 0.801633 0.801633	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0 0 0
Aa Co Ipha eta Co- Ipha eta Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	eefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d e^a Unif Q alpha beta F I Co- a b c d d e^a Q alpha beta F C Q alpha beta F I Co- a b b c c d d c d d c c c c c c c c c c c	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0 0 0
Co- Co- Co- Co- Co- Co- Co- Co- Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	eefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d e^a Unif P Q alpha beta F I Co- a c d e^a Cc Q alpha beta F I Co- a b b ta f F I Co- a b b	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0 0 0
Aa Co Ipha eta Co- Ipha eta Co-	-0.01147 39.62551 Transfer c Subbasin At. A A Onstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	eefficient 0 Emission 35366.586 1 219586.15 353,366.59 353,366.59 353,318.22 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d e^a Unif Q alpha beta F I Co- a b c d d e^a Q alpha beta F C Q alpha beta F I Co- a b b c c d d c d d c c c c c c c c c c c	-0.40722 0.06677 Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Pa ban Community Sec Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	tor 1340138 36431.42 6.78 1500.712 1293531 0 0 0 0 0 0 0

#### Subbasin Profit 1030805476 Transfer coefficient 0 Subbasin Emission 419848.993 At-1 353202.434 419848.993 А Emission Pass Approve Pig Farm Sector Urban Community Sector Revenue Revenue 0 Constant 0 Constant P 0 Abatement Cost 0 0 Abatement Cost 0 Q 0 т 0 Q 0 Т 0 alpha Ō Emission 0 alpha 0 Emission 0 beta 0 beta 0 Pig Farm Profit Urban Profit 0 0 0 0 0 0 Co-effcient Co-effcient -1.18494 -0.22111 0.719655 0.808064 b 0.523361 0.472857 С d -0.13651 -0.27929 e^a 0.305765 0.801633 e^a Aquaculture Sector Factory Sector Constant Revenue 1408819958 Constant Revenue 0 Р 55502500 Abatement Cost 373727824 Р 0 Abatement Cost 0 Q 25.383 т 10.21 0 0 T. 0 3193750 Emission 419848.993 alpha alpha 0 Emission 0 55186.69 0 beta beta 81066956 Aquaculture Profit 1030805476 0 Factory Profit 0 1400804 0 Co-effcient Co-effcient 3.679473 -2.7065 b 1.381092 0.466506 b 0.544964 0.169197 d -0.01147 -0.40722 d 39.62551 0.06677 e^; Uniform Tax 10.21 Subbasin Profit 1.030.805.475.72 Transfer coefficient 419,848.94 Subbasin Emission 353,366.59 419,848.94 At-1 А Emission Pass Approve **Pig Farm Sector** Urban Community Sector Constant Revenue 0 Constant Revenue 0 P 0 Abatement Cost 0 0 0 Abatement Cost 0 0 Q 0 Emission Emission alpha 0 0 alpha 0 0 beta 0 beta 0 Pig Farm Profit Urban Profit 0 n 0 n 0 0 Co-effcient Co-effcient -0.22111 -1.18494 a 0.719655 0.808064 b 0.523361 0.472857 c d -0.13651 -0.27929 d e^a 0.305765 0.801633 e^a Aquaculture Sector Factory Sector Constant 55502500 Revenue 1408819958 Constant Revenue 0 Abatement Cost 373727824 0 Abatement Cost 0 Q 25.383 10.21 Q 0 0 alpha 3193750 Emission 419848.942 alpha 0 Emission 0 55186.69 0 beta beta 81066956 1400804 Aquaculture Profit 1030805476 Factory Profit 0 0 Co-effcient Co-effcient 3.679473 0.466506 -2.7065 1.381092 b 0.544964 0.169197 c d -0.01147 -0.40722 39.62551 0.06677

#### Table C-6: Mathematical Decision-making model of Non-uniform and Uniform tax in sub-basin LM

## Table C-7: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin RFm

	Subbasin							
	Transfer coe Subbasin En		0					
	Subbasin En At-1							
	A	2777309	.128					
	A*	2,787,159	.76			Emission P	ass App	prove
		Pig Farm Sector	г		Urb	oan Community Se	ctor	
с	onstant	Revenue	42681357	Con	stant	Revenue	11173465.5	
•	587	Abatement Cost		Р	0	Abatement Cost	1011631.32	
<u>ک</u>	72711	_ T	0.38	Q	48806	T	6.42	
ilpha )eta	5.53 13.6	Emission	292070.654	alpha beta	27.75382 3.006664	Emission	44008.6812	
:	402091.83	Pig Farm Profit	41757319	F	1354553	Urban Profit	9879298.42	
	988869.6			i	146743.3			
	-effcient				fcient			
,	-1.18494 0.719655			ab	-0.22111 0.808064			
•	0.523361			D	0.808064			
l	-0.136506			d	-0.27929			
e^a	0.3057645			e^a	0.801633			
		Aquaculture Sect	or			Factory Sector		
с	onstant	Revenue	7688317305	Con	stant	Revenue	5798532010	
• 7	55502500	Abatement Cost		P	-	Abatement Cost	2782917.41	
2	138.522	т	10.11	Q	325375.6	Т	1.05	
lpha	1859804.5	Emission	1361943.8	alpha	9.558863	Emission	1079286	
eta:	32788.411 257623844	Aquaculture Prof	it 6474089590	beta F	11.1041 3110221	Factory Profit	5794615843	
	4541916.3			12 7	3613003	a story rivin		
	-effcient			Co-et	fcient			
) )	3.679473			a	-2.7065			
•	0.466506			b	1.381092			
	0.544964 -0.01147			c d	0.169197 -0.40722			
	0.544964		,989.60	c d e^a	0.169197	573	_	
¦ ⊧^a	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1	fficient ission 2,705 419	,009.95 ,848.94	c d e^a	0.169197 -0.40722 0.06677	573	_	
: 	0.544964 -0.01147 39.625506 Stibbasin P Transfer coel Stibbasin Em	fficient ission 2,705 419	,989.95	c d e^a	0.169197 -0.40722 0.06677	573 Emission	Pass Ap	prove
:	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1	fficient ission 2,705 419	1999-95 848-94 889-95 159-70	c d e^a	0.169197 -0.40722 0.06677			prove
i e^a	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1	fficient ission 2,705 419 2,785 2,787	1999-95 848-94 889-95 159-70	c d e^a	0.169197 -0.40722 0.06677	Emission		prove
і "^а	0.544964 -0.01147 39.625506 Subbasin P Transfer cet Subbasin et At-1 A A*	fficient assion 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos	099 95 648 94 858 95 159 76 or 42681357 at 1126296 33	c d e^a Unit	0.169197 -0.40722 0.06677 orm Tax orm tax	Emission Irban Community Se Revenue Abatement Cost	ector 11173465.5 986829.066	prove
с.	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin LM At-1 A A A' Onstant S87 72711	fficient assion 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos T	2099.95 648.94 689.95 119.70 xr 42681357 at 1126296.33 5.73	c d e^a Dnit	0.169197 -0.40722 0.06677 orms Tax up senstant 0 48806	Emission Irban Community Se Revenue Abatement Cost T	ector 11173465.5 986829.066 5.73	prove
r^a Ci Ipha	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1 A A' onstant 553	fficient assion 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos	099 95 648 94 858 95 159 76 or 42681357 at 1126296 33	c d e^a Una Co appa	0.169197 -0.40722 0.06677 0.06677 0.06677 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.000000	Emission Irban Community Se Revenue Abatement Cost	ector 11173465.5 986829.066	prove
с.	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin LM At-1 A A A' Onstant S87 72711	fficient assion 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos T	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Dnit	0.169197 -0.40722 0.06677 orms Tax up senstant 0 48806	Emission Irban Community Se Revenue Abatement Cost T	ector 11173465.5 986829.066 5.73	prove
l Aa Ci Ipha eta	0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1 A A* Onstant 557 72711 5.53 13.6 402091.83 90009.8	fficient Instant 2,705 419 2,785 2,765 2,767 Pig Farm Secto Revenue Abatement Cot T Emission	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Unit P O alpha beta F I	0.169197 -0.40722 0.06677 orm Tax orm Tax 0 westant 0 48806 27.75302 3.006664 1354553 1467433	Emission Irban Community Se Revenue Abatement Cost T Emission	ector 11173465.5 986829.066 5.73 40099.199	prove
l Aa Ci Ipha eta	0.544964 -0.01147 39.625506 Subbasin En Subbasin En At-1 A A Constant 587 72711 55.50 13.6 90009.8 90009.8	fficient Instant 2,705 419 2,785 2,765 2,767 Pig Farm Secto Revenue Abatement Cot T Emission	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Unit P O alpha beta F I	0.169197 -0.40722 0.06677 orm Tax orm Tax 0 48806 27.75302 3.006564 1354553 146743.3	Emission Irban Community Se Revenue Abatement Cost T Emission	ector 11173465.5 986829.066 5.73 40099.199	prove
l Aa Ci Ipha eta	0.544964 -0.01147 39.625506 Subbasin En At-1 A A* Onstant 557 72711 5.53 13.6 402091.83 90009.8	fficient Instant 2,705 419 2,785 2,765 2,767 Pig Farm Secto Revenue Abatement Cot T Emission	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Unit P O alpha beta F I	0.169197 -0.40722 0.06677 orm Tax orm Tax 0 westant 0 48806 27.75302 3.006664 1354553 1467433	Emission Irban Community Se Revenue Abatement Cost T Emission	ector 11173465.5 986829.066 5.73 40099.199	prove
Co Co	0.544964 -0.01147 39.625506 Subbasin En Subbasin En At-1 A A Constant 687 72711 5.50 13.6 402091.83 900009.6 efficient -1.18494 0.719655 0.523361	fficient Instant 2,705 419 2,785 2,765 2,767 Pig Farm Secto Revenue Abatement Cot T Emission	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Unit P O alpha beta F I Co a b e e	0.169197 -0.40722 0.06677 form Tax 0 form Ta	Emission Irban Community Se Revenue Abatement Cost T Emission	ector 11173465.5 986829.066 5.73 40099.199	prove
Co Co	0.544964 -0.01147 39.625506 Subbasin P Transfe 25506 Subbasin Em At-1 A A A A bonstant 5.57 72711 5.57 13.5 402081.83 900009.6 -effclent -1.18494 0.719055 0.523361 -0.1985506	fficient Instant 2,705 419 2,785 2,765 2,767 Pig Farm Secto Revenue Abatement Cot T Emission	009.95 648.94 889.95 759.70 xr 42681357 at 1126296.33 5.73 26031.7096	c d e^a Unit P O alpha beta F I Co- a b e d	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 erm Tax 0 48806 27,75302 3.006664 1354653 146743,3 effclent -0.22110 0.472857 -0.27929	Emission Irban Community Se Revenue Abatement Cost T Emission	ector 11173465.5 986829.066 5.73 40099.199	prove
Lange Co Co	0.544964 -0.01147 39.625506 Subbasin En Subbasin En At-1 A A Constant 687 72711 5.50 13.6 402091.83 900009.6 efficient -1.18494 0.719655 0.523361	fficient ission 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Co T Emission Pig Farm Profil	2099.95 848.94 889.95 119.70 xt 42681357 at 1126296.33 5.73 20031.7096 t 41401315	c d e^a Unit P O alpha beta F I Co a b e e	0.169197 -0.40722 0.06677 form Tax 0 form Ta	Emission Irban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 11173465.5 986829.066 5.73 40099.199	prove
i Is^a Ipha eta Co	0.544964 -0.01147 39.625506 Subbasin Em At-1 A A A A Constant 5.57 72711 5.57 13.5 402081.83 900009.6 -effcient -1.18494 0.719655 0.523361 -0.196505 0.3057645	fficient Ission 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos T Emission Pig Farm Profit	2099 35 2099 35 2099 35 2099 35 2099 35 2009 35 200	c d e^a Unit P o alpha beta F I Co a b e a a a a a	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Irban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 11173465.5 986829.066 5.73 40099.199 9911028	prove
i Is^a Ipha eta Co	0.544964 -0.01147 39.625506 Subbasin P Transfer coef Subbasin Em At-1 A A A onstant 5.53 13.6 402091.83 50009.8 s0009.8 -0.19655 0.523361 -0.19655 0.3057645 onstant	fficient ission 2,705 419 2,705 2767 Pig Farm Secto Revenue Abatement Cos T Emission Pig Farm Profil	2009.95 848.94 889.95 xr xr 42681357 at 1125296.33 5.73 20091.7096 t 41401315 tor 7000017305	c d e^a Unit P o alpha beta F I Co a b e a a a a a	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 erm Tax 0 48806 27,75302 3.006664 1354653 146743,3 effclent -0.22110 0.472857 -0.27929	Emission Irban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit	sector 11173465.5 986829.066 5.73 40099.199 9811028 9811028	prove
Co Co Co Co Co Co	0.544964 -0.01147 39.625506 Subbasin Em At-1 A A A A Constant 5.57 72711 5.57 13.5 402081.83 900009.6 -effcient -1.18494 0.719655 0.523361 -0.196505 0.3057645	fficient Ission 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos T Emission Pig Farm Profit	2009.95 248.94 2689.95 259.70 or 42681357 at 1126296.33 5.73 20031.7096 t 41401315 t 41401315 at 75000317305 at 1192755637	c d e^a Unit P o alpha beta F I Co a b e a a a a a	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Irban Community Se Revenue Abatement Cost T Emission Urban Profit	5790532010 4547382 19	prove
Co Co Co Co Co Co Co Co Co Co	0.544964 -0.01147 39.625506 Transfer coef Subbasin En Ar.4 A A* onstant 5.53 13.6 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 9000000.8 900000.8 90000000000	fficient ission 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Cos T Emission Pig Farm Profit	2009.95 848.94 889.95 xr xr 42681357 at 1125296.33 5.73 20091.7096 t 41401315 tor 7000017305	c d e^a Unit P Q appa beta F I Co a b ta b c a d e^a C C Q appa C Q appa	0.169197 -0.40722 0.06677 orm Tax orm	Emission Irban Community Se Revenue Abatemeent Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	sector 11173465.5 986829.066 5.73 40099.199 9811028 9811028	prove
Co Co Co Co Co	0.544964 -0.01147 39.625506 Subbasin En Subbasin En At-1 A A Constant 687 72711 553 13.6 402091.83 90009.6 effcient -1.18494 0.719655 0.523361 -0.19556 0.523361 -0.19556 0.523361 -0.19556 0.553361 -0.19555 0.55341 -0.19555 0.553500 -0.1955550 -0.195	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha Co alpha	0.169197 -0.40722 0.06677 erm Tax erm	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove
Co Co Co Co Co Co Co Co Co Co	0.544964 -0.01147 39.625506 Transference Subbasin Em Ar.4 A A' onstant 5.57 72211 5.53 13.6 402081.83 900099.6 efficient -1.18494 0.719655 0.523361 -0.3057645 onstant 55502500 138.522 1059004.5 32788.411 2576238441	fficient ission 2,705 419 2,785 2,707 Pig Farm Secto Revenue Abatement Co T Emission Pig Farm Profit Aquaculture See Revenue Abatement Co T	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P Q appa beta F I Co a b ta b c a d e^a C C Q appa C Q appa	0.169197 -0.40722 0.06677 otm Tax otm Tax 0 otm Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Irban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	5798532010 5.73 5.73 40099.199 8911028 5.798532010 4547382.19 5.73	prove
Co Ipha Co Ipha Co Co Ipha eta	0.544964 -0.01147 39.625506 Transfer coef Subbasin En At-1 A A Constant 553 13.6 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.83 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 90009.8 402091.8 90009.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 900000.8 9000000.8 90000000000	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P O alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha beta F I I Co alpha beta F I I	0.169197 -0.40722 0.06677 orm Tax orm	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove
Co Ipha Co Ipha Co Co Ipha eta	0.544964 -0.01147 39.625506 Transference Subbasin Em Ar.4 A A' onstant 5.57 72211 5.53 13.6 402081.83 900099.6 efficient -1.18494 0.719655 0.523361 -0.3057645 onstant 55502500 138.522 1059004.5 32788.411 2576238441	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P O alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha beta F I I Co alpha beta F I I	0.169197 -0.40722 0.06677 otm Tax otm Tax 0 otm Tax 0 0 0 0 0 0 0 0 0 0 0 0 0	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove
Co Ipha Co Ipha Co Co Ipha eta	0.544964 -0.01147 39.625506 Transfer coef Subbasin En At-1 A A Constant 5.53 13.6 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 50009.8 0.523361 -0.19655 0.523361 -0.196556 0.3057645 0.3057645 332788.411 257623044 4591916.3 -effcient 3.679473 0.466506	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P O alpha beta F I Co alpha beta F I Co alpha beta F I Co alpha beta F I I Co alpha beta F I I	0.169197 -0.40722 0.06677 orm Tax orm	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove
Co Co Co Co Co Co Co Co Co Co Co Co Co C	0.544964 -0.01147 39.625506 Subbasin Em At-1 A A Onstant 5.57 72711 5.57 13.5 402081.83 900095.6 effcient -1.18494 0.719055 0.523361 -0.196506 0.3057645 0.502500 138.522 105900.4 532788.411 257623844 4541910.3 effcient 3.679473 3.679473 0.465506	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P o alpha beta F I co-a b c d a <sup>t</sup> a Co- a b c c d a <sup>t</sup> a Co- a b c c d a b c c a b c c d c a b c c a b c c a b c c a b c c a b c c a b t c a b c a b t a b c a b b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a a b b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b b c a b c a b b c a b c a b c a b c a b c a b c a b c a b c c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b b c a b c a b c a b c a b c a b c a b a b	0.169197 -0.40722 0.06677 etm Tax etm Tax etm Tax etm Tax etm 48806 27,75302 3.006664 1354653 140743,3 effclent -0.221929 0.601633 emstant 325375.8 9.550063 11.1041 3110221 3013003 effclent -2.2765 1.301092 0.0169197	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove
Aa Cr Pha eta Co Co Co Co Co Co	0.544964 -0.01147 39.625506 Transfer coef Subbasin En At-1 A A Constant 5.53 13.6 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 402091.83 50009.8 50009.8 0.523361 -0.19655 0.523361 -0.196556 0.3057645 0.3057645 332788.411 257623044 4591916.3 -effcient 3.679473 0.466506	Ifficient Ission 2,705 419 2,785 2,707 Pig Farm Secte Revenue Abatement Cot T Emission Pig Farm Profit Aquaculture Sec Revenue Abatement Cot T Emission	2009.95 2009.95 2009.95 2009.70 2009.70 2009.709 2009.709 2009.709 2009.709 2009.709 2009.709 2009.705 1192753637 5.73 2007507.06	c d e^a Unit P O alpha beta F I Co- a F I Co- a F I Co- a	0.169197 -0.40722 0.06677 orm Tax orm	Emission Irban Community Se Revenue Abatemeent Cost T Emission Virban Profit Factory Sector Revenue Abatement Cost T Emission	5790532010 4547382 19 8911028	prove

