

① ✓

# Sustainable Agriculture: *Possibility and Direction*

## Proceedings of the 2<sup>nd</sup> Asia-Pacific Conference on Sustainable Agriculture

18-20 October 1999  
Phitsanulok, Thailand

Hosted by

Naresuan University, Thailand

American Association for the Advancement of Science  
Science Society of Thailand under the Patronage of H.M. the King  
Thailand's National Science and Technology Development Agency  
Department of Agriculture, Ministry of Agriculture and Cooperatives  
Department of Biology, Chulalongkorn University



ISBN 974-7579-31-6

## Contents

### Preface

*Professor Dr. Siriwat Wongsiri, Chairman of Program Committee*

### Report Address

*Mr. Samrit Chaiwanakupt, Dean of Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Thailand*

### Opening Remarks

*H.E. Dr. Ampol Senanarong, Privy Councilor*

### Welcome Address and Introduction

*Professor Dr. Sujin Jinhayon, President of Naresuan University, Thailand*

### SPECIAL LECTURE

- Sustainable Agriculture and Life Long Education in School ..... 1  
*Khwankeo Vajarodaya, Grand Chamberlain*

### KEYNOTE LECTURES

- The Department of Agriculture: Providing the Foundations for Sustainable Agriculture  
Development in Thailand ..... 3  
*Vijai Nopamornbodi*
- Equitable Partnership with Asian Rural Women for Sustainability and Sustenance ..... 11  
*Revathi Balakrishnan*
- MATO-MATID Technology; Resume/Abstract of 30 Years Work of  
Professor Maneewan Kamonpatana ..... 23  
*Maneewan Kamonpatana*
- Sustainable Agriculture – Where to from Here? ..... 27  
*E.C.A. Runge*
- Biotechnology and Sustainable Agriculture ..... 45  
*Sutat Sriwatanapongse*

## CONCURRENT SESSION A

Sustainable Agriculture and Biodiversity Conservation .....	55
<i>David S. Woodruff</i>	
California's Pest Management Alliance Program as a Model for Sustainable Agriculture? The Commercial Poultry Alliance Example .....	63
<i>Leslie A. Hickle</i>	
Integrated Pest Management of Diamondback Moth <i>Plutella xylostella</i> in Cabbage in Bangladesh .....	67
<i>V.M. Salokhe, Mohammad Babul Hossain, G.K. Hansen</i>	
Sweet Potato Pests in Thailand and Sustainable Cultivation .....	75
<i>Jutharat Attajarusit</i>	
Integrated Systems and Processes towards Sustainable Agriculturally Based Livelihood in Northern Thailand .....	85
<i>Phrek Gypmantasiri, Aree Wiboonpongse, Songsak Sriboonchitta and Budsara Limnirankul</i>	
QPM Maize Based Poverty Alleviation and Sustainable Development at Maoli Village .....	97
<i>He Zhonghu and Zhao Lihua</i>	
Patterns of Agricultural Sustainability .....	101
<i>George W. Bird</i>	
The New Development of Sustainable Agriculture: The Construction of Ecological Villages .....	107
<i>Tang Longfei, Weng Boqi, Liu Zhongzhu and Liu Xiashi</i>	
Thai Agriculture in the New Millennium .....	115
<i>Sitanon Jesdapipat</i>	
A Sustainability Concept for Alleviating the Fruit Industry Crisis in Thailand .....	125
<i>Thongchai Yantarasri and Jinda Sornsrivichai</i>	
Success-Case-Replication; An Innovative and Cost-effective Tool for Sustainable Agriculture .....	131
<i>Jan B. Orsini</i>	
Microbial Dimension to Sustainable Agriculture: Balancing the Demands for Nutrient Input with the Desire to Maintain Soil Biodiversity .....	145
<i>Anthony G. O'Donnell and Melanie Seaman</i>	
A Catchment Approach to Research on Soil Erosion in the Marginal Uplands of Asia .....	151
<i>Eric T. Craswell and Amado Maglinao</i>	

