Sustainability of crop production systems under future climate scenarios

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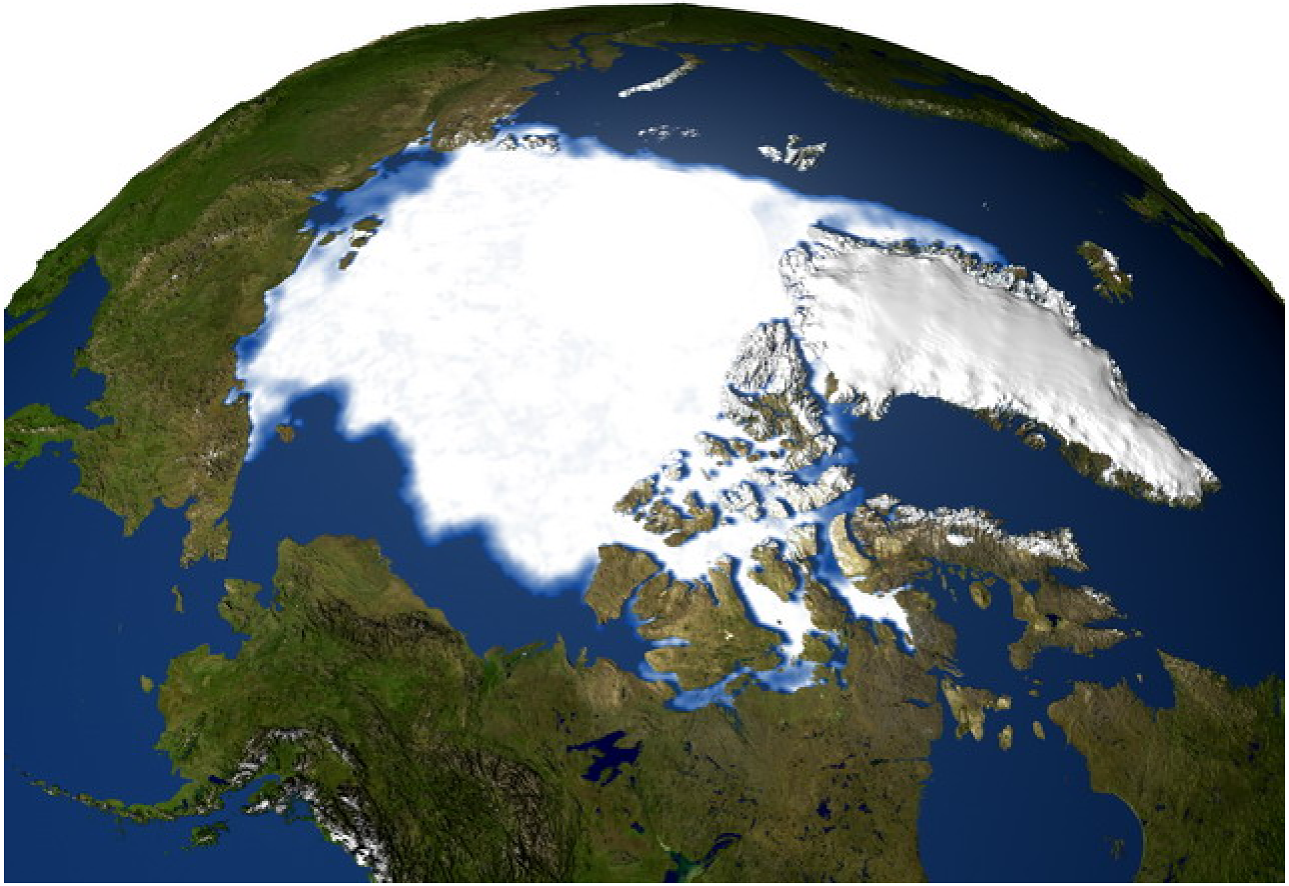
Issues

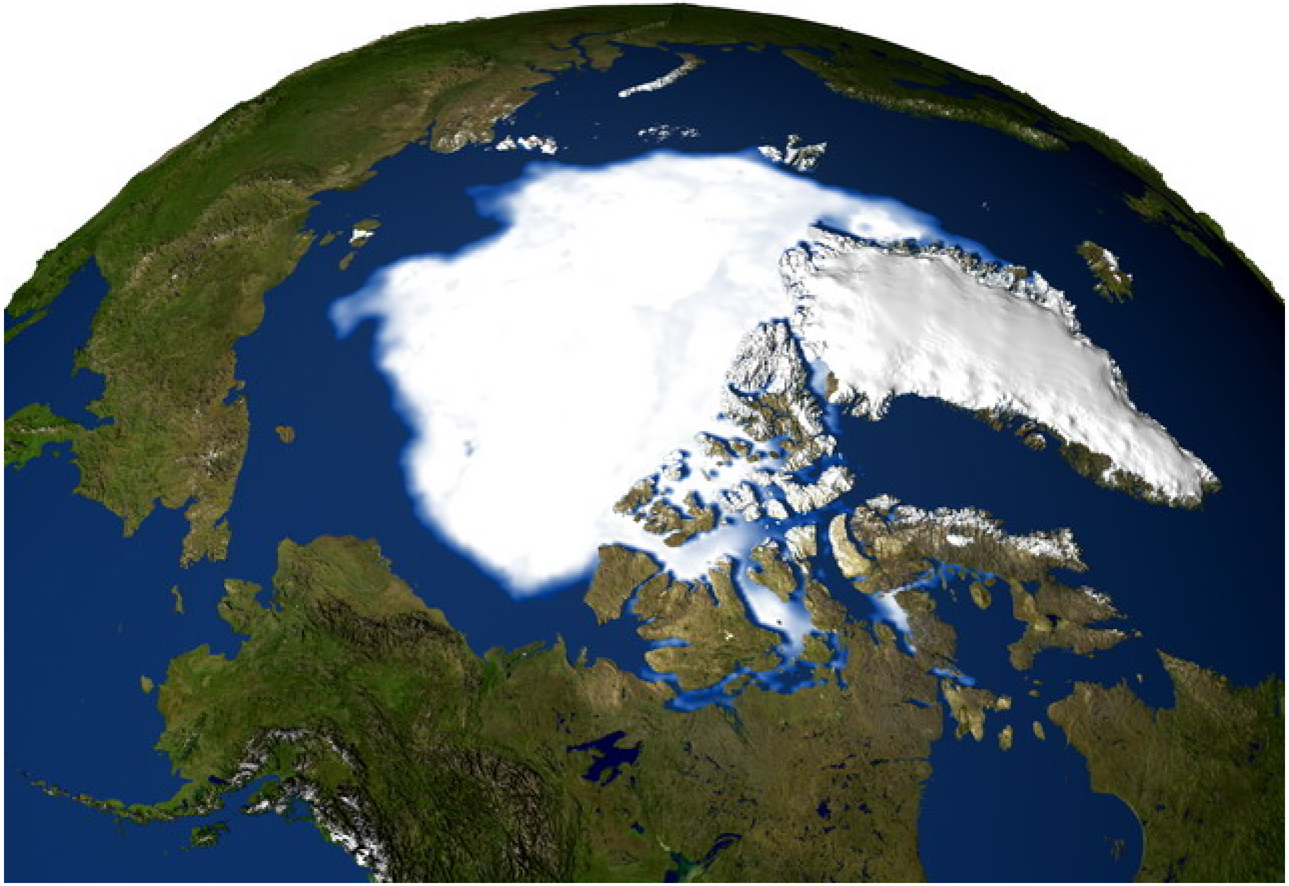
- Changes at the global scale
- Rice and sugarcane production systems and climate changes
- Study methods
- Results of CNX & KKC
- System approach for SA
- Summary

