Organic Carbon Storage and Management Strategies of the Rural Soils on the Basis of Soil Information System in Taiwan

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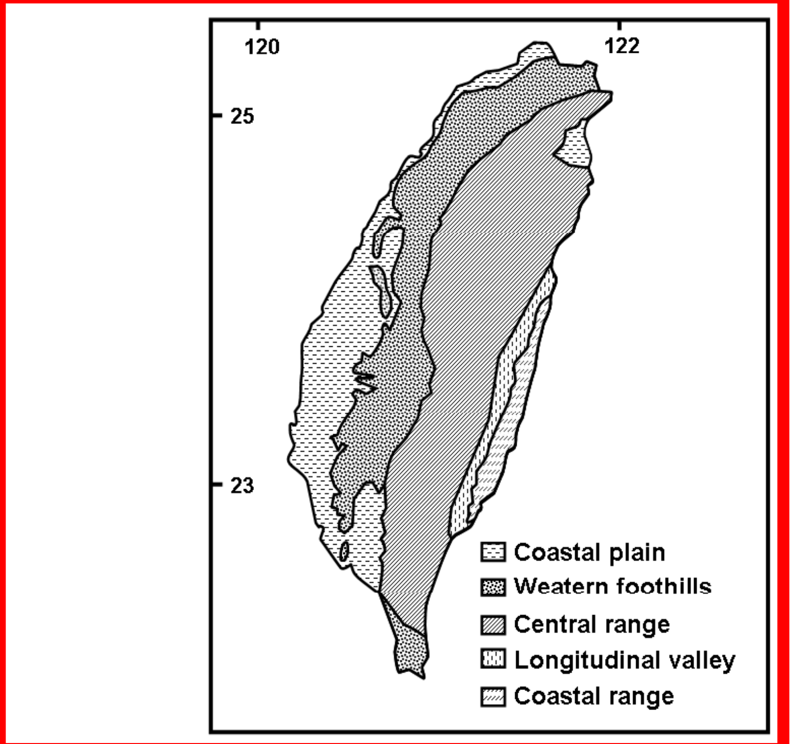
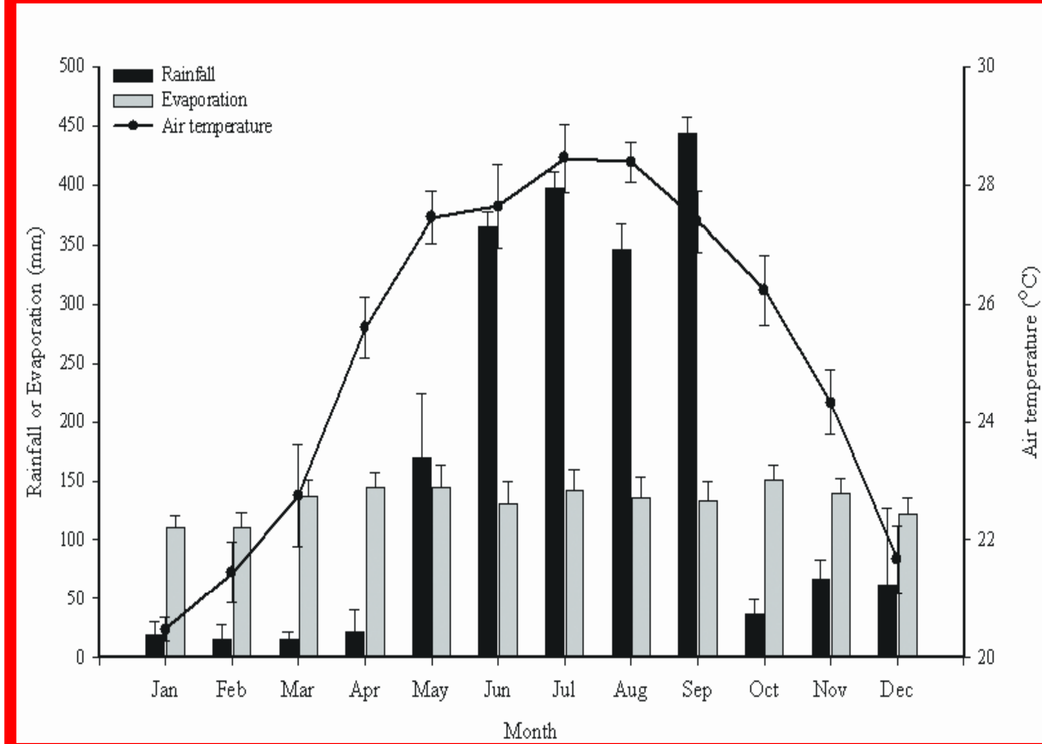
NPUST