### Table C-8: Mathematical Decision-making model of Non-uniform and Uniform taxin sub-basin LP

	Subbasi	n Profit 5929363389							
	Transfer c								
		Emission 154432.288							
	At-								
	A A'						Emission P	aee A	pprove
		Pig Farm Sector				Ur	ban Community See		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
	nstant	Revenue	1350100		Cor	nstant	Revenue	2643154.95	
P Q	587 2300	Abatement Cost T	17063.158	0		0 11705	Abatement Cost T	113932.293 4.43	
u alpha	5.475	Emission	0.19 12259.019		pha	14.1707	Emission	4.43	
beta	13.6875	Liniooioii	12200.010	be		1.535159	Linicolon	1102.10010	
F	12592.5	Pig Farm Profit	1330707.6	F		165868	Urban Profit	2497402.87	
۱.	31481.25			- P		17969.04			
a Co-	effcient -1.18494				Co-e	ffcient -0.22111			
a b	0.719655			b		0.808064			
с	0.523361			c		0.472857			
d	-0.13651			d		-0.27929			
e^a	0.305765			e^	a	0.801633			
		Aquaculture Sector					Factory Sector		
Co	nstant	Revenue	175221393		Cor	nstant	Revenue	5798532010	
Р	55502500	Abatement Cost	47148460	Р		10-10	Abatement Cost	375827.997	
Q	3.157	T	7.51	Q		346093	T	2.43	
alpha beta	3193750 57031.25	Emission	72009.745	al	pha eta	1.339211 0.455305	Emission	62980.728	
F	10082669	Aquaculture Profit	127532139	F		463491.6	Factory Profit	5798003139	
I I	180047.7			<b>I</b>		157577.8			
	effcient				Co-e	ffcient			
a	3.679473			a		-2.7065			
a b	3.679473 0.466506			a b c		1.381092			
a b c d	3.679473	Profit 5,929,457,591	.33				4.93		
a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1	efficient mission 154,572 2,785,689	- .92 .95	c d		1.381092 0.169197 -0.40722 0.06677	4.93		
a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin E	efficient mission 154,572	- .92 .95 .92	c d		1.381092 0.169197 -0.40722 0.06677	4.93 Emission	Pass A	Approve
a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer co Subbasin Er At-1 A	efficient mission 154,572 2,785,689 154,572	- .92 .95 .92	c d		1.381092 0.169197 -0.40722 0.06677			Approve
a b c d e^a	3.679473 0.466506 0.544964 -0.01147 39.62551 Transfer co Subbasin Er At-1 A	efficient mission 154,572 2,785,689 154,572 154,830	- .92 .95 .92	c d	Un	1.381092 0.169197 -0.40722 0.06677	Emission		Approve
a b c d <u>e^a</u>	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Ei At-1 A A	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector	- .92 .95 .92 .30	c d	Un	1.381092 0.169197 -0.40722 0.06677	Emission Urban Community So	ector	Approve
a b c d e^a e^a Co P Q	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A' nstant 587 2300	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T	92 ,95 ,92 ,30 1350100 25229,372 4,93	c d	Un C P Q	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax constant 0 11705	Emission Urban Community Se Revenue Abatement Cost T	ector 2643154.95 116623.763 4.93	Approve
a b c d e^a O o alpha	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Ei At-1 A A A' nstant 587 2300 5.475	efficient mission 154,572 2,765,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost	- 92 95 95 92 30 1350100 25229.372	c d	Un P Q alpha	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707	Emission Urban Community So Revenue Abatement Cost T Emission	ector 2643154.95 116623.763	Approve
a b c d e^a e^a Co P Q alpha beta	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin ET At-1 A A A' nstant 587 2300 5.475 13.6875	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission	92 95 95 30 1350100 25229.372 4.93 698.56973	c d	Un C P Q	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155	Emission Urban Community So Revenue Abatement Cost T Emission	ector 2643154.95 116623.763 4.93 6606.72211	Approve
a b c d e^a e^a Cor P Q alpha beta	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Ei At-1 A A A' nstant 587 2300 5.475	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T	92 ,95 ,92 ,30 1350100 25229,372 4,93	c d	Un P Q alpha beta	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707	Emission Urban Community Se Revenue Abatement Cost T Emission 9 Urban Profit	ector 2643154.95 116623.763 4.93	Approve
a b c d d e*a P Q alpha beta F I Co-4	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Ei Subbasin Ei At-1 A A A' nstant 587 2300 5.475 13.6875 12592.5 31481.25 effcient	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission	92 95 95 30 1350100 25229.372 4.93 698.56973	c d	Un P Q alpha beta F I C	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165868 17969.04 o-effcient	Emission Urban Community So Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211	Approve
a b c d e^a e^a P Q alpha beta F I Co-4 a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin E At-1 A A A Saft 2300 5.475 13.6875 12592.5 31481.25 234451.25 234451.25	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission	92 95 95 30 1350100 25229.372 4.93 698.56973	c d	Un C P Q alpha beta F I C c a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 11705 14.1707 1.535155 165688 17969.04 -effcient -0.22111	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211	Approve
a b c d e*a P Q alpha beta F I Co-4 a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Ei Subbasin Ei At-1 A A A' nstant 587 2300 5.475 13.6875 12592.5 31481.25 effcient	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission	92 95 95 30 1350100 25229.372 4.93 698.56973	c d	Un P Q alpha beta F I C	1.381092 0.169197 0.06977 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165868 17969.04 o-effcient -0.22111 0.808064	Emission Urban Community So Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211	Approve
a b c d d e^a P Q alipha beta F I Co-o a b c c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A' nstant 587 2300 5.475 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 13.6875 1.18494 0.719655	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission	92 95 95 30 1350100 25229.372 4.93 698.56973	c d	Un P Q alpha beta F I C a b c d	1.381092 0.169197 0.040722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 0-effcient -0.22111 0.808064 0.472857 -0.27925	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211	\ <u>\pprove</u>
a b c d d e^a d P Q alpha beta F I Co-4 a b c d	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A Saf Saf 2300 5.475 13.6875 12592.5 31481.25 5ffcient -1.18494 0.719655 0.523861	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	.92 .95 .92 .30 1350100 25229.372 4.93 638.56973 1321426.7	c d	Un P Q alpha beta F I C a b c	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165668 17969.04 0-effcient -0.22111 0.808064 0.472857	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211	lpprove
a b c c d d e * a b c c d d e * a	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasine II At-1 A A A' nstant 587 2300 5.475 13.6875 12592.5 31481.25 23481.25 23481.25 23481.25 23481.25 23481.25 23481.25 23481.25 2361 -1.18494 0.719655 0.52361 -0.305765	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	.92 .95 .92 .30 1350100 25229.372 4.93 698.56973 1321426.7	c d	Un P Q alpha F I C C a b c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 -effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit	ector 2643154.95 116623.763 4.93 6606.72211 2493960.05	\ <u>tpprove</u>
a b c c d d d e^*a alipha beta i Co-ta b c c d c c d c c c c c c c	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin E At-1 A A A' nstant 587 2300 5.475 13.6875 13.6875 13.6875 13.5875 13.5875 13.5875 13.5875 13.5875 1.2592.5 31481.25 effcient -1.18494 0.719655 0.523361 0.305765	efficient mission 154,572 2,765,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	.92 .95 .92 .30 1350100 25229.372 4.93 698.56973 1321426.7	c d	Un P alpha beta F I Cc a c d e*a	1.381092 0.169197 0.040722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 0-effcient -0.22111 0.808064 0.472857 -0.27925	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue	ector 2643154.95 116523.763 4.93 6606.72211 2493960.05 5798532010	ipprove
a b c c d d e^*a O O O D D D D D D D C O I D C O I D D C O I D D C O I D D C O I D C I D D C I D D C I D D C C D D C C D D C C D D C C D D C C D D C C D D C C D D C C D D D C C D D D C C D D D C C D D D C C D D D C C D D D D C C D D D D D C D	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Et At-1 A A A A A A A A A A A A A A A A A A A	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit		c d	Un C P Q alpha beta F I C c d c c d c C C P O C C P Q D D C C P Q D D D D C C P Q D D D D D D D D D D D D D D D D D D	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 14.1707 1.535155 14.1707 1.535155 14.1707 0.22111 0.808064 0.472857 -0.27929 0.801633	Emission Urban Community So Revenue Abatement Cost T Emission Urban Profit G Factory Sector Revenue Abatement Cost	2643154.95 116623.763 4.93 6606.72211 2493960.05	\pprove
a b c c d d e*a F P Q alpha beta F I Co-to c c d d e*a Co-to c c Q Q	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er Athenation State Subbasin Er Athenation State Subbasin Er Athenation State	efficient mission 154,572 2,765,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	.92 .95 .92 .30 1350100 25229.372 4.93 698.56973 1321426.7 1321426.7 175221393 46923960 4.93	c d	Un P Q alpha beta F I C C d e^a a C C Q Q	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 -effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 2643154.95 116523.763 4.93 6606.72211 2493960.05 5798532010	\pprove
a b c c d d e*a P O alpha beta F I Co-d d e*a Co-d d d e*a Co-d d d e*a Co-d d beta S Co-d d d d c c d d c c c c c c c c c c c c	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin ET At-1 A A A A A A A A A A A A A A A A A A A	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un C P Q alpha beta F I C c d c c d c C C P O C C P Q D D C C P Q D D D D C C P Q D D D D D D D D D D D D D D D D D D	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 14.1707 1.535155 14.1707 1.535155 14.1707 1.535155 14.1707 0.22111 0.808064 0.472857 -0.27929 0.801633 constant 346093 1.339211 0.455305	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit G Factory Sector Revenue Abatement Cost T Emission	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	\pprove
a b c d d <u>e^aa</u> P Q alpha beta F I Co-4 a beta Co-4 d e^a Co-4 d P Q alpha beta F	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A' nstant 587 2300 5.475 13.6875 12592.5 31481.25 effcient -1.18494 0.719655 0.52361 -0.13651 0.305765 nstant 55502500 3.157 3193750 57031.25 10082669	efficient mission 154,572 2,785,689 154,572 154,830 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	.92 .95 .92 .30 1350100 25229.372 4.93 698.56973 1321426.7 1321426.7 175221393 46923960 4.93	c d	Un P Q alpha beta F I C C d e^A Q alpha	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 constant -346093 1.339211 0.455305	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit G Factory Sector Revenue Abatement Cost T Emission G Factory Profit	ector 2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93	\ <u>pprove</u>
a b c c d d e*a alpha beta F Co- c c d e*a Q alpha beta F I	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin E Subbasin E At-1 A A A' nstant 567 2300 5.475 13.6875 12592.5 31481.25 effcient -1.18494 0.719655 0.523361 0.305765 nstant 55502500 3.157 3193750 57031.25 10082669 180047.7	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un P Q alpha beta F I C d d e*a d d d e*a Alpha beta F I	1.381092 0.169197 0.069177 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 0.472857 0.27929 0.801633 constant 0.427857 0.27929 0.801633 constant 34.0933 1.339211 0.455306 157577.8	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit G Factory Sector Revenue Abatement Cost T Emission G Factory Profit	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	hpprove
a b c d d e^a P Q alpha beta F I c d d e^a Q alpha beta F I Co-4 F I Co-4 F I Co-4 Co Co I Co I Co I Co I Co I Co I Co I	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin Er At-1 A A' nstant 587 2300 5.475 13.6875 12592.5 31481.25 effcient -1.18494 0.719655 0.52361 -0.13651 0.305765 nstant 55502500 3.157 3193750 57031.25 10082669	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un P Q alpha beta F I C d d e*a d d d e*a Alpha beta F I	1.381092 0.169197 -0.40722 0.06677 iform Tax constant 0 11705 14.1707 1.535156 14.1707 1.535156 14.1707 1.535156 1.41707 1.535156 0.22111 0.808064 0.472857 -0.27929 0.801633 i.339211 0.455305 463491.6 157577.8	Emission Urban Community Se Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	Approve
a b c d d <u>e^aa</u> P Q alpha beta F I Co-4 d d e^a Q alpha beta F F I Co-4 a c d c d d c d d c d d e^a a Co-4 a b c d d c d a b ta b c d a b c d a b c d a b c d a c d a c a c d a c c d a c c d a c c c a c c c c c c c c c c c c c c	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin ET At-1 A A A A A A A A A A A A A A A A A A A	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un P Q abpta F I C d d e*a Q alpha beta F I C C	1.381092 0.169197 0.069197 0.06677 iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 -effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 :constant 34.39211 0.455306 1.339211 0.455306	Emission Urban Community Se Revenue Abatement Cost T Emission Urban Profit G Factory Sector Revenue Abatement Cost T Emission Factory Profit	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	\pprove
a b c d d e^a a b b c d d e^a c d d e^a Co-t a b c c d c c d c c d c c d c c d c c d c c d c c d c c d a lpha beta F I Co-t c a lpha beta F I Co-t c a lpha beta F Co-t c a b ta F Co-t c a b ta F Co-t c a b ta F Co-t c a b ta F Co-t c a b ta Co-t c a b ta Co-t c a b ta Co-t c a b ta Co-t c a b ta Co-t c c c c c c c c c c c c c c c c c c c	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin ET At-1 A A A A A A A A A A A A A A A A A A A	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un P Q alpha beta F I C d e*a C Q alpha beta F I C Q alpha beta F I C C D C C D C C D C C D C C C C C C C	1.381092 0.169197 -0.40722 0.06677 -0.0722 0.06677 -0.0722 0.06677 -0.06677 -0.0722 0.1705 -0.2711 0.808064 0.472857 -0.27929 0.801633 -0.27929 -0.	Emission Urban Community Se Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	\pprove
a b b c c d d d d e^*a D D D D D D D D D D D D D D D D D D D	3.679473 0.466506 0.544964 -0.01147 39.62551 Subbasin E At-1 A A A' nstant 567 2300 5.475 13.6875 12592.5 31481.25 effcient -1.18494 0.719655 0.523361 0.305765 mstant 55502500 3.157 3193750 557031.25 10082669 180047.7 effcient 3.679473 0.466506	efficient mission 154,572 2,785,688 154,572 154,800 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	1350100 25229.372 4.93 698.56973 1321426.7 175221393 46923960 4.93 109171.9	c d	Un P Q alpha beta F I C d d e*a d b t c c d d e*a D D t L C c a b b	1.381092 0.169197 0.069197 0.06677 iform Tax iform Tax constant 0 11705 14.1707 1.535155 165688 17969.04 0.472857 0.27929 0.801633 constant 0.428537 0.27929 0.801633 constant 346093 1.339211 0.455306 1.57577.5 5-effcient -2.7065 1.381092	Emission Urban Community Se Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	2643154.95 116623.763 4.93 6606.72211 2493960.05 5798532010 461208.577 4.93 38095.7304	\pprove

### Table C-9: Mathematical Decision-making model of Non-uniform and Uniform tax in sub-basin RG

	Subbasin I						
	Transfer coe Subbasin En						
	Subbasin En At-1	154432.288					
	А	2427598.635					
	A*	2,449,402.78				Emission F	
		Pig Farm Sector			Ui	rban Community Se	ctor
	onstant	Revenue	85861664		Constant	Revenue	3613478.47
P	587	Abatement Cost	1699788.51	P	0	Abatement Cost	200908.755
Q alpha	146272 5.5490121	Emission	0.3 773438.037	Q alph	16002 a 18.2563	T Emission	4.44 12637.6506
beta	13.576482	Linioolon		beta		Linicolon	12001.0000
F	811665.1	Pig Farm Profit	83929844.1	F	292137.3	Urban Profit	3356458.55
۱ د	1985859.2 <b>5-effcient</b>				31648.2 Co-effcient		
a	-1.18494			a	-0.22111		
b	0.719655			b	0.808064		
c	0.523361			c	0.472857		
d e^a	-0.136506 0.3057645			d e^a	-0.27929 0.801633		
- u	0.0001040	Aquaculture Sector			0.001000	Factory Sector	
	opotont	-	2223374648		Constant	-	4927476700
Р	onstant 55502500	Revenue Abatement Cost	2223374648 598264234	Р	Constant _	Revenue Abatement Cost	4837476702 2412780.7
Q.	40.059	Т	7.51	Q	404836.1	Т	1.35
alpha	3193750	Emission	913726.697	alph		Emission	727796.251
beta E	57031.25 127938431	Aquaculture Profit	1618248326	beta	4.499067 2715798	Factory Profit	4834081396
i	2284614.8	Aquaculture Front	1010240320	i	1821385	ractory Front	4034001330
Co	o-effcient				Co-effcient		
а	3.679473			a	-2.7065		
-							
b	0.466506			b	1.381092		
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P		1	b c d e^a	1.381092 0.169197 -0.40722 0.06677 Uniform Tax	3.46	
b c d	0.466506 0.544964 -0.01147 39.625506	ficient ission 2,444,084.0 154,572.9	7	c d	0.169197 -0.40722 0.06677	3.46	
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coef Subbasin Emi At-1	ficient ission 2,444,084.0	7 2 7	c d	0.169197 -0.40722 0.06677	3.46 Emission I	Pass Appr
-	0.466506 0.544984 -0.01147 39.625506 Subbasin P Transfer coef Subbasin Emi At-1 A	fficient ission 2,444,084.0 154,572.9 2,444,084.0	7 2 7	c d	0.169197 -0.40722 0.06677 Uniform Tax		
n c d e^aa	0.466506 0.544984 -0.01147 39.625506 Subbasin P Transfer coef Subbasin Emi At-1 A	fficient ission 2,444,084.0 154,572.9 2,444,084.0 2,449,402.7	7 2 7 8 85861664	c d	0.169197 -0.40722 0.06677 Uniform Tax	Emission I	ector 3613478.47
b c d e^a C P	0.466506 0.544964 -0.01147 39.625506 Subbasin Pri Transfer coef Subbasin Emi At-1 A A'	fficient ission 2,444,084.0 154,572.9 2,444,084.0 2,444,084.0 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost	7 2 7 8 85861664 2280061.46	c d e^a	0.169197 -0.40722 0.06677 Uniform Tax	Emission I Jrban Community Se Revenue Abatement Cost	ctor 3613478.47 190262.18
b c d <u>e^a</u> C P Q	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A' onstant 587 146272	fficient ission 2,444,084.0 154,572.9 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T	7 2 7 8 85861664 2280061.46 3.46	c d e^a	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 16002	Emission f Jrban Community Se Revenue Abatement Cost T	ector 3613478.47 190262.18 3.46
b c d e^a e^a c C P Q alpha beta	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A A onstant 587 146272 5.5490121 13.576482	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	c d e^a P Q alp bet	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c d e^a e^a e^a P Q alpha beta F	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1	fficient ission 2,444,084.0 154,572.9 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T	7 2 7 8 85861664 2280061.46 3.46	c d e^a	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 16002 ha 18.2563 ta 1.97766 292137.3	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46
b c d <u>e^aa</u> P Q alpha beta F F	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm At-1 A A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985569.2	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	c d e^a P Q alp bet	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c d e^a P Q alpha beta F I Co a	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	C d e^a P O ap bet F I a	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c d e^a P Q alpha beta F I Co a b	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	e d e*a P ap bet F I a b	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c d e^a P Q alpha beta F I Co a	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm At-1 A A A onstant 587 146272 5.5490121 13.576482 811665.1 13.576482 811665.1 985659.2 -effcient -1.18494 0.719655 0.523361	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	C d e*a	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-efficient -0.22111 0.808064 0.472857	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c d d e^a P Q alpha beta F I Co a b c	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	e d e*a P ap bet F I a b	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27829	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b b c d d C P Q alpha beta F I Co a b c c d	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506	fficient ission 2,444,084.0 154,572.3 2,444,084.0 154,572.3 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission	7 2 7 8 85861664 2280061.46 3.46 89954.3499	e d e*a P alp bet F I a b c d	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27829	Emission I Jrban Community Se Revenue Abatement Cost T Emission	ector 3613478.47 190262.18 3.46 15357.9534
b c c d e^a P Q alpha beta F I C c c c c c c c c C C C C C C C C C C	0.466506 0.544964 -0.01147 39.625506 <b>Subbasin Emi</b> At-1 A A * onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 2,444,084.0 154,572.9 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue	7 2 7 8 85561664 2280061.46 3.46 89954.3499 83270360.5	e d e*a P Q ap bet F I a b c d e*a	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27829	Emission f Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue	etor 3613478.47 190262.18 3.46 15357.9534 3370077.78
b c d d c c d a b b c c d d c c d c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm At-1 A A A' onstant 587 146272 5.5490121 13.576482 811665.1 13.576482 811665.1 13.576482 811665.1 -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 2,444,084.0 154,572.3 2,444,084.0 2,4	7 2 7 8 85861664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5	C d e*a P Q be be F I a b c c d e*a	0.169197 -0.40722 0.06677 Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit	etor 3613478.47 190262.18 3.46 15357.9534 3370077.78 4837476702 3168099.04
b c d d e^a P Q alpha beta F F I Co a b c c d d e^a Q Q	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	7 2 8 85561664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 2223374648 593029679 3.46	e d e*a P Q alp bet F I I a b c c d e*c	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Constant 0.808064 0.472857 -0.27929 0.801633 Constant 404836.1	Emission I Jrban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 3613478.47 190262.18 3.46 15357.9534 3370077.78 4837476702 3168099.04 3.46
b c d d c c d a b b c c d d c c d c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm At-1 A A A' onstant 587 146272 5.5490121 13.576482 811665.1 13.576482 811665.1 13.576482 811665.1 -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 2,444,084.0 154,572.3 2,444,084.0 2,4	7 2 7 8 85861664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5	C d e*a P Q be be F I a b c c d e*a	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant 404836.1 ha 6.708389	Emission I Jrban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 3613478.47 190262.18 3.46 15357.9534 3370077.78 4837476702 3168099.04
b c d d e^a P P O alpha beta F I Co a b c d c c d C C Q alpha	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	7 2 8 85561664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 2223374648 593029679 3.46	¢ d e*a P O alp bet F I a b ¢ c d e*a a P O alp bet P O alp bet P O alp bet A P O alp bet A A A A A A A A A A A A A A A A A A A	0.169197 -0.40722 0.06677 Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Constant 0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant 4.04936.1 ha 6.708389 ta 4.499067 2715798	Emission I Jrban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 3613478.47 190262.18 3.46 15357.9534 3370077.78 4837476702 3168099.04 3.46
b c d d e^a P O alpha beta F C c d e^a C C Q alpha beta F I I	0.466506 0.544964 -0.01147 39.625506 <b>Subbasin Em</b> <b>Transfer coef</b> <b>Subbasin Em</b> <b>At-1</b> A <b>A</b> <b>onstant</b> 587 146272 5.5490121 13.576482 811665.1 1385659.2 <b>-effcient</b> -1.18494 0.719655 0.523361 -0.136506 0.3057645 <b>Onstant</b> 55502500 40.059 3193750 57031.25 127938431 2284614.8	fficient 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	7 2 8 85661664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5 22223374648 593029679 3.46 1965909.69	¢ d e*a P O alp bet F I a b ¢ c d e*a a P O alp bet P O alp bet P O alp bet A P O alp bet A A A A A A A A A A A A A A A A A A A	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant ha 6.708389 ta 4.499067 2715798 1821385	Emission I Irban Community Se Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	4837476702 3163979534 3370077.78
b c d d e^a P O alpha beta F C c d e^a C C Q alpha beta F I I	0.466506 0.544964 -0.01147 39.625506 Subbasin Emi At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645	fficient 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	7 2 8 85661664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5 22223374648 593029679 3.46 1965909.69	¢ d e*a P O alp bet F I a b ¢ c d e*a a P O alp bet P O alp bet P O alp bet A P O alp bet A A A A A A A A A A A A A A A A A A A	0.169197 -0.40722 0.06677 Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Constant 0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant 4.04936.1 ha 6.708389 ta 4.499067 2715798	Emission I Irban Community Se Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	4837476702 3163979534 3370077.78
b c d d e^a P Q alpha beta F C c d b c c d c c d c c d c c d c c d c c d c c d c c d c c d c c d c c d c alpha beta f c c d d c c alpha beta f c c alpha beta f c c c alpha beta f c c c c c c c c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm Transfer coef Subbasin Emi At-1 A A onstant 587 146272 5.5490121 13.576482 811665.1 138576482 811665.1 1385659.2 effcient -1.18494 0.7136550 0.523361 -0.136506 0.3057645 S5502500 40.059 31393750 57031.25 127938431 2284614.8 -effcient 3.679473 0.466506	fficient 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	7 2 8 85661664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5 22223374648 593029679 3.46 1965909.69	¢ d e*a P Q ap bet F I a b ¢ ¢ 4 e*4 a P Q ap bet F I a b b t f I a b	0.169197 -0.40722 0.06677 Uniform Tax Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Co-effcient -0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant ha 6.708389 ta 4.499067 2715798 1821385 Co-effcient -2.7065 1.381092	Emission I Jrban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	4837476702 3163979534 3370077.78
b c d d e^a P Q alpha beta b c c c c c Q alpha beta F F Q alpha beta f F Q alpha beta c c a Q alpha beta c c c c c c c c c c c c c c c c c c c	0.466506 0.544964 -0.01147 39.625506 Subbasin Pin At-1 A A' onstant 587 146272 5.5490121 13.576482 811665.1 1985859.2 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 onstant 55502500 40.059 3193750 57031.25 127938431 2284614.8 -effcient 3.679473	fficient 2,444,084.0 154,572.3 2,444,084.0 2,449,402.7 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T Emission	7 2 8 85661664 2280061.46 3.46 89954.3499 83270360.5 83270360.5 83270360.5 22223374648 593029679 3.46 1965909.69	e d e*a P Q alp bet F F I I a b c c d e*a I I a b t t F I I a alp bet I I a alp bet I I a alp bet I I I a alp bet I I I I I I I I I I I I I I I I I I I	0.169197 -0.40722 0.06677 Uniform Tax 0 Constant 0 16002 ha 18.2563 ta 1.977766 292137.3 31648.2 Constant 0.22111 0.808064 0.472857 -0.27929 a 0.801633 Constant 40436.1 ha 6.708389 ta 4.499067 2715798 1821385 Co-effcient -2.7065	Emission I Jrban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	4837476702 3163979534 3370077.78