Changes at the Global scale

Arctic ice sheet in 1979



Arctic ice sheet in 2005

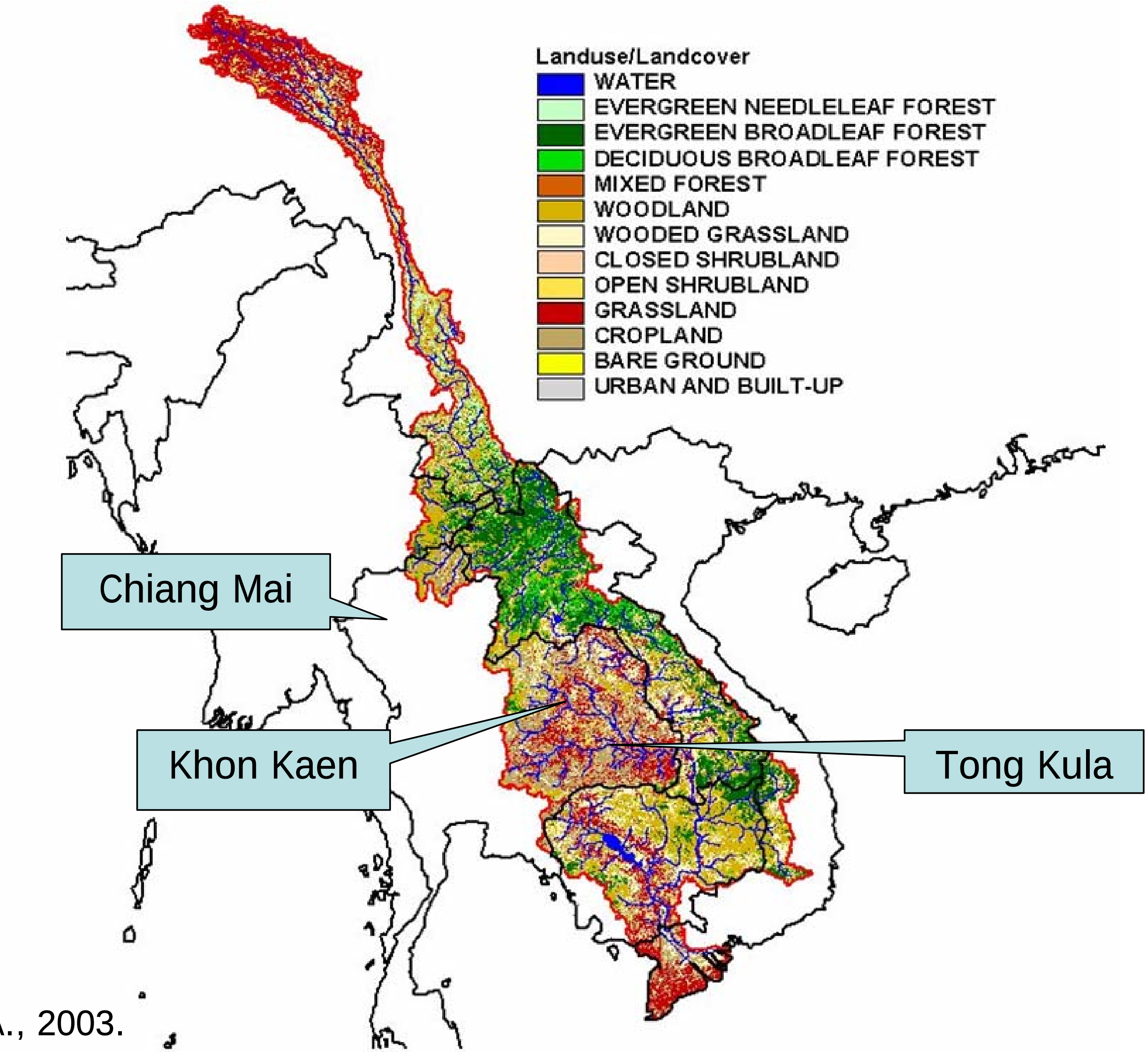


Predicted impact of GC

- Increasing flood risk from melting glaciers
- Rising sea levels could leave 200 million people permanently displaced
- Declining crop yields, particularly in Africa
- Increasing extreme weather patterns

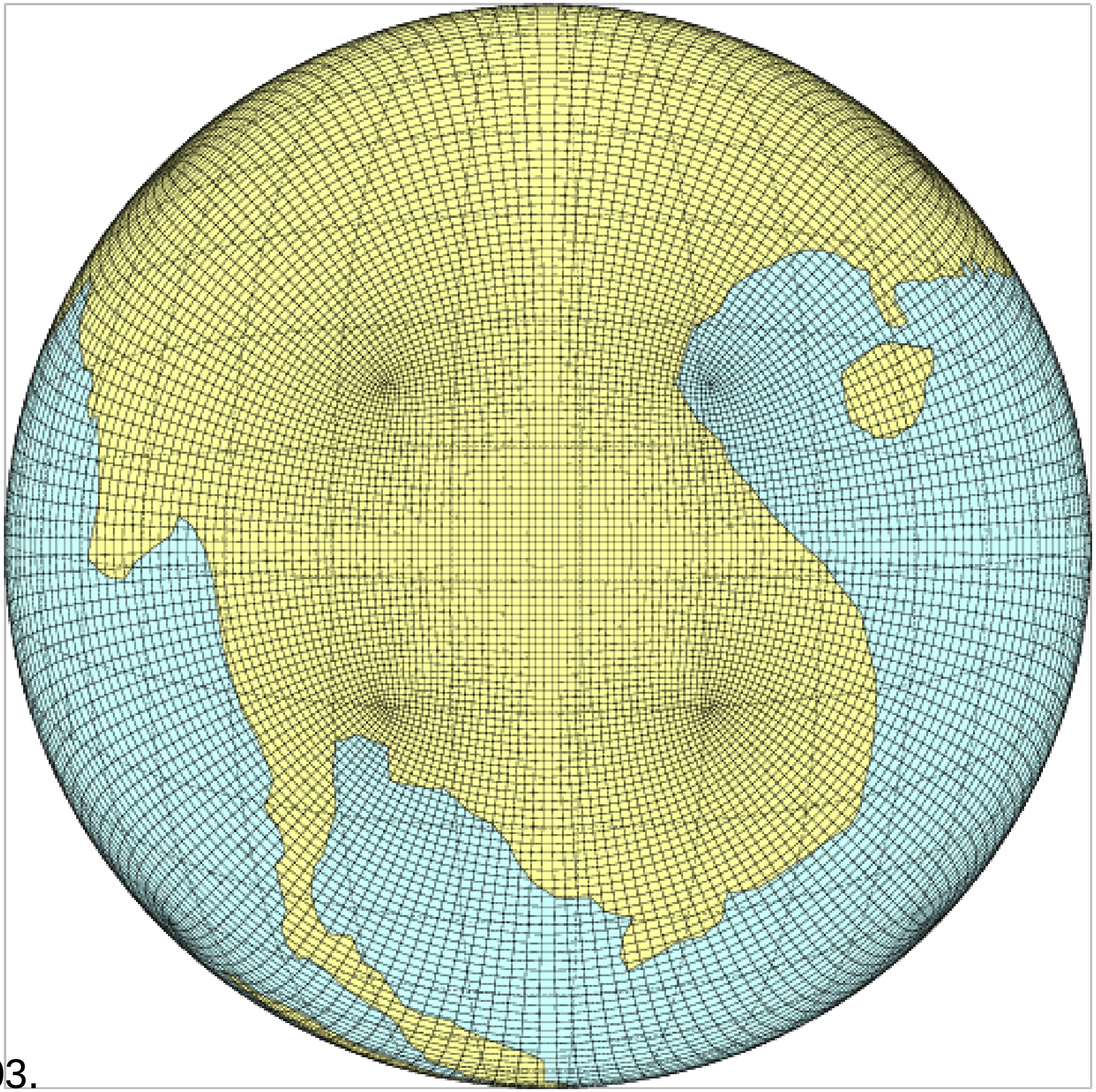
Source: The Stern Review The Economics of Climate Change
http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

Locations



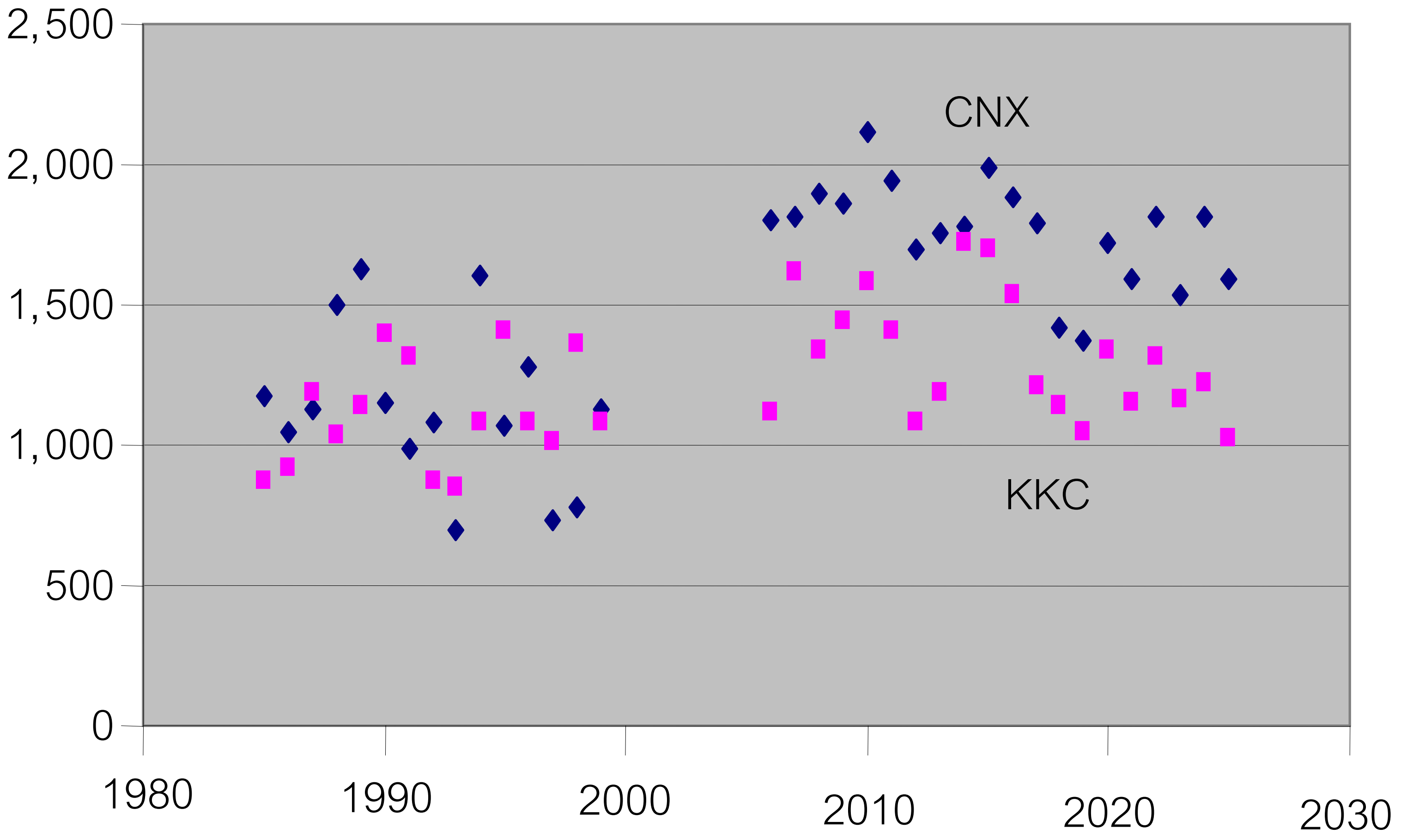
Snidvongs, A., 2003.

