TABLE OF CONTENTS

i

Page

TABLE OF CONTENTS	i
LIST OF TABLES	iv
LIST OF FIGURES	vii
INTRODUCTION	1
OBJECTIVES	3
Evapotrappoiration	т 1
	4
Delinition	4
Measurement of Evapotranspiration	6
Methods for Estimating Evapotranspiration	8
Remote Sensing	27
Principles of Remote Sensing	27
Basic Principles of Electromagnetic Wave Propagation	28
Basic Concept	29
Related Studies	37
Evapotranspiration	37
Remote Sensing	39
Evapotranspiration and Remote Sensing	42
MATERIALS AND METHODS	45
Materials and Equipment	45
The Automatic Weather Station (AWS)	45
Remote Sensing Materials	45
Data Requirement	46
Methodology	46

TABLE OF CONTENTS (Continued)

Estimating Evapotranspiration Based on Bowen Ratio	47
Method	
Analysing Evapotranspiration and Remote Sensing	52
Parameters Reflecting Evapotranspiration	
Model formulation	54
Study Area	55
Paddy Field	55
Teak Plantation	56
RESULTS AND DISCUSSION	58
Energy Balance and Actual Evapotranspiration	58
Paddy Field	58
Teak Plantation	71
Comparison of Evapotranspiration Between Paddy Field and	81
Teak Plantation	
Formulating Prediction Models	85
Estimation Evapotranspiration Using Remote Sensing	88
Normalized Distribution Index (NDVI)	88
Surface Temperature	93
Surface Albedo	95
Statistic Analysis	102
Paddy Field	102
Teak Plantation	109
Evaporative Fraction (EF)	112
Estimation Evapotranspiration (ETest)	112

TABLE OF CONTENTS (Continued)

The Application of Study Results to the ET for Selected Sub-	121
Watershed	
CONCLUSION AND RECOMMENDATION	129
Conclusion	129
Recommendation	133
LITERATURE CITED	135

LIST OF TABLES

Table		Page
1	Site Location and The Level of Sensors in Flux Measurement	50
2	Energy Balance and Evapotranspiration in Sukhothai Paddy Field,	59
	Jan 2002 – Aug. 2004	
3	Average of Energy Balance Throughout 2002 year in Sukhothai	60
	paddy Field	
4	Average of Energy Balance Throughout 2003 year in Sukhothai	61
	paddy Field	
5	Average of Energy Balance Throughout 2002 year in Sukhothai	62
	Paddy Field	
6	Evapotranspiration Throughout 2002 year in Sukhothai paddy Field	67
7	Evapotranspiration Throughout 2003 year in Sukhothai Paddy Field	69
8	Evapotranspiration Throughout 2004 year in Sukhothai Paddy Field	70
9	Energy Balance and Evapotranspiration in Mae-Moh Teak	72
	Plantation, Lampang Jan. 2002 – Aug. 2004	
10	Average of Energy Balance Throughout 2002 year in Lampang	73
	Teak Plantation	
11	Average of Energy Balance Throughout 2003 year in Lampang	75
	Teak Plantation	
12	Average of Energy Balance Throughout 2004 year in Sukhothai	77
	Paddy Field	
13	Evapotranspiration Throughout 2002 year Lampang Teak Plantation	79
14	Evapotranspiration Throughout 2003 year in Lampang Teak	80
	Plantation	
15	Evapotranspiration Trroughout 2004 year in Lampang Teak	82
	Plantation	

LIST OF TABLES (Continued)

Table		Page
16	Comparison Solar Radiation, Rainfall Amount and	83
	Evapotranspiration Between Paddy Field and Teak Plantation	
17	Mathematical Model for Estimate Actual Evapotranspiration from	86
	Climatic Factors of Sukhothai Paddy Field.	
18	Mathematical Model for Estimate Actual Evapotranspiration from	87
	Climatic Factors of Lampang Teak Plantation	
19	NDVI in Each Satellite Images of Paddy Field and Teak Plantation	89
20	The LST of Each Image in paddy Field and Teak Plantation	96
21	The Surface Albedo of Each Image in paddy Field and Teak	103
	Plantation	
22	ANOVA of ET and RS data in paddy field	108
23	ANOVA of ET and RS data in rice planting season of paddy field	108
24	ANOVA of ET and RS data in off rice planting season of paddy field	109
25	ANOVA of ET and RS data in teak plantation	110
26	ANOVA of ET and RS data in rainy season of teak plantation	111
27	ANOVA of ET and RS data in dry season of teak plantation	111
28	Evaporative Fraction in Each Satellite Image in Paddy Field and	113
	Teak Plantation	
29	Estimation Evapotranspiration in Each Satellites Image in Paddy	117
	Field and Teak Plantation	
30	Land use Utilization in Mae-Moh Sub-Watershed, Amphoe Thuen,	125
	Changwat Lampang	
31	Land use Utilization in Mae-Moh Sub-Watershed, Amphoe Thuen,	128
	Changwat Lampang	