219

## Table C-10: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin LQ

	Subbasi	in Profit	462160160							
	Transfer c		02100100							
	Subbasin		8745.255							
	At A		2427598.6							
	A		8745.255 8,746.01					Emission Pa	nss /	Approve
		-	n Sector				Urt	oan Community Sec		
		_								
PCO	onstant		enue	3111100	, I		nstant 0	Revenue	2033230.9	
Q	587 5300		ent Cost T	58291.08 2.16			9004	Abatement Cost T	424239.35 63.37	
alpha	5.618245		sion	3683.84		Ipha	38.33775	Emission	1869.7248	
beta	13.90237					oeta	4.153257			
F	29776.7	Pig Fari	m Profit	3044852	F	-	345193.1	Urban Profit	1490507	
1	73682.55				· ·		37395.92			
a Co.	-effcient -1.18494					Co-	effcient -0.22111			
b	0.719655				i i		0.808064			
с	0.523361				c		0.472857			
d	-0.13651				c		-0.27929			
e^a	0.305765					e^a	0.801633			
		Aquacultu	ure Sector					Factory Sector		
C	onstant	Reve	enue	50895793	6 1	Co	nstant	Revenue	420964441	
Р	55502500	Abatem	ent Cost	14025576	F	,	10- 0	Abatement Cost	34808.384	
Q	0.917		г	61.53	C		8387.7	Т	24.56	
alpha beta	3193750	Emis	ssion	2614.55		lpha beta	3.407206	Emission	577.13969	
beta F	57031.25 2928669	Aquacult	ure Profit	36709343			1.37631 28578.62	Factory Profit	420915458	
i i	52297.66	Aquacuto	urerrone	30103343	li li		11544.07	TactoryTront	420313430	
Co	effcient					Co-	effcient			
а	3.679473				a		-2.7065			
b	0.466506				L L		1.381092			
c d	0.544964 -0.01147				0		0.169197 -0.40722			
e^a	39.62551									
	33.02331				•	e^a	0.06677			
~ a				-	e		0.06677			
<u>. a</u>	Subbasin		462,301,612. -	68	le		0.06677 ifform Tax	33.05		
<u>v a</u>	Subbasin Transfer co Subbasin E	efficient mission	8,744.	92	le			33.05		
<u>. a</u>	Subbasin Transfer co Subbasin E At-'	efficient mission	8,744. 2,444,084.	92 D7	e			33.05		
<u> </u>	Subbasir Transfer co Subbasin E At- A	befficient imission 1	- 8,744, 2,444,084, 8,744,	92 07 92	ł				488	Approve
• •	Subbasin Transfer co Subbasin E At-'	oefficient mission 1	- 8,744. 2,444,084. 8,744. 8,746.	92 07 92	e		iform Tax	Emission P		Approve
	Subbasir Transfer co Subbasin E At-' A A	efficient mission 1 Pig Far	8,744, 2,444,084, 8,744, 8,746, m Sector	92 07 92 01		Un	iform Tax U	Emission P rban Community Se	ctor	Approve
Co	Subbasin Transfer co Subbasin E At- A A A' nstant	efficient mission 1 Pig Far Rev	8,7443 2,444,084, 8,7443 8,746, m Sector venue	92 07 92 01 3111100	le	Un	aiform Tax U Constant	Emission P rban Community Se Revenue	ctor 2033230.9	Арргоче
Co P	Subbasin Transfer co Subbasin E At- A A A A S87	efficient mission 1 Pig Far Rev	8,744. 2,444,084. 8,744. 8,746. rm Sector venue nent Cost	92 07 92 01 3111100 80890.76	le	Un P	iform Tax U Constant 0	Emission P rban Community Se	ctor 2033230.9 368036.35	Арргоче
Co P Q alpha	Subbasin Transfer cc Subbasin E At- A A A Sa sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa Sa	efficient mission 1 Pig Far Rev Abaten	8,7443 2,444,084, 8,7443 8,746, m Sector venue	92 07 92 01 3111100	(e	Un C P Q alpha	iform Tax U Constant 9004 38.33775	Emission P rban Community Se Revenue Abatement Cost	ctor 2033230.9	Approve
Co P Q alpha beta	Subbasin Transfer cc Subbasin E At- A A A Sar Sar Sar Sar Sar Sar Sar Sar Sar Sar	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021	e	Un P Q	iform Tax U Constant 9004 38.33775 4.153257	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha	Subbasin Transfer co Subbasin E At- A A A N stant 587 5300 5.618245 13.90237 29776.7	efficient mission 1 Pig Far Rev Abaten Emi	8,744. 2,444,084, 8,744. 8,746. m Sector venue nent Cost T	92 07 92 01 3111100 80890.76 33.05	(	Un C P Q alpha	iform Tax U Constant 0 9004 38.33775 4.153257 345193.1	Emission P rban Community Se Revenue Abatement Cost T	ctor 2033230.9 368036.35 33.05	Approve
Co P Q alpha beta F I	Subbasin Transfer cc Subbasin E At- A A A Sar Sar Sar Sar Sar Sar Sar Sar Sar Sar	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021	ſ	Un Q alpha F I	iform Tax U Constant 9004 38.33775 4.153257	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a	Subbasin Transfer cc Subbasin E At- A A Subbasin E At- A A Solo Solo Solo Solo Solo Solo Solo	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021	ľ	Un Q alpha beta F I Ca a	U Constant 0 9004 38.33775 4.153257 345193.1 37395.92 o-effcient -0.22111	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a b	Subbasin Transfer co Subbasin E At- A A S 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021		Un P Q alpha beta F I Ca a b	iform Tax U Constant 0 9004 38.33775 345193.1 37395.92 0-efficient -0.22111 0.808064	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a b c	Subbasin Transfer co Subbasin E At- A A nstant 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655 0.523361	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021		Un Q alpha beta F I Ca a b c	utorstant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808054 0.472857	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a b	Subbasin Transfer co Subbasin E At- A A S 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655	efficient mission 1 Pig Far Rev Abaten Emi	8,744 2,444,084 8,744 8,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,746 3,744 8,746 8,766 8,	92 07 92 01 3111100 80890.76 33.05 334.1021		Un P Q alpha beta F I Ca a b	iform Tax U Constant 0 9004 38.33775 345193.1 37395.92 0-efficient -0.22111 0.808064	Emission P rban Community Se Revenue Abatement Cost T Emission	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a b c d	Subbasin Transfer co Subbasin E At- A Subbasin E At- Composite Subbasin S87 5300 5.618245 13.90237 29776.7 73682.55 478245 13.90237 29776.7 73682.55 616ient -1.18494 0.719655	pefficient mission 1 Pig Far Ret Abaten Emi Pig Far	8,744 2,444 (84) 8,744 8,744 8,746 mm Sector venue nent Cost T ission mm Profit	92 07 92 01 3111100 80890.76 33.05 334.1021		Un Q alpha beta F I C a a b c d	U Constant 0 9004 38.33775 4.153257 345193.1 3735.92 0-effcient -0.22111 0.808064 0.472857 -0.27929	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a b c d d e^a	Subbasin Transfer co Subbasin E At- A A nstant 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765	Pig Far Rev Abaten Pig Far Emi Pig Far	8,744 2,444,064 8,744 8,744 8,746 mm Sector venue nent Cost T T T mm Profit	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167		Un Q alpha beta F I C a a c d e^a	u Constant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit	etor 2033230.9 368036.35 33.05 3110.0677 1562406.8	Approve
Co P Q alpha beta F I Co- a b c d e^a Co	Subbasin Transfer co Subbasin E At- A Subbasin E At- Composite Subbasin S87 5300 5.618245 13.90237 29776.7 73682.55 478245 13.90237 29776.7 73682.55 616ient -1.18494 0.719655	Pefficient mission 1 Pig Far Rev Abaten Emi Pig Far Pig Far Aquacut Rev	8,744 2,444 (84) 8,744 8,744 8,746 mm Sector venue nent Cost T ission mm Profit	92 07 92 01 3111100 80890.76 33.05 334.1021		Un Q alpha beta F I C a a b c c d e^a	U Constant 0 9004 38.33775 4.153257 345193.1 3735.92 0-effcient -0.22111 0.808064 0.472857 -0.27929	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit	ctor 2033230.9 368036.35 33.05 3110.0677	Approve
Co P Q alpha beta F I Co- a c d d e^a Q Q	Subbasin Transfer co Subbasin E At- A Subbasin E At- B Subbasin E At- Subbasin Subba	Pefficient mission 1 Pig Far Rev Abaten Emi Pig Far Pig Far Aguacut Rev Abaten	8,744 2,444,084 8,7443 8,7443 8,7463 mm Sector venue nent Cost T mm Profit	92 07 92 01 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05		Un C P Q alpha beta F I C d e^a a C C Q Q	uform Tax U Constant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 8387.7	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 2033230.9 368036.35 33100.677 1562406.8 420964441 37931.229 33.05	Approve
Co P Q alpha beta F I Co- a d e^a Q alpha	Subbasin Transfer cc Subbasin E At- A Subbasin E At- Comment State 587 5300 5.618245 13.90237 29776.7 73682.55 13.90237 29776.7 73682.55 0.523861 0.305765 0.523361 0.305765 0.55502500 0.917 3193750	Pefficient mission 1 Pig Far Rev Abaten Emi Pig Far Pig Far Aguacut Rev Abaten	8,744 2,444,084 8,744 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074		Un P Q alpha beta F I C G a b c d e^a ( P Q alpha	U Constant 0 9004 38.33775 4.153257 345193.1 3735.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant -8387.7 3.407206	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost	etor 2033230.9 368036.35 33.05 3110.0677 1562406.8 420964441 37931.229	Approve
Co P Q alpha beta F I Co- a c d e^a Q Q alpha beta	Subbasin Transfer cc Subbasin E At- A A nstant 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 0.523361 -0.13651 0.305765 0.523361 -0.13651 0.305765 0.55502500 0.917 3193750 57031.25	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost T ission	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05 4833.388		Un P Q alpha beta F I Ca a b c c d e^a ( P Q alpha beta	U Constant 0 9004 38.33775 4.153257 345193.1 73395.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 8387.7 3.407206 1.37531	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 2033230.9 368036.35 310.0677 1562406.8 420964441 37931.229 33.05 467.35998	Approve
Co P Q alpha beta F Co- a c d e^a Q Q alpha beta F	Subbasin Transfer co Subbasin E At- A Subbasin E At- A Subbasin E At- Subbasin E At- Subbasin E Subbasin Subasin Subbasin Subasin Subbasin Subasin	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,7443 8,7443 8,7463 mm Sector venue nent Cost T mm Profit	92 07 92 01 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05		Un P Q alpha beta F I C G a b c d e^a ( P Q alpha	u Constant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 8387.7 3.407206 1.37631 28578.62	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	etor 2033230.9 368036.35 33100.677 1562406.8 420964441 37931.229 33.05	Approve
Co P Q alpha beta F I Co- a c d e^a Q alpha beta F I	Subbasin Transfer cc Subbasin E At- A A nstant 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 0.523361 -0.13651 0.305765 0.523361 -0.13651 0.305765 0.55502500 0.917 3193750 57031.25	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost T ission	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05 4833.388		Un P Q alpha beta F I C C d P Q alpha beta F I I	U Constant 0 9004 38.33775 4.153257 345193.1 73395.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 8387.7 3.407206 1.37531	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 2033230.9 368036.35 310.0677 1562406.8 420964441 37931.229 33.05 467.35998	Approve
Co P Q alpha beta F I Co- a d e^a Q alpha beta F I Co- a	Subbasin Transfer co Subbasin E At- A Subbasin E At- A Subbasin E At- Subbasin E At- Subbasin E Subbasin Subasin Subbasin Subasin Subbasin Subasin	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost T ission	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05 4833.388		Un P Q alpha beta F I C d d e^a C Q alpha beta F I Q alpha beta F I Q alpha C d Q alpha S tota C q d alpha S tota C q d alpha S tota S S S S S S S S S S S S S S S S S S S	U Constant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808064 0.472657 -0.27929 0.801633 Constant 8387.7 3.407206 1.37631 28578.62 1.1544.07 0-effcient -2.7065	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 2033230.9 368036.35 310.0677 1562406.8 420964441 37931.229 33.05 467.35998	Approve
Co P Q alpha beta F I Co- a c d e^a alpha beta F I Co- a b	Subbasin Transfer co Subbasin E At- A nstant 587 5300 5.618245 13.90237 29776.7 73682.55 effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 nstant 55502500 0.9171 3193750 57031.25 29228669 52297.66 effcient 3.679473 0.466506	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost T ission	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05 4833.388		Un C P Q alpha beta F I C d e^a a Q alpha beta C C Q alpha F I C Q alpha beta C C d C d d e^a b C d d b d b d b d b d b d b d b d b d	U Constant 0 9004 386.33775 4.153257 345193.1 37735.92 0-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 8387.7 3.407206 1.37631 28578.62 1.1544.07 0-effcient -2.7065 1.381092	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 2033230.9 368036.35 310.0677 1562406.8 420964441 37931.229 33.05 467.35998	Approve
Co P Q alpha beta F I Co- a g Q alpha beta F I Co- a	Subbasin Transfer co Subbasin E At- A Subbasin E At- A Subbasin E At- Base Subbasin Subasin Subbasin Subbasin Subbasin Subbasin Subbasin S	Pig Far Rev Abaten Pig Far Emi Aguacut Rev Abaten Emi	8,744 2,444,084 8,744 8,744 8,746 m Sector venue nent Cost T ission m Profit ture Sector venue nent Cost T ission	92 97 92 91 3111100 80890.76 33.05 334.1021 3019167 50895793 13927074 33.05 4833.388		Un P Q alpha beta F I C d d e^a C Q alpha beta F I Q alpha beta F I Q alpha C d Q alpha S tota C q d alpha S tota C q d alpha S tota S S S S S S S S S S S S S S S S S S S	U Constant 0 9004 38.33775 4.153257 345193.1 37395.92 0-effcient -0.22111 0.808064 0.472657 -0.27929 0.801633 Constant 8387.7 3.407206 1.37631 28578.62 1.1544.07 0-effcient -2.7065	Emission P rban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 2033230.9 368036.35 310.0677 1562406.8 420964441 37931.229 33.05 467.35998	Approve

### Table C-11: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin RH

	Subbasir		ŧ.					
	Transfer co							
	Subbasin E							
	At-							
	A A'	1490960.848 1,491,139.85	5			Emission I	2200	Approve
						ban Community Se		Approve
		Pig Farm Sector			or	ban Community Se	ctor	
	onstant	Revenue	160103663	Co	nstant	Revenue	38923016.43	
Р	587	Abatement Cost	4223481.1	Р	0	Abatement Cost	23477529.85	
Q	272749	Т	3.33	Q	171266	т	43.99	
alpha	5.299371	Emission	172943.34	alpha	101.3766	Emission	149055.7772	
beta F	12.6815 1445398	Pig Farm Profit	155304281	beta F	17.40665 17362363	Urban Profit	8888522.941	
	3458867	rigrammon	100004201		2981167	onsannione	0000022.041	
Co	-effcient			Co-e	effcient			
a	-1.18494			a	-0.22111			
b	0.719655			b	0.808064			
c di	0.523361			c d	0.472857			
a e^a	-0.13651 0.305765			e^a	-0.27929 0.801633			
	0.000700	A		C a	0.001033	Franker C. A		
		Aquaculture Sector				Factory Sector		
	onstant	Revenue	263803383		nstant	Revenue	29533795937	
P	55502500	Abatement Cost	72697450	Р	-	Abatement Cost	85204938.12	
Q alpha	4.753 3193750	T Emission	61.53 13551.744	Q alpha	3254048 9.253179	T Emission	30.03 1155409.985	
aipna beta	57031.25	Emission	10001.744	beta	7.102444	Emission	1155409.905	
F	15179894	Aquaculture Profit	190272093	F	30110287	Factory Profit	29413894037	
I	271069.5	•		1.2	23111694	-		
Co	-effcient			Co-e	effcient			
a	3.679473			a	-2.7065			
b	0.466506			b	1.381092			
) ;	0.544964			c	0.169197			
) ; 	0.544964 -0.01147 39.62551 Subbasin Transfer cor	efficient		c d e^a		27.79		
) ; 1	0.544964 -0.01147 39.62551 Subbasin	fficient hission 1,490,770 8,744	70 92	c d e^a	0.169197 -0.40722 0.06677	27.76		
) ; 1	0.544964 -0.01147 39.62551 Transfer cer Subbasin En At-1	fficient hission 1,490,770	70 92 70	c d e^a	0.169197 -0.40722 0.06677	27 79 Emission	Pass	Approve
) : :	0.544964 -0.01147 39.62551 Transfer cer Subbasin En At-1	fficient nission 1,490,770 8,744 1,490,778	70 92 70	c d e^a	0.169197 -0.40722 0.06677			Approve
b c d e^a	0.544964 -0.01147 39.62551 Transfer cer Subbasin En At-1	rfficient nission 1,490,770 8,744 1,490,778 1,491,109	70 92 70	c d e^a	0.169197 -0.40722 0.06677	Emission		Approve
b c d e^a	0.544964 -0.01147 39.62551 Transfer cee Subbasin Lin At-1 A A	fficient nission 1,490,770 8,744 1,490,776 1,491,109 Pig Farm Sector	92 70 85	c d e^a	0.169197 -0.40722 0.06677	Emission Irban Community S	ector	Approve
b c d e^a co	0.544964 -0.01147 39.62551 Subbasin 1 Transfer see Subbasin In At-1 A A* A*	rfficient nission 1,490,770 8,744 1,490,776 1,491,139 Pig Farm Sector Revenue Abatement Cost T	70 92 70 85 160103663 544666 27.79	c d e^a Uni	0.169197 -0.40722 0.06677 form Tax form Tax 0 uonstant 0 171266	Emission Irban Community S Revenue Abatement Cost T	ector 38923016.43 21237635.9 27.79	Approve
b c d e^a Co D ulpha	0.544964 -0.01147 39.62551 Transfer soe Subbasin In At-1 A A* enstant 5.29071	rfficient nission 1,490,770 8,744 1,490,778 1,490,778 1,491,799 Pig Farm Sector Revenue Abatement Cost	70 92 70 85 160103663 5448646	c d e^a Uni	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3766	Emission Irban Community S- Revenue Abatement Cost	ector 38923016.43 21237635.9	Approve
b c d e^a co	0.544964 -0.01147 39.62551 Subbasin In At-1 A A A* enstant 587 272749 5.299771 12.6815	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e^a Uni	0.169197 -0.40722 0.06677 form Tax form Tax 0 0 171266 107.40555	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d e^a Co D ulpha	0.544964 -0.01147 39.62551 Transfer soe Subbasin In At-1 A A* enstant 5.29071	rfficient nission 1,490,770 8,744 1,490,776 1,491,139 Pig Farm Sector Revenue Abatement Cost T	70 92 70 85 160103663 544666 27.79	c d e^a Uni	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3766	Emission Irban Community S Revenue Abatement Cost T	ector 38923016.43 21237635.9 27.79	Approve
b c d e^a c o o o o o o o o o o o o o o o o o o	0.544964 -0.01147 39.62551 Subbasin In At-1 A A A A A A A A A A A A A	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e^a Uni P O alpha beta F I	0.169197 -0.40722 0.06677 form Tax form Tax 0 171266 101.3766 17.405555 17.4055555 17.4055555 17.40555555555555555555555555555555555555	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d e^a So Mpha seta : Co-	0.544964 -0.01147 39.62551 Tampfer set Subbasin En Ar-1 A A A Subbasin En Ar-1 A A A Subbasin En Ar-1 A A A Subbasin En Ar-1 A A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin En Ar-1 A Subbasin Ar-1 A Subbasin En Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A Subbasin Ar-1 A A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 A Ar-1 Ar-1	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e*a Uni P O alpha beta F I C o alpha	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171266 101.3706 17.40565 17362363 2901167 -effcient -0.22111	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d e^a ilpha seta co-	0.544964 -0.01147 39.62551 Transfer soe Subbasin In At-1 A A* enstant 5.299071 12.6815 1445386 3450067 effclent -1.18494 0.719055	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e^a Uni P O alpha beta F I Co a b	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3766 17.40665 17.362363 2901167 -effcient -0.22111 0.000064	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d d e^a ) o lipha seta Co- i i )	0.544964 -0.01147 39.62551 Transfer soc Subbasin In At-1 A A *** *****************************	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e^a Uni P O alpha beta F I Co a b c a b	0.169197 -0.40722 0.06677 form Tax form Tax 0 171286 101.3766 17.40655 17.4055 1	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d d heta i co- i i i i i	0.544964 -0.01147 39.62551 Transfer soe Subbasin In At-1 A A* enstant 5.299071 12.6815 1445386 3450067 effclent -1.18494 0.719055	Hicient 1,490,770 8,244 1,480,776 1,491,129 Pig Farm Sector Revenue Abatement Cost T Emission	70 92 70 85 160103663 5446646 27.79 26763.995	c d e^a Uni P O alpha beta F I Co a b	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3766 17.40665 17.362363 2901167 -effcient -0.22111 0.000064	Emission Irban Community S Revenue Abatement Cost T Emission	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
) d d d d d d d d d d d d d d d d d d d	0.544964 -0.01147 39.62551 Tramfer cer Subbasin En Ar-1 A A Subtasin En Ar-1 A A Subtasin En Ar-1 A A Subtasin En Ar-1 Subtasin En Ar-1 Ar-1 Ar-1 Ar-1 Ar-1 Ar-1 Ar-1 Ar-1	rfficient nission 1,490,770 8,744 1,490,776 1,491,109 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	70 92 70 85 160103663 5446646 27.79 26763.995	c d e*a Uni P O alpha beta F I Co a b e d d	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171266 101.3766 17.40565 17362363 2901167 -effcient -0.22111 0.000064 0.472857 -0.227929	Emission Revenue Abatement Cost T Emission Urban Profit	ector 38923015.43 21237635.9 27.79 213436.2109	Approve
b c d d e^a ) lipha eta ; Co- i ; t i ; ;	0.544964 -0.01147 39.62551 Tramfer set Subbasin En Ar-1 A A * *******************************	Aquaculture Sector	70 92 70 85 160103663 5446846 27.79 26763.995 153911246	c d e*a Unu P O alpha beta F I Co a b e d e*a	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171266 101.3706 17.40565 17.362363 2901167 -effcent -0.22111 0.000064 0.472857 -0.27929 0.801633	Emission Arban Community S- Revenue Abatement Cost T Emission Urban Profit	ector 38923016.43 21237635.9 27.79 213436.2109 11753988.23	Approve
o b b d d h h h h h h h h h h h h h h h h	0.544964 -0.01147 39.62551 Transfer soft Subbasin In At-1 A A* mestant 5.299071 12.6815 5.299071 12.6815 1445386 0450067 effclent -1.18494 0.719055 0.523361 0.305765 mestant	fficient nission 1,490,770 8,744 1,490,776 1,491,139 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquiaculture Sector Revenue	70 92 70 95 160103663 544646 27.79 26763.995 153911246 253003093	c d e*a Unu P O alpha beta F I Co a b e d e*a	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171266 101.3766 17.40565 17362363 2901167 -effcient -0.22111 0.000064 0.472857 -0.227929	Emission Arban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue	ector 38923016.43 21237635.9 27.79 213436.2109 11753988.23 29533795937	Approve
> : I Ipha eta Co- i i Aa a Co-	0.544964 -0.01147 39.62551 Tramfer set Subbasin En Ar-1 A A * *******************************	Aquaculture Sector	70 92 70 85 160103663 5446846 27.79 26763.995 153911246	c d e*a Unu P O alpha beta F I Co a b e d e*a	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171266 101.3706 17.40565 17.362363 2901167 -effcent -0.22111 0.000064 0.472857 -0.27929 0.801633	Emission Arban Community S- Revenue Abatement Cost T Emission Urban Profit	ector 38923016.43 21237635.9 27.79 213436.2109 11753988.23	Approve
b c d e*a co- b b b b b co- co- co- co- co- co- co- co- co- co-	0.544964 -0.01147 39.62551 Transfer soft Subbasin In At-1 A A* enstant 5.299071 12.6815 1445386 3450067 effclent -1.18494 0.719055 0.523841 -0.19655 0.52550 -0.19750 -0.19750 -0.19655 0.52550 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.197500 -0.1975000 -0.197500 -0.197500 -0.1975000 -0.197	efficient nission 1,490,770 8,244 1,490,770 1,490,7	70 92 70 .85 160103663 544646 27.79 20763.995 153911246 153911246	c d e^a Uni P O alpha beta F I Co a beta F I Co a d d e^a	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3706 17.40565 17.362363 2901167 -effcient -0.22111 0.000064 0.472857 -0.221929 0.801633 onstant 3254048 9.253179	Emission Irban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314898 29	Approve
b c d d e^a ) o o o o o o o o o o o o o o o o o o	0.544964 -0.01147 39.62551 Transfer soe Subbasin In At-1 A A* enstant 567 272749 5.29971 12.6815 1445388 3450067 effcient -1.18494 0.719555 0.523361 -0.13651 0.305765 enstant 55502500 4.753 3193750 57031 25	efficient hission 1,490,770 8,244 1,491,799	2530033003 2070 2070 20763 20778 200	c d e*a Unit P O alpha beta F I Co a b e ta P O C P O C P O C P O C P O C P O C P O C P O C P O C P O C C O C C O C C O C C O C C O C C O C C O C C O C	0.169197 -0.40722 0.06677 form Tax form Tax 0 171268 101.3706 17.40655 17.40655 17.40655 17.40655 17.40555 17.40555 17.40555 17.40555 17.40555 17.92929 0.02111 0.000064 0.472857 -0.22111 0.000064 0.472857 -0.22929 0.601633 0005tant 3254048 9.250179 7.102464	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve
b c d e*a S s s s s s co- s s s s s s co- s s s co- s s s s s s s s s s s s s s s s s s s	0.544964 -0.01147 39.62551 Transfer coo Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A A A Subbasin In Ar. A A A Subbasin In Ar. A A A A A A A A A A A A A A A A A A	Hiciant 1,490,770 8,744 1,490,770 8,744 1,490,770 8,744 1,490,770 8,770 1,491,709 1,491,709 1,491,709 1,491,709 1,490,770 1,490,770 8,770 1,490,770 1,491,109	26:3003080 720 20 20 20 20 20 20 20 20 20 20 20 20 2	c d e^a Uni P O alpha beta F I Co a beta F I Co a d d e^a	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171268 101.3766 17.40565 17362363 2901167 -0.22111 0.909064 0.472857 -0.221929 0.801633 onstant 3254048 9.253179 7.102444 30110287	Emission Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatemat Cost T	ector 38923016 43 21237635.9 27.79 213436.2109 11753988.23 29533795937 83314888.29 27.78	Approve
b c d d e^a b b b b b b b c o b c o b c o c o c o c	0.544964 -0.01147 39.62551 Transfer soft Subbasin In At-1 A A* 567 272749 5.299071 12.6815 1445386 0450067 effclent -1.18494 0.719655 0.523841 -0.305765 0.523841 -0.305765 0.523841 -0.305765 0.523841 2170894	efficient hission 1,490,770 8,244 1,491,799	2530033003 2070 2070 20763 20778 200	c d e^a Uni P O a a beta F I Co a b ta f I Co a b ta F I Co a b ta F I I Co a b ta F I I I I I I I I I I I I I I I I I I	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3706 17.40565 17.362363 2901167 -0.22111 0.000064 0.472857 -0.221929 0.801633 0005tant 3254048 9.253179 7.102444 30110287 223111694	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve
b c d d e^a b b b b b b b c o b c o b c o c o c o c	0.544964 -0.01147 39.62551 Transfer coo Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A Subbasin In Ar. A A A A Subbasin In Ar. A A A Subbasin In Ar. A A A A A A A A A A A A A A A A A A	efficient hission 1,490,770 8,244 1,491,799	2530033003 2070 2070 20763 20778 200	c d e^a Uni P O a a beta F I Co a b ta f I Co a b ta F I Co a b ta F I I Co a b ta F I I I I I I I I I I I I I I I I I I	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 171268 101.3766 17.40565 17362363 2901167 -0.22111 0.909064 0.472857 -0.221929 0.801633 onstant 3254048 9.253179 7.102444 30110287	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve
b c d d e^a b b b b b b b c o b c o b c o c o c o c	0.544964 -0.01147 39.62551 Transfer soft Subbasin En At-1 A A S87 272749 5.299071 12.6815 1445398 0450067 effclent -1.18494 0.719055 0.52361 40.13651 0.305765 0.523361 40.13651 0.305765 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 21.30516 21.30516 21.30516 21.30516 21.30516 21.30517 21.305	efficient hission 1,490,770 8,244 1,491,129	2530033003 2070 2070 20763 20778 200	c d e^a Uni P O alpha beta F I Co a b e d e <sup>*</sup> a Co a b b e d f I Co a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b c a b c a b b c a b b c a b b c a b c a b b c a b c a b c a b c a b b c a b c a b b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b b c a b c a b c a b b c a b c a b c a b b c a b b c a b b c a b b c a b b b c a b b c a b b b c a b b c a b b b a b b c a b b b c a b b c a b b c a b c b c	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3706 17.40565 17.362363 2901167 -0.22111 0.000064 0.472857 -0.221929 0.801633 0.00054 0.472857 -0.27929 0.801633 000554048 9.253179 7.102444 30110287 -2.7065 1.301092	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve
b c d d e^a ) lipha seta 1 1 1 2 1 1 2 1 1 2 1 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 2 1 2 1 2 1 2 1 2 1 1 2 2 1 1 2 2 1 1 2 1 1 2 1 2 1 1 1 2 1 2 1 2 1	0.544964 -0.01147 39.62551 Tampfer 2015 Subbasin En Ar-1 A A - - - - - - - - - - - - - - - - -	efficient hission 1,490,770 8,244 1,491,129	2530033003 2003 2015 20763.995 153911246 25763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20792.2079	c d d e*a unu p o alpha beta F l Co a b e d e*a C P O alpha beta F l Co a b e c d d co a b c c d d co a b c c d d co a b c c d d co a b c c d d co a co a co a co a co a co a c	0.169197 -0.40722 0.06677 Form Tax Form Tax 0 0.171266 101.3706 17.40565 17.362363 2901167 -0.22111 0.000064 0.472857 -0.22929 0.801633 0005tant 3254048 9.253179 7.102444 30110287 2.3111094 -2.7065 1.301092 0.165197	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve
b c d d e^a ) lipha seta 1 1 1 2 1 1 2 1 1 2 1 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 1 2 2 1 2 1 2 1 2 1 2 1 2 1 1 2 2 1 1 2 2 1 1 2 1 1 2 1 2 1 1 1 2 1 2 1 2 1	0.544964 -0.01147 39.62551 Transfer soft Subbasin In At-1 A A S87 272749 5.299071 12.6815 1445398 0450067 effclent -1.18494 0.719055 0.52361 40.13651 0.305765 0.523361 40.13651 0.305765 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 0.523361 21.30516 21.30516 21.30516 21.30516 21.30516 21.30516 21.30517 21.305	efficient hission 1,490,770 8,244 1,491,129	2530033003 2003 2015 20763.995 153911246 25763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20763.995 20792.2079	c d e^a Uni P O alpha beta F I Co a b e d e <sup>*</sup> a Co a b b e d f I Co a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b b c a b c a b c a b b c a b c a b b c a b b c a b c a b b c a b c a b c a b b c a b c a b b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b c a b b c a b c a b c a b b c a b c a b c a b b c a b b c a b b c a b b c a b b b c a b b c a b b b c a b b c a b b b a b b c a b b b c a b b c a b b c a b c b c	0.169197 -0.40722 0.06677 form Tax form Tax 0 0.171268 101.3706 17.40565 17.362363 2901167 -0.22111 0.000064 0.472857 -0.221929 0.801633 0.00054 0.472857 -0.27929 0.801633 000554048 9.253179 7.102444 30110287 -2.7065 1.301092	Emission Abar Community S Revenue Abartement Cost T Emission Urban Profit Factory Sector Revenue Abartement Cost T Emission	ector 38923016 43 21237635 9 27 79 213436.2109 11753988.23 11753988.23 295337959937 83314859 29 27 79 1220042.710	Approve