## CONCURRENT SESSION B

Developing a Soil Quality Monitoring System for Sustainable Crop Production .....	163
<i>P.H. Williams, M.H. Beare, K.C. Cameron and T.J. van der Weerden</i>	
Globally Developing An Organic Farming System with BMW (Bacteria-Mineral-Water) Technology (A Case Study on Yonezawago Ranch Agro-Coop. Ltd. in Japan) .....	169
<i>Taichi Yamamoto</i>	
Participatory Action Research: Alternative Methodology to Research Management for Sustainable Agriculture .....	173
<i>Avorn Opatpatanakit</i>	
Small Farm Agriculture: Meeting Future Food Needs Sustainably .....	179
<i>Peter Rosset</i>	
The Rice-Wheat Consortium: An Ecoregional Initiative of the Consultative Group on International Agricultural Research (CGIAR) for the Indo-Gangetic Plains of South Asia .....	199
<i>Peter R. Hobbs</i>	
Beekeeping for Sustainable Agriculture .....	211
<i>Siriwat Wongsiri, Thadsanee Chaiyawong and Sawang Piyapichat</i>	
A Study on Green Manuring Technique for Sustainable Maize Production .....	217
<i>A. Suwanarit, N. Lekhasoonthrakorn, J. Rungchuang and S. Kritapirom</i>	

CONCURRENT SESSION C

Land Evaluation for Combining Economic Crops Using GIS and Remotely Sensed Data .....	229
<i>C. Mongkolsawat, P. Thirangoon and P. Kuptawutinan</i>	
Nutrient Management in the Context of Sustainable Agriculture .....	235
<i>J. Keith Syers, Sumalee Suthipradit and Anthony G. O'Donnell</i>	
Developing Sustainable Pest Management for Rice in Cambodia .....	243
<i>Gary C. Jahn, Khiev Bunnarith, Pol Chanthy, Chhorn Nel, Pheng Sophea and Preap Visarto</i>	
Sustainable Agriculture and the Biological Conservation of Fragmented Populations .....	259
<i>Sukamol Srikwan</i>	
Growth, Yield and Yield Components of Rice Plants under Nature Farming in Japan .....	265
<i>Preecha Neera, Manabu Katano and Toshihiro Hasegawa</i>	
Some Points of View on Sustainable Agriculture in Japan and Asia – Development of the Multi-Cropping of Rice and Sustainability in Mekong Delta, Vietnam .....	275
<i>Kotaro Ohara</i>	
Doing It Together Means Doing It Better (Sometimes): The Case for Organisational Change in Agricultural R&D .....	287
<i>Peter Cox, Gary Jahn and Mah Solieng</i>	
Integrated Farming - a New Approach for the Development of Agriculture in Bangladesh to Meet the Challenges of Food Security in the 21st Century .....	299
<i>M.M. Karim, S.M.A. Hossain and M.A. Kashem</i>	
Development of Sustainable Farming Systems in Northeast Thailand .....	317
<i>Nobuyuki Kabaki, Tadashi Yoshihashi, Akinori Noguchi</i>	
Relevance of Precision Farming Technologies to Sustainable Agriculture in Asia and the Pacific .....	325
<i>Ancha Srinivasan</i>	
POSTER SESSIONS	
Use of Neem's Product as Fungistatic Effect on Soil Borne Pathogens and Soil Amendment .....	339
<i>Sirirat Sanyong</i>	
Effect of Pod Ages and Media on Seed Germination and Seedling Development in <i>Vanda coerulea</i> .....	347
<i>Sumidtra Supinrach</i>	
Cropping Systems for Sustainable Agriculture in Lower Northern Thailand .....	351
<i>Sirirat Sanyong, Vicharn Amarakul, Sombat Chuenchooklin and Vijitr Udeye</i>	
Canal System Management in Large Irrigation Systems Experience from the Phitsanulok Irrigation Project, Thailand .....	357
<i>Sombat Chuenchooklin</i>	
Effects of Fertilization and Citronella Grass Leaves Mulching on Yield and Common Cutworm ( <i>Spodoptera litura</i> F.) Quantity in Broccoli .....	365
<i>Pramote Pornsuriya and Pornthip Pornsuriya</i>	
Effect of Chemical Fertilizer With and Without Peanut Stover Applications for Peanut Long-term Production .....	371
<i>S. Ratanarat, S. Jongruaysup, S. Suchartkul and S. Ratanarat</i>	
List of Participants .....	374

CONCURRENT SESSION C

## Land Evaluation for Combining Economic Crops Using GIS and Remotely Sensed Data

C. Mongkolsawat P. Thirangoon and P. Kuptawutinan

Computer Centre Khon Kaen University, Khon Kaen Thailand 40002.