Stretched coordinate system for CCAM modeling of the Mekong basin

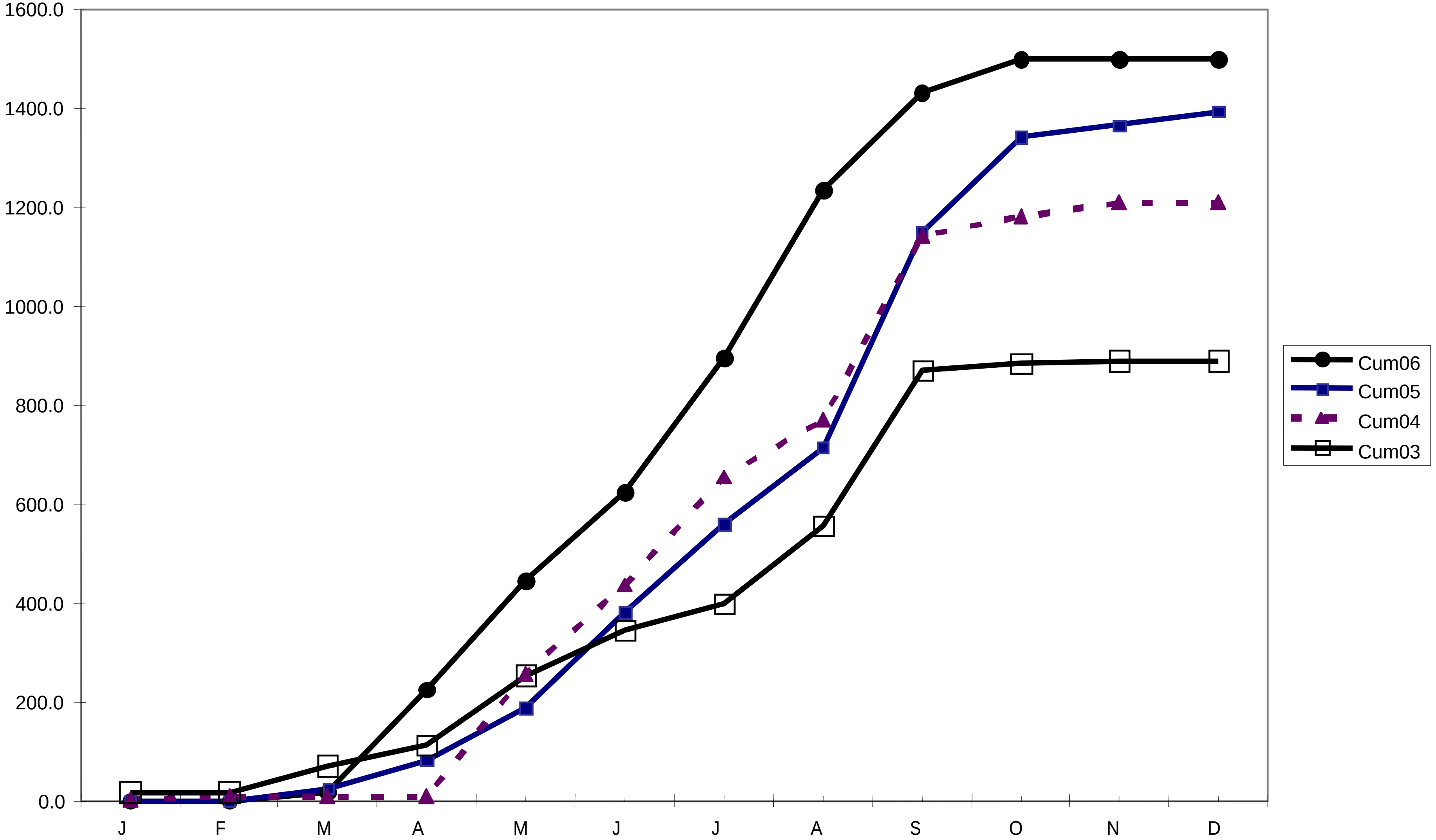


Snidvongs, A., 2003.