Table C-12: Mathematical Decision-making model of Non-uniform and Uniform	
tax in sub-basin RI	

	Subbasin I Transfer coe							
	Subbasin En							
	At-1	1490960.848						
	A	34733722.14						
	A*	36,703,767.54				Emission F		Approve
		Pig Farm Sector			Ur	ban Community Se	ctor	
	onstant	Revenue	37103683		nstant	Revenue	45407952.86	
P	587	Abatement Cost	605284.261	P	0	Abatement Cost	3816552.775	
Q alpha	63209 5.4374658	T Emission	0.15 550828.186	Q alpha	209526 30.61558	T Emission	2.13 500428.9967	
beta	13.033452	Linisaion	330020.100	beta	3.421803	LIIII33IOII	300420.3301	
F	343696.78	Pig Farm Profit	36415774.5	F	6414760	Urban Profit	40525486.32	
1	823831.46 -effcient			1 60.	716956.6 effcient			
a co	-1.18494			a	-0.22111			
b	0.719655			b	0.808064			
c	0.523361			c d	0.472857			
d e^a	-0.136506 0.3057645			d e^a	-0.27929 0.801633			
		Aquaculture Sector				Factory Sector		
6	onstant	Revenue	3415851410	Con	nstant	Revenue	54158796949	
Р	55502500	Abatement Cost	913268905	P	-	Abatement Cost	9202713.134	
Q	61.5441	Т	4.27	Q	4134001	т	0.12	
alpha boto	3193750	Emission	2453207.25	alpha	3.519481	Emission	31229257.71	
beta F	57031.25 196556469	Aquaculture Profit	2492107311	beta F	11.46183 14549538	Factory Profit	54145846725	
i i	3509937			i	47383229			
Co	-effcient				-2.7065			
	3.679473			a				
b	3.679473 0.466506 0.544964			b	1.381092 0.169197			
) ; :	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfet coef	flicient -		b c d e^a	1.381092	012		
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P	ficient -	70 70	b c d e^a	1.381092 0.169197 -0.40722 0.06677			
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer cod Subbasin Em At 1	ficient	70 70	b c d e^a	1.381092 0.169197 -0.40722 0.06677	Emission		Approve
a b c d e^a	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coel Subbasin Em At-1 A	Miclent	70 70 70 54	b c d e^a	1.381092 0.169197 -0.40722 0.06677	Emission Juban Community S	ector	Approve
b c d e*a	0.466506 0.544964 -0.01147 39.625506 Subbasin Pro Al-1 A A	Miclent ission 36,126,427 1,490,778 36,126,427 36,703,767 90,703,767 Pig Farm Sector Revenue	70 70 70 54 37103683	b c d e^a	1.381092 0.169197 -0.40722 0.06677	Emission Urban Community Si Revenue	ector 45407952.86	Approve
b c d e*a	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin P Transfer coet Subbasin P At-1 A A' onstant	fficient	70 70 20 54 37103683 589275 37	b c d e^a	1.381092 0.163197 -0.40722 0.06677 Morm Tax	Emission Urban Community Si Revenue Abatement Cost	45407952.86 3451918.205	Approve
b c d e^a C p Q alpha	0.466506 0.544964 -0.01147 39.625506 Subbasin Pro At-1 A A A A A A A A A A A A A A A A A A A	Miclent ission 36,126,427 1,490,778 36,126,427 36,703,767 90,703,767 Pig Farm Sector Revenue	70 70 70 54 37103683	b c d e^a Un Un C O alpha	1.381092 0.169197 -0.40722 0.06677 Morm Tax Constant 0 209526 00.61550	Emission Urban Community Si Revenue	ector 45407952.86	Approve
b c d e^a C Q	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coef Subbasin P A.1 A A * onstant 587 63209 5.4374050 13.003452	Miclent Ission 38,128,427 1,40,778 38,125,427 38,125,427 38,125,427 38,703,707 Pig Farm Sector Revenue Abatement Cost T Emission	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a tin	1.381092 0.169197 -0.40722 0.06677 #orm Tax #orm Tax 0.06526 30.91550 3.421003	Emission Isban Corramunity S Revenue Abatement Cost T Emission	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d e^a C p Q alpha	0.466506 0.544964 -0.01147 39.625506 Subbasin Pro At-1 A A A A A A A A A A A A A A A A A A A	fficient ission 36,126,427 1,480,778 36,126,427 36,126,427 36,703,767 Pig Farm Sector Revenue Abatement Cost T	70 70 54 37103683 589275.37 0.12	b c d e^a Un Un C O alpha	1.381092 0.169197 -0.40722 0.06677 Morm Tax Constant 0 209526 00.61550	Emission Urban Community S Revenue Abatement Cost T	45407952.86 3451918.205 0.12	Approve
b c d e^a P Q alpha beta F I Co	0.466506 0.544964 -0.01147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A * * * * * * * * * * * * * * * * *	Miclent Ission 38,128,427 1,40,778 38,125,427 38,125,427 38,125,427 38,703,707 Pig Farm Sector Revenue Abatement Cost T Emission	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un Un O alpha beta F I	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax constant 0 209526 30.81550 3.421003 6414760 716056.5 effcient	Emission Isban Corramunity S Revenue Abatement Cost T Emission	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d e^a P Q alpha beta F I Co a	0.466506 0.544964 -0.01147 39.625506 Stibbanin P Transfer coel Subbanin Fin At.1 A A A A Constant 587 63209 5.4374050 13.033452 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4394052 3.4395052 3.4397052 3.4395052 3.439705	Miclent Ission 38,128,427 1,40,778 38,125,427 38,125,427 38,125,427 38,703,707 Pig Farm Sector Revenue Abatement Cost T Emission	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un P o alpha beta F I C c a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.61550 3.421003 6.414760 7.16956.6 -effcient -0.22111	Emission Isban Corramunity S Revenue Abatement Cost T Emission	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d e^a P Q alpha beta F I Co	0.466506 0.544964 -0.01147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A * * * * * * * * * * * * * * * * *	Miclent Ission 38,128,427 1,40,778 38,125,427 38,125,427 38,125,427 38,703,707 Pig Farm Sector Revenue Abatement Cost T Emission	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un C o alpha F I C c a b c	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax constant 0 209526 30.81550 3.421003 6414760 716056.5 effcient	Emission Isban Corramunity S Revenue Abatement Cost T Emission	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d d e^a P O alpha beta F i Co a b c	0.466506 0.544964 0.01147 39.625506 Stibbasin P Transfer coel Subbasin Fm At.1 A A A A A Constant 557 65209 5.4374050 13.033452 3.43665.70 8.23831.45 -cffcient 1.19194 0.719655 0.523061 -0.336506	Miclent Ission 38,128,427 1,40,778 38,125,427 38,125,427 38,125,427 38,703,707 Pig Farm Sector Revenue Abatement Cost T Emission	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un P o alpha beta F I C c a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.61559 30.61559 30.61559 30.61559 30.61559 0.6144700 716056.6 o-effcient 0.808064 0.472057 -0.27929	Emission Isban Corramunity S Revenue Abatement Cost T Emission	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d d e^a P O alpha beta F i Co a b c	0.466506 0.544964 0.01147 39.625506 Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P A 4 A A A A C S S S S S S S S S S S S S S S	ficient ission 36,126,427 1,490,773 36,126,427 36,703,707 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un C o alpha F I C c a b c	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.81550 3.421003 6414760 7.16556.6 effcient 0.22111 0.808084 0.472057	Emission Aban Community S Revenue Abatement Cost T Limission Urban Profit	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d e*a Co P O alpha beta F F I Co d d c c d d e*a	0.466506 0.544964 0.001147 39.625506 Stibbanin P Transfer coef Subbanin Fin Alt.1 A A' omstant 587 63209 5.4374050 13.003452 3.4394052 3.439452 3.4394052 3.43	Miclent ission 36,126,427 1,480,778 36,126,427 36,703,707 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit	70 70 70 54 371103683 589275 37 0.12 670339.996 36433906.0	b c d e^a Un P o alpha beta F I C c a b c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.61550 30.61550 30.61550 30.61550 30.61550 30.61550 5.edf(eint -0.22111 0.808064 0.472057 -0.472929 0.801633	Emission Whan Community S Revenue Abatement Cost T Limission Urban Profit	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.07	Approve
b c d e*a Co P O alpha beta F F I Co d d c c d d e*a	0.466506 0.544964 0.01147 39.625506 Stibbasin P Transfer coel Subbasin Fm At.1 A A A A A Constant 557 65209 5.4374050 13.033452 3.43665.70 8.23831.45 -cffcient 1.19194 0.719655 0.523061 -0.336506	Miclent Ission 36,126,427 1,400,778 36,136,427 36,136,427 36,136,427 36,140 7,400,782 36,140 36,140 7 Revenue Abatement Cost T Emission Pig Farm Profit	70 70 75 54 37103683 589275 37 0.12 670339.996	b c d e^a Un P o alpha beta F I C c a b c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.61559 30.61559 30.61559 30.61559 30.61559 0.6144700 716056.6 o-effcient 0.808064 0.472057 -0.27929	Emission Weban Community So Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue	45407952.86 3451918.205 0.12 716956.5935	Approve
b c d d e*a P O alpha beta F F i Co d d e*a Co d P O O	0.466506 0.544964 0.001147 39.625506 Stibbanin Pr Transfer coel Subbanin Fin Alt.1 A A' onstant 557 63209 5.4274060 13.003452 3.4366.70 823831.45 -effcient -1.16194 0.719655 0.3057645 onstant 55502500 81.5441	Miclent ission 36,126,427 1,480,778 36,126,427 36,703,707 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	70 70 70 54 37103683 568275.37 0.12 670339.956 36433966.0 36433966.0 36433966.0	b c d e^a Un P O alpha beta F I C c a b c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0 209526 30.61550 30.61550 30.61550 30.61550 30.61550 30.61556 50-effcent -0.22111 0.808064 0.472057 -0.27929 0.801633	Emission Woan Community S Revenue Abatement Cost T Linission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 45407952.86 3451918.205 0.12 716856.5835 41069999.07 54158796049 9202720.758 0.12	Approve
b c d d e*a Co alpha beta F I Co d d c d d c c d d a b c c d d alpha beta Co D c c d d c c d c d c c d c c c c c c c	0.466506 0.544964 -0.01147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A' oustant 587 63209 5.4374050 13.003452 34566 70 82383145 -offcient -1.18494 0.718655 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136555 0.522301 -0.136565 0.522301 -0.136565 0.522301 -0.136555 0.522301 -0.136565 0.522301 -0.136555 0.522307 -0.136555 0.522307 -0.136555 0.522307 -0.136555 0.522307 -0.136555 0.522307 -0.136555 0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.136555 -0.522307 -0.1555 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.52550 -0.5255 -0.52550 -0.55550 -0.55550 -0.55550 -0.55550 -0.55550 -0.55550 -0.555550 -0.555550 -0.555555550 -0.55	Miclent Ission 36,126,427 1,40,778 36,125,427 26,703,767 Big Farm Sector Revenue Abatement Cost Pig Farm Profit Pig Farm Profit	70 70 70 54 37103683 589275 37 0.12 670339.396 36433966.0 36433966.0 344158514410 500524369	b c d e^a Un o alpha beta F l c d e^a a b c d e^a a	1.381092 0.169197 -0.40722 0.06677 Morm Tax form Tax 0 209526 30.91550 3.421003 6414760 716956.6 5-effcient 0.22111 0.808064 0.472057 -0.27929 0.801633 Constant 4134001 3.519481	Emission Wean Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.87 41069999.87 54158796049 9202720.758	Approve
b c d d e*a P O alpha beta F I Co d d d d d c c d d d d d d d d d d l f i l Co l D c d d d d d d d d d d d d d d d d d d	0.466506 0.544964 0.001147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfe	Miclent Ission 36,126,427 1,40,778 36,126,427 36,126,126,126,126 36,126,126,126,126,126 36,126,126,126,126,1	70 70 70 54 37103683 589275 37 0.12 670339.396 36433966.0 36433966.0 3415851410 5005524369 0.12 3509836.85	b c d e^a Un P O alpha beta F I C c a b c c d e^a	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0.0007 0.0015550 0.051550 0.051550 0.051550 0.02111 0.808084 0.472057 -0.22111 0.808084 0.472057 -0.22111 0.808084 0.472057 -0.27929 0.801633 iformstant 4134001 3.519481 11.46103	Emission Wean Community S Revenue Abatemeent Cost T Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.87 41069999.87 54158706049 9202720.750 0.12 31229194.16	Approve
b c d d e*a P O alpha beta F C C d d c c d d e*a C C d d e*a F I	0.466506 0.544964 0.001147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A' onstant 587 63209 5.4374050 13.003452 34566 70 823831.45 effcient -1.18494 0.719655 0.523061 -0.39566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 -0.52500 -0.395566 -0.	Miclent ission 36,126,427 1,480,778 36,126,427 36,703,707 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	70 70 70 54 37103683 568275.37 0.12 670339.986 36433966.0 36433966.0 36433966.0	b c d e^a Un o alpha beta F I C c d e*a C d alpha beta F I	1.381092 0.169197 -0.40722 0.06677 form Tax form Tax 0.209526 30.81550 3.421003 6414760 3.421003 6414760 0.22111 0.806084 0.472057 -0.27929 0.801633 constant 4134001 3.519481 11.46103 14549530 47383229	Emission Woan Community S Revenue Abatement Cost T Linission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 45407952.86 3451918.205 0.12 716856.5835 41069999.07 54158796049 9202720.758 0.12	Approve
b c d d e*a F F C d d d c d d d c d d d f C c d d f C c d d f f C c d d f f f C c d c d c d c d c d c c c d d f f f f f	0.466506 0.544964 0.001147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Subbasin P Subb	Miclent Ission 36,126,427 1,40,778 36,126,427 36,126,126,126,126 36,126,126,126,126,126 36,126,126,126,126,1	70 70 70 54 37103683 589275 37 0.12 670339.396 36433966.0 36433966.0 3415851410 5005524369 0.12 3509836.85	b c d e^a Un o alpha beta F I C c d e*a C d alpha beta F I	1.381092 0.169197 -0.40722 0.06677 iform Tax iform Tax 0.0617 0 209526 30.61550 3.421003 6414760 7.16056.5 -effcient 0.42111 0.808084 0.472057 -0.27929 0.801633 ionstant 4134001 3.519481 11.46183 14549530 4738329 -effcient	Emission Wean Community S Revenue Abatemeent Cost T Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.87 41069999.87 54158706049 9202720.750 0.12 31229194.16	Approve
b c d d e*a F F C d d d c d d d c d d d f C c d d f C c d d f f C c d d f f f C c d c d c d c d c d c c c d d f f f f f	0.466506 0.544964 0.001147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A' onstant 587 63209 5.4374050 13.003452 34566 70 823831.45 effcient -1.18494 0.719655 0.523061 -0.39566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 0.523061 -0.395566 -0.52500 -0.395566 -0.	Miclent Ission 36,126,427 1,40,778 36,126,427 36,126,126,126,126 36,126,126,126,126,126 36,126,126,126,126,1	70 70 70 54 37103683 589275 37 0.12 670339.396 36433966.0 36433966.0 3415851410 5005524369 0.12 3509836.85	b c d e^a Un o alpha beta F I C c d e*a C d alpha beta F I	1.381092 0.169197 -0.40722 0.06677 form Tax form Tax 0.209526 30.81550 3.421003 6414760 3.421003 6414760 0.22111 0.806084 0.472057 -0.27929 0.801633 constant 4134001 3.519481 11.46103 14549530 47383229	Emission Wean Community S Revenue Abatemeent Cost T Unission Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.87 41069999.87 54158706049 9202720.750 0.12 31229194.16	Approve
b c d d e*a Co alpha beta F I Co d d e*a Ca alpha beta F I Co alpha beta c d d e*a	0.466506 0.544964 -0.01147 39.625506 Transfer coef Subbasin P Transfer coef Subbasin P Transfer coef Subbasin P Al-1 A A' oustant 587 63209 5.4374050 13.003452 34365.70 82383146 -effcient -1.16494 0.718655 0.522081 -0.3057645 0.305766 0.305766 0.305766 0.305766 0.305766 0.305766 0.305766	Miclent Ission 36,126,427 1,40,778 36,126,427 36,126,126,126,126 36,126,126,126,126,126 36,126,126,126,126,1	70 70 70 54 37103683 589275 37 0.12 670339.396 36433966.0 36433966.0 3415851410 5005524369 0.12 3509836.85	b c d e^a Un beta F I c d e^a e^a C P O alpha beta F I c c a b c c d e^a	1.381092 0.169197 -0.40722 0.06677 form Tax form Tax 0.00007 0.000540 0.209526 0.001530 0.414700 0.209526 0.001530 0.414700 0.22111 0.800084 0.422057 -0.22111 0.800084 0.422057 -0.22192 0.801633 constant 4134001 3.519481 11.46103 3.519481 11.4614950 47383229 0-efficient -2.7065	Emission Wean Community S Revenue Abatemeent Cost T Unission Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 45407952.86 3451918.205 0.12 716956.5935 41069999.87 41069999.87 54158706049 9202720.750 0.12 31229194.16	Approve