LIST OF TABLES (Continued)

Table		Page
32	The Monthly Suitable Models for Estimation daily ET in Paddy Field and Teak Plantation	130

LIST OF FIGURES

Figure		Page
1	The Energy Balance for Various Low Latitude Climate Types	21
2	Spectrum of Electromagnetic Energy	29
3	Percentage of Absorption and Reflection in Each Types of Satellites	31
4	Normal Wavelength and Existing Wavelength	32
5	Schematic of Instrument (Automatic Weather Station : AWS) at	48
	Paddy Field	
6	Schematic of Instrument (Automatic Weather Station : AWS) at Teak	49
	Plantation	
7	Automatic Weather Station, Sukhothai Paddy Field	55
8	Automatic Weather Station, Lampang Teak Plantation	57
9	Comparison Solar Radiation, Rainfall Amount and	57
	Evapotranspiration in Paddy Field	
10	Comparison Solar Radiation, Rainfall Amount and	84
	Evapotranspiration in Teak Plantation	
11	Normalized Distribution Index (NDVI) in Sukhothai Paddy Field and	90
	Lampang Teak Plantation during August 2002 – January 2003	
12	Normalized Distribution Index (NDVI) in Sukhothai Paddy Field and	91
	Lampang Teak Plantation during February 2003 – July 2003	
13	Normalized Distribution Index (NDVI) in Sukhothai Paddy Field and	92
	Lampang Teak Plantation during August 2003 – December 2003	
14	The relationship between ET and NDVI (a) in paddy field (b) in teak	94
	plantation	
15	Surface Temperature in Sukhothai Paddy Field and Lampang Teak	97
	Plantation during August 2002 – January 2003	

LIST OF FIGURES (Continued)

Figure		Page
16	Surface Temperature in Sukhothai Paddy Field and Lampang Teak	98
	Plantation during February 2003 – July 2003	
17	Surface Temperature in Sukhothai Paddy Field and Lampang Teak	99
	Plantation during August 2003 – December 2003	
18	The relationship between ET and surface temperature (a) in paddy	100
	field (b) in teak plantation	
19	Comparison Between Estimation and Measurement of Surface	101
	Temperature in Paddy Field	
20	Comparison Between Estimation and Measurement of Surface	104
	Temperature in Teak Plantation	
21	Surface Albedo in Sukhothai Paddy Field and Teak Plantation	105
	During August 2002 – January 2003	
22	Surface Albedo in Sukhothai Paddy Field and Teak Plantation	106
	During February 2003 – July 2003	
23	The relationship between ET and surface albedo (a) in paddy field	107
	(b) in teak plantation	
24	Surface Albedo in Sukhothai Paddy Field and Teak Plantation	114
	During August 2003 – December 2003	
25	Evaparative Fraction (EF) in Sukhothai Paddy Field and Lampang	115
	Teak Plantation During August 2002 – January 2003	
26	Evaparative Fraction (EF) in Sukhothai Paddy Field and Lampang	116
	Teak Plantation During February 2003 – July 2003.	
27	Evaparative Fraction (EF) in Sukhothai Paddy Field and Lampang	118
	Teak Plantation During August 2003 – December 2003.	

viii

LIST OF FIGURES (Continued)

Figure		Page
28	Estimation Evapotranspiration (ETest) in Sukhothai Paddy Field and	119
	Lampang Teak Plantation During August 2002 – January 2003	
29	Estimation Evapotranspiration (ETest) in Sukhothai Paddy Field and	120
	Lampang Teak Plantation During February 2003 – July 2003.	
30	Relationship between ET(measuremant) & ET(estimated) (a) in	122
	paddy field (b) in teak plantation	
31	The Boundary of Mae-Moh Sub-Watershed, Amphoe Thuen,	123
	Changwat Lampang	
32	Land use Utilization in Mae-Moh Sub-Watershed, Amphoe Ngao,	124
	Changwat Lampang	