Topography and climate of Taiwan





Contents

- Soil Orders in rural soils of Taiwan
- Soil organic C (SOC) stocks with different depths in Soil Orders in rural soils of Taiwan
- Changes of SOC content in rural soils with time and SOC accumulation rate
- The alteration of SOC sequestration in different land uses
- Strategies of SOC sequestration in the rural soils

The estimation of SOC pools in Taiwan

- For estimating total SOC pool in Taiwan, there was about **347 Tg,** which included **123 Tg** for cultivated soil and **224 Tg** for forest soil stored in upper 100 cm of soils. (172 soil pedons of cultivated and forest soils) ***(Chen and Hseu, 1997).***
- The lands in Taiwan are characterized by extent altitude ranges (from sea level to 3900 m) and diverse land uses, especially for rural soils.
- More than 30% of the total area is croplands and it is important to estimate the SOC storage for cropped soils to evaluate the SOC sequestration and emission potential of greenhouse gases of rural soils.

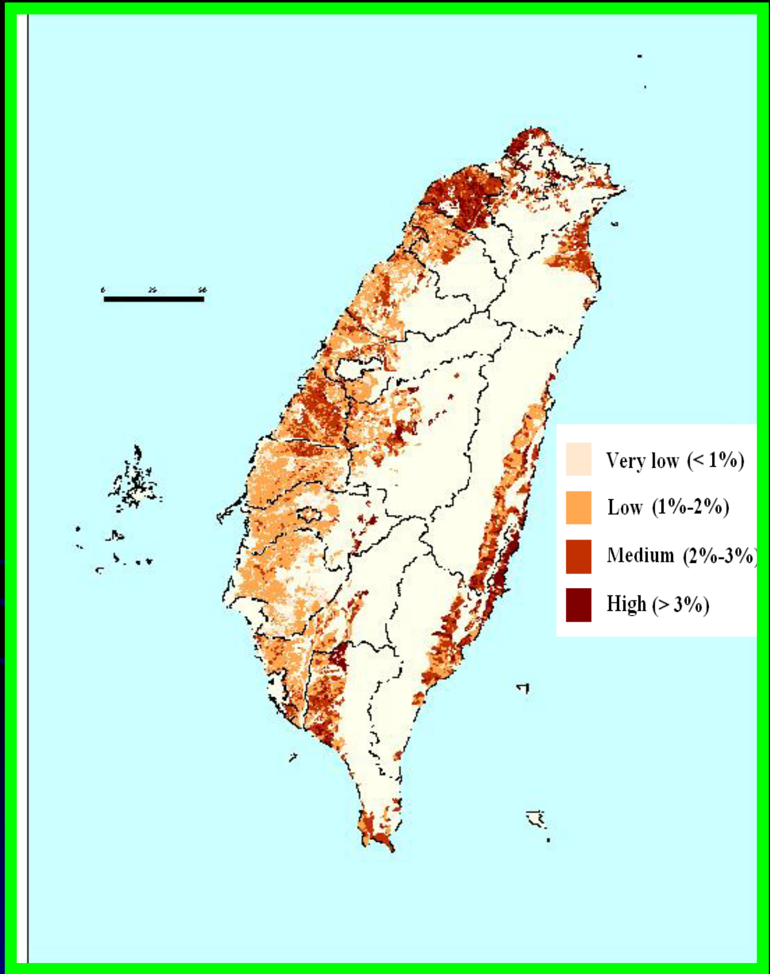
The effect of land use on SOC sequestration

- Tillage systems (e.g. annually tilled, biennially tilled or alternative tillage) or land use in rural soils (e.g. rice-growing, dry farmland and fallow) will alter C sequestration and greenhouse gases emission as compared with those of native soils.
- Alteration of forest or pasture to cropland will decrease the SOC storages. *(Guo and Gifford, 2002; Lettens et al., 2005; Falloon et al., 2006)*
- Losses of SOC from the conversion of prairie to agriculture have resulted in 24 to 89% loss in North American. *(Knops and Tilman, 2000; Kucharik et al., 2001)*