E-mail: charat@kku1.kku.ac.th

### Abstract

In general, land evaluation for agricultural land use is formulated by classifying lands with different capabilities. The suitability for various potential land uses is identified in relation to individual crop requirements. Within the planning area, an assessment of crop combinations is needed in order to lessen a price risk. This evaluation was then formulated with objective of classifying units of land as to their suitability for combining economic crops using GIS and remotely sensed data.

The study area, Song Kram Watershed, covers extensively in the Sakon Nakhon basin, Northeast Thailand with an area of about 13,080 km<sup>2</sup>. The major economic crops in the area are rice, cassava, sugar-cane and pasture crops. The suitability assessment for each crop was conducted using the method as described in FAO guidelines for land evaluation for rainfed agriculture. For each crop, land unit was created from overlay process of the defined theme layers or land qualities on which the suitability is based. As a result, suitability map layers with their associated class attributes for rice, cassava, sugar-cane and pasture crops were obtained. Furthermore, the overlay process was then performed on these suitability map layers with selection criteria of only highly and moderately suitable classes. The resultant map obtained is a result of combination of the defined suitability class of combining crops (rice, cassava, sugar-cane and pasture) within the area. Economically, the planning alternative that best matches land use to land suitability should therefore be the most valuable and efficient.

### Introduction

In Northeast Thailand, the agricultural land use cover an area of 71.09%, rice and field crops share about 44.78 and 25.41% respectively (Land Development Department LDD 1989). The major field crops in the watershed are sugar-cane and cassava which occupy the upland, well drained soils. Pasture is a minor consumer of water so the planners are interested in developing the livestock. The suitability of land for rice, sugar-cane, cassava and pasture is needed to maximize the production.

FAO guideline on the land evaluation system (1983) is widely adopted. The system was based on defined land qualities as related to individual crop. Establishment of land unit that best matches land use to its suitability is principal concept used. Sys et al (1991) applied the FAO concept and developed the crop requirements based on the experiment / experiences in tropical areas. Bo-heng (1990) established spatial model for land evaluation in China using remote sensing data and GIS. FAO (1983) also suggested the land evaluation for suitability of crop combination can support the alternatives for the proper decision. This suggestion is due to markets and prices that are liable to change from one crop to another. Consequently, development of land suitability map for combining crops is needed in order to reduce the price risk. There still needs to develop the modeling of land suitability for crop combination using computer based GIS and remote sensing data. The principal purpose of this study is to classify the land in relation to its suitability for crop combination using GIS and remotely sensed data.

## Study Area

The study area, the Song Kram Watershed, is located in Northeast Thailand and covers an area of about 13,081 km<sup>2</sup>. Mean annual rainfall ranges 1300-1800 m.m. Geologically, the Song Kram is formed by thick sequence of Mesozoic sediment, the Korat group ranging in age from upper Triassic to Tertiary. The extensive area is formed by flat to gently undulating alluvial plains which are drained easterly flowing drainage system. Apart from the gently undulating plains, the other prominent topography of the area is the Phu-Phan range which lies in the southern part of the watershed. Paddy fields, field crops and the remnant of dipterocarp trees are common on the undulating plains. The dry dipterocarp forest is the main type found on the Phu-Phan mountain range. Soils are formed from alluvium and have inherently low in fertility.

## Methodology

The suitability evaluation for each crop (rice, cassava, sugar-cane and pasture crop) was based mainly on the method as described by FAO(1983). For each crop, land units resulting from the overlay process of the selected land qualities were established. The selected land qualities include water availability (W), oxygen availability (O), nutrient availability index (NAI), water retention capacity (R) root conditions (D), salt hazards (S) and topography (T). The requirements of each crop were reviewed from a number of publications (FAO (1983), FAO (1991), LLD (1990) Sys et al (1993), Delante (1993)) in combination with experimental reports and regional experiences. Determinations of the various factor rating and values assigned for each land quality are summarized in the table 1, 2, 3 and 4 for rice, cassava, sugar-cane and pasture respectively. Each land quality is a thematic layer in the GIS in which contains spatial data and its associated attributes.