Rainfall between 1985-2030: CCAM 1.5xCO_2 scenario

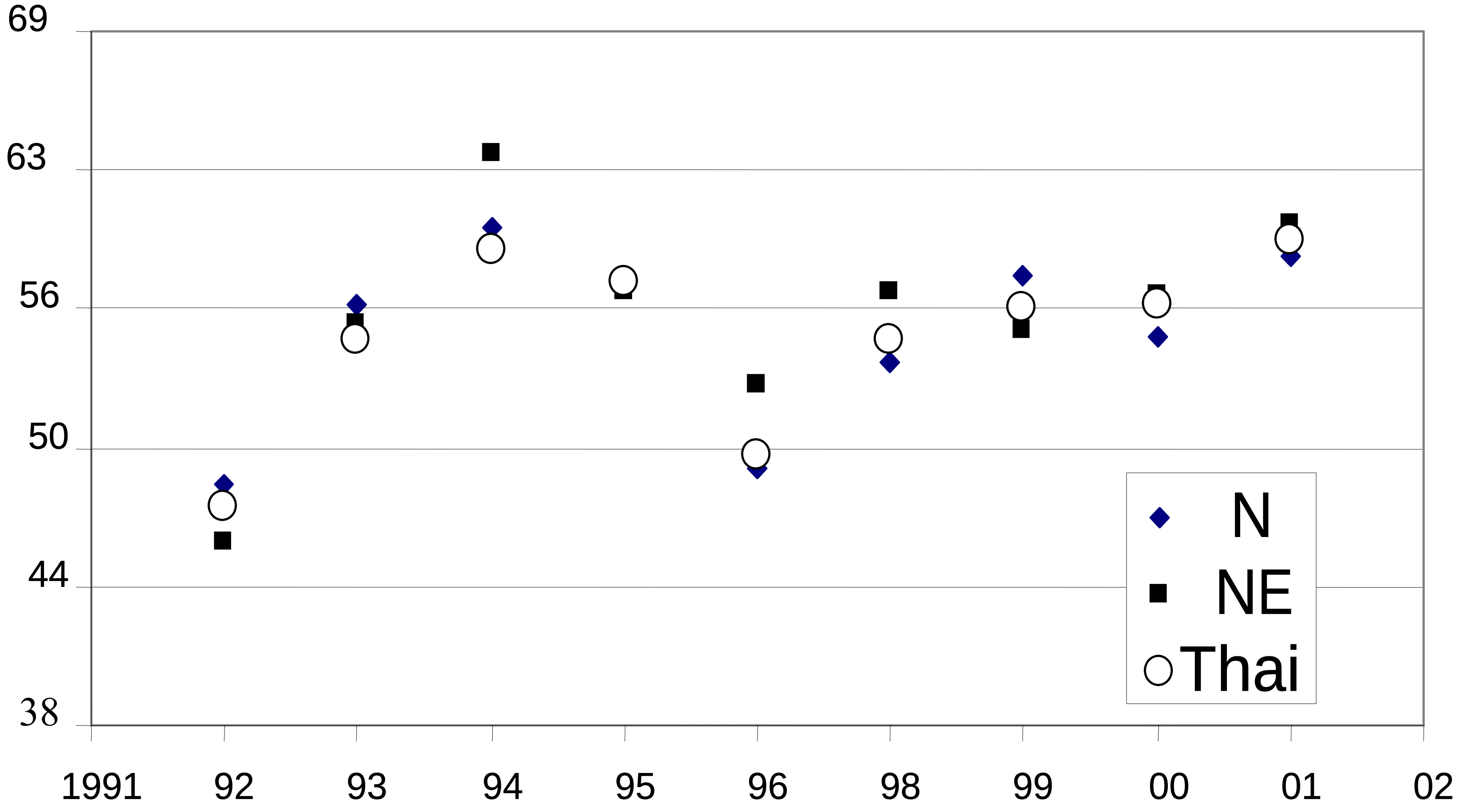


Recorded rainfall, Chiang Mai



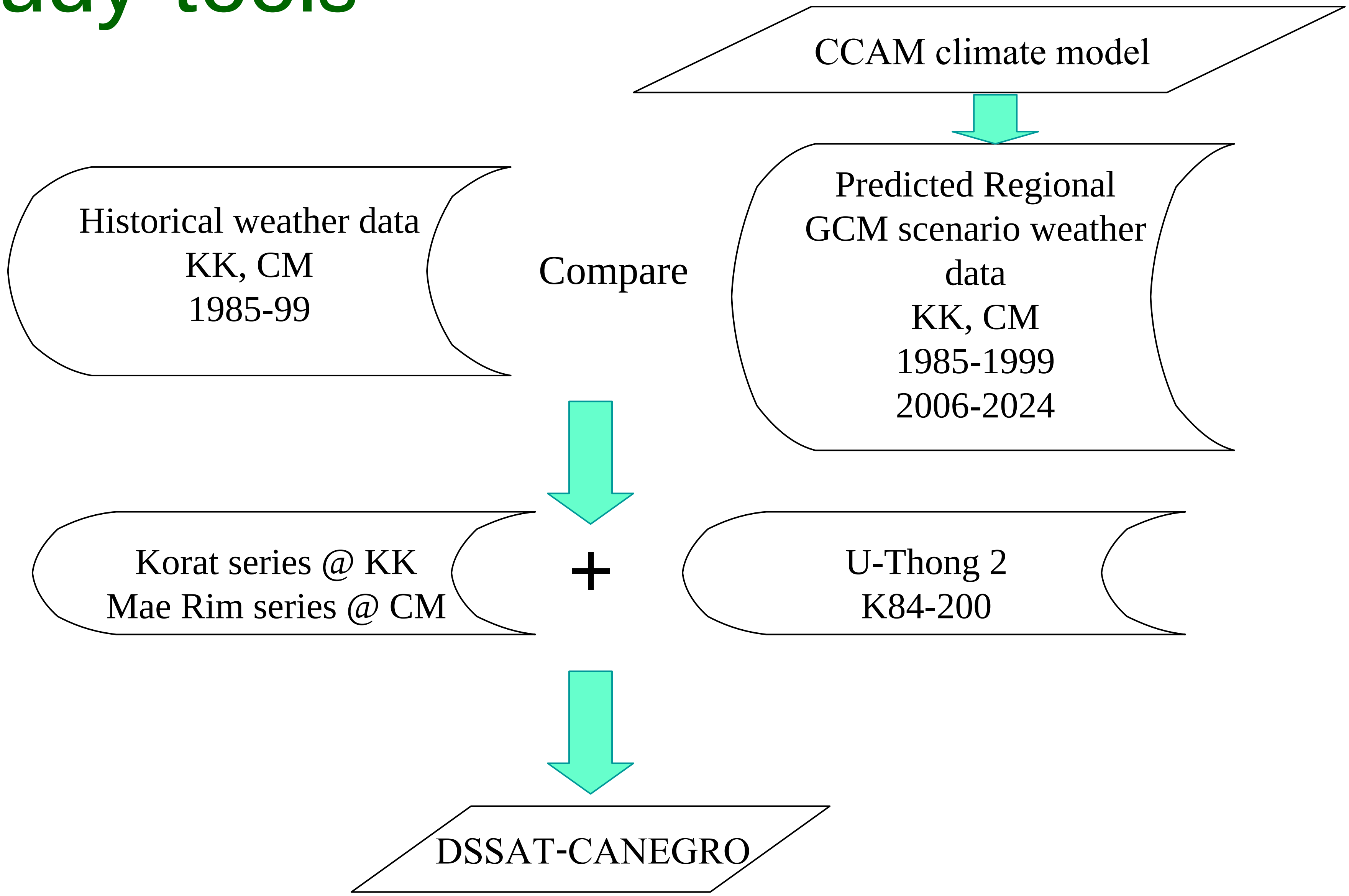
Impacts on sugarcane production systems

Fresh sugarcane yield (T/ha)

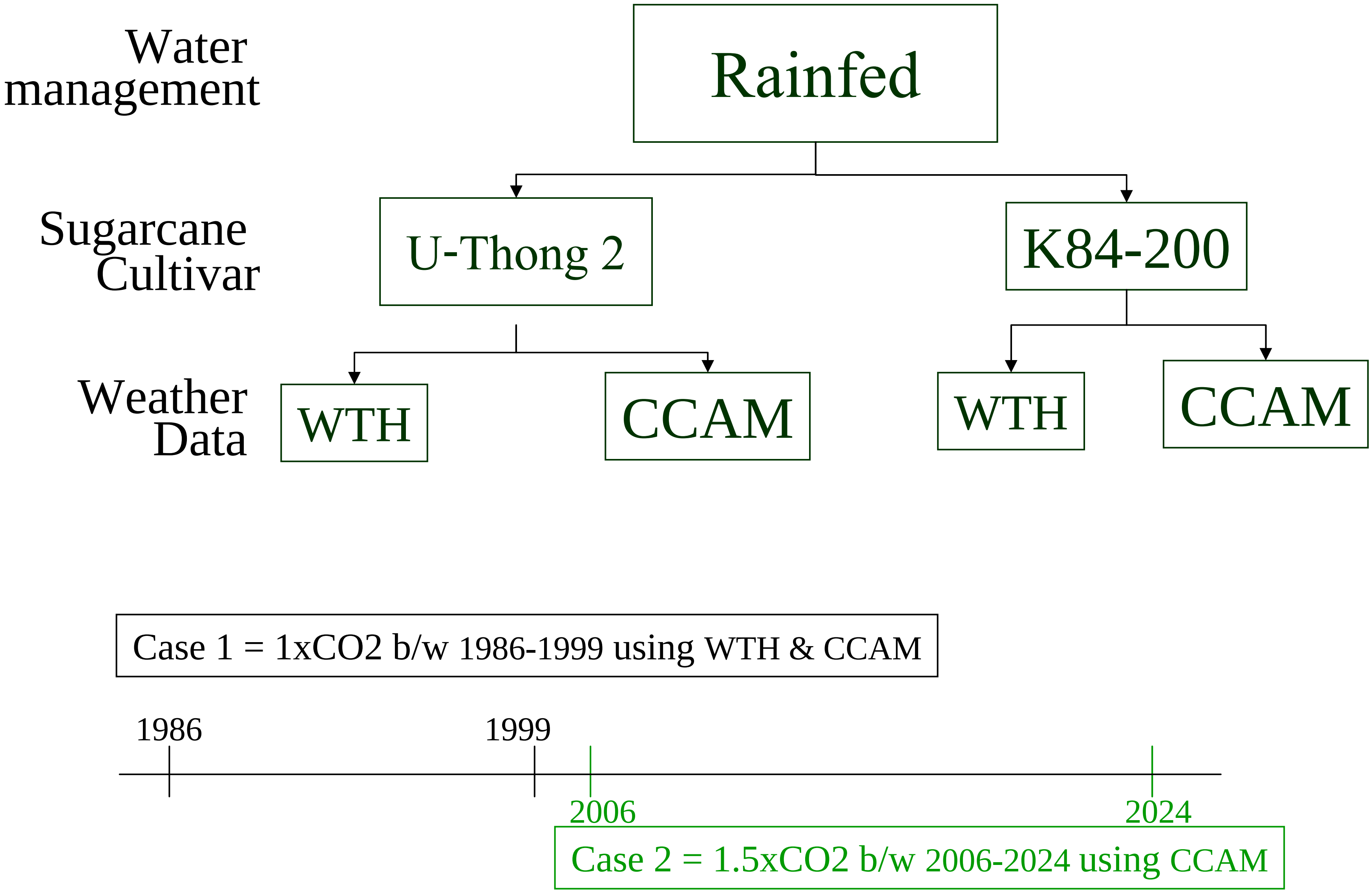


OAE, 1991-2001

Study tools


CCAM climate model
Historical weather data
KK, CM
1985-99
Compare
Predicted Regional
GCM scenario weather
data
KK, CM
1985-1999
2006-2024
Korat series @ KK
Mae Rim series @ CM
+
U-Thong 2
K84-200
DSSAT-CANEGRO