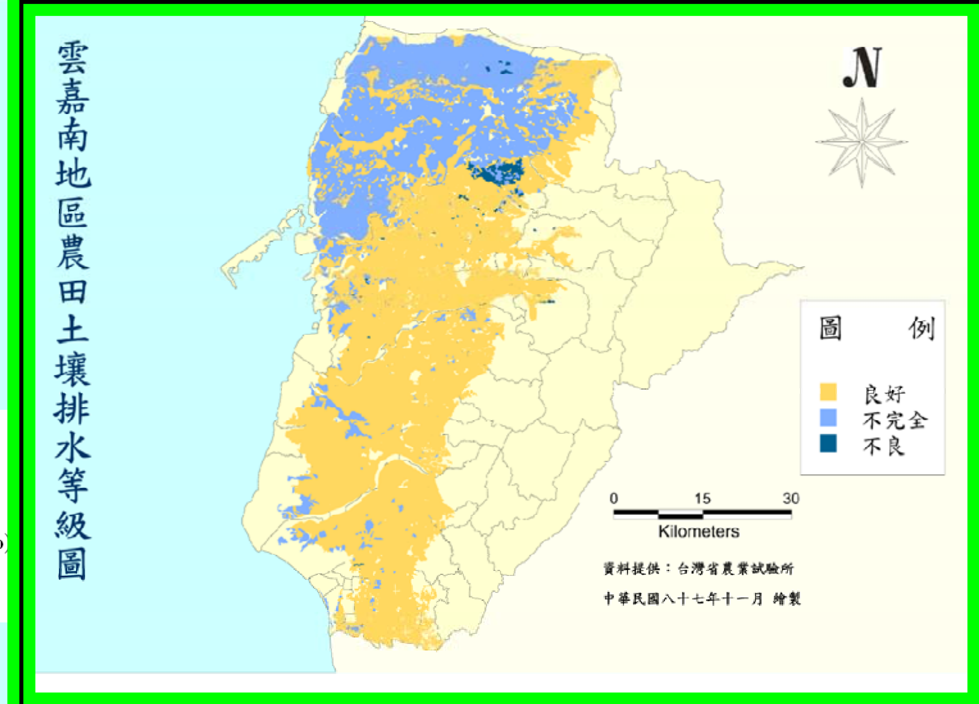
How Soil Information Systems (SIS) help us to estimate C sequestration?

- An excellent tool to help researcher to gain the area of different land uses in unique area.
- To help government to establish a clear scenario of low productivity soils and degradation soils
- To suggest national overview of the relative extent of physical resources limitation to agriculture and other forms of land use and highlighting area which called for the treatment or management of specific land resources constraints.

SIS item maps in Taiwan (1)