The water availability was based on the amount of annual rainfall. The nutrient availability index based on the method developed by Radcliffe et al (1982) and is given by  $NAI = N \times P \times K \times pH$ . The spatial information for each diagnostic factor of NAI can be derived from LDD soil map. For pasture crop the pH is only a factor for NAI. The water retention capability is extracted from the diagnostic of soil texture and particle size. Moreover, soil map can provide information about root condition and salt hazards. The topography is a combination of slope gradient and landform which are derived using digital evaluation model and satellite data respectively. Each of land qualities with their associated attributes are digitally performed in a GIS to eventually produce the thematic layers. The factors rating defined in the table 1, 2, 3 and 4 were attribute database as related to diagnostic factors.

Table 1.

Land  
quality  
Water  
availability  
Oxygen  
availability  
Nutrient  
Availability  
Index  
(NAI)

Water  
retention  
capacity  
Root  
Conditions  
Salt  
hazards  
Topography

Table 2.

Land  
quality  
Water  
availability  
Oxygen  
availability  
Nutrient  
Availability  
Index  
(NAI)

Water  
retention  
capacity  
Root  
Conditions  
Salt  
hazards  
Topography

Table 1. Land quality and factor rating for low land rice.

Land use requirement			Factor or rating			
Land quality	Diagnostic factor	unit	1.0	0.8	0.5	0.2
Water availability (W)	Annual rainfall	mm.	>1,500	1,100-1,500	800-1,100	<800
Oxygen availability (O)	Soil drainage-	-	poor / very poor	poor	well	very well
Nutrient Availability Index (NAI)	NAI		≥0.60	0.40-0.60	0.10-0.40	<0.10
	N	%	>0.2	0.1-0.2	<0.1	-
	P	ppm	>25	10-25	<10	-
	K	ppm	>60	30-60	<30	-
	pH	-	5.6-7.3	7.4-7.8, 5.1-5.5	7.9-8.4, 4.0-5.0	>8.4, <4.0
Water retention capacity (R)	Soil texture	-	CL, Si, SCL, SiL, C, AC	L, SiCL, SiC, SL	LS	G, S, SC
Root Conditions (D)	Soil depth	cm.	>50	25-50	15-25	<15
Salt hazards (S)	Soil salinity potential	-	Low	Medium	High	non-saline
Topography (T)	Land form and slope	-	FL	LT	MT, HT, FS, M slope <5%	MT, HT, FS, M, slope >5%

Table 2. Land quality and factor rating for cassava.

Land use requirement			Factor or rating			
Land quality	Diagnostic factor	unit	1.0	0.8	0.5	0.2
Water availability (W)	Annual rainfall	mm.	1,100-1,500	900-1,100, 1,500-2,500	500-900, 2,500-4,000	<500, >4,000
Oxygen availability (O)	Soil drainage-	-	well	moderate	poor	very poor
Nutrient Availability Index (NAI)	NAI		≥0.60	0.40-0.60	0.10-0.40	<0.10
	N	%	>0.2	0.1-0.2	<0.1	-
	P	ppm	>25	6-25	<6	-
	K	ppm	>60	30-60	<30	-
	pH	-	6.1-7.3	7.4-7.8, 5.1-6.0	7.9-8.4, 4.0-5.0	>8.4, <4.0
Water retention capacity (R)	Soil texture	-	L, Si, SiL, S, CL, CL	SiCL, LS, SL	SiC, S	C, G, SC, AC
Root Conditions (D)	Soil depth	cm.	>150	100-150	50-100	<50
Salt hazards (S)	Soil salinity potential	-	Low	Medium	High	non-saline
Topography (T)	Land form and slope	-	MT, HT, FS, M slope <5%	MT, HT, FS, M slope 5-12%	MT, HT, FS, M slope 12-20%	MT, HT, FS, M slope >20%, FI, LT

Table 3. Land quality and factor rating for sugar-cane.