## Table C-13: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin LS

587         Abatement Cost         509815.52         P         0         Abatement Cost         305           0         52225         T         0.13         0         98663         T         305           1pha         5.848876         Emission         514155.88         alpha         52.97503         Emission         445           13.12669         Fission         514155.88         alpha         52.97503         Urban Profit         189           685541.2         Fission         30079419         F         52.27507         Urban Profit         189           0.35457.6         Pig Farm Profit         30079419         F         52.97605         Urban Profit         189           0.411494         -         Co-effcient         Co-effcient         1         594845         1         594945           0.719655         Co         Go 302765         c         0.472857         c         1         40         1         19         1         59         1         40         0.27929         c         1         40         1         305         1         40         1         305         1         1         1         1         1         305         1         305 </th <th>Subbasin Emissio At-1 A A A' Pig Constant 587 Aba 52225 a 5.846876 52225 a 5.846876 52225 a 5.846876 53225 a 5.846876 5685541.2 Co-officient -1.18494 0.719655 0.523361 -0.13851 0.305765 Aqu Constant 55502500 Aba 3193750</th> <th>n 34635332.28 5037226.181 3463532.28 34,675,725.07 Farm Sector Revenue 3065607 tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941</th> <th>52 P 13 Q 88 alpha 19 F I C c d d e*a 45</th> <th>Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633</th> <th>rban Community S Revenue Abatement Cost T Emission Urban Profit</th> <th></th> <th>prove</th>	Subbasin Emissio At-1 A A A' Pig Constant 587 Aba 52225 a 5.846876 52225 a 5.846876 52225 a 5.846876 53225 a 5.846876 5685541.2 Co-officient -1.18494 0.719655 0.523361 -0.13851 0.305765 Aqu Constant 55502500 Aba 3193750	n 34635332.28 5037226.181 3463532.28 34,675,725.07 Farm Sector Revenue 3065607 tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	rban Community S Revenue Abatement Cost T Emission Urban Profit		prove
At-1         5037226 181 34635332.28         Emission Pass           Pig Farm Sector         Urban Community Sector         Emission Pass           S87         Abatement Cost         509315.52         P         0         Abatement Cost         309315.52           S87         Abatement Cost         509315.52         P         0         Abatement Cost         309315.52           Ipha         5.848876         Emission         514155.88         alpha         52255         T         0.13         0         98663         T         445           Joba         5.848876         Emission         514155.88         alpha         6.029059         Emission         445           Joba         9.84875         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           Gestell 2         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           0.719655         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           0.719655         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           0.719655         Pig Farm Profit         30079473	At-1 A A Y Fig Constant 587 Ab/ 52225 a 5.848876 1 33.12669 305457.6 Pig 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13861 0.305765 Aqu Constant 55502500 Ab/ 14.978 a 3193750	5037226.181 34635332.28 3463532.28 Term Sector Revenue 3065607 tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941 Farm Profit 3007941 Control Cost 20678253 T 3.9	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	rban Community S Revenue Abatement Cost T Emission Urban Profit	ector 20862973.86 3059630.416 1.92 445059.7059	prove
A         34635332.28 34,675,725.07         Emission Pase           Fig Farm Sector         Urban Community Sector           Constant         Revenue         30656075         Constant         Revenue         208           587         Abatement Cost         509615.52         P         0         Abatement Cost         305           52225         T         0.13         0         98663         T           19ha         5.448676         Emission         514155.88         alpha         52.97503         Emission         445           305457.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           685541.2         Co-efficient         -         -         -0.22111         169           0.523361         c         0.4072857         Urban Profit         169           0.523361         c         0.4072857         -         4           0.305765         Abatement Cost         226782530         2         -           0         14.978         T         3.91         0         11134486         T           14.978         T         3.91         0         11134486         T         -	A A' Pig Constant 587 Ab 52225 a 5.848876 13.12669 305457.6 Pig 685541.2 Co-officient -1.18494 0.719655 0.523361 0.305765 Aqu Constant 55502500 14.978 a 3183750	34635332.28           34,675,725.07           Farm Sector           Revenue         3065607           tement Cost         509815.5           T         0.1           Emission         514155.8           Farm Profit         3007941           culture Sector         83131644           Revenue         22678253           T         3.9	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	rban Community S Revenue Abatement Cost T Emission Urban Profit	ector 20862973.86 3059630.416 1.92 445059.7059	prove
Pig Farm Sector         Urban Community Sector           Constant         Revenue         30656075         Constant         Revenue         208           587         Abatement Cost         509815.52         P         0         Abatement Cost         305           0         52225         T         0.13         0         98663         T         305           1pha         5.848876         Emission         514155.88         alpha         52.97503         Emission         445           1305457.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           0         0.5437.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           0.605511.2         Co-effcient         a         -0.22111         b         0.808084         5           0.719655         b         0.808084         c         0.472857         5         5           1         -0.13851         c         0.801633         T         3.05         3         5           0         14.978         T         3.91         0         11134486         T         3.95           14.978	Pig Constant 587 Abi 52225 a 5.84876 133/2669 305457.6 Pig 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 Aqu Constant 55502500 Abi 14.978 a 3193750	Farm Sector Revenue 3065607 tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	rban Community S Revenue Abatement Cost T Emission Urban Profit	ector 20862973.86 3059630.416 1.92 445059.7059	prove
Constant         Revenue         30656075 509         Constant         Revenue         208           587         Abatement Cost         509815.52         P         0         Abatement Cost         305           1         52225         T         0.13         0         98663         T         305           1         514155.88         alpha         522675         Urban Profit         30079419         F         5222675         Urban Profit         189           305457.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         189           685541.2         Co-effcient         a         -0.22111         189         189485	Constant 587 Abi 52225 a 5.848876 13.12669 305457.6 Pi 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 Aqu Constant 55502500 14.978 a 3193750	Revenue 3065607 tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	Constant 0 98663 52.97503 6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Revenue Abatement Cost T Emission Urban Profit	20862973.86 3059630.416 1.92 445059.7059	
587         Abatement Cost         509815.52         P         0         Abatement Cost         305           1         52225         T         0.13         0         98663         T         305           1pha         5.848876         Emission         514155.88         alpha         52.97503         Emission         445           305457.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         189           685541.2         -         -         Co-effcient         -         594845         -         189           -1.18494         -         -         Co-effcient         -         Co-effcient         - <th>587 Ab: 52225 a 5.848876 b 13.12669 305457.6 Pit 685541.2 Co-effcient -1.18494 0.719655 0.523381 -0.13651 0.305765 Constant 55502500 14.978 a 3193750</th> <th>tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9</th> <th>52 P 13 Q 88 alpha 19 F I C c d d e*a 45</th> <th>0 98663 52.97503 6.029059 5226675 594845 <b>co-effcient</b> 0.22111 0.808064 0.472857 -0.27929 0.801633</th> <th>Abatement Cost T Emission Urban Profit</th> <th>3059630.416 1.92 445059.7059</th> <th></th>	587 Ab: 52225 a 5.848876 b 13.12669 305457.6 Pit 685541.2 Co-effcient -1.18494 0.719655 0.523381 -0.13651 0.305765 Constant 55502500 14.978 a 3193750	tement Cost 509815.5 T 0.1 Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	52 P 13 Q 88 alpha 19 F I C c d d e*a 45	0 98663 52.97503 6.029059 5226675 594845 <b>co-effcient</b> 0.22111 0.808064 0.472857 -0.27929 0.801633	Abatement Cost T Emission Urban Profit	3059630.416 1.92 445059.7059	
52225         T         0.13         0         98663         T         445           ipha         5.848876         Emission         514155.88         alpha         52297503         Emission         455           305457.6         Pig Farm Profit         30079419         F         5226675         Urban Profit         169           685541.2         I         594845         Co-effcient         a         -0.22111         169           -1.18494         0.305765         E         0.808064         5         5         5           0.523361         c         0.808064         c         0.472857         5         5           0.305765         Aquaculture Sector         c         0.472857         5         5         5           1         -0.13651         -         c         0.472857         5         5           4         0.305765         Abatement Cost         226782530         P         -         Abatement Cost         306           1         4.4978         T         3.91         0         11134466         T         308           14.978         T         3.91         0         11134466         T         308	52225 a 5.848976 1.33,12659 305457.6 Pi 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 Aqu Constant 55502500 Aba 14.978 a 3193750	T 0.1 Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	13 Q 88 alpha 19 F 1 C a b c c d e^a 45	98663 52.97503 6.029059 5226675 594845 <b>co-effcient</b> -0.22111 0.808064 0.472857 -0.27929 0.801633	T Emission Urban Profit	1.92 445059.7059	
Ippa         5.848876         Emission         514155.88         Ippa         52.97503         Emission         445           13.12669         beta         0.029059         F         5226675         Urban Profit         189           685541.2         594845         Souther Profit         30079419         F         5226675         Urban Profit         189           1         -1.18494         -         Co-effcient         -         Co-effcient         - </td <td>a 5.848876 1.312669 305457.6 Pig 685541.2 Co-officient -1.18494 0.719655 0.523361 -0.305765 Aqu Constant 55502500 Abz 14.978 a 3193750</td> <td>Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22676253 T 3.9</td> <td>88 alpha beta 19 F I C b c d e^a 45</td> <td>52.97503 6.029059 5226675 594845 <b>:o-effcient</b> -0.22111 0.808064 0.472857 -0.27929 0.801633</td> <td>Emission Urban Profit</td> <td>445059.7059</td> <td></td>	a 5.848876 1.312669 305457.6 Pig 685541.2 Co-officient -1.18494 0.719655 0.523361 -0.305765 Aqu Constant 55502500 Abz 14.978 a 3193750	Emission 514155.8 Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22676253 T 3.9	88 alpha beta 19 F I C b c d e^a 45	52.97503 6.029059 5226675 594845 <b>:o-effcient</b> -0.22111 0.808064 0.472857 -0.27929 0.801633	Emission Urban Profit	445059.7059	
beta       6.029059       Urban Profit       159         305457.6       Pig Farm Profit       30079419       F       5226875       Urban Profit       169         6655541.2       5       594845       5       594845       5       169         0.118494       a       -0.22111       b       0.808064       5       5         0.719655       c       0.472857       c       0.472857       5       5         1       -0.13651       c       0.472857       c       0.801633       5         1       -0.13651       e*a       0.801633       5 <t< td=""><td>1 13.12669 305457.6 Pit 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 Aque Constant 55502500 14.978 a 3193750</td><td>Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9</td><td>19 F I C d d e^a 45</td><td>6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633</td><td>Urban Profit</td><td></td><td></td></t<>	1 13.12669 305457.6 Pit 685541.2 Co-effcient -1.18494 0.719655 0.523361 -0.13651 0.305765 Aque Constant 55502500 14.978 a 3193750	Farm Profit 3007941 culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	19 F I C d d e^a 45	6.029059 5226675 594845 co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633	Urban Profit		
305457.6       Pig Farm Profit       30079419       F       5226675       Urban Profit       169         665541.2       I       534845       I       534845       I       534845       I       169         1       -1.18494       a       -0.22111       I       5000064       I       I       169       I       16	305457.6 Pig 685541.2 Co-effcient -1.18494 0.719655 0.523361 0.523361 0.305765 Pig 0.305765 Pig Constant 55502500 Aba 14.978 a 3193750 Pig	culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	19 F I C a b c d e^a 45	5226675 594845 <b>co-effcient</b> -0.22111 0.808064 0.472857 -0.27929 0.801633		16948828.81	
685541.2       I       594845         Co-effcient       Co-effcient       -0.22111         -1.18494       a       -0.222111         0.719655       b       0.808064         0.523361       c       0.472857         -0.13651       d       -0.27929         *a       0.305765       e*a       0.801633         Factory Sector         Constant       Revenue       831316445       Constant       Revenue       3.00         55502500       Abatement Cost       226782530       P       -       Abatement Cost       59         1       14.978       T       3.91       0       11134486       T       300         1pha       3193750       Emission       665268.02       alpha       5.156587       Emission       300         eta       53312.5       beta       3.957577       Emission       300         eta       68382.6       1       44065331       1       44065531         0       0.4465506       1       3.057473       3.06       1       44065531       1         0       0.4465056       5       5       5       5       5       1	685541.2 Co-efficient -1.18494 0.719655 0.523361 0.305765 Aqu Constant 55502500 Aba 14.978 a 3193750	culture Sector Revenue 83131644 tement Cost 22678253 T 3.9	45	594845 <b>co-effcient</b> -0.22111 0.808064 0.472857 -0.27929 0.801633		10040020.01	
-1.18494     a     -0.22111       0.719655     b     0.808064       0.523361     c     0.472857       1     -0.13651     d     -0.27929       *a     0.305765     e*a     0.801633       Factory Sector       Constant     Revenue     831316445     Constant     Revenue     3.06       0     55502500     Abatement Cost     226782530     P     -     Abatement Cost     3.06       0     14.978     T     3.91     0     11134486     T     3.06       14.978     T     3.91     0     11134486     T     3.06       47835988     Aquaculture Profit     601932717     F     57415944     Factory Profit     3.06       88382.6     I     44065531     Co-efficient     -     -     -       3.679473     I     0     1.381092     I     3.06       0     0.4465066     I     3.81092     I     I       0     0.466506     I     3.81092     I     I       0     0.466506     I     0.408197     I     I       0     0.468506     I     0.189197     I     I       0     0.189197     I <td>-1.18494 0.719655 0.523361 -0.13651 0.305765 Aqu Constant 55502500 14.978 a 3193750</td> <td>Revenue 83131644 tement Cost 22678253 T 3.9</td> <td>a b c d e^a 45</td> <td>-0.22111 0.808064 0.472857 -0.27929 0.801633</td> <td>Factory Sector</td> <td>2</td> <td></td>	-1.18494 0.719655 0.523361 -0.13651 0.305765 Aqu Constant 55502500 14.978 a 3193750	Revenue 83131644 tement Cost 22678253 T 3.9	a b c d e^a 45	-0.22111 0.808064 0.472857 -0.27929 0.801633	Factory Sector	2	
0.719655       b       0.808064         0.523361       c       0.472857         -0.13651       e*a       0.801633         *a       0.305765       e*a       0.801633         *a       0.305765       e*a       0.801633         *a       0.801633       Encory Sector       55502500         Adatement Cost       226782530       P       -       Abatement Cost       59         0       14.978       T       3.91       O       11134486       T       1         Ipha       3193750       Emission       665268.02       alpha       5.156587       Emission       3.00         47835988       Aquaculture Profit       601932717       F       57415944       Factory Profit       3.02         686382.6       I       Co-efficient       I       Co-efficient       I       Co-efficient       I       S.02         3.679473       J       G       1.381092       J       I       J       J       J         0.0466506       J       0.1619197       G       0.1619197       J       J       J       J       J       J       J       J       J       J       J       J       J	0.719655 0.523361 0.305765 0.305765 Constant 55502500 14.978 a 3193750	Revenue 83131644 tement Cost 22678253 T 3.9	45 b c d e^a	0.808064 0.472857 -0.27929 0.801633	Factory Sector	-	
0.523361 -0.13651       c       0.472857 d       -0.27929 -0.27929         • a       0.305765       e^a       0.801633         Factory Sector         Constant       Revenue       831316445       Constant       Revenue       3.06         55502500       Abatement Cost       226782530       P       -       Abatement Cost       59         14.978       T       3.91       Q       11134486       T       300         Ipha       3193750       Emission       665260.02       alpha       5.156587       Emission       330         47835988       Aquacuiture Profit       601932717       F       57415944       Factory Profit       3.06         683832.6       I       4/4056531       Co-efficient       3.06       3.06       3.06       3.06         3.679473       3.679473       a       -2.7065       5       5       5       5         0.544964       0.0619197       c       0.1381092       c       1.381092       5         0.01147       0.01147       d       0.040722       5       5       5	0.523361 -0.13651 0.305765 Aqu Constant 55502500 Aba 14.978 a 3193750	Revenue 83131644 tement Cost 22678253 T 3.9	45 c d e^a	0.472857 -0.27929 0.801633	Factory Sector	-	
d     -0.13651     d     -0.27929       Aquaculture Sector     e^a     0.801633       Constant     Revenue     831316445     Constant     Revenue     3.06       0     55502500     Abatement Cost     226782530     P     -     Abatement Cost     3.06       1     14.978     T     3.91     O     11134486     T       1     3.93750     Emission     665268.02     alpha     5.165687     Emission     3.06       47835988     Aquaculture Profit     601932717     F     57415944     Factory Profit     3.06       88382.6     I     4     44065531     Co-efficient     Co-efficient     Co-efficient     Co-efficient       3.679473     Co     1.381092     Co-efficient     Co-lise197     Co-lise197       0     0.468506     b     1.381092     Co-efficient     Co-lise197       0     0.0118917     C     0.0118917     Co-efficient     Co-efficient       0     0.1381092     C     Co-lise197     C       0     0.189197     C     Co-efficient     C       0     0.189197     C     Co-lise197     C       0     0.189197     C     C       0     0.189	-0.13651 0.305765 Aqu Constant 55502500 Abs 14.978 ia 3193750	Revenue 83131644 tement Cost 22678253 T 3.9	d e^a 45	-0.27929 0.801633	Factory Sector	_	
Aa         0.305765         e^a         0.801633           Constant         Revenue         831316445         Constant         Revenue         3.06           55502500         Abatement Cost         226782530         P         -         Abatement Cost         59           1         4.978         T         3.91         O         11134486         T         59           1         4.9785         Emission         665268.02         alpha         5.156587         Emission         330           eta         59312.5         Emission         665268.02         alpha         5.1566587         Emission         300           eta         59312.5         Emission         661932717         F         57415944         Factory Profit         3.06           88882.6         Co-effcient         Co-effcient         Co-effcient         Co-effcient         E         3.079473         E         543002         E         E         543002         E         543002         E         E         543002         E         E         543002         E         E         55002500         E         E         55002500         E         E         565002         E         E         560002         E	0.305765 Aqu Constant 55502500 Ab: 14.978 a 3193750	Revenue 83131644 tement Cost 22678253 T 3.9	45	0.801633	Factory Sector		
Constant         Revenue         831316445         Constant         Revenue         3.00           55502500         Abatement Cost         226782530         P         Abatement Cost         59           14.978         T         3.91         0         11134486         T         59           1pha         3193750         Emission         665268.02         alpha         5.156587         Emission         330           eta         59312.5         Aquaculture Profit         601932717         F         57415944         Factory Profit         3.06           Co-effcient         -	Constant 55502500 Aba 14.978 a 3193750	Revenue 83131644 tement Cost 22678253 T 3.9		Constant	Factory Sector		
55502500         Abatement Cost         226782530         P         -         Abatement Cost         59           14.978         T         3.91         0         11134486         T         51           lpha         3193750         Emission         665268.02         alpha         5156587         Emission         330           seta         59312.5         beta         3.95772         Emission         3.06           47835988         Aquaculture Profit         601932717         F         57415944         Factory Profit         3.06           608982.6         I         44065531         Go-effcient         Co-effcient         I         44065531           3.679473         Go.4466506         b         1.381092         I         1.381092         I           0.544964         Go.10819197         Go.10819197         Go.10819197         I         Go.1081917         I         I	55502500 Aba 14.978 a 3193750	tement Cost 22678253 T 3.9		Constant			
55502500         Abatement Cost         226782530         P         -         Abatement Cost         59           14.978         T         3.91         0         11134486         T         51           lpha         3193750         Emission         665268.02         alpha         5156587         Emission         330           seta         59312.5         beta         3.95772         Emission         3.06           47835988         Aquaculture Profit         601932717         F         57415944         Factory Profit         3.06           608982.6         I         44065531         Go-effcient         Co-effcient         I         44065531           3.679473         Go.4466506         b         1.381092         I         1.381092         I           0.544964         Go.10819197         Go.10819197         Go.10819197         I         Go.1081917         I         I	14.978 a 3193750	tement Cost 22678253 T 3.9			Revenue	3.06198E+11	
Ippa         3193750         Emission         665268.02         alpha         5.156587         Emission         330           teta         59312.5         beta         3.957572         beta         5.056531         beta         beta         5.056531         beta         5.056531         beta         5.056531         beta         5.05656         beta         5.05657         beta         5.056531         beta         5.05676         beta         5.056767         beta <td< td=""><td>a 3193750</td><td></td><td></td><td>-</td><td>Abatement Cost</td><td>59177136.5</td><td></td></td<>	a 3193750			-	Abatement Cost	59177136.5	
beta         3.957572           47835988         Aquaculture Profit         601932717         F         57415944         Factory Profit         3.06           88882.6         I         44065531         I         44065531           Co-efficient         Co-efficient         Co-efficient         I           3.679473         a         -2.7065         D           0.544964         c         0.169197         I           0.01147         d         -0.40722						0.73	
47835988         Aquaculture Profit         601932717         F         57415944         Factory Profit         3.06           88382.6         I         44065531         I         44065531         I         44065531           Co-efficient         Co-efficient         Co-efficient         I         5406563         I         1381092         I         I         14065631         I         1381092         I         I         I         14065631         I         1381092         I	08012.0	mission 665268.0			Emission	33010848.67	
888382.6         I         44065531           Co-effcient         Co-effcient           3.679473         a         -2.7065           0.466506         b         1.381092           0.544964         c         0.169197           -0.01147         d         -0.40722	47835988 Agu	culture Profit 60193271			Factory Profit	0 3.06114E+11	
3.679473         a         -2.7065           0.466506         b         1.381092           0.544964         c         0.169197           -0.01147         d         -0.40722		00100211	i		, and y result		
0.466506         b         1.381092           0.544964         c         0.169197           -0.01147         d         -0.40722			C				
0.544964 c 0.169197 -0.01147 d -0.40722							
-0.01147 d -0.40722							
*a 39.62551 e*a 0.06677	39.62551		e*a	0.06677			
Subbasin Emission         34,291,368,25           At-1         S.053,101,60           A         34,291,300,25	At-1	5,053,101.60					
A* 34,675,725.07 Emission Pass	A*	34,675,725.07			Emission	Carl Contractor	
Dia Form Contes	P	g Farm Sector			China and	Pass Ar	prove
Pig Farm Sector Urban Community Sector			122	11.1.5	Urban Community		prove
Constant Revenue 30555075 Constant Revenue 208		Revenue 30656	Contraction of the second s	Constant	Urban Community : Revenue	Sector 20862973.86	prove
Constant Revenue 30556075 Constant Revenue 208 587 Abatement Cost 625165.59 P 0 Abatement Cost 283	587 AI	Revenue 30656 atement Cost 62516	66.59 P	Constant 0	Urban Community : Revenue Abatement Cost	ector 20862973.86 2821518.127	prove
Constant         Revenue         30656075         Constant         Revenue         206           587         Abatement Cost         625166.59         P         0         Abatement Cost         285           2         52225         T         0.74         Q         98663         T	587 AI 52225	Revenue 30656 atement Cost 62516 T	66.59 P 0.74 Q	Constant 0 98663	Urban Community Revenue Abatement Cost T	iector 20862973.86 2821518.127 0.74	prove
Constant         Revenue         30656075         Constant         Revenue         206           587         Abatement Cost         625166.50         P         0         Abatement Cost         280           0         52225         T         0.74         Q         98663         T           lpha         5.848876         Emission         115389.38         alpha         52.97503         Emission         594	587 Al 52225 a 5.848876	Revenue 30656 atement Cost 62516 T	66.59 P 0.74 Q 89.36 alpl	Constant 0 98663 Na 52.97503	Urban Community Revenue Abatement Cost T	ector 20862973.86 2821518.127	prove
Constant         Revenue         30656075         Constant         Revenue         208           587         Abatement Cost         625166.50         P         0         Abatement Cost         28           52225         T         0.74         0         98663         T         9         6         4batement Cost         28         6         15         15         15         16	587 Al 52225 a 5.848876 13.12009 305457.6 P	Revenue 30656 atement Cost 62516 T Emission 11538	66.59 P 0.74 Q 89.36 alpl bet	Constant 0 98663 ha 52.97503 a 6.029059 5226675	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74	prove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           b         52225         T         0.74         Q         58663         T         283           bpta         5.848876         Emission         115389.38         alpha         52.97503         Emission         594           cta         13.12099         305457.6         Pig Farm Profit         29945520         F         5220675         Urban Profit         170           685551.2         I         504645         5         1         504645         5	587 Al 52225 a 5.846876 b 13.12099 305457.6 P 685541.2	Revenue 30656 atement Cost 62516 T Emission 11538	66.59 P 0.74 Q 89.36 alpl bet	Constant 0 58663 ha 52.97503 a 6.029059 5226675 594845	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74 594845.0087	ipt ove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         88683         T         283           1pha         5.848978         Emission         115389.38         alpha         52.97503         Emission         59           eta         13.12609         Emission         29945520         E         5226075         Urban Profit         17           685561.2         Co-effcient         Co-effcient         Co-effcient         504845         50	587 Al 52225 a 5.848878 b 13.12689 305457.6 P 685541.2 Co-effcient	Revenue 30656 atement Cost 62516 T Emission 11538	66.59 P 0.74 Q 89.36 alpl bet	Constant 0 98663 ha 52.97503 a 6.029059 5226675 594845 Co-effcient	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74 594845.0087	ipt ove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         58663         T         283           6phas         5.848876         Emission         115389.38         aphas         5.97503         Emission         594           101         30557.6         Pig Farm Profit         29945520         F         5220875         Urban Profit         170           685541.2         I         504645         5         1         504645         5	587 Al 52225 a 5.848878 13.12699 305457.6 P 685541.2 Co-effcient -1.18494	Revenue 30656 atement Cost 62516 T Emission 11538	66.59 P 0.74 Q 89.38 alpi 15520 F 1 1	Constant 0 98663 ha 52.97503 a 6.029059 5226675 594845 Co-efficient -0.22111	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74 594845.0087	ipt ove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         0         98663         T         283           alpha         5.848878         Emission         115389.38         alpha         52.97503         Emission         59           305457.6         Pig Farm Profit         29945520         F         5226975         Urban Profit         170           685541.2         Co-effcient         Co-effcient         Co-effcient         1         594845           -1.18494         -1.18494         -0.22111         0.000004         0         0.00004           0.719655         -0.472857         -0.472857         -0.472857         -0.472857         -0.472857	587 Al 52225 a 5.848876 b 13.12089 205457.6 P 685541.2 Co-effcient -1.18484 0.719655 0.553361	Revenue 30656 atement Cost 62516 T Emission 11538	66.59 P 0.74 Q 89.36 alpi bet 15520 F 1 a b c	Constant 0 98663 ha 52.97503 s226075 594845 Co-effcient 0.020111 0.000064 0.472857	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74 594845.0087	aprove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         263           52225         T         0.74         0         96663         T         263           state         T         0.74         0         96663         T         263           gba         5.846876         Emission         115389.38         alpha         52.97503         Emission         59           g05457.6         Pig Farm Profit         29945520         F         5226675         Urban Profit         170           685541.2         Co-effcient         a         -0.22111         504645         170           0.719655         0         0.000004         a         -0.22111         170           0.719655         0         0.000004         a         -0.22111         170           0.523361         a         0.472857         a         -0.22111         170           0.523361         a         0.472857         a         -0.27929         170	587 Al 52225 a 5.848876 i 13.12089 005457.6 P 685541.2 Co-effcient -1.18484 0.719055 0.523861 -0.13651	Revenue 30656 atement Cost 62516 T Emission 11538	66.50 P 0.74 Q 89.38 alph 15520 F I a b c c d	Constant 0 98663 ha 52.97503 a 6.029059 5226675 594845 Co-effcient -0.22111 0.000064 0.472857 -0.27929	Urban Community : Revenue Abatement Cost T Emission	iector 20862973.86 2821518.127 0.74 594845.0087	prove
Constant         Revenue         30655075         Constant         Revenue         203           587         Abatement Cost         625165.59         P         0         Abatement Cost         263           52225         T         0.74         0         96663         T         263           s52265         T         0.74         0         96663         T         263           s686876         Emission         115389.36         alpha         52.97503         Emission         594           905457.6         Pig Farm Profit         29945520         F         5226075         Urban Profit         170           685541.2         Co-effcient         a         -0.22111         170           Co-effcient         a         -0.22111         1         1         1           0.719655         0         503567         4         -0.27929         4         -0.47929         4         -0.47929         4         -0.27929         -1         -0.27929         -1         -0.27929         -1         -0.27929         -1         -0         -0.27929         -1         -0         -0.27929         -1         -0         -0         -0         -0.27929         -1         -0	587 Al 52225 a 5.848876 i 13.12099 305457.6 P 685541.2 Co-effcient -1.18484 0.719055 0.523361 -0.13651 0.305765	Revenue 30656 atement Cost 62516 T Emission 11538 g Farm Profit 29945	66.50 P 0.74 Q 89.38 alph 15520 F I a b c c d	Constant 0 98663 ha 52.97503 a 6.029059 5226675 594845 Co-effcient -0.22111 0.000064 0.472857 -0.27929	Urban Community : Revenue Abatement Cost T Emission Urban Profit	Sector 20862973.86 2821518.127 0.74 594845.0087 17601270.43	prove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625165.59         P         0         Abatement Cost         283           52225         T         0.74         0         96663         T         283           sbatement Cost         115389.36         alpha         52.97503         Emission         594           eta         13.12699         90547.6         Pig Farm Profit         29945520         F         522675         Urban Profit         170           685541.2         Co-effcient         -         -         504845         170         170           -0.18444         0.79955         Co-effcient         a         -0.22111         170           -1.18484         0.305765         0         6.0472567         0         6.000004           -0.13651         -         0         0.272567         -         -           -0.305765         -         -         -         6.27257         -           -0.305765         -         -         -         -         -           -0.305765         -         -         -         -         -           -	587 Al 52225 a 5.848876 i 13.12089 305457.6 P 685541.2 Co-effcient -1.18484 0.719655 0.553361 -0.13651 0.305765 Ag	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945	66.50 P 0.74 Q 199.38 alph 15520 F 1 a b c d e^a	Constant 0 96653 ha 52.97503 \$22075 \$24845 Co-effcient 0.22111 0.000064 0.472857 -0.27929 0.801633	Urban Community : Revenue Abatement Cost T Emission Urban Profit Factory Secto	Sector 20062973.86 2821518.127 0.74 594045.0087 17601270.43	abt ove
Constant         Revenue         3055075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         98663         T         283           pha         5.84876         Emission         11539.36         alpha         5227503         Emission         594           a         0.029039         Deta         0.029039         Urban Profit         176           0.685541.2         Co-efficient         a         -0.22111         176           -0.79655         D         0.000004         -         -           0.732381         E         0.000004         -         -           -0.305765         e         0.472657         -         -         -           -0.305765         e*a         0.801833         -         -         -           -0.305765         -         e*a         0.801833         -         -	587 Al 52225 a 5,84876 13,12009 305457,8 P 865551 2 Co-offcient -1,18494 0,719055 0,523361 -0,13651 0,305785 Ag Constant	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 831316	66550 P 0.74 Q 89.38 alpi 55520 F i a bet i bet i a b c c d e^a 6445	Constant 0 96653 ha 52.97503 \$22075 \$24845 Co-effcient 0.22111 0.000064 0.472857 -0.27929 0.801633	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43	abt ove
Constant         Revenue         30555075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         98663         T         283           states         Emission         115389.38         alpha         52,97503         Emission         599           a05457.6         Pig Farm Profit         29945520         F         5226075         Urban Profit         170           58550.50         Pig Farm Profit         29945520         F         5226075         Urban Profit         170           1.18494         -         -         504845         -         170         170           0.73351         -         0.022111         D         0.000064         -         -           -         0.305765         -         -         0.472857         -         -         -           -         0.305765         -         -         6231316445         -         -         -           -         Aguaculture Sector         -         -         Abatement Cost         591         -         -	587 Al 52225 5 a 584876 i 13.12009 305457.6 P 685541 2 Co-effcient -1.18494 0.719055 0.523361 -0.13651 0.305765 Aq Constant 55502500 Al	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945	66550 P 0.74 Q 189.38 alpl bet 15520 F 1 a b c d d e <sup>+</sup> a 6445 P	Constant 0 98653 ha 52.97503 520075 504845 Coeffcient 0.22111 0.00004 0.472857 -0.27929 0.801833 Constant	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost	Sector 20062973.86 2821518.127 0.74 594045.0087 17601270.43	opt over
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         98663         T         283           1         52225         T         0.74         Q         98663         T         283           1         52225         F         0.74         Q         98663         T         283           eta         13.12699         Bit Size         Bit Size         Bit Size         599         beta         6.029099         Beta         6.029099         Beta         6.0290199         170         170           0.85551 2         Co-efficient         -         0.022017         Urban Profit         170           0.719655         0         0.000004         -         0.22111         -         6           0.305785         -         0         0.000004         -         -         -         -           4         0.305785         -         0.27339         -         -         -         -           4         0.305785         -         0.0	587 Al 52225 35248576 13.12009 305457.6 P 5855512 Co-offcient -1.10494 0.719055 0.523351 -0.13651 0.305785 Ag Constant 55502500 Al 14.978 a 3193780	Revenue 30655 atement Cost 62516 T 11538 g Farm Profit 29945	66550 P 0.74 Q 89.38 alpi 55520 F 1 1 55520 F 1 1 8 6445 P 0.74 Q 0.74 Q 0.74 Q	Constant 0 96663 ha 52 87503 a 0.029039 504845 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633 Constant 11134486 ha 5.156587	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Urban Profit Factory Secto Revenue Abatement Cost T Emis sion	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 3.06190E+11 59410034.46	oprove
Constant         Revenue         30555075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           1         52225         T         0.74         Q         98663         T         283           1         52496         Emission         115389.38         alpha         52.9750         Emission         599           305457.6         Pig Farm Profit         29945520         F         5220575         Urban Profit         170           6855541.2         Co-effcient         -         504845         -         170           0.719955         0.523361         -         0.000004         -         -           0.719955         0.523361         -         0.02929         -         -           0.305765         Emission         50         0.000004         -         -           0.305765         Emission         291316445         Constant         Revenue         90           0.305765         Abatement Cost         226031478         P         -         Abatement Cost         59           0.143750         Abatement Cost         226031478         P <td>587 Al 52225 5225 a 584876 b 13.12009 305457.6 P 885561 2 Co-effcient - 1.18494 0.719055 0.523361 - 0.13651 0.305765 Aq Constant 55502500 Al 14.978 a 3183750 b 59312.5</td> <td>Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838</td> <td>665.50 P 0.74 Q 89.38 alpl bet 15520 F 1 3 5520 F 1 4 4 4 4 4 4 4 82.63 alpl bet 5 5 2 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9</td> <td>Constant 0 98653 ha 52.97503 520075 504845 Coeffcient 0.00004 0.472857 0.20111 0.00004 0.472857 0.801633 Constant 11134486 ha 5.166587 a 5.165877</td> <td>Urban Community : Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Secto Revenue Abatement Cost T Emission</td> <td>Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25</td> <td>opt over</td>	587 Al 52225 5225 a 584876 b 13.12009 305457.6 P 885561 2 Co-effcient - 1.18494 0.719055 0.523361 - 0.13651 0.305765 Aq Constant 55502500 Al 14.978 a 3183750 b 59312.5	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	665.50 P 0.74 Q 89.38 alpl bet 15520 F 1 3 5520 F 1 4 4 4 4 4 4 4 82.63 alpl bet 5 5 2 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Constant 0 98653 ha 52.97503 520075 504845 Coeffcient 0.00004 0.472857 0.20111 0.00004 0.472857 0.801633 Constant 11134486 ha 5.166587 a 5.165877	Urban Community : Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Secto Revenue Abatement Cost T Emission	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25	opt over
Constant         Revenue         30655075         Constant         Revenue         205           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         58663         T         283           194.5         5294878         Emission         115389.38         alpha         522057         T         599           eta         13.12699         3035457.6         Pig Farm Profit         29945520         F         5220875         Urban Profit         170           6855541.2         Co-effcient         -         2000004         -         170         170           0.719655         0.523381         -         0.000004         -         292920         -         -           ^4a         0.305765         -         -         0.472857         -         0.000004         -         -           -0.13651         -	587 Al 52225 J 52225 J 5286876 J 13.12009 J 305457.8 P 685541.2 Co-officient -1.18484 J 0.719955 J 5.53351 J 0.305765 Ag Constant 55502500 Al 14.978 J 3193750 J 59312.5 Ag	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	665.50 P 0.74 Q 89.38 alpl bet 15520 F 1 3 5520 F 1 4 4 4 4 4 4 4 82.63 alpl bet 5 5 2 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Constant 0 96663 ha 52.97503 4 0.029099 5504645 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633 Constant 11134486 ha 5.156587 a 3.957572 57415944	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit	Sector 20862973.86 2821518.127 0.74 594845.0087 17601270.43 3.06190E+11 59410034.46 0.74	non office
Constant         Revenue         30555075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           1         52225         T         0.74         Q         98663         T         283           1         52496         Emission         115389.38         alpha         52.9750         Emission         599           305457.6         Pig Farm Profit         29945520         F         5220575         Urban Profit         170           6855541.2         Co-effcient         -         504845         -         170           0.719955         0.523361         -         0.000004         -         -           0.719955         0.523361         -         0.02929         -         -           0.305765         Emission         50         0.000004         -         -           0.305765         Emission         291316445         Constant         Revenue         90           0.305765         Abatement Cost         226031478         P         -         Abatement Cost         59           0.143750         Abatement Cost         226031478         P <td>587 Al 52225 a 5,84876 13,12009 305457,6 P 865551 2 <b>Co-offcient</b> -1,10494 0,719055 0,523361 -0,13651 0,305765 <b>Constant</b> 55502500 Al 14,978 a 3183750 9,59312,5 47005900 Au 888382,6</td> <td>Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838</td> <td>665.50 P 0.74 Q 89.38 alpl bet 15520 F 1 3 5520 F 1 4 4 4 4 4 4 4 82.63 alpl bet 5 5 2 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9</td> <td>Constant 0 96653 ha 52 87503 a 0.029099 504845 Co-effcient -0.22111 0.00004 0.472857 -0.27829 0.801633 Constant 11134486 ha 5.156587 a 3.957572 3.957572</td> <td>Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit</td> <td>Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25</td> <td>iprove</td>	587 Al 52225 a 5,84876 13,12009 305457,6 P 865551 2 <b>Co-offcient</b> -1,10494 0,719055 0,523361 -0,13651 0,305765 <b>Constant</b> 55502500 Al 14,978 a 3183750 9,59312,5 47005900 Au 888382,6	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	665.50 P 0.74 Q 89.38 alpl bet 15520 F 1 3 5520 F 1 4 4 4 4 4 4 4 82.63 alpl bet 5 5 2 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Constant 0 96653 ha 52 87503 a 0.029099 504845 Co-effcient -0.22111 0.00004 0.472857 -0.27829 0.801633 Constant 11134486 ha 5.156587 a 3.957572 3.957572	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25	iprove
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         58663         T         283           1         52225         T         0.74         Q         58663         T         283           1         5249763         Emission         115389.38         alpha         5229573         Emission         59           1         549876         Pig Farm Profit         29945520         F         5220675         Urban Profit         170           68555112         Co-effcient         -         0.029039         Urban Profit         170           0.719655         0.523361         -         0.000004         -         0.022111         -           -0.719655         -         -         0.000004         -         0.022111         -         -           -0.719655         -         -         Apaaculture Sector         -         -         -         Abatement Cost         59           -1.44778         T         0.74         0         11134485         T	587 Al 52225 S 52225 S 522657 S 52267 S 5225 S 5225 S 5225 S 5225 S 5225 S 5225 S 5225 S 5225 S 5225 S 5255 S 52555 S 52555 S 52555 S 52555 S 52555 S 52555 S 52555 S 52	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	66.50 P 0.74 Q 199.38 alpi bet 15520 F 1 a b c d d e*a d e*a 0.74 Q 82.63 alpi 1478 P 0.74 Q 82.63 alpi 1478 P	Constant 0 98663 ha 52.97503 a 0.029099 5.904645 Co-effcient 0.000004 0.472857 -0.27959 0.801833 Constant 11134486 ha 5.1595877 a 3.957572 57415944 44065531 Co-effcient -2.7085	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25	
Constant         Revenue         30655075         Constant         Revenue         202           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           52225         T         0.74         Q         98663         T         283           6         52225         T         0.74         Q         98663         T         283           6         845763         Emission         115389.38         alpha         5229573         Emission         59           6         845541.2         P         6         6485541         5002005         F         5220675         Urban Profit         170           0.718651         -         0.020014         -         2945520         F         6022075         Urban Profit         170           0.719955         -         0.020014         -         202         -         -           0.305785         -         -         0.22111         -	587 Al 52225 52225 52265 13.12009 305457.6 P 585554 2 Co-effcient -1.10494 0.719055 0.523351 -0.13651 0.305765 Co-effcient a 3183750 9.59312.5 4705596 Ag 88382.5 Co-effcient 3.879473 0.405506	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	66.50 P 0.74 Q 89.38 alpi bet iss20 F i a b c d e^a 0.74 Q c.4 0.74 Q 0.74 Q 0.	Constant 0 9663 ha 52 87503 a 6.029099 5.504845 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801833 Constant 11134486 ha 5.165887 a 3.957572 5.7415944 44065531 Co-effcient -2.7085 1.301092	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25	
Constant         Revenue         30656075         Constant         Revenue         200           587         Abatement Cost         625166.59         P         0         Abatement Cost         283           strain         52225         T         0.74         0         98663         T         283           pha         5.849878         Emission         115389.36         alpha         5.22007         Emission         59           attemption         9945520         F         5.22007         Urban Profit         170           685541.2         Co-effcient         -         50.02009         Urban Profit         170           0.719655         0.523361         -         0.000004         -         -         -           -0.13551         -         0.000004         -         -         -         -         -           -0.13551         -         0.000004         - </td <td>587         Al           a         5.848876           i         13.12009           305457.6         P           685561.2         Co-effcient           -1.18494         0.719055           0.523361         -0.13651           0.305765         Aq           Constant         55502500           14.978         a           a         3183750           i         53012.5           47035966         Aq           888382.5         Co-effcient           3.879473         0.466506           0.466506         0.544654</td> <td>Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838</td> <td>66.50 P 0.74 Q 89.38 alpl bet 15520 F 1 1 2 4 4 4 4 4 4 4 4 82.63 alpl 6 4 4 82.63 alpl 1 82.63 bet 77564 F 1 3 82.63 bet 1 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9</td> <td>Constant 0 98653 ha 52.9753 520675 504845 Coeffcient 0.00004 0.472857 0.20111 0.00004 0.472857 0.2012 0.801833 Constant 11134486 ha 5.166857 5.7415944 44065531 Co effcient 2.7085 1.301092 0.160197</td> <td>Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit</td> <td>Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25</td> <td></td>	587         Al           a         5.848876           i         13.12009           305457.6         P           685561.2         Co-effcient           -1.18494         0.719055           0.523361         -0.13651           0.305765         Aq           Constant         55502500           14.978         a           a         3183750           i         53012.5           47035966         Aq           888382.5         Co-effcient           3.879473         0.466506           0.466506         0.544654	Revenue 30656 atement Cost 62516 T 11538 g Farm Profit 29945 uculture Sector Revenue 8010316 atement Cost 226031 T 88838	66.50 P 0.74 Q 89.38 alpl bet 15520 F 1 1 2 4 4 4 4 4 4 4 4 82.63 alpl 6 4 4 82.63 alpl 1 82.63 bet 77564 F 1 3 82.63 bet 1 82.63 bet 1 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Constant 0 98653 ha 52.9753 520675 504845 Coeffcient 0.00004 0.472857 0.20111 0.00004 0.472857 0.2012 0.801833 Constant 11134486 ha 5.166857 5.7415944 44065531 Co effcient 2.7085 1.301092 0.160197	Urban Community : Revenue Abatement Cost T Emis sion Urban Profit Factory Secto Revenue Abatement Cost T Emis sion Factory Profit	Sector 20862973.86 2821518.127 0.74 594645.0087 17601270.43 306190E+11 59410034.46 0.74 326892751.25	