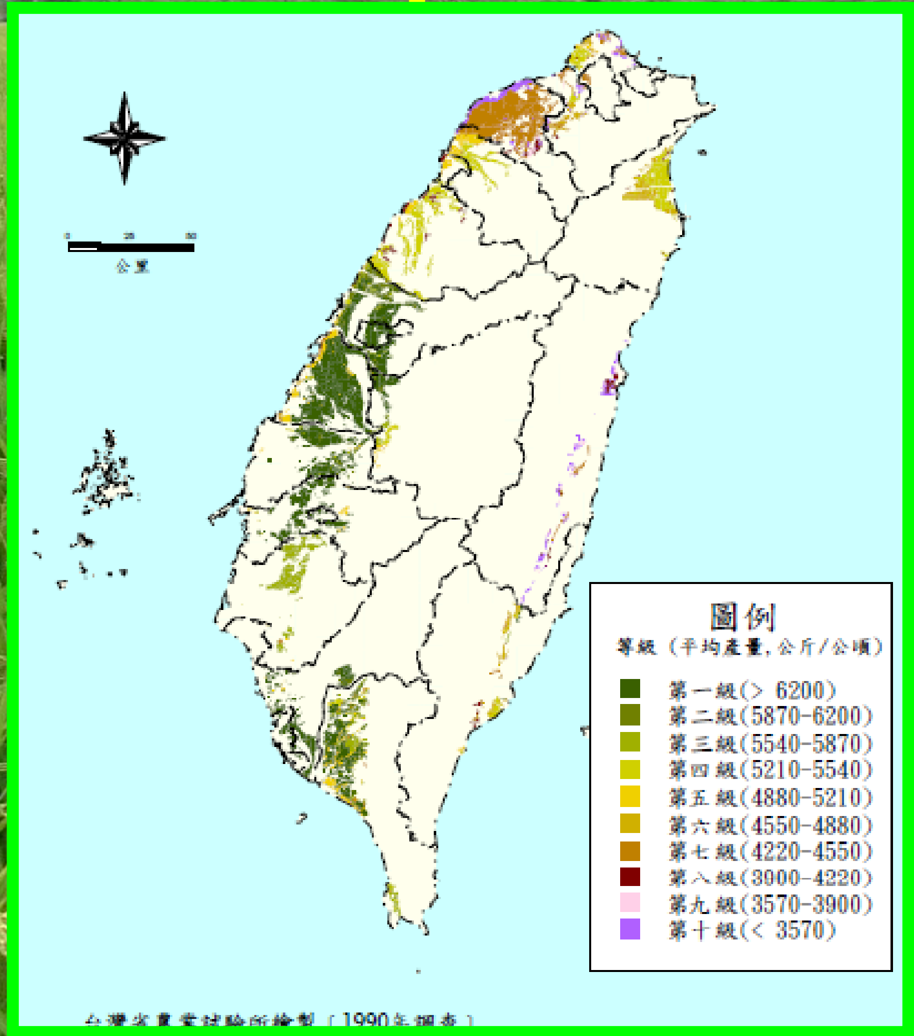


SOC contents (%)



Drainage level

SIS item maps in Taiwan (2)



Productivity (kg/ha)

The area of Soil Orders in rural soils of Taiwan

Soil Order	Area (km^2)	Percentage of total rural soils (%)
Inceptisols	8,590	51
Alfisols	3,668	22
Ultisols	1,624	9.6
Entisols	1,142	6.8
Andisols	195	1.2
Mollisols	191	1.1
Oxisols	50	0.3
Histosols	6	0.04
Vertisols	1	<0.01
Miscellaneous lands	1,363	8.1
Total	16,830	100

73%

Inceptisols and Alfisols are dominant Orders

Bulk density (Mg/m^3) of different Soil Orders in Taiwan

Soil Orders	0-30 cm Mean	CV	n	30-50 cm Mean	CV	n	50-100 cm Mean	CV	n
				Cultivated soils (n=140)					
Inceptisols	1.52	19	40	1.63	17	40	1.62	22	40
Alfisols	1.44	8	11	1.57	7	11	1.63	6	10
Ultisols	1.16	30	29	1.49	9	29	1.52	8	29
Entisols	1.40	11	39	1.55	10	38	1.54	9	38
Andisols	0.48	-	1	0.69	-	1	0.69	-	1
Mollisols	1.47	38	9	1.47	24	8	1.48	20	8
Oxisols	1.49	0	3	1.51	5	3	1.46	4	3
Histosols	0.20	-	1	0.20	-	1	0.20	-	1
Vertisols	1.81	21	7	1.82	17	7	1.80	13	6

Bulk density data are crucial in converting the organic carbon content from a by-weight basis to a by-volume basis (e.g., kg/m^2 to 100 cm depth of soil).

The rural SOC stocks with different depths in Soil Orders of Taiwan (n=140)

Soil Order	0-30 cm			0-50 cm			0-100 cm			Ratio[a]	
	Mean	CV	n	Mean	CV	n	Mean	CV	n	A	B
	kg/m^2	%		kg/m^2	%		kg/m^2	%		%	%
Vertisols	10.0	45	4	13.4	37	4	17.0	31	4	59	79
Mollisols	7.27	31	10	9.49	36	10	11.7	54	10	62	81
Inceptisols	5.58	56	128	7.88	58	128	11.5	82	128	48	68
Entisols	5.44	55	146	6.96	60	146	8.66	65	146	63	80
Ultisols	4.86	79	66	6.95	80	66	9.68	73	66	50	72
Alfisols	4.75	55	18	6.43	52	18	9.49	51	18	50	68
Oxisols	3.82	67	15	5.26	74	16	8.86	73	16	43	59
Average	**5.97**			**8.06**			**11.0**			**54**	**72**