Case 1: 1986-1999

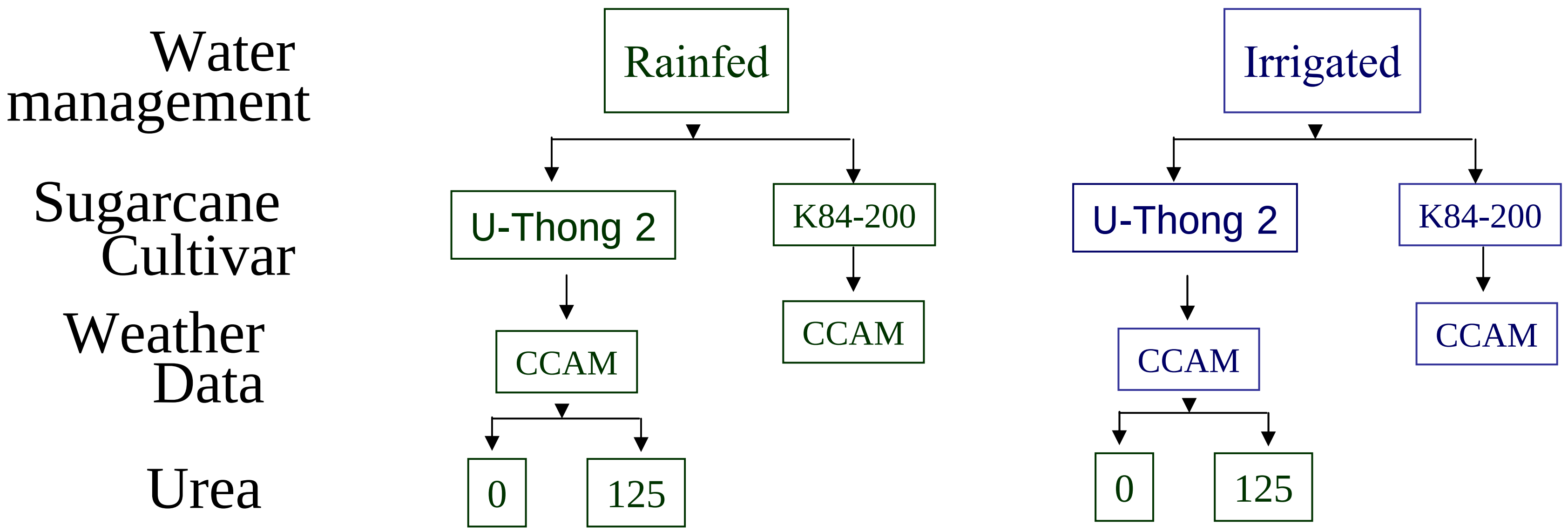


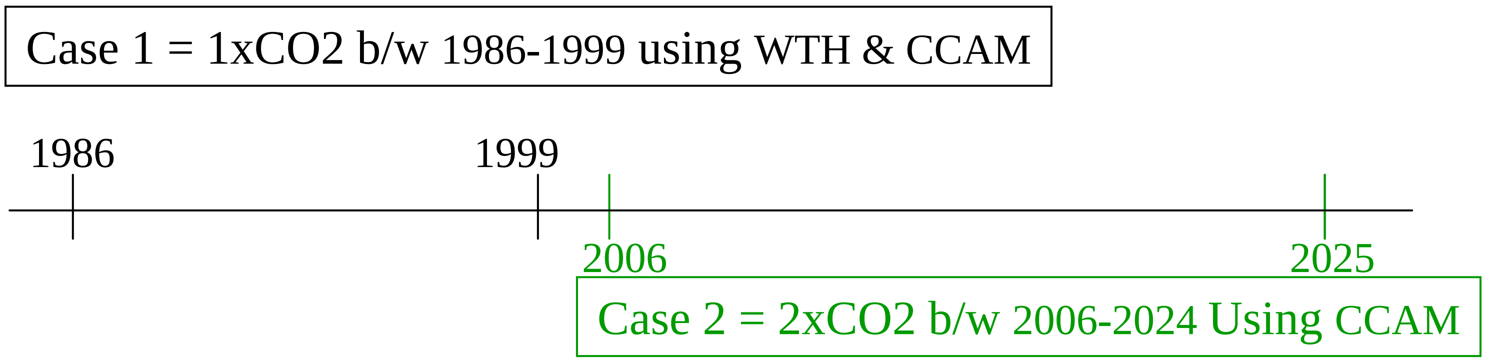
Case 1: 1986-1999

Locations	Cultivar	Yield using Actual weather Data	Yield using Simulated Weather Data	Reported yield
Khon Kaen	UT2	58.5(3.9)	50.7(5.2)	56.2
	K84-200	57.6(3.8)	50.3(4.9)	56.2
Chiang Mai	UT2	56.7(4.2)	46.0(5.1)	54.8
	K84-200	56.0(4.0)	45.9(4.9)	56.2

Note: Numbers in parenthesis are standard deviation.

Case 2: 2006-2024





Case 2: 2006-2024

		Simulated Fresh Cane Yield (T/ha)			
		Rainfed Urea rate (kg/ha)		Irrigated Urea rate (kg/ha)	
Locations	Cultivars	0	125	0	125
Khon Kaen	U-Thong2	59.5(19.6)	60.2(20.2)	108.3(10.3)	109.1(10.2)
	K84-200	58.8(19.3)	59.4(19.7)	103.4(9.7)	103.9(9.7)
Chiang Mai	U-Thong2	41.0(15.6)	43.3(15.7)	93.9(11.7)	99.9(11.6)
	K84-200	41.0(14.8)	43.1(15.0)	90.5(11.2)	95.0(10.5)

Note: Numbers in parenthesis are standard deviation.

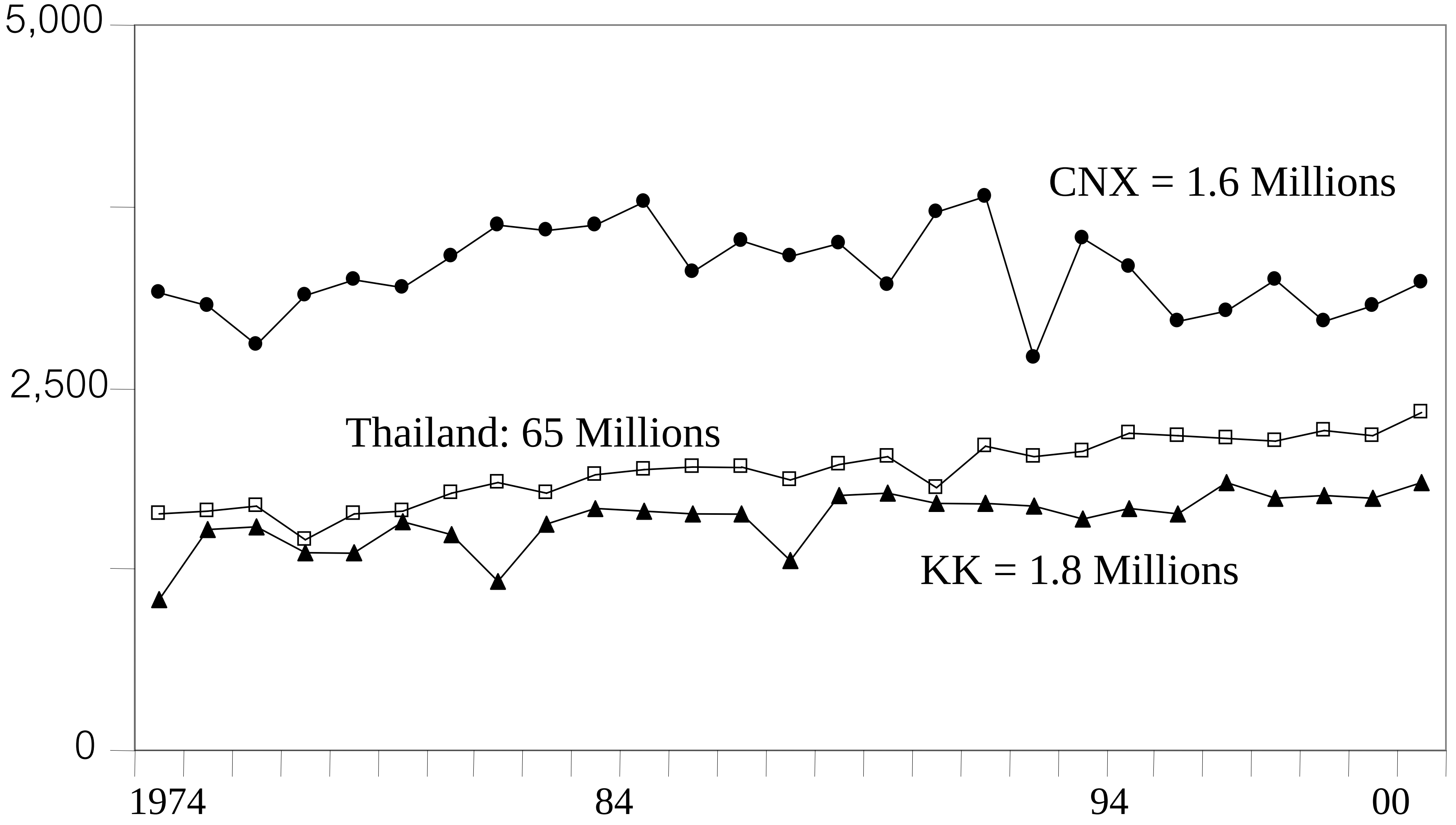
Case 2: 2006-2024

		Simulated Sugar Yield (T/ha)			
		Rainfed Urea rate (kg/ha)		Irrigated Urea rate (kg/ha)	
Locations	Cultivars	0	125	0	125
Khon Kaen	U-Thong2	2.34(1.52)	2.40(1.57)	6.43(0.96)	6.50(0.96)
	K84-200	2.29(1.47)	2.34(1.50)	5.95(0.89)	5.99(0.89)
Chiang Mai	U-Thong2	1.20(1.12)	1.29(1.13)	5.07(1.01)	5.63(1.00)
	K84-200	1.18(1.06)	1.26(1.08)	4.76(0.94)	5.16(0.89)

Note: Numbers in parenthesis are standard deviation.