Land use requirement			Factor or rating			
Land quality	Diagnostic factor	unit	1.0	0.8	0.5	0.2
Water availability (W)	Annual rainfall	mm	1,600-2,500	1,100-1,600 2,500-3,000	900-1,100 3,000-4,000	<900 >4,000
Oxygen availability (O)	Soil drainage-	-	well	moderate	poor	very poor
Nutrient Availability Index (NAI)	NAI	-	≥0.60	0.40-0.60	0.10-0.40	<0.10
	N	%	>0.2	0.1-0.2	<0.1	-
	P	ppm	>25	6-25	<6	-
	K	ppm	>60	30-60	<30	-
	pH	-	5.6-7.3	7.4-7.8, 4.5-5.5	7.9-8.4, 4.0-4.4	>8.4, <4.0
Water retention capacity (R)	Soil texture	-	L, Si, SiCL SiL, SCL, C L, SL	LS	SiC,	C, G, S SC, AC
Root conditions (D)	Soil depth	cm.	>100	50-100	25-50	<25
Salt hazards (S)	Soil salinity potential	-	Low	Medium	High	non-saline
Topography (T)	Land form and slope	-	MT, HT, FS, M slope <5%	MT, HT, FS, M slope 5-12%	MT, HT, FS, M slope 12-20%	MT, HT, FS, M slope >20%, FL, LT

Table 4. Land quality and factor rating for pasture.

Land use requirement			Factor or rating			
Land quality	Diagnostic factor	unit	1.0	0.8	0.5	0.2
Water availability (W)	Annual rainfall	mm.	1,500-4,000	1,000-1,500 4,000-6,000	400-1,000	<400 >6,000
Oxygen availability (O)	Soil drainage-	-	well	moderate	poor	very poor
Nutrient Availability Index (NAI)	pH	-	5.1-6.5	6.6-7.3,	7.4-8.4,	>8.4
				4.5-5.0	4.0-4.4	<4.0
Water retention capacity (R)	Soil texture	-	L, Si, SiL S, Cl SL, SiCL, C L	LS	C, AC, G SiC, S	SC
Root Conditions (D)	Soil depth	cm.	>50	25-50	15-25	<15
Salt hazards (S)	Soil salinity potential	-	Low	Medium	High	non-saline
Topography (T)	Land form and slope	-	MT, HT, FS, M slope <12%	MT, HT, FS, M slope 12-20%, LT	MT, HT, FS, M slope 20-35%, FL	MT, HT, FS, M slope >35%

Remark

Soil : C = Clay, CL = Loam, L = Loam, Si = Silt, SiL = Silty Loam, Silty Clay, SL = Sandy Loam  
 LS = Loamy Sand, SCL = Sandy Clay Loam = SiCL = Silty Clay Loam, S = Sand, G = Gravel soil,  
 Ac = Alluvial Complex, SC = Slope Complex  
 Salt hazard : 1 very high, 2 = high, 3 = moderate, 4 = low, 5 = underlying salt rock, 6 = none  
 Land form  
 FL = Flood plain, LT = Low Terrace, MT = Middle Terrace, HT = high Terrace, FS = Foot Slope,  
 M = Mountain

Suitabil  
to produ  
layers y  
presente  
layers w  
map for

Table 5.

Results

T  
criteria of  
shown in

Table 6.

Class

highly su  
suitable  
highly su  
suitable  
highly su  
highly sui  
suitable f  
non-suitc

village  
water bo

Total

The  
of selected  
to lessen th  
are highly s  
area, the pr  
highly suita  
Some 11.71  
observed th  
sugar-cane.

To e  
against the c  
ton/ha for ri  
In c  
alternatives



The evaluation model for each crop is Defined using the value of factor rating as follows : Suitability =  $W \times O \times NAI \times R \times D \times S \times T$ . The overlay process of these layers was performed to produce a resultant polygonal layer upon which the evaluation model was applied. The resultant layers yield suitability maps for rice, cassava, sugar-cane according to the resultant values as presented in the table 5. Furthermore, the overlay process was then performed on these suitability layers with selection criteria of only highly and moderately suitable classes. The land suitability map for combination of the selected crops can be produced accordingly.

Table 5. Suitability evaluation for each crop.

Value	Class
>0.2	Highly suitable
0.1-0.2	Moderately suitable
0.01-0.1	Marginally suitable
<0.01	Unsuitable

## Results and discussion

The suitability map for economic crops is a combination of the selected crops with selection criteria of only highly and moderately suitable classes (Fig. 1). The suitability area of the crops is shown in table 6.