### Table C-14: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin RJ

	Subbasin	Profit	25210498513	3					
	Transfer co		(						
	Subbasin E		5037226.181						
	At-1 A	l	34733722.14						
	A A'		5037226.181 5.064.448.14				Emission	Pass	Approve
			m Sector				rban Community Se		
		Ŭ							
P	Constant		enue	3665228	PCC	onstant	Revenue	12961700.77	
Q	587 6244		nent Cost T	48221.6503 0.11	Q	0 61179	Abatement Cost T	984669.2258 1.86	
alpha	5.6702434	Emi	ssion	59843.0542	alpha	27.39997	Emission	147567.8618	
beta	13.394635		_		beta	3.21609			
F	35405 83636.1	Pig Far	m Profit	3610423.61	F	1676303 196757.1	Urban Profit	11702555.32	
' Co	p-effcient				Co-	effcient			
а	-1.18494				a	-0.22111			
b	0.719655				b	0.808064			
c d	0.523361 -0.136506				c d	0.472857 -0.27929			
e^a	0.3057645				e^a	0.801633			
		Aquacult	ture Sector		1///		Factory Sector		
	onotant			0400747660		motort		22654000425	
Р	onstant 55502500		enue nent Cost	2123747660 570648432	P	onstant -	Revenue Abatement Cost	23654889435 4446928.854	
Q.	38.264		T	3.96	Q	613674.5	T	0.57	
alpha	3193750	Emi	ssion	1652862.84	alpha	9.586287	Emission	3176952.423	
beta F	57653.013 122205650	Aquaeus	ture Profit	1546553891	beta F	6.951844 5882860	Factory Profit	23648631643	
ŗ –	2206034.9	Aquacui	areriont	1340333031	i (	4266169	ractory Pront	20040001040	
1.2	o-effcient				Co-	effcient			
a L	3.679473				a	-2.7065			
b c	0.466506 0.544964				b c	1.381092 0.169197			
d	-0.01147				d	-0.40722			
e^a									
_	39.625506				e^a	0.06677			
		Profit 2	5.216.997.645	5.26			0.74		
	Subbasin I Transfer coe	efficient	5,216,997,645	- <i>111 6</i> 7		0.06677 niform Tax	0.74		
	Subbasin I Transfer coe Subbasin En	efficient	5,053,101	- 1.60			0.74		
	Subbasin I Transfer coe	efficient		- 1.60 7.70			0.74		
	Subbasin I Transfer coe Subbasin En At-1	efficient	5,053,101 36,126,427	- 1.60 7.70 1.60			0.74 Emission	Pass	Арргоvе
	Subbasin I Transfer coe Subbasin En At-1 A	efficient nission	5,053,101 36,126,427 5,053,101	- 1.60 7.70 1.60					Approve
	Subbasin I Transfer coe Subbasin En At-1 A	efficient nission Pig Fa	5,053,101 36,126,427 5,053,101 5,064,448	- 1.60 7.70 1.60	U		Emission		Арргоче
р С	Subbasin I Transfer coo Subbasin En At-1 A A A' Sonstant 587	efficient nission Pig Fa Re	5,053,101 36,126,427 5,053,101 5,064,448 arm Sector evenue ment Cost	60 7.70 60 3.14 3665228 60627.97	P	niform Tax Constant 0	Emission Urban Community S Revenue Abatement Cost	ector 12961700.77 908649.9354	Approve
C P Q	Subbasin In Transfer coe Subbasin En At-1 A A A' Constant 587 6244	efficient nission Pig Fa Re Abater	5,053,101 36,126,427 5,053,101 5,064,448 arm Sector evenue ment Cost T	- 1.60 7.70 1.60 3.14 3665228 60627.97 0.74	P Q	niform Tax Constant 0 61179	Emission Urban Community S Revenue Abatement Cost T	ector 12961700.77 908649.9354 0.74	Арргоче
р С	Subbasin I Transfer coo Subbasin En At-1 A A A' Sonstant 587	efficient nission Pig Fa Re Abater	5,053,101 36,126,427 5,053,101 5,064,448 arm Sector evenue ment Cost	60 7.70 60 3.14 3665228 60627.97	P	niform Tax Constant 0 61179	Emission Urban Community S Revenue Abatement Cost T	ector 12961700.77 908649.9354	Арргоче
C P Q alpha	Subbasin I Transfer coe Subbasin En At-1 A A * * * * * * * * * * * * * * * * *	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,427 5,053,101 5,064,448 arm Sector evenue ment Cost T	- 1.60 7.70 1.60 3.14 3665228 60627.97 0.74	U P Q alpha	Constant 0 61179 27.3997 3.21609 1676303	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74	Approve
C P Q alpha beta F I	Subbasin In Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	. 60 7.70 8.60 3.14 36655228 60627.97 0.74 111184.4296	U P Q alpha beta F I	Constant 0 61179 27.3997 3.21609 1676303 196757.1	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co a	Subbasin I Transfer coe Subbasin En At-1 A A Constant 587 6244 5.6702434 13.394635 35405 83636.1 b-effcient -1.18494	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	. 60 7.70 8.60 3.14 36655228 60627.97 0.74 111184.4296	U P Q alpha F I C a	Constant 0 61179 27.3997 3.21609 1675303 196757.1 30-effcient -0.22111	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co a b	Subbasin In Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 effcient -1.18494 0.719655	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	. 60 7.70 8.60 3.14 36655228 60627.97 0.74 111184.4296	U P Q aipha beta F I C a b	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.808064	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co a b ¢	Subbasin I Transfer coe Subbasin En At-1 A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 0-effcient -1.18494 0.719655 0.523361	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	. 60 7.70 8.60 3.14 36655228 60627.97 0.74 111184.4296	Un P O alpha beta F I C a b c	Constant 0 61179 27.3997 3.21609 1676303 196757.1 60-effcient -0.22111 0.809064 0.472857	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co a b	Subbasin In Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 effcient -1.18494 0.719655	efficient nission Pig Fa Re Abater Em	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	. 60 7.70 8.60 3.14 36655228 60627.97 0.74 111184.4296	U P Q aipha beta F I C a b	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.808064	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co a b c d	Subbasin I Transfer coe Subbasin En At-1 A Constant 587 6244 5.6702434 13.394635 35405 35405 35405 3636.1 b-effcient -1.18494 0.719655 0.523361 -0.136506	fficient hission Pig Fa Re Abater Em Pig Fa	5,053,101 36,126,425 5,053,101 5,064,445 arm Sector evenue ment Cost T iission	- 60 70 60 314 3665228 60627.97 0.74 11184.4296 3596323.55	P Q alpha beta F I C a b c c d	Constant 0 61179 27.3997 3.21609 167533 196757.1 96.757.1 -0.22111 0.808064 0.472857 -0.27929	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I C a b c c d e *a	Subbasin I Transfer coe Subbasin En At-1 A Constant 587 6244 5.6702434 13.394635 35405 35405 35405 3636.1 b-effcient -1.18494 0.719655 0.523361 -0.136506	efficient hission Pig Fa Re Abater Em Pig Fa	5,053,101 36,126,427 5,053,101 5,064,446 arm Sector evenue ment Cost T nission arm Profit	- 60 70 60 314 3665228 60627.97 0.74 11184.4296 3596323.55	P olphabeta F I C a b c c d e^a	Constant 0 61179 27.3997 3.21609 167533 196757.1 96.757.1 -0.22111 0.808064 0.472857 -0.27929	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12961700.77 908649.9354 0.74 196757.1491	Approve
C P Q alpha beta F I Co d e^a d C Q P	Subbasin In Transfer coe Subbasin En At-1 A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 9-effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645	efficient hission Pig Fa Re Abater Pig Fa Pig Fa Aquacu Re	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T nission arm Profit	2123747660 568761997	P Q alpha beta F I C a b c d e^a a	Constant 0 61179 27.3994 3.21609 1676303 196757.1 0.22111 0.808064 0.472857 -0.27929 0.801633 Constant	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795808.228	Approve
C P Q alpha beta F C d d e^a a C C Q Q	Subbasin En Transfer coe Subbasin En At-1 A A' constant 587 6244 5.6702434 13.394635 3.5405 83636.1 0.719655 0.523361 -0.719655 0.523361 -0.36506 0.3057645 constant 55502500 38.264	Fficient hission Pig Fa Re Abater Pig Fa Pig Fa Aquacu Re Abater	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T arm Profit atture Sector evenue ment Cost T	2123747660 506797 0.74 11184.4296 3596323.55	P P alpha beta F I C a b c d d e^a a Q Q	Constant 0 61179 27.39997 3.21609 167503 196757.1 0.808064 0.472857 -0.27929 0.801633 Constant 613674.5	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 11907450.54 23654889435 4795808.228 0.74	Approve
C P alpha beta F I C d d c c C Q alpha	Subbasin En Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Sonstant 555025000 38.264 3193750	Fficient hission Pig Fa Re Abater Pig Fa Pig Fa Aquacu Re Abater	5,053,101 36,126,427 5,053,101 5,064,446 evenue ment Cost T aission arm Profit	2123747660 568761997	P Q alpha beta F I C a b c d e^a Q alpha	Constant 0 61179 27.39997 3.21609 167503 196757.1 0.808064 0.472857 -0.27929 0.801633 Constant 613674.5	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795808.228	Approve
C P alpha beta F C c d e*a Q alpha beta F	Subbasin En Transfer coe Subbasin En At-1 A A' constant 587 6244 5.6702434 13.394635 3.5405 83636.1 0.719655 0.523361 -0.136506 0.3057645 constant 55502500 38.264 3193750 57653.013 122205650	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T arm Profit atture Sector evenue ment Cost T	2123747660 506797 0.74 11184.4296 3596323.55	P P alpha beta F I C a b c d d e^a a Q Q	Constant 0 61179 27.39997 3.21609 167503 196757.1 0.808064 0.472857 -0.27929 0.801633 Constant 613674.5 9.586287 6.951844 5862860	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 11907450.54 23654889435 4795808.228 0.74	Approve
C P alpha beta F I C d d e alpha beta F I	Subbasin En Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83638.1 effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Sonstant 55502500 38.264 3193750 57653.013 122205650 2206034.9	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T aission arm Profit	2123747660 588761997 0.74 22123747660 568761997 0.74 2206034.91	P Q alpha beta F I C a b c d e^a Q alpha beta F I	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 613674.5 9.565287 6.951844 5862866 4266189	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795608.228 0.74 2639125.115	Approve
C P Q alpha E C Q alpha beta F I C C	Subbasin In Transfer coe Subbasin En At-1 A a constant 587 6244 56702434 13.394635 35405 836536.1 0.719655 0.523361 -0.136506 0.3057645 constant 55502500 38.264 3193750 57653.013 122205650 2206034.9 effcient	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T aission arm Profit	2123747660 588761997 0.74 22123747660 568761997 0.74 2206034.91	P Q alpha beta F I C a b c d e^a Q alpha beta F I	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.80064 0.472857 -0.27929 0.801633 Constant 613674.5 9.566287 6.951844 5862860 4266189 50-effcient	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795608.228 0.74 2639125.115	Approve
C P O alpha beta F I C d d d e^a O alpha beta F I	Subbasin En Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Sonstant 55502500 38.264 3193750 57653.013 122205650 2206034.9 -effcient 3.679473 0.466506	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T aission arm Profit	2123747660 588761997 0.74 22123747660 568761997 0.74 2206034.91	P Q alpha beta F I C a b c d e^a Q alpha beta F I	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 613674.5 9.565287 6.951844 5862866 4266189	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795608.228 0.74 2639125.115	Approve
C P Q alpha beta F I C Q alpha beta F I C Q a beta S C Q Q alpha beta C Q Q Alpha D C Q Q C Q C Q C Q C Q C Q C Q C Q C Q	Subbasin En Transfer coe Subbasin En At-1 A a constant 587 6244 5.6702434 13.394635 35405 836536.1 0.719655 0.523361 -0.136506 0.3057645 constant 55502500 38.264 3193750 57653.013 12206650 2206034.9 constant 3.679473 0.466506 0.544964	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T aission arm Profit	2123747660 588761997 0.74 22123747660 588761997 0.74 2206034.91	P Q alpha beta F I C a b c d d e^a a P Q alpha beta F I C a b b c d e^a a C d d e^a a C d d e^a a c d d e f a b c c d c d c d c d c d c d c d c d c d	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0-effcient -0.22111 0.80064 0.472857 -0.27929 0.801633 Constant 613674.5 9.566287 6.951844 5862860 4266189 50-effcient -2.7065 1.381092 0.165197	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795608.228 0.74 2639125.115	Approve
C P alpha beta F C b c c d d e a a b b t C c a a b b	Subbasin En Transfer coe Subbasin En At-1 A A Sonstant 587 6244 5.6702434 13.394635 35405 83636.1 -effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Sonstant 55502500 38.264 3193750 57653.013 122205650 2206034.9 -effcient 3.679473 0.466506	fficient nission Pig Fa Re Abater Em Pig Fa Aquacu Re Abater Em	5,053,101 36,126,422 5,053,101 5,064,446 arm Sector evenue ment Cost T aission arm Profit	2123747660 588761997 0.74 22123747660 588761997 0.74 2206034.91	P Q alpha beta F I C a b c d e^a Q alpha beta F I Q alpha beta F I C a b b C a b b c d d b c d d b c d d b b c d b b c d b b c d b b c d b b c d b b c d b b c d b b c d b c d b c d b c d b c d b c d c d	Constant 0 61179 27.3997 3.21609 1676303 196757.1 0.22111 0.808064 0.472857 0.27128 0.801633 Constant 613674.5 9.565287 6.951844 5862860 4266189 50-effcient -2.7065 1.381092	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 12961700.77 908649.9354 0.74 196757.1491 11907450.54 23654889435 4795608.228 0.74 2639125.115	Арргоче