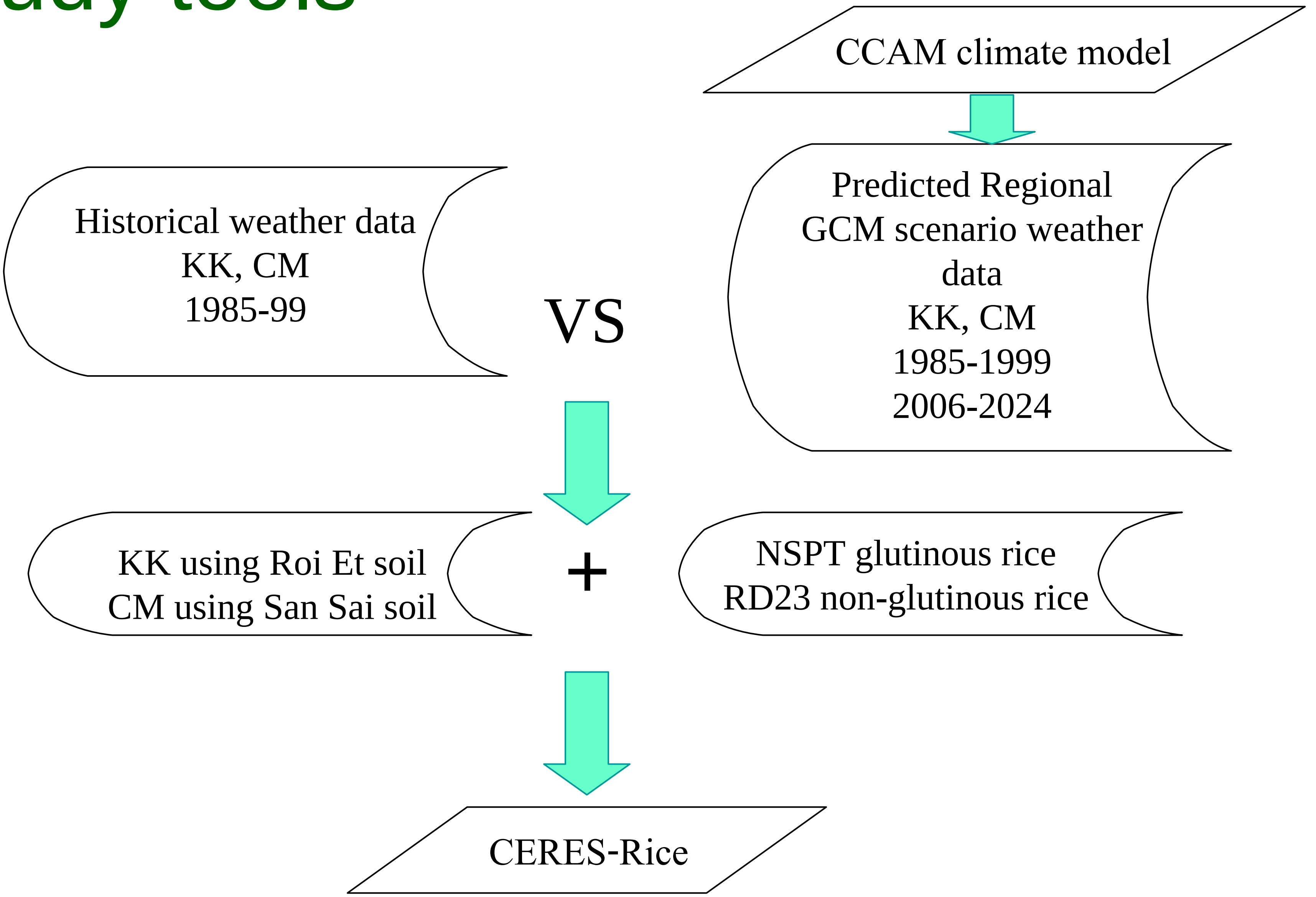
Impacts on rice production systems

Rice yield (kg ha^{-1}) and population

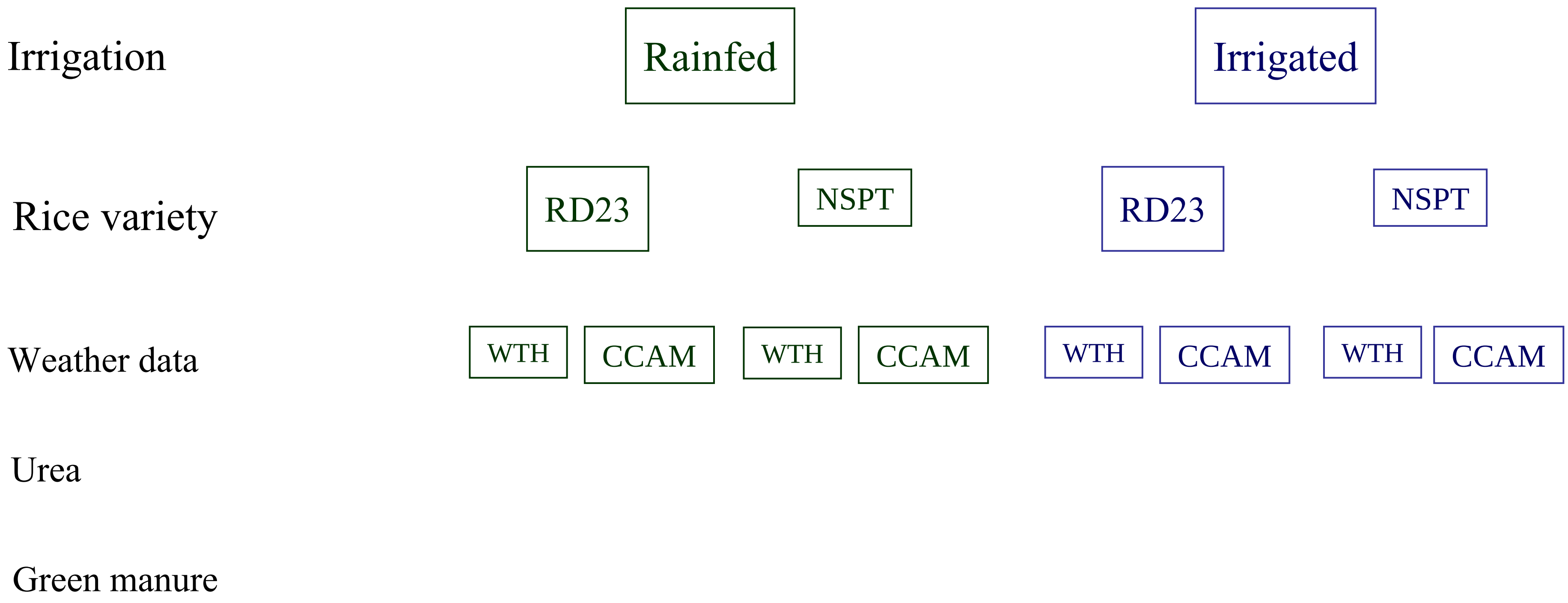


OAE, 1975-2001

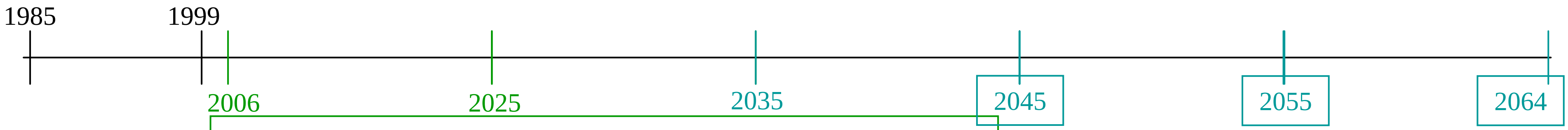
Study tools


CCAM climate model
Historical weather data
KK, CM
1985-99
VS
Predicted Regional
GCM scenario weather
data
KK, CM
1985-1999
2006-2024
KK using Roi Et soil
CM using San Sai soil
+
NSPT glutinous rice
RD23 non-glutinous rice
CERES-Rice