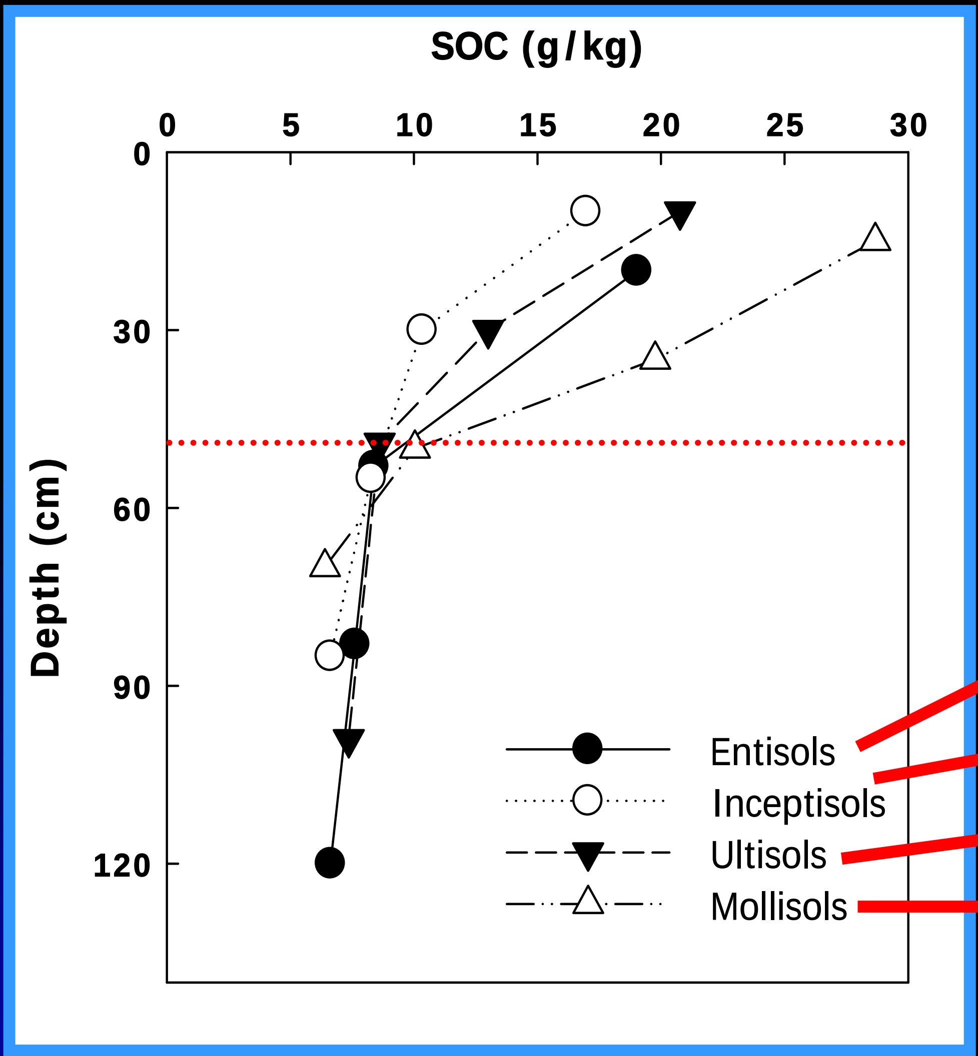
A stand for the ratio of the soil organic carbon stock of 0-30 cm divided by in the 0-100 cm zone; B stand for the ratio of the soil organic carbon stock of 0-50 cm divided by in the 0-100 cm zone.

The estimated total SOC pools (Tg) in different depths of Taiwanese rural soils

Soil Order	0-30 cm	0-50 cm	0-100 cm
Inceptisols	47.9	67.7	98.8
Alfisols	17.4	23.6	34.8
Entisols	6.21	7.95	9.89
Ultisols	7.89	11.3	15.7
Mollisols	1.39	1.81	2.23
Oxisols	0.19	0.26	0.44
Vertisols	0.01	0.01	0.02
Total	81.0	113	162