	Subbasin	Profit 48	390386601						
	Transfer coe	efficient	0						
	Subbasin En		646479.49						
	At-1		635332.28						
	A A'		646479.49				Emission	2000	Anneci
	A'		53,191.05		_		Emission F		Approv
		Pig Farm	Sector			Ur	ban Community Se	ctor	
	Constant	Reven	ue	569390		Constant	Revenue	8427918.52	
Р	587	Abatemen	t Cost	6235.48072	Р	0	Abatement Cost	713712.34	
Q	970	т		0.09	Q	41373	т	1.99	
alpha		Emissi	on	9442.95	alpha	29.83258	Emission	100173.189	
beta	12.98				beta	3.231863		0	
F	5761.8	Pig Farm	Profit	562304.654		1234263	Urban Profit	7514861.54	
۰ ۱	12590.6 Co-effcient				1 0	133711.9 o-effcient			
ลั	-1.18494				a	-0.22111			
b	0.719655				b	0.808064			
с	0.523361				с	0.472857			
d	-0.136506				d	-0.27929			
e^a	0.3057645				e^a	0.801633			
		Aquacultur	e Sector				Factory Sector		
	Constant	Reven	ue	3432330103		Constant	Revenue	2400331774	
Р	55502500	Abatemen		936336705	Р		Abatement Cost	2327468.54	
Q	61.841	T	_	3.91	Q	202907.2	T	1.2	
alpha	3193750	Emissi	on	2746875.51	alpha	14.28067	Emission	789987.842	
beta	59312.5				beta	5.207676			
F	197504694	Aquacultur	e Profit	2485253115	F	2897650	Factory Profit	2397056320	
<u></u>	3667944.3 Co-effcient				1	1056675 o-effcient			
	3.679473					-2.7065			
-					b	1.381092			
b	0.466506 0.544964				b c	1.381092 0.169197			
b c d	0.466506						4		
a b c d e^a	0.466506 0.544964 -0.01147 39.625506 Subbasin P	rofit 4,89	0,798,383.33	3	c d e^a	0.169197 -0.40722	3.35		
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em	fficient iission 👘	- 3,648,165.8	• (///	c d e^a	0.169197 -0.40722 0.06677	3.35	-	
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em At-1	fficient lission 3 3	- 3,648,165.8 4,291,368.2	9	c d e^a	0.169197 -0.40722 0.06677	3.35		
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coe Subbasin Em At-1 A	fficient iission 3 :	- 3,648,165.8 4,291,368.2 3,648,165.8	9 5 9	c d e^a	0.169197 -0.40722 0.06677		Pass	Approve
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em At-1	fficient ission 3 3	- 3,648,165.8 4,291,368.2 3,648,165.8 3,653,191.0	9 5 9	c d e^a	0.169197 -0.40722 0.06677	Emission		Approve
b c d	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coe Subbasin Em At-1 A	fficient iission 3 :	- 3,648,165.8 4,291,368.2 3,648,165.8 3,653,191.0	9 5 9	c d e^a	0.169197 -0.40722 0.06677			Арргоче
b c d e^a	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em At-1 A A Constant	fficient iission 3 3 Pig Farm Reven	3,648,165,85 4,291,368,25 3,648,165,85 3,653,191,05 Sector	9 5 5 569390	c d e^a	0.169197 -0.40722 0.06677 Iniform Tax U Constant	Emission   Irban Community Se Revenue	ector 8427918.52	Арргоче
b c d e^aa ₽	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coe Subbasin Em At-1 A A Constant 587	fficient iission 3 3 Pig Farm Reven Abatemer	3,648,165,85 4,291,368,25 3,648,165,85 3,653,191,05 Sector	5 5 5 5 569390 9626.09156	c d e^a	0.169197 -0.40722 0.06677 Iniform Tax V Constant 0	Emission I Irban Community Se Revenue Abatement Cost	ector 8427918.52 799670.096	Арргоче
p Q	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A' Constant 587 970	fficient iission 3 Pig Farm Reven Abatemer T	3,648,165.8 4,291,368.2 3,648,165.8 3,653,191.0 Sector iue nt Cost	5 5 5 569390 9626.09156 3.35	c d e^a U P Q	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373	Emission I Irban Community Se Revenue Abatement Cost T	ector 8427918.52 799670.096 3.35	Арргоче
p Q alpha	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A A' Constant 587 970 5.94	fficient iission 3 3 Pig Farm Reven Abatemer	3,648,165.8 4,291,368.2 3,648,165.8 3,653,191.0 Sector iue nt Cost	5 5 5 5 569390 9626.09156	c d e^a U U P Q alpha	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 a 29.83258	Emission I Irban Community Se Revenue Abatement Cost	ector 8427918.52 799670.096	Арргоче
P Q alpha beta	0.466506 0.544964 -0.01147 39.625506 Subbasin Em At-1 A A' Constant 587 970	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	5 5 5 569390 9626.09156 3.35	c d e^a U P Q	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 29.83258 3.231683	Emission I Irban Community Se Revenue Abatement Cost T	ector 8427918.52 799670.096 3.35	Арргоие
P Q alpha F	0.466506 0.544964 -0.01147 39.625506 Subbasin Pm At-1 A A A' Constant 587 970 5.94 12.98 5761.8 12590.6	fficient iission 3 Pig Farm Reven Abatemer T	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e^a U U P Q alpha	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 a 29.83258	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргоче
P Q alalpha F I C	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin R At-1 A A A' Constant 587 970 5.94 12.98 5.761.8 12590.6 co-effcient	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e*a U U P Q alaba beta F I	0.169197 -0.40722 0.06677 Iniform Tax Iniform Tax U Constant 0 41373 29.83258 3.231863 1.234263 1.234263 1.33711.9 Co-effcient	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргоче
e c d e*a P Q Q alpha beta F I C C a	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 :o-effcient -1.16494	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e^a U U Q alpha beta F I C a	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 29.83258 3.231863 1234263 133711.9 Co-effcient -0.22111	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргоус
b c d e^a P Q alpha beta F I C a b	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A A A' Constant 587 970 5.94 12.98 5761.8 12590.6 oc-efficient -1.18494 0.719655	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e*a U U P O alphi beta F I c a b	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 2.283258 3.231653 1234263 1234263 1234263 1234263 1234263 0.23111 0.808064	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргоус
b c d d e^a P Q alpha beta F I C a b c	0.466506 0.544964 -0.01147 39.625506 Subbasin P Transfer coet Subbasin Em At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 :o-effcient -1.16494	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e^a U U Q alpha beta F I C a	0.169197 -0.40722 0.06677 Iniform Tax Iniform Tax U Constant 0 41373 2.28.8328 3.231863 1.234263 1.234263 1.33711.9 Co-effcient -0.22111 0.808064 0.472657	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргоча
P Q alipha beta F C a b b c c	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A 4 * Constant 587 970 5.94 12.98 5761.8 12590.6 to-effcient -1.18494 0.719655 0.523361	fficient ission 3 Pig Farm Reven Abatemen T Emiss	3,648,165,8 4,291,368,2: 3,648,165,8: 3,653,191,0: Sector nue nt Cost ion	569390 9626.09156 3.35 392.310206	c d e^a U P Q alpha beta F I C a b c	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 2.283258 3.231653 1234263 1234263 1234263 1234263 1234263 0.23111 0.808064	Emission I Irban Community Se Revenue Abatement Cost T Emission	ector 8427918.52 799670.096 3.35 66667.8942	Арргои
P Q alipha beta F C a b b c c	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 so-effcient -1.16494 0.719655 0.523361 -0.136506	fficient ission 3 Pig Farm Reven Abatemer T Emiss Pig Farm	3,648,165,8 4,291,368,2: 3,648,165,8: 3,665,191,0: Sector iue nt Cost ion Profit	569390 9626.09156 3.35 392.310206	c d e^a U P Q alpha beta F I C a b c d	0.169197 -0.40722 0.06677 Iniform Tax Iniform Tax U Constant 0 41373 29.83258 3.231683 1.234263 1.33711.9 Co-efficient -0.22111 0.808064 0.472857 -0.27929	Emission I Irban Community Se Revenue Abatemnt Cost T Emission Urban Profit	ector 8427918.52 799670.096 3.35 66667.8942	Арргоче
P Q Q alipha beta F I C a b c d d e^a	0.466506 0.544964 -0.01147 39.625506 <b>Subbasin Em</b> At-1 A A' <b>Constant</b> 587 970 5.94 12.98 5761.8 12590.6 <b>io-effcient</b> -1.16494 0.719655 0.523361 -0.136506 0.3057645	fficient ission 3 Pig Farm Reven Abatemen T Emiss Pig Farm	3,648,165,8 4,291,368,2 3,648,165,8 3,663,191,0 Sector nue nt Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669	c d e^a U P Q alpha beta F I C a b c d	0.169197 -0.40722 0.06677 hiform Tax Constant 0 41373 29.83258 3.231683 1234263 133711.9 Co-efficient -0.22111 0.809064 0.472857 -0.27929 0.801633	Emission I Irban Community Se Revenue Abatemat Cost T Emission Urban Profit Factory Sector	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98	Арргоч
P Q Q alipha beta F C C d d c c	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A A' Constant 587 5761.8 12590.6 5761.8 12590.6 5761.8 12590.6 5.94 12.98 5761.8 12590.6 5.94 5.94 5.94 5.94 5.94 5.94 5.95 5.94 5.94	fficient ission 3 Pig Farm Reven Abatemer T Emiss Pig Farm Aquacultur Reven	5,648,155,81 4,291,368,2: 3,648,1155,81 3,653,191,02 Sector nue t Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669	c d e*a U P Q alpha beta F I c d e*a	0.169197 -0.40722 0.06677 Iniform Tax Iniform Tax U Constant 0 41373 29.83258 3.231683 1.234263 1.33711.9 Co-efficient -0.22111 0.808064 0.472857 -0.27929	Emission 1 Irban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98	Approve
P Q alipha F I C a b b c c d d e^a a	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A 4 Constant 587 970 5.94 12.98 5761.8 12590.6 coeffcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Constant 55502500	fficient ission 3 Pig Farm Reven Abatemen T Emiss Pig Farm	5,648,155,81 4,291,368,2: 3,648,1155,81 3,653,191,02 Sector nue t Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669 558449.669	c d e^a U P Q alpha beta F I C a b c d	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 2.28,83258 3.231863 1.234263 1.234263 1.234263 1.234263 1.234263 1.234263 0.22141 0.808064 0.472857 -0.27929 0.801633 Constant	Emission I Irban Community Se Revenue Abatemat Cost T Emission Urban Profit Factory Sector	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82	Арргоче
P Q alpha beta F C b c c d e A a P Q	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A A' Constant 587 5761.8 12590.6 5761.8 12590.6 5761.8 12590.6 5.94 12.98 5761.8 12590.6 5.94 5.94 5.94 5.94 5.94 5.94 5.95 5.94 5.94	fficient ission 3 Pig Farm Reven Abatemer T Emiss Pig Farm Aguacultur Reven Abatemer	3,648,165,8 4,291,368,2 3,648,165,8 3,653,191,0 Sector nue nt Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669	c d e*a U P Q habeta F I C a beta F I C a beta F I C a beta P Q a habeta P Q a habeta P Q a habeta P Q a habeta P A B A B A B A B A B A B A B A B A B A	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231683 1234263 133711.9 Co-efficient -0.22111 0.808054 0.472857 -0.27929 0.801633 Constant 202907.2	Emission I trban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98	Арргоче
P C d d e*a P Q alpha beta F I C c d d e*a P Q d alpha	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 5.94 12.98 5761.8 12590.6 coeffcient -1.16494 0.719655 0.523361 -0.136506 0.3057645 Constant 55502500 61.841	fficient ission 3 Pig Farm Abatemen T Emiss Pig Farm Aquacultur Reven Abatemen T	3,648,165,8 4,291,368,2 3,648,165,8 3,653,191,0 Sector nue nt Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669 558449.669 3432330103 934697344 3.35	c d e^a U U P Q alpha beta F I C a b c d e^a	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231683 1234263 133711.9 Co-efficient -0.22111 0.808054 0.472857 -0.27929 0.801633 Constant 202907.2	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35	Арргоче
P C d d e*a P Q alipha beta F i C c d d e*a P Q Q alipha	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A * Constant 587 970 5.94 12.98 5761.8 12590.6 5.94 12.98 5761.8 12590.6 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 59312.5 197504694	fficient ission 3 Pig Farm Abatemen T Emiss Pig Farm Aquacultur Reven Abatemen T	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	569390 9626.09156 3.35 392.310206 558449.669 558449.669 3432330103 934697344 3.35	c d e*a U P O alpha beta F I C a b c c d e*a P P O alpha P P O alpha P P O alpha	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231653 1234263 133711.9 Co-efficient -0.22111 0.808054 0.472857 -0.27929 0.801633 Constant 202907.2 14.29067 5.207676 2837650	Emission I trban Community Se Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35	Approve
P Q alalpha F I C a C d d c c d d d e*a P Q alalpha beta F I C C d d f I	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin P Transfer coet Subbasin P At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 co-effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 59312.5 197504694 3667944.3	fficient ission 3 Pig Farm Abatemen Abatemen Pig Farm Aguacultur Reven Abatemen T Emiss	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	34322330103 934587344 3.35 392.310206 558449.669	c d e*a U P Q alpha beta F I C d e*a P Q alpha beta F I C f I	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 2.28328 3.231663 1.33711.9 Co-effcient -0.22111 0.808064 0.472857 -0.27929 0.801633 Constant 202907.2 1.422067 5.207676 2.897650 1056675	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35 380815.002	Approve
P q alpha beta F G c d d c c d d g a b b c c d d f I C Q a b b c c d f C C C C C C C C C C C C C C C C C C	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A 4 Constant 587 970 5.94 12.98 5761.8 12590.6 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 53312.5 197504694 3667944.3 5607944.3 5607944.3	fficient ission 3 Pig Farm Abatemen Abatemen Pig Farm Aguacultur Reven Abatemen T Emiss	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	34322330103 934587344 3.35 392.310206 558449.669	c d e*a U P Q alpha beta F I C a beta F C d e*a F I C Q a beta F I I	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231863 1.234263 1.33711.9 Co-effcient -0.27111 0.808064 0.472857 -0.27929 0.801633 Constant 202907.2 1.4.2067 5.207876 2897650 1056875 Co-effcient	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35 380815.002	Арргоч
P Q alipha beta F I C a b b c d d e^a a F I C Q alipha b b ta F I C Q a a I D ta C d a I C C d d d d d d d d d d d d d d d d d	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A Constant 587 970 5.94 12.98 5761.8 12590.6 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 59312.5 197504694 3667944.3 3.679473	fficient ission 3 Pig Farm Abatemen Abatemen Pig Farm Aguacultur Reven Abatemen T Emiss	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	34322330103 934587344 3.35 392.310206 558449.669	c d e^a U U P Q alpha beta F I C a b c c d e^a F I C a alpha beta F I C a alpha beta F I C a alpha beta I F G a alpha beta F I C alpha B C alpha C a a a a a a a a alpha C a a a a a a a a a a a a a a a a a a	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231663 133711.9 Co-offcient -0.22111 0.808054 0.472857 -0.27929 0.801633 Constant 202907.2 14.29067 5.207676 2837650 1056675 Co-offcient -2.7065	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35 380815.002	Арргоче
P e^a alpha beta F G C C Q Q alpha beta F C Q Q alpha beta F C C C C C	0.466506 0.544964 -0.01147 39.625506 Transfer coel Subbasin P Transfer coel Subbasin P At-1 A A' Constant 587 970 5.94 12.98 5761.8 12590.6 co-effcient -1.18494 0.719655 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 59312.5 197504694 3667944.3 3679473 0.466506	fficient ission 3 Pig Farm Abatemen Abatemen Pig Farm Aguacultur Reven Abatemen T Emiss	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	34322330103 934587344 3.35 392.310206 558449.669	c d e*a U P O alphi beta F I c d e*a P O alphi beta F I I C a b b c d e*a	0.169197 -0.40722 0.06677 Iniform Tax U Constant 0 41373 2.28328 3.231683 1.234263 3.231683 1.234263 3.231683 1.234263 0.2711 0.808064 0.472857 -0.2711 0.808064 0.472857 -0.2799 0.801633 Constant 202907.2 1.428067 5.207676 2897650 01056675 5.207676 2897650	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35 380815.002	Approve
e c d d d d d alpha beta F c d d e^a alpha beta F C a alpha c c d d c c d d d c c d d c c d d d d	0.466506 0.544964 -0.01147 39.625506 Transfer coet Subbasin Em At-1 A Constant 587 970 5.94 12.98 5761.8 12590.6 0.523361 -0.136506 0.3057645 Constant 55502500 61.841 3193750 59312.5 197504694 3667944.3 3.679473	fficient ission 3 Pig Farm Abatemen Abatemen Pig Farm Aguacultur Reven Abatemen T Emiss	3,648,165 & 8 4,291,368 2: 3,648,165 & 8 3,653,191 D Sector nue nt Cost ion Profit	34322330103 934587344 3.35 392.310206 558449.669	c d e^a U U P Q alpha beta F I C a b c c d e^a F I C a alpha beta F I C a alpha beta F I C a alpha beta I F G a alpha beta F I C alpha B C alpha C a a a a a a a a alpha C a a a a a a a a a a a a a a a a a a	0.169197 -0.40722 0.06677 Iniform Tax 0 Constant 0 41373 29.83258 3.231663 133711.9 Co-offcient -0.22111 0.808054 0.472857 -0.27929 0.801633 Constant 202907.2 14.29067 5.207676 2837650 1056675 Co-offcient -2.7065	Emission I Irban Community Se Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission	etor 8427918.52 799670.096 3.35 66667.8942 7404910.98 24000331774 3132805.82 3.35 380815.002	Approve

Table C-15: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin RK



#### Table C-16: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin LT

	Subbasir							
	Transfer co							
	Subbasin E -At							
	At-	1 35562136.6i 16946234.3i						
	Â		·			Emission	Pass	Арргоче
		Pig Farm Sector			U	rban Community Se	ector	
6	onstant	Revenue	0	Cor	nstant	Revenue	12316254.12	
P		Abatement Cost	0	P	0	Abatement Cost	2901901.437	
Q	0	Т	0	Q	60461	Т	1.84	
alpha	0	Emission	0	alpha	81.15806	Emission	440469.0935	
beta	0			beta	9.738967			
F	0	Pig Farm Profit	0	F	4906897 588827.7	Urban Profit	8603889.553 0	
Co	effcient			Co-e	ffcient			
a	-1.18494			a	-0.22111			
b	0.719655			b	0.808064			
c	0.523361			c	0.472857			
d	-0.13651			d	-0.27929			
e^a	0.305765			e^a	0.801633			
		Aquaculture Sector				Factory Sector		
	onstant	Revenue	7020455723		istant	Revenue	31575430892	
P	55502500	Abatement Cost	280563515	P	-	Abatement Cost	16560156.21	
Q alpha	126.489 467868.3	T Emission	3.91 823034.034	Q alpha	1941030 10.33128	T Emission	0.43	
aipria beta	467668.3	LINISSION	525554.054	beta	10.92126	LINISSION	.0002701.20	
F	59180188	Aquaculture Profit	6736674144	F	20053326	Factory Profit	31552127161	
I	1099061			1. 7	21198492			
	effcient			Co-e	ffcient			
a	3.679473 0.466506			a	-2.7065			
				b	1.381092			
c	0.544964 -0.01147			b c d	0.169197 -0.40722			
c d	0.544964 -0.01147 39.62551 Subbasin Transfer co	efficient		c d e^a	0.169197	0.44		
c di	0.544964 -0.01147 39.62551 Subbasin	efficient mission 17,110,499 35,578,297	53 18	c d e^a	0.169197 -0.40722 0.06677	0.44		
c d	0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1	efficient mission 17,116,499	57 18 53	c d e^a	0.169197 -0.40722 0.06677	0.44 Emission	Pass	Арргоче
c d	0.544964 -0.01147 39.62551 Subbasin Transfer co Subbasin Er At-1	efficient mission 17,110,499 35,578,297 17,116,499	57 18 53	c d e^a	0.169197 -0.40722 0.06677		1	Approve
	0.544964 -0.01147 39.62551 Subbasin Tramsfer co Subbasin E At-1 A A	efficient mission 17,110,499 35,578,207 17,116,420 17,164,785 Pig Farm Sector Revenue	53 18 53 07	c d e^a Unit	0.169197 -0.40722 0.06677	Emission Irban Community S Revenue	ector 12316254.12	10
c d e^a e^a c s	0.544964 -0.01147 39.62551 Subbasin E Subbasin E At-1 A A A'	efficient mission 17,110,499 35,578,297 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,110,499 17,116,499 17,1	53 18 53 07 0	c d e^a Unat	0.169197 -0.40722 0.06677	Emission Irban Community S- Revenue Abatement Cost	12316254.12 2675914.129	10
c d e^a c P Q	0.544964 -0.01147 39.62551 Subbasin Transfer Co Subbasin Ei At-1 A A A*	efficient mission 17,110,499, 35,578,277 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,110,499 17,	50 18 53 07 0 0	c d e^a Unit	0.169197 -0.40722 0.06677	Emission Irban Community S Revenue Abatement Cost T	ector 12316254.12 2675914.129 0.44	
c d e^a Co P O alpha	0.544964 -0.01147 39.62551 Subbasin E Subbasin E At-1 A A A'	efficient mission 17,110,499 35,578,297 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,116,409 17,110,499 17,116,499 17,1	53 18 53 07 0	c d e^a Unat	0.169197 -0.40722 0.06677	Emission Irban Community S- Revenue Abatement Cost	12316254.12 2675914.129	
c d e^a c o o o o nipha	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A A motant 0 0 0 0 0	efficient mission 17,110,499, 35,578,277 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,116,400 17,110,499 17,	50 18 53 07 0 0	c d e^a Unit	0.169197 -0.40722 0.06677 erm Tax erm Tax erstant 0 60461 91.15006 9.739667 4306897	Emission Irban Community S Revenue Abatement Cost T	ector 12316254.12 2675914.129 0.44	
c d e^a e^a c s p o alpha beta F	0.544964 -0.01147 39.62551 Subbasin Er Subbasin Er At-1 A A* A*	efficient mission 17,116,499, 35,578,297 17,116,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit P Co P o alpha beta F I	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 enstant 0 50461 9.733667 4906897.7	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d e^a Co P Q alpha beta F I Co-	0.544964 -0.01147 39.62551 Subbasin E At-1 A A A' mstant 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,499, 35,578,297 17,116,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit P Co P o alpha beta F I	0.169197 -0.40722 0.06677 orm Tax orm Tax umstant 0 80461 9.736967 4905897 4905897 efficient	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d e^a e^a e P o alpha beta F I Co- a	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A A mstant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,499, 35,578,297 17,116,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit P Co P o alpha beta F I	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 sostant 0 58961 9.738967 49068927.7 effcient -0.22111	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d <u>e^a</u> Cc P o alpha beta F I	0.544964 -0.01147 39.62551 Subbasin E At-1 A A A' mstant 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,499, 35,578,297 17,116,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit 9 0 alpha beta F I Co- a	0.169197 -0.40722 0.06677 orm Tax orm Tax umstant 0 80461 9.736967 4905897 4905897 efficient	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
Co Co D D D D D D D D D D D D D D D D D	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A Mostant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,499, 35,578,297 17,16,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit P Q alpha beta F I Co- a b c d	0.169197 -0.40722 0.06677 erm Tax erm Tax erm Tax 0.061 9.738667 4906997 588827.7 effcient -0.27111 0.873664 0.472857 -0.27829	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d e^a C P Q alpha beta F I Co- a b	0.544964 -0.01147 39.62551 Subbasin E At-1 A A A M Subbasin E At-1 A A A C U U U U U U U U U U U U U U U U	efficient mission 17,116,499, 35,578,297 17,16,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unat P Q alpha beta F I Co a b ta b ta b ta	0.169197 -0.40722 0.06677 orm Tax orm Tax 0 souther 0 9.738967 4906897 9.738967 4906897 9.738967 4906897 9.738967 4906897 9.738967 4005897 400522 400527 400527 400522 400522 9.738967 400522 40052 400522 400522 40052 400522 40050 40052 400550 40050 4005000 40050000000000	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d e^a P alpha beta F I Co- a b s d	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A Mostant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,499, 35,578,297 17,16,400, 17,164,705, Pig Farm Sector Revenue Abatement Cost T Emission	53 18 53 07 0 0 0	c d e^a Unit P Q alpha beta F I Co- a b c d	0.169197 -0.40722 0.06677 erm Tax erm Tax erm Tax 0.061 9.738667 4906997 588827.7 effcient -0.27111 0.873664 0.472857 -0.27829	Emission Ir ban Corramunity Sr Revenue Abatement Cost T Emission	ector 12316254.12 2675914.129 0.44 500027.6669	
c d d e^a Co P D D b otta F i Co- a b s c d d e*a	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A Mostant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,110,499, 35,578,277 17,116,400 17,	53 18 53 07 0 0 0	c d e^a Unit P Co alpha beta F I Co- a b c d d e*a	0.169197 -0.40722 0.06677 erm Tax erm Tax erm Tax 0.061 9.738667 4906997 588827.7 effcient -0.27111 0.873664 0.472857 -0.27829	Emission Aban Community S Revenue Abatement Cost T Emission Urban Profit	ector 12316254.12 2675914.129 0.44 500027.6669	17 19 19 19 19 19 19 19 19 19 19 19 19 19
c d d c e p o o a b b t a c o c c d d e *a C c c c c c c c c c c c c c c c c c c	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A A A A A A A A A A A A C C C C C	efficient mission 17,110,499, 35,578,277 17,116,400 17,164,705 Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Pig Farm Profit	53 18 53 57 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unat P O alpha beta F I Co a beta F I Co a D b co a D Co	0.169197 -0.00722 0.06677 orm Tax orm Tax 0 strutt 0 508277 490690 9.73957 490690 490690 9.73957 490690 9.73957 490690 490600 490600 490600 490600 49060000000000	Emission Irban Community S Revenue Abatement Cost T Emission Urban Profit	231575430892.1	17 19 19 19 19 19 19 19 19 19 19 19 19 19
c d d e*a Co P O O O O O O O O O O O O O O O O O O	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A* metant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,110,499, 35,578,277 12,116,400 17,164,785. Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	50 18 53 57 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P Co alpha beta F I Co- b c d d e^a Co O O	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 60461 01.15006 9.738667 4905897.7 588827.7 effcient -0.27111 0.80564 0.472857 -0.27829 -0.291030	Emission Irban Community Sr Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 12316254.12 2675914.129 0.44 500027.0609 9381255.82 31575430892 16670690.11 0.44	10 12 13 13 14 14 14 14 14 14 14 14 14 14 14 14 14
c d d e*a Cc P Q Q abbeta F I c c a c c a Cc Q Q abbha	0.544964 -0.01147 39.62551 Transfer co Subbasin El At-1 A A mestant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,439, 35,578,207 17,116,409, 17,164,005 17,164,005 17,164,005 17,164,005 17,164,005 17,164,005 17,164,005 Revenue Abatement Cost	53 18 53 57 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e*a Unit P Co alpha beta F I Co alpha c- a b co alpha Co alpha	0.169197 -0.40722 0.06677 erm Tax erm	Emission Irban Comamunity So Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue	231575430892.1	10 12 13 13 14 14 14 14 14 14 14 14 14 14 14 14 14
c d d e^a Cc P P o alpha beta b to c d d e^a Co c c c c c c c c c c c c c c c c c c	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A* metant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,439, 35,578,247 17,116,439, 35,578,247 17,116,439,17,116,439,116,116,116,116,116,116,116	50 18 53 57 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P Co alpha beta F I Co- b c d d e^a Co O O	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 60461 01.15006 9.738667 4905897.7 588827.7 effcient -0.27111 0.80564 0.472857 -0.27829 -0.291030	Emission Irban Corramunity S Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	231575430892.14 2675914.129 0.44 500027.6669 9381255.82 31575430892 16670690.11 0.44 15420611.24	
c d d e*a Cc P D o alpha beta F I c o a b b ta Cc P O Cc Cc Cc Cc Cc Cc Cc Cc Cc Cc Cc Cc Cc	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A A A A A A C C C C C C C C C C C	efficient mission 17,110,499, 35,578,277 12,116,400 17,164,785. Pig Farm Sector Revenue Abatement Cost T Emission Pig Farm Profit Aquaculture Sector Revenue Abatement Cost T	53 18 53 07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e*a Unit P Co alpha beta F I Co alpha c- a b co alpha Co co co co co co co co co co co co co co	0.169197 -0.40722 0.06677 erm Tax erm Tax erm Tax 0 0 00401 01.5006 9.73967 43068927.7 43068927.7 43068927.7 43068927.7 43068927.7 4306827.7 0.27129 0.001633 erstant 1941030 10.33120 10.33120	Emission Irban Community Sr Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T	ector 12316254.12 2675914.129 0.44 500027.0609 9381255.82 31575430892 16670690.11 0.44	
c d d e^a Cc P 9 9 9 9 9 4 5 6 6 6 6 6 6 6 6 6 7 0 9 0 4 1 9 0 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0.544964 -0.01147 39.62551 Subbasin Er At-1 A A A A A A A C C C C C C C C C C C C	efficient mission 17,116,439, 35,578,247 17,116,439, 35,578,247 17,116,439,17,116,439,116,116,116,116,116,116,116	53 18 53 07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P o alpha beta F I co- a b ca e*a Co Q alpha beta F I Co P Co P Co D alpha F I Co F I Co Co	0.169197 -0.40722 0.06677 erm Tax erm Tax erm Tax 0 0 0.0472827 0.0472827 4306897 4306897 -0.27129 0.001633 erstant 1941030 10.32126 20.03128 10.472857 -0.27829 0.001633	Emission Irban Corramunity S Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	231575430892.14 2675914.129 0.44 500027.6669 9381255.82 31575430892 16670690.11 0.44 15420611.24	
c d d e^a Cc P D d beta beta beta c c d e^a d f F I Co- a d f F I Co- a d f F C c d c c a d f f c c a d f f f c c c c c c c c c c c c c c c c	0.544964 -0.01147 39.62551 <b>Subbasin E</b> At-1 A A A* mestant 0 0 0 0 0 0 0 efficient -1.10494 0.719655 0.523861 0.305765 <b>efficient</b> -1.10494 0.719655 0.523861 0.305765 <b>efficient</b> -1.10494 0.305765 <b>efficient</b> -1.26489 407050.3 2668.962 59180188 1099061 efficient 2.579473	efficient mission 17,116,439, 35,578,247 17,116,439, 35,578,247 17,116,439,17,116,116,116,116,116,116,116,116,116	53 18 53 07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P Co alpha beta F I Co- alpha beta F I Co- alpha beta F I Co- alpha	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 60461 01.15006 9.738567 4906897 588827.7 effcient -0.27111 0.805054 0.472857 -0.27829 -0.27829 -0.27829 0.001633 enstant 1941030 10.39128 2053326 21189492 effcient -2.2705	Emission Irban Corramunity S Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	231575430892.14 2675914.129 0.44 500027.6669 9381255.82 31575430892 16670690.11 0.44 15420611.24	
c d d e^a Cc P 9 9 9 9 9 4 5 6 6 6 6 6 6 6 6 6 7 0 9 0 4 1 9 0 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0.544964 -0.01147 39.62551 <b>Subbasin E</b> At-1 A A A A A A A A A A A A A A A A A A A	efficient mission 17,116,439, 35,578,247 17,116,439, 35,578,247 17,116,439,17,116,116,116,116,116,116,116,116,116	53 18 53 07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P O aipha beta F I Co- a b c a D b c a Co- a b t I Co- a b t I Co- b t I Co- b t I Co- b t I Co- c a D b t I Co- c a D b S Co- c a D b S Co- c a D b S Co- c a D b S Co- c a D b S Co- c a D b S Co- c S C Co- c S C C Co- c S C Co- C C Co- C C Co- C Co- C Co- C Co- C Co- C C Co- C Co- C Co- C C Co- C C C C	0.169197 -0.40722 0.06677 orm Tax orm Tax orm Tax 0 60461 01.15006 9.733667 4305697 9.733667 4305697 9.733667 4305697 9.733667 4305697 0.27129 0.001630 enstant 1941030 10.30128 10.30128 21198482 2119842 211984848 211984	Emission Irban Corramunity S Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	231575430892.14 2675914.129 0.44 500027.6669 9381255.82 31575430892 16670690.11 0.44 15420611.24	
s d d c p p p p p c c r s c c a s c c c a s c c c s c c c s c c c s c c c s c c s c c s c c s c c s c c s c c s s c s c s c s c s c s c s c s c s c s s c s s c s s c s s c s s c s c s s s c s s c s s c s s c s s c s s c s s c s s c s s c s s s c s s s c s s s c s s s c s s s s s c s s c s	0.544964 -0.01147 39.62551 Transfer co Subbasin Er At-1 A A A mestant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	efficient mission 17,116,439, 35,578,247 17,116,439, 35,578,247 17,116,439,17,116,116,116,116,116,116,116,116,116	53 18 53 07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	c d e^a Unit P Co alpha beta F I Co- alpha beta F I Co- alpha beta F I Co- alpha	0.169197 -0.40722 0.06677 erm Tax erm Tax 0 60461 01.15006 9.738567 4906897 588827.7 effcient -0.27111 0.805054 0.472857 -0.27829 -0.27829 -0.27829 0.001633 enstant 1941030 10.39128 2053326 21189492 effcient -2.2705	Emission Irban Corramunity S Revenue Abatement Cost I Emission Urban Profit Factory Sector Revenue Abatement Cost I Emission	231575430892.14 2675914.129 0.44 500027.6669 9381255.82 31575430892 16670690.11 0.44 15420611.24	