Case 1: 1985-1999

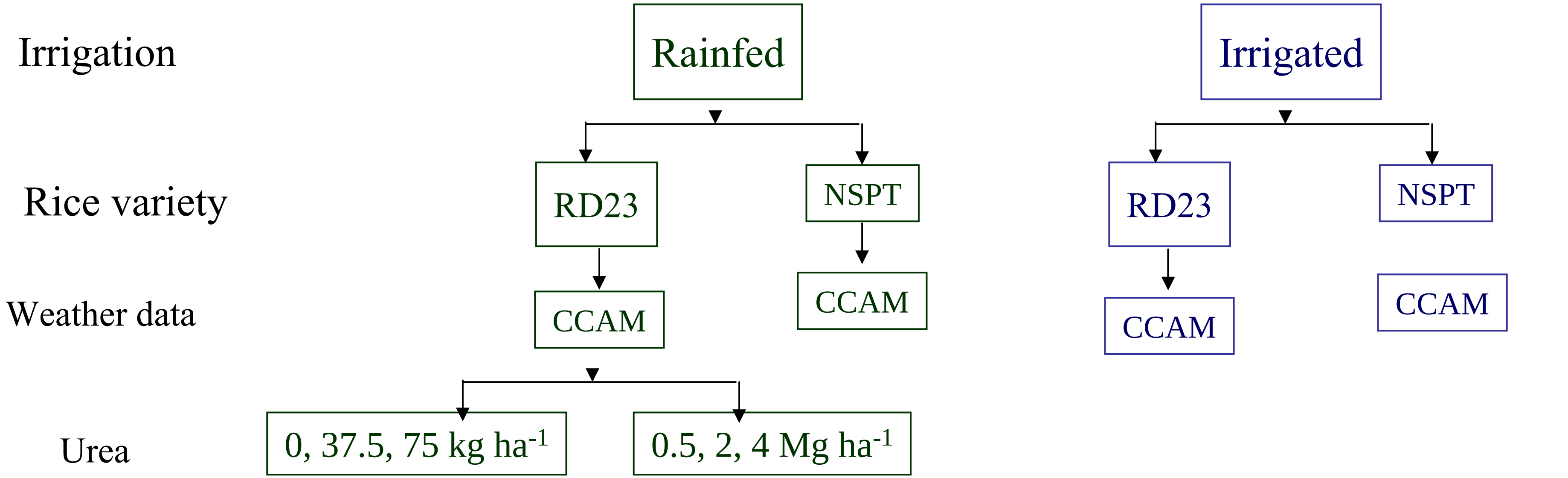


Case 1 = 1xCO_2 b/w 1985-1999 Using WTH & CCAM

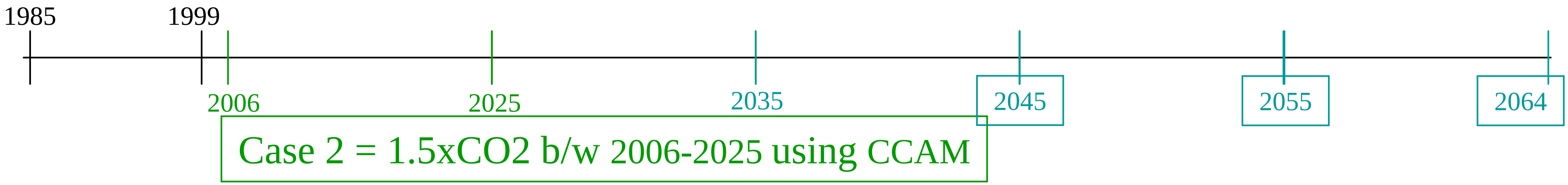


Case 2 = 1.5xCO_2 b/w 2006-2025 Using CCAM

Case 2: 2006-2024



Total of 12 management rice production strategies



Case 1: 1985-1999

Provinces	Water	Rice variety	Rice yield (Mg ha^{-1}) WTH	MK3	OAE
KKC	Rainfed	**NSPT**	**2.20**	**0.89**	**1.67**
		RD 23	**2.63**	**1.00**	**1.67**
	Irrigated	**NSPT**	**2.58**	**2.48**	**1.67**
		RD 23	**3.08**	**3.26**	**1.67**
		RMSE	**1.00**	**1.03**	
CNX	Rainfed	**NSPT**	**3.54**	**2.64**	**3.33**
		RD 23	**4.20**	**2.98**	**3.33**
	Irrigated	**NSPT**	**4.03**	**3.98**	**3.33**
		RD 23	**4.77**	**5.16**	**3.33**
		RMSE	**0.91**	**1.04**	

Case 2: 2006-2024

Rice yield at KKC (Mg ha^{-1})

		Rainfed Urea (kg ha^{-1})			Irrigated Urea (kg ha^{-1})		
Rice var	GM (kg ha^{-1})	0	37.5	75	0	37.5	75
NSPT	6000	0.78	1.50	1.99	1.71	2.69	3.04
	500	0.74	1.48	1.97	1.54	2.53	2.89
RD23	6000	0.90	1.76	2.35	2.27	3.58	4.01
	500	0.84	1.73	2.33	1.96	3.31	3.76

Case 2: 2006-2024

Rice yield at CNX (Mg ha^{-1})

		Rainfed Urea (kg ha^{-1})			Irrigated Urea (kg ha^{-1})		
Rice var	GM (kg ha^{-1})	0	37.5	75	0	37.5	75
NSPT	6000	5.60	5.73	5.94	7.74	7.86	8.04
	500	2.70	3.43	4.07	3.83	4.37	4.87
RD23	6000	6.56	6.67	6.89	9.88	10.00	10.21
	500	3.20	4.24	5.09	1.96	5.78	6.43

Impacts of the changes

- At CNX, under future climate scenarios

  Simulated RI yields ↑

  Simulated SC yields ↑

- At KKC,

  Simulated RI yields ↓

  Simulated SC yields ↑

Impacts of high rainfall

- More energy needed for harvested grain
- May lead to more leaching, lower efficiency of chemical fertilizers

Summary of “climate change” & crop production systems

- It is possible to use a process-oriented rice model to simulate the production under various climatic, edaphic, and management conditions
- Slight impact on rice production during the next 20 years, except much higher rainfall volume in CNX areas.
- Need to develop warning systems.

Proposing system approach to deal with the changes for SA

The many concepts on Sustainability

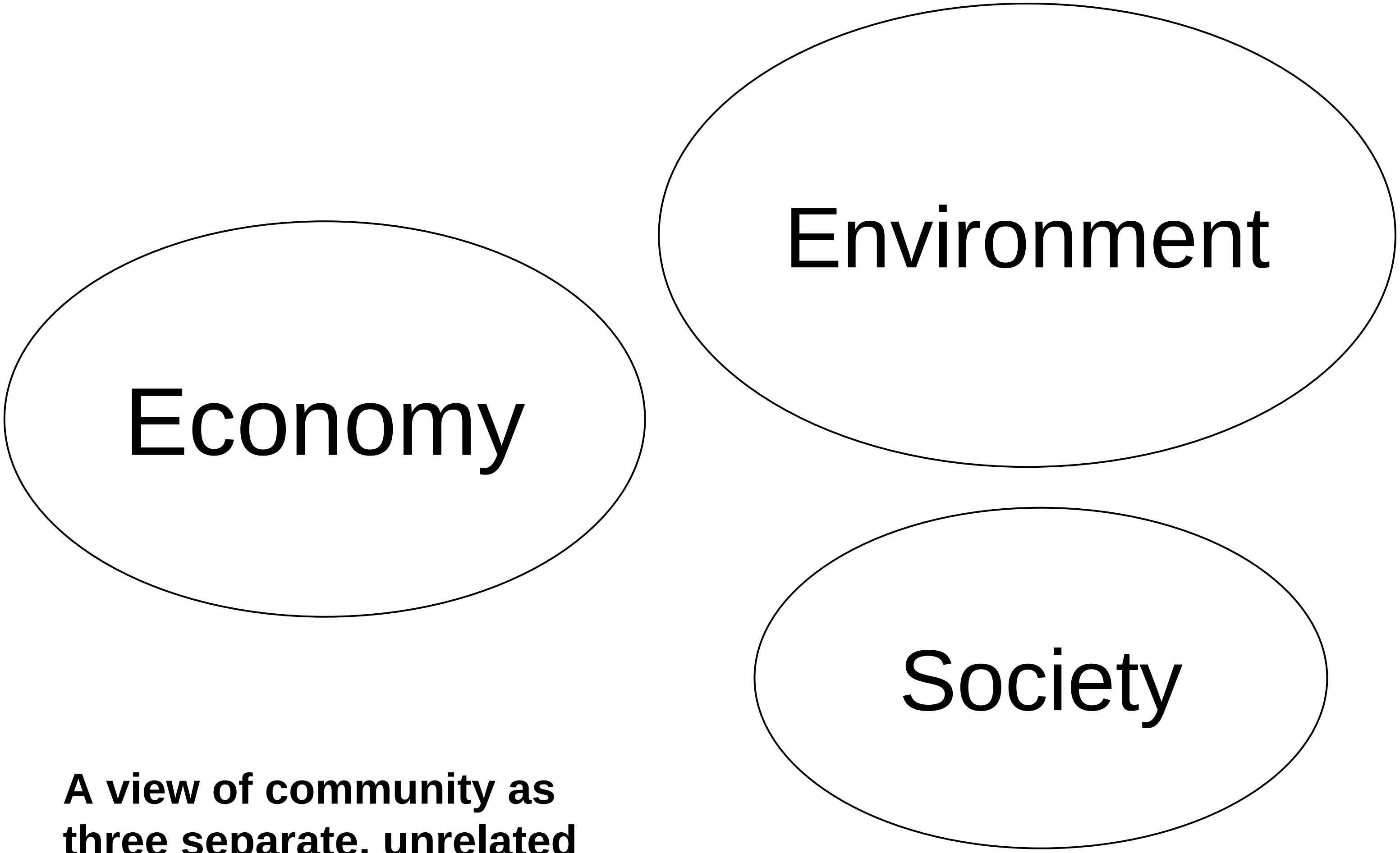
Brundtland Report (1987)