Over than 60% SOC are in Inceptiosols

Vertical distribution of SOC contents in Soil Orders of Taiwan



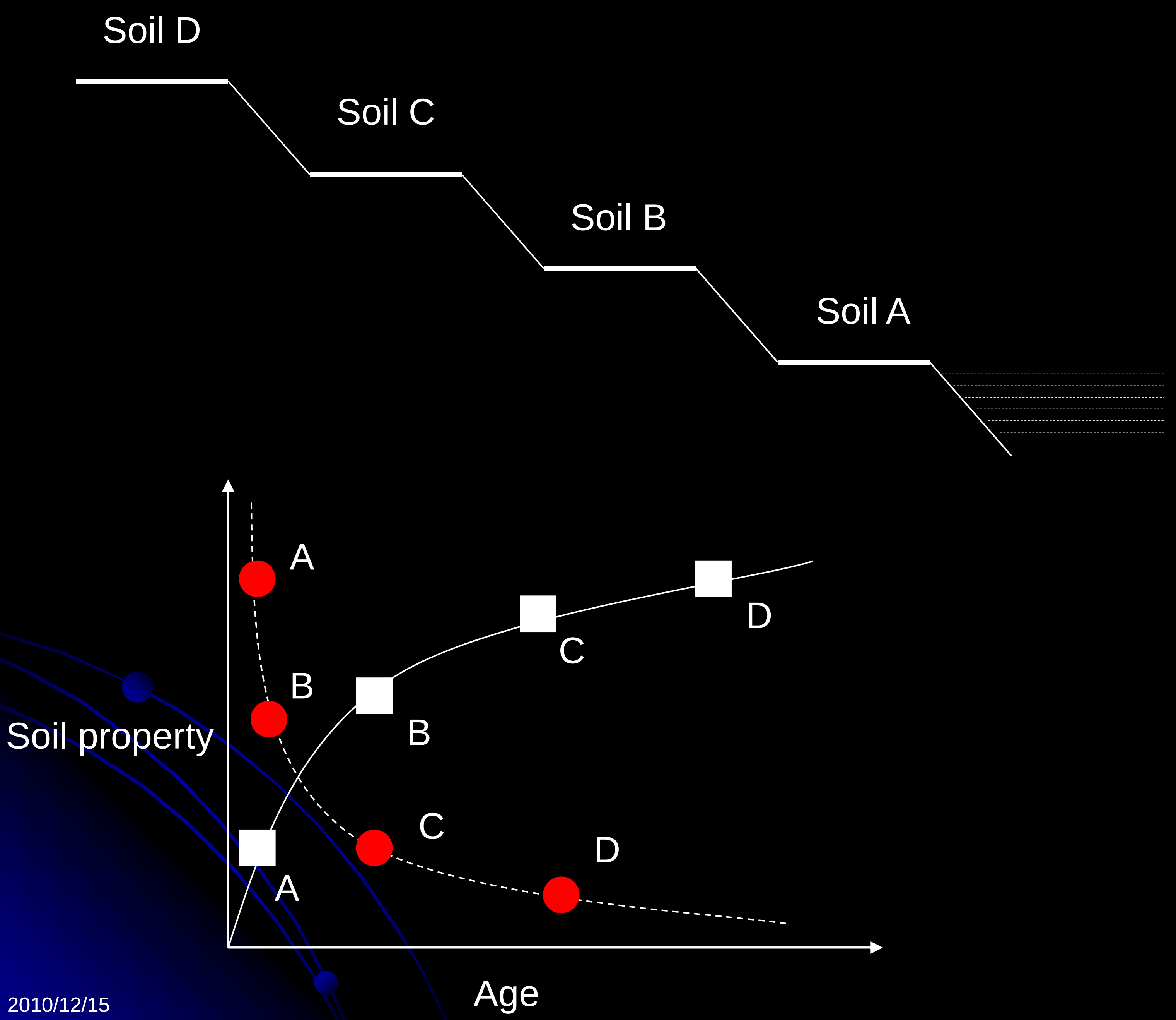
- SOC contents within 50-cm were clearly different among Soil Orders.
- Mollisols > Inceptisols >Entisols >Ultisols

Changes of SOC content in rural soils from some counties of Taiwan during 1950 to 1994 (legacy data)