### Table C-17: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin LU

	Subbasin							
	Transfer coe		0					
	Subbasin En		/500.14					
	At-1 A		3234.38 7500.14					
	A'	33,193,0				Emission	Pass	Арргоуе
		Pig Farm Sec				rban Community Se		
		-				-		
	onstant	Revenue	8805		Constant	Revenue	20179296.57	
P	587	Abatement Co			0	Abatement Cost	673508.1026	
Q alpha	150 7.3	T Emission	0. 1180.7196		99061 11.61593	T Emission	1.9 99001.05162	
aipna beta	10.95	Emission	1100.7190	beta	1.336702	Emission	99001.05162	
F	1095	Pig Farm Prot	fit 87068.511		1150686	Urban Profit	19317686.46	
1	1642.5	0		1	132415			
	-effcient			C	o-effcient			
a	-1.18494			a	-0.22111			
b c	0.719655 0.523361			b	0.808064 0.472857			
c d	-0.136506			c d	-0.27929			
e^a	0.3057645			e^a	0.801633			
	0.0001040	Aguagarthurs	ator.		0.001000	Eastory Carton		
		Aquaculture Se				Factory Sector		
	onstant	Revenue	604938398		Constant	Revenue	64926053872	
P	55502500	Abatement Co			-	Abatement Cost	18798942.8	
Q alpha	108.993 2826591.7	T Emission	3.9 4284528.2		7095279 3.430088	T Emission	0.27 28352790.12	
beta	52493.845	LIIISSIOI	4204320.2	beta	5.412315	Linission	20002700.12	
F	308078706	Aquaculture Pr	ofit 457208110		24337434	Factory Profit	64899599675	
I	5721461.7			1	38401886	-		
	-effcient			C	o-effcient			
a	3.679473 0.466506			a b	-2.7065			
					1.381092			
c	0.544964			c	0.169197			
c d	0.544964 -0.01147 39.625506 Subbasin P Transfer coo	flicient	65,220.78			0.20		
c d	0.544964 -0.01147 39.625506 Subbasin P Transfer soc Subbasin Em At-1 A	fficient dission 32,8 17,1 32,0	03,314.06 16,499.50 00,014.06	c d	0.169197 -0.40722 0.06677			
; 1	0.544964 -0.01147 39.625506 Subbasin P Transfer coor Subbasin Em At-1	fficient dission 32,8 17,1 32,0 33,1	03,314,06 16,499,53 03,314,06 03,053,54	c d	0.169197 -0.40722 0.06677	Emission		Approve
c d	0.544964 -0.01147 39.625506 Subbasin P Transfer soc Subbasin Em At-1 A	fficient dission 32,8 17,1 32,0	03,314,06 16,499,53 03,314,06 03,053,54	c d	0.169197 -0.40722 0.06677			Approve
c d e^a	0.544964 -0.01147 39.625506 Subbasin P Transfer soc Subbasin Em At-1 A	fficient dission 32,8 17,1 32,0 33,1	03,314,06 16,499,53 03,053,54 etor 88	c d e^a	0.169197 -0.40722 0.06677	Emission		Approve
c d e^a c. P	0.544964 -0.01147 39.625506 Subbasin En At-1 A A A*	fficient dission 32,8 17,1 32,0 33,11 Pig Farm Sec	03,314,06 10,499,53 03,053,54 etor 88 ost 977,599	050 005 P	0.169197 -0.40722 0.06677 Uniform Tax	Emission Urban Community S	ector 20179296.57 620968.5291	Approve
c d e^a c. P Q	0.544964 -0.01147 39.625506 Subbasin P Transfer cor Subbasin Em AC1 A A A A Subbasin Em	fficient aiusion 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T	03,314,06 16,499,53 03,053,54 03,053,54 etor 88 ont 977,599 (	с d е*а 050 005 025 0	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061	Emission Uthan Community S Revenue Abatement Cost T	ector 20179296.57 620968.5291 0.29	Approve
P Q alpha	0.544964 -0.01147 39.625506 <b>Subbasin P</b> <b>Transfer com</b> <b>At-1</b> A <b>A</b> <b>a</b> <b>subtasin Em</b> <b>At-1</b> A <b>b</b> <b>subtasin Em</b> <b>At-1</b> A <b>a</b> <b>b</b> <b>subtasin Em</b> <b>At-1</b> A <b>b</b> <b>subtasin E</b> <b>subtasin E</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>su</b>	fficient ifssion 32,8 17,1 32,0 33,1 Pig Farm Sec Revenue Abatement C	03,314,06 10,499,53 03,053,54 etor 88 ost 977,599	с d e^a 050 006 Р 029 027 афр	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 ha 11.61583	Emission Urban Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291	Approve
c d e^a Cr P Q alpha	0.544964 -0.01147 39.625506 Subbasin En At-1 A A* Onstant 587 150 7.3 10.95	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 P 229 Q 907 alph	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 ha 11.61583 a 1.306702	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a Cr P Q alpha beta F	0.544964 -0.01147 39.625506 <b>Subbasin P</b> <b>Transfer com</b> <b>At-1</b> A <b>A</b> <b>a</b> <b>subtasin Em</b> <b>At-1</b> A <b>b</b> <b>subtasin Em</b> <b>At-1</b> A <b>a</b> <b>b</b> <b>subtasin Em</b> <b>At-1</b> A <b>b</b> <b>subtasin E</b> <b>subtasin E</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>subtasin</b> <b>su</b>	fficient aiusion 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 P 229 Q 907 alph	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 ha 11.61583	Emission Urban Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29	Approve
c d e^a C P Q alpha beta F I	0.544964 -0.01147 39.625506 Subbasin En At-1 A A- A- Sonstant 587 150 7.3 10.95 1095 1642.5 efficient	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 P 229 Q 907 alph	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 ha 11.61533 a 1.306702 1150606 132415 Co-effcient	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a P Q alpha beta F I Co a	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 129 007 1555 555 1 1 1 1	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061 ha 11.61583 a 1.306702 1150006 132415 Co-effcient -0.22111	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a P Q alpha beta F I Co a b	0.544964 -0.01147 39.625506 Subbasin Pr At-1 A A A Subbasin Em At-1 A A A Subbasin Em At-1 A A Subbasin Em At-1 A A Subbasin Em At-1 A A Subbasin P Com Subbasin Em At-1 A A Subbasin At-1 Subbasin At-1 Subbasin At-1 Subbasin At-1 Subbasin At-1 A A Subbasin At-1 Subbasin At-1 Subbasin At-1 Subbasin At-1 Subbasin At-1 A A Subbasin At-1 A A Subbasin At-1 Subbasin At-1 Subbasin At-1 A A Subbasin At-1 Subbasin	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 P 029 O 907 alpi 555 F 1 a b	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 11.05702 115000 132415 Co-effcient -0.22111 0.000064	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a P Q alpha beta F I Co a b c	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	050 006 129 007 1555 555 1 1 1 1	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061 ha 11.61583 a 1.306702 1150006 132415 Co-effcient -0.22111	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a P D alipha beta F Co a b c c d	0.544964 -0.01147 39.625506 Subbasin P Transfer cee Subbasin Em At-1 A A A a sonstant 587 150 7.3 10.95 1095 1095 1095 1095 1095 1095 1095 10	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 10,499,53 03,053,54 etor 60st 977,539 475,330	с d e*a 050 006 Р 029 Q 907 афр 555 F I а b с	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99061 11.81583 a 1.309702 1150606 132415 Co-effcient 0.22111 0.000064 0.472857	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
e d e^a P Q alpha beta F I Co a b e d	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	fficient aiusion 32,8 17,1 32,0 33,1 Pig Farm See Revenue Abatement C T Emission	03,314,06 16,499,53 03,053,54 etor 88 ont 977,599 475,330 Mit 00934	050 006 129 007 14pt 555 555 6 1 1 2 0 907 1 1 0 4 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061 ha 11.61583 a 1.306702 1150006 132415 Co-effcient -0.22111 0.000046 0.472857 -0.27929	Emission Urhan Community S Revenue Abatement Cost T Emission	ector 20179296.57 620968.5291 0.29 132415.0205	Approve
c d e^a Co alpha beta F Co a b c c d d e^a	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	filicient dission 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T Emission Pig Farm Pro	03,314,06 16,499,53 03,053,54 etor 88 ont 977,599 475,330 Mit 00934	050 005 005 129 007 14pt 555 1 1 a b c d d e <sup>+</sup> a	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99061 ha 11.61583 a 1.30670 132415 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633	Emission Urhan Community S Revenue Abatement Cost T Emission Urban Profit	ector 20179296.57 620968.5291 0 29 132415.0205 19519927.60	Approve
c d e^a Co alpha beta F Co a b c c d d e^a	0.544964 -0.01147 39.625506 Subbasin Em At-1 A A a sonstant 587 150 7.3 10.95 1562.5 efficient -1.18494 0.719655 0.523361 -0.136506 0.3057845	fikient dission 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T Emission Pig Farm Pro	03,314,06 16,499,53 03,014,06 03,055,54 etor 60st 977,539 1 475,330 Mit 00934.	050 005 P 128 P 207 alpi 555 F 1 a b c d e*a 900	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061 ha 11.61583 a 1.306702 1150006 132415 Co-effcient -0.22111 0.000046 0.472857 -0.27929	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue	ector 20179296.57 620968.5291 0.29 132415.0205 19519927.00	Approve
c d d e^a Co a b b c d d e^a a b c c c c c c c c c c c c c c c c c	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A Constant 587 150 7.3 10.95 1642.5 effcient -1.18494 0.719055 0.523361 -0.136506 0.3057845	filicient dission 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T Emission Pig Farm Pro	03,314,06 16,499,33 03,053,54 etor 88 ont 977,590 475,330 Mit 00934 iector 6049393 ont 1465713	050 005 P 005 P 129 Q 907 alpl 555 F 1 a b c d e*a 900 900 P 1 344 P 0 229 Q	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99061 ha 11.61583 a 1.30670 132415 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633	Emission Urhan Community S Revenue Abatement Cost T Emission Urban Profit	ector 20179296.57 620968.5291 0 29 132415.0205 19519927.60 19519927.60 64925052072 19191728.57 0.29	Approve
c d d C alpha beta F C c d e*a C C Q Q d b c d C C C C C C C C C C C C C C C C C C	0.544964 -0.01147 39.625506 Subbasin Pr Transfer cice Subbasin Em A-1 A A a sonstant 587 150 7.3 10.95 10425 effcient -1.18484 0.719655 0.523361 -0.136506 0.3057845 sonstant 55502500 108.993 2826591.7	filicient absion 32,8 17,1 32,0 33,11 Pig Farm See Revenue Abatement C T Emission Pig Farm Pro	03,314,06 16,499,33 03,053,54 etor 88 ont 977,599 475,330 Mit 00934 iector 6049303 ont 1455713	050 006 P 029 Q 907 alpi 555 F 1 a b c d e*a 903 344 P 0,29 Q	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99051 ha 11.61533 a 1.304702 1150066 132415 Co-effcient -0.22111 0.000054 0.472857 -0.27929 0.801633 Constant 7095279 ha 3.430088	Emission Urhan Community S Revenue Abatement Cost T Emission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T Emission	ector 20179296 57 620968 5291 0 29 132415.0205 19519927.60 64926053072 19191728 57	Approve
c d d C alpha beta F C c d e*a C C Q Q d b c d C C C C C C C C C C C C C C C C C C	0.544964 -0.01147 39.625506 Subbasin P Transfer cor Subbasin Em AC-1 A. A. A. A. a. onstant 567 150 7.3 10.95 1642.5 effcient -1.16494 0.719655 0.523361 -0.136506 0.3057645 onstant 555502500 108.993 2826591.7 52493.0455	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vit 09934. vit 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 055 025 025 027 0907 0907 0907 0 0 0 0 0 0 0 0 0 0 0 0	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90061 ha 11.61583 a 1.306702 1150000 132415 Co-effcient 1.304702 1.150000 1.32415 Co-effcient 0.000004 0.472657 0.801633 Constant 7005279 ha 3.430088 a 5.412215	Emission Urban Community S Revenue Abatemeent Cost T Enission Urban Profit Urban Profit Factory Sector Revenue Abatement Cost T Emission	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve
c d e^a P Q alpha beta F I Co a b c d d e <sup>*</sup> a	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	fildent dission 32,8 17,1 32,0 33,11 Pig Farm Sec Revenue Abatement C T Emission Pig Farm Pro Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ost 977,539 475,330 Mit 89994 fit 89994 ector 8049989 ost 1455713 t 572146	050 055 025 025 027 0907 0907 0907 0 0 0 0 0 0 0 0 0 0 0 0	0.169197 -0.40722 0.06677 Uniform Tax 0 90061 ha 11.61583 a 1.308702 1150006 132415 Co-effcient -0.22111 0.000064 0.472857 -0.27929 0.801633 Constant 7095279 ha 3.430088 a 5.412315 2.4337434	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	ector 20179296.57 620968.5291 0 29 132415.0205 19519927.60 19519927.60 64925052072 19191728.57 0.29	Approve
c d d e*a C P P Q alpha F I C C d d e*a C C C P Q alpha beta F I	0.544964 -0.01147 39.625506 Subbasin Pr Transfer cee Subbasin Em A:1 A a sonstant 587 150 7.3 10.95 1095 1095 1095 effcient -1.18484 0.719655 0.523361 -0.136506 0.3057645 So502500 108.993 2028991.7 52493.0455 20070706 5721461.7	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vit 09934. vit 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 055 025 025 027 0907 0907 0907 0 0 0 0 0 0 0 0 0 0 0 0	0.169197 -0.40722 0.06677 Uniform Tax 0 99061 1.61533 a 1.304702 1150406 132415 Co-effcient 0.22111 0.000064 0.472857 -0.27929 0.0001633 Constant 7055279 ha 3.430088 a 5.412215 2.4337434 3.8401865	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve
c d d e*a C P P Q alpha F I C C d d e*a C C C P Q alpha beta F I	0.544964 -0.01147 39.625506 Subbasin Fit At-1 A A A A A A A A A A A A A A A A A A A	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vit 09934. vit 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 055 025 025 027 0907 0907 0907 0 0 0 0 0 0 0 0 0 0 0 0	0.169197 -0.40722 0.06677 Uniform Tax 0 90061 ha 11.61583 a 1.308702 1150006 132415 Co-effcient -0.22111 0.000064 0.472857 -0.27929 0.801633 Constant 7095279 ha 3.430088 a 5.412315 2.4337434	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve
c d d e*a C P Q alpha F I Co a beta c d d e*a Co Q alpha F I Co Q alpha F I Co Q a b t C C Q a b t S C C C C C C C C C C C C C C C C C C	0.544964 -0.01147 39.625506 Subbasin P Transfer cee Subbasin Em A1-1 A A a onstant 587 150 7.3 10.95 1095 1642.5 effcient -1.18484 0.719655 0.523361 -0.136505 0.3057645 Social 2826591.7 52493.045 30070706 5721461.7 effcient 3.679473 0.465050	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vitt 09934. vitt 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 055 055 129 907 140 555 555 1 1 a b c d d e a d e a 1 2 900 344 900 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 80 80 80 80 80 80 80 80 80 80 80 80 80	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 90051 11.61503 a 1.309702 1150605 132415 Co-efficient -0.22111 0.00004 0.472857 -0.27929 0.801633 Constant 7005279 ha 3.4300866 a 5.412315 2.4337430 35401866 Co-efficient -2.7065 1.301082	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve
c d d e^a P Q alpha beta F I Co a d d e*a Co P Q alpha beta F I Co a d d e a d beta C i C i C i C i C i C i C i C i C i C	0.544964 -0.01147 39.625506 Subbasin Fit AC-1 A A A A A A A A A A A A A	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vitt 09934. vitt 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 006 006 007 907 555 555 555 555 555 55 55 55 55 55 55	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99061 ha 11.61583 a 1.306702 1150606 132415 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633 Constant 7095279 ha 3.430088 a 5.412315 2.4337434 2.4337434 2.4337434	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve
c d d e*a C P Q alpha F I Co a beta c d d e*a Co Q alpha F I Co Q alpha F I Co Q a b t C C Q a b t S C C C C C C C C C C C C C C C C C C	0.544964 -0.01147 39.625506 Subbasin P Transfer cee Subbasin Em A1-1 A A a onstant 587 150 7.3 10.95 1095 1642.5 effcient -1.18484 0.719655 0.523361 -0.136505 0.3057645 Social 2826591.7 52493.045 30070706 5721461.7 effcient 3.679473 0.465050	filicient dission 32,8 17,1 32,0 33,11 Pig Farm See Abatement C T Emission Pig Farm Pro	03,314,06 10,499,53 03,053,54 etor 88 ont 977,539 475,330 vitt 09934. vitt 09934. ector 6049383 ont 1455713 ont 1455713 ont 1455713	050 055 055 129 907 140 555 555 1 1 a b c d d e a d e a 1 2 900 344 900 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 89 344 1 80 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	0.169197 -0.40722 0.06677 Uniform Tax Constant 0 99061 11.61503 a 1.309702 115066 132415 Co-effcient -0.22111 0.00004 0.472857 -0.27929 0.801633 Constant 7005279 ha 3.4300866 co-effcient -2.7065 5.301092	Emission Urban Community S Revenue Abatement Cost T Emission Urban Profit Factory Sector Revenue Abatement Cost T Emission Factory Profit	64926053072 19197285 201729285 229 132415.0205 19519927.60 64926053072 1919172857 0.29 26948962.02	Approve

Table C-18: Mathematical Decision-making model of Non-uniform and Uniformtax in sub-basin RL

#### **BIOGRAPHY**

Mr. Rachasak Klayklung was born on June 08, 1977 in Chonburi, Thailand. He attended Triamudomsuksa School in Bangkok and graduated in 1994. He received his Bachelor's Degree in Computer Science from Faculty of Science, Thammasat University and Master's Degree in Environmental and Natural Resources in Economics from Faculty of Economics, Chulalongkorn University in 1999 and 2000, respectively. After that, he pursued his Philosophy of Doctoral Degree studies in the International Postgraduate Programs in Environmental Management, Inter-Department of Environmental Management, Chulalongkorn University, Bangkok, Thailand in April 2002.



ุลถาบนวทยบรการ จุฬาลงกรณ์มหาวิทยาลัย