SA = “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

The three key areas of debate are:

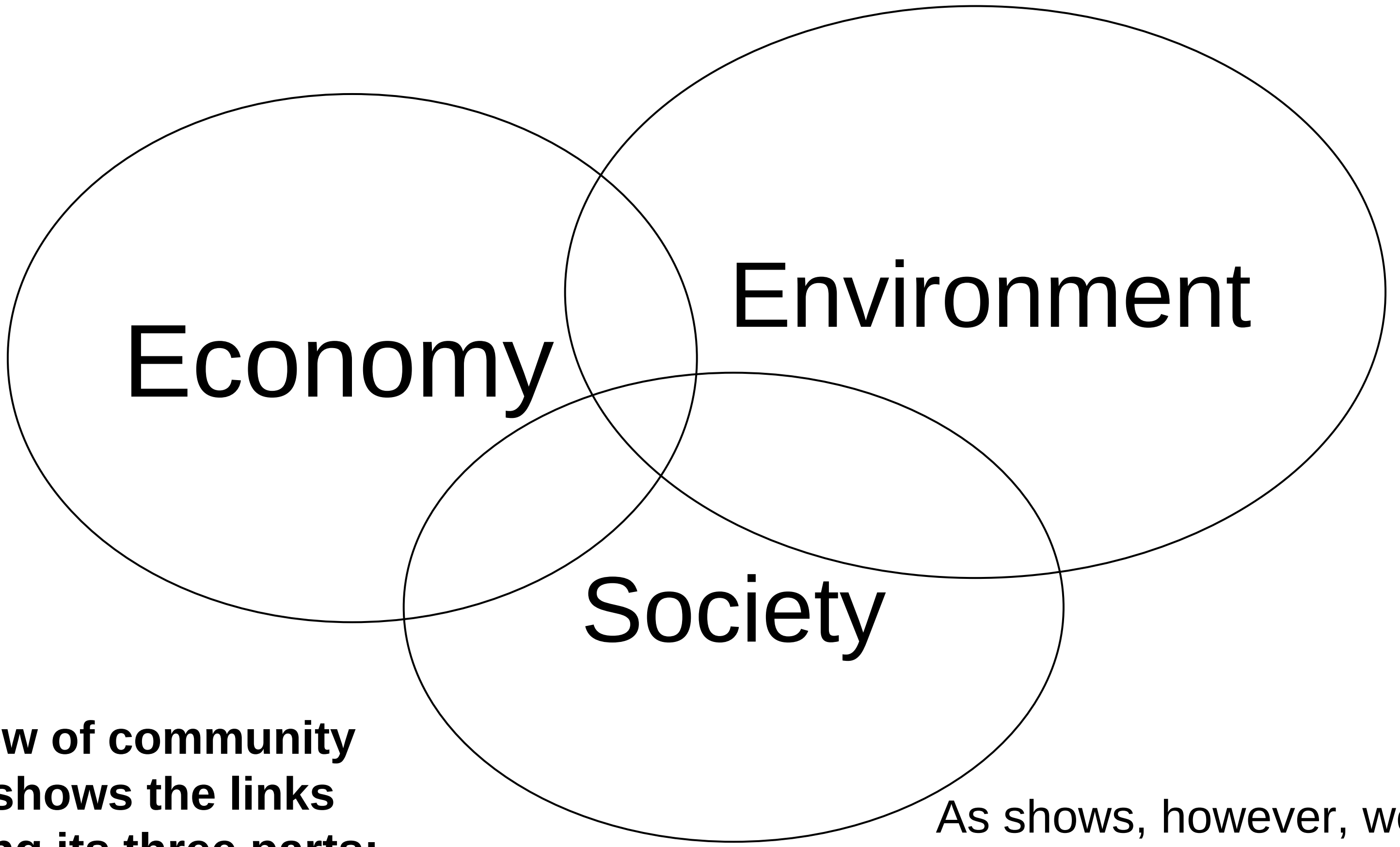
- time scale
- the environment
- social sustainability

Common approach



A view of community as three separate, unrelated parts: an economic part, a social part and an environmental part.

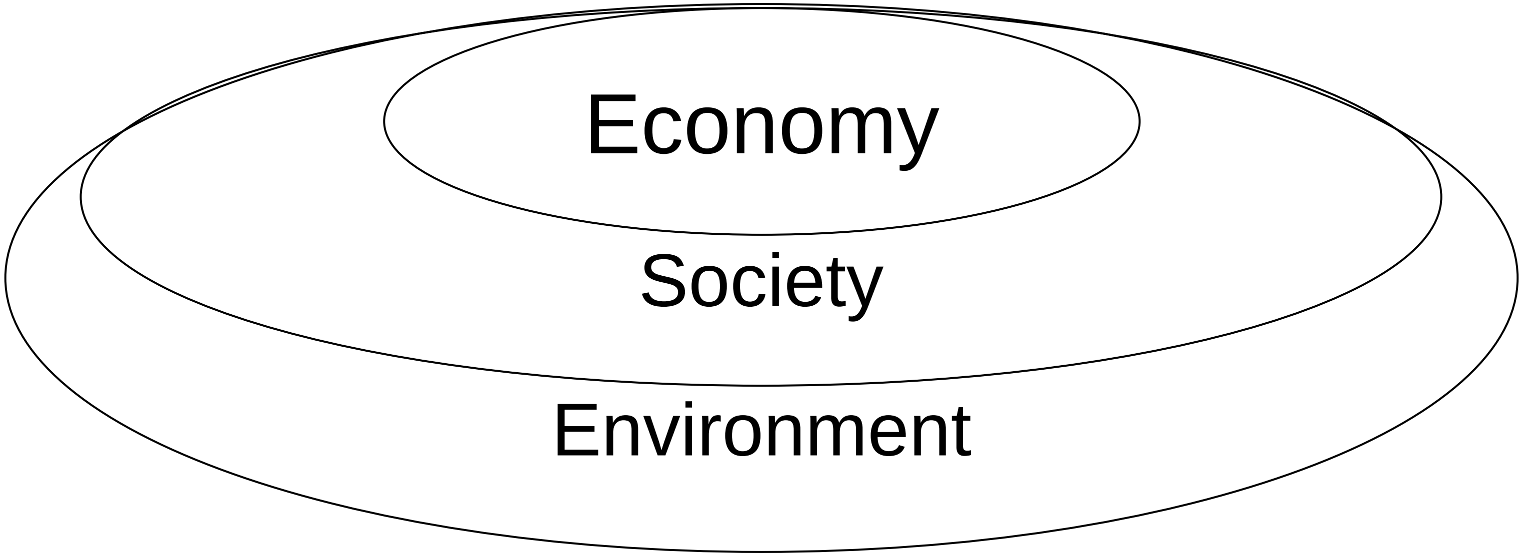
Proposing system approach



A view of community that shows the links among its three parts: the economic part, the social part and the environmental part.

As shows, however, we can make an even better picture of a sustainable community than the three partially connected circles shown above.

A System Approach for SA



A view of community as three concentric circles: the economy exists within society, and both the economy and society exist within the environment.

Simulation models and other ICT tools allow integration among components.

Conclusions

- Needs to broaden general public learning and understanding about Global Climate Change.
- Needs for new incentives and policies for ensuring the sustainability of agricultural and ecosystem services under predicted changes.
- To meet the demands of improving yields without compromising environmental integrity or public health.

Acknowledgements

- ICASA (http://www.icasa.net) for DSSAT4 models
- Thailand Research Fund (TRF) for financial support

Thank you