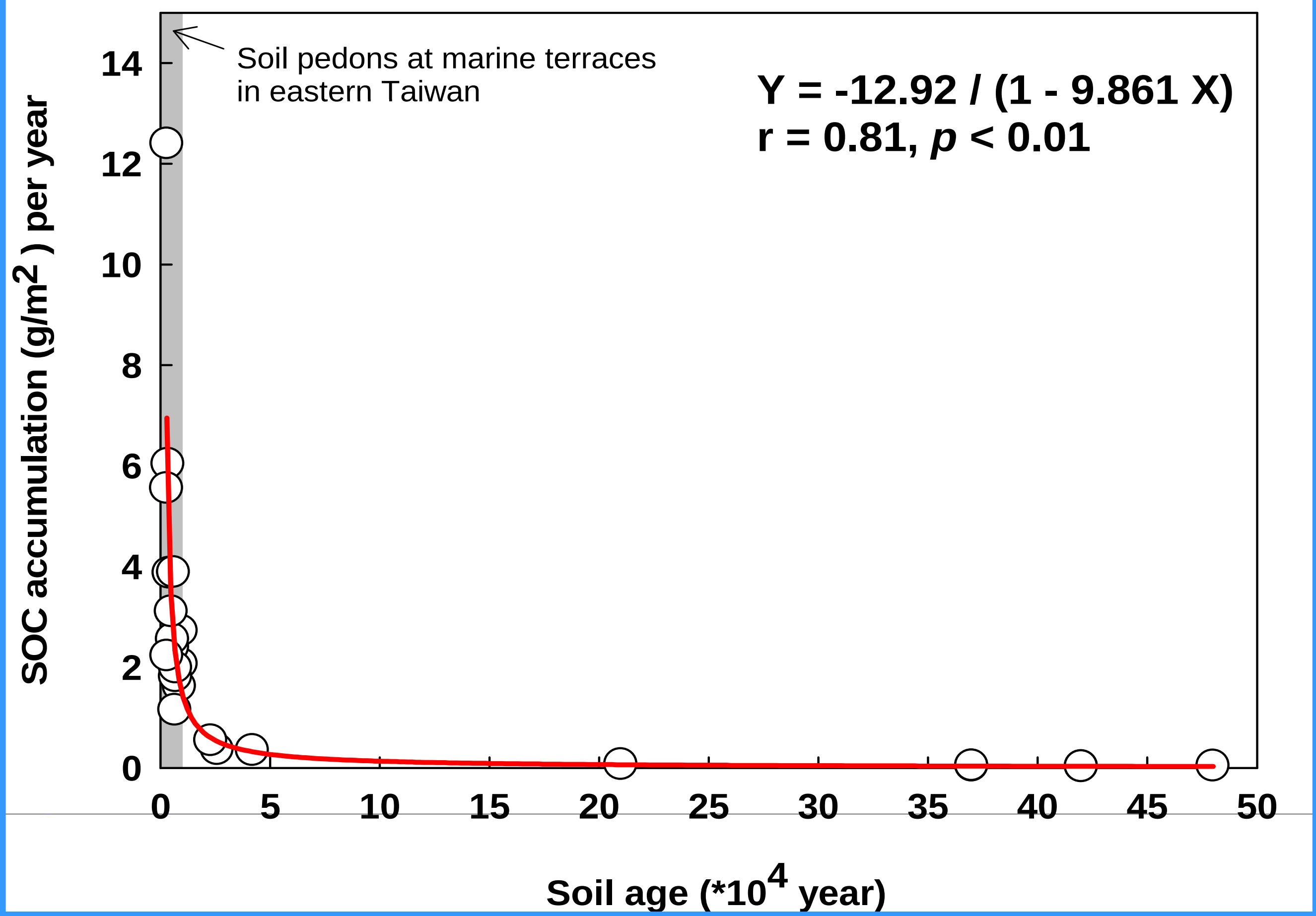
Location	Soil organic matter content (%)			
	1950	1967	1981	1994
Sinchen (Hualian)	2.30±0.38 (7)	2.34±0.88 (142)	2.52±0.93 (21)	2.60±1.17 (213)
Jian (Hualian)	2.35±0.33 (3)	1.44±0.41 (273)	2.21±0.57 (21)	2.24±0.66 (494)
Hihshang (Taitung)	-[a] (0)	2.69±0.57 (160)	2.89±0.63 (19)	3.39±1.04 (493)
Beinan (Taitung)	2.83±0.94 (18)	2.10±0.75 (160)	2.89±0.82 (19)	2.64±0.88 (502)
Dashe (Kaohsiung)	1.81±0.43 (4)	1.36±0.49 (161)	1.57±0.75 (8)	1.34±0.61 (220)
Yongkang (Tainan)	1.21±0.52 (6)	1.00±0.36 (303)	1.10±0.42 (5)	1.61±0.56 (308)
Changhua (Changhua)	2.53±0.31 (6)	1.80±0.83 (426)	2.44±0.63 (20)	2.93±0.96 (469)
Hemei (Changhua)	1.49±0.36 (7)	1.92±0.56 (329)	2.06±0.54 (42)	2.66±1.40 (522)

Values are shown