Table 6. The suitability area for rice, cassava, sugar-cane and pasture, Song Kram Watershed, NE Thailand

Class	%	Km2
highly suitable for rice	7.31	955.50
suitable for rice	0.09	11.20
highly suitable for sugar-cane / cassava	11.71	1571.83
suitable for sugar-cane / cassava	0.34	44.15
highly suitable for sugar-cane	1.44	188.71
highly suitable for pasture	31.37	4091.16
suitable for pasture	36.04	4701.82
non-suitable	5.92	761.51
village	2.62	341.97
water body	3.16	413.58
Total	100	13081.47

The study provides information about the suitability of land for not only a combination of selected crops but also individual crop. This is to offer the alternatives for agricultural land use to lessen the price risk. The areas have inherently low nutrient status so that the pasture crops are highly suitable and cover extensively in the study area. According to the land qualities in the area, the principal limiting factors are the soil depth and fertility. The result indicated that the highly suitable land for rice covers an area of about 7 percents and is restricted in the flood plain. Some 11.71 percent of the watershed is highly suitable for cassava and sugar-cane. It should be observed that the highly suitable area for pasture occupies the suitable area of the cassava and sugar-cane.

To evaluate the reliability of the method developed, the suitability classes were checked against the crop yields. The crop yields of highly suitable class were on average 4.17, 75 and 25 ton/ha for rice, sugar-cane and cassava respectively.

In conclusion suitability map of crop combination in the area can help support the alternatives to lessen the price risk. The alternatives for agricultural land use are dynamic and



Fig. 1. Land suitability for economic crops, Song Kram Watershed, North-East Thailand.

varied according to the marketing price of the product. The process of developing alternatives for the watershed then requires a method of selection which has greatest value in terms of the cost effectiveness. The decision maker can make the proper decision given sufficient knowledge.

In addition, GIS layers established can enhance the planning alternatives within the watershed with reasonable information in terms of location. Perspectively, economic analysis to determine the cost of input and the values of output in the suitability map is needed to make these tasks meaningful to planning.

**References**

1. Bo-heng Li. 1990. Application of Remote Sensing and GIS, China's Land Survey, Evaluation and Administration. Proceedings of the 11th ACRS vol 11 Nov. 15-21, 990 Guangzhou, china.
2. Delante, V.Z., 1993. Land Suitability Classification for cassava, pineapple and Rubber using GIS in A. Pluak Daeng, Rayong Prov. M.Sc. Res. study, AIT Thailand.
3. FAO. 1983. Guidelines : Land Evaluation for Rainfed Agriculture Soils Bulletin No.52 Rome : 237.
4. FAO. 1991. Guidelines : Land Evaluation for Extensive Grazing. FAO Soils Bulletin No. 58. Rome.
5. Land Development Department. 1975. Detailed – Reconnaissance Soil map. Sakhon Nakhon. Min. of Agriculture and cooperatives.
6. Land Development Department. 1975. Detailed – Reconnaissance Soil map. Nong Khai Min. of Agriculture and cooperatives.
7. Land Development Department. 1975. Detailed – Reconnaissance Soil map. Udon Thani. Min. of Agriculture and cooperatives.
8. Land Development Department. 1987. Detailed – Reconnaissance Soil map. Nakhon Phanom. Min. of Agriculture and cooperatives.
9. Land Development Department. 1990. Land Evaluation for Economic crops. Min. of Agriculture and cooperatives.
10. Land Development Department. 1993. NE Land use Planning. Document No. 05/06/36 Min. of Agriculture and cooperatives.
11. Land Development Department. 1996. Land Evaluation for Economic crops Min. of Agriculture and cooperatives.
12. Radcliffe D.J. and Rochette L. Maize in Angonia. 1983. An analysis of factors of production. Field Report 30, FAO/ UNDP MOZ/75/011, Maputo.
13. Sys. C., Ranst. V and Debaveye. J. 1991. Land Evaluation Part I, Part II Agricultural publication No. 7, ITC Ghent.
14. Sys. C., Ranst. V, Debaveye J. and Beernaert. F. 1993. Land Evaluation Part III, crop requirements. Agricultural publication No.7, ITC Ghent.

CONCURRI

J. I

= D-  
N-  
= D-  
N-  
P-

**Introducti**

Sust  
the land res  
Implicit in t  
At th  
implemte  
the farmer a  
acceptability  
which do no  
Soil f  
it is a comple  
basis. Howev  
and soil organ  
taken to mea  
Accor  
in any discuss  
include, inter  
crop yields pe  
a quick and la  
The in  
exceeding nut  
threat to susta  
and farmer- ac  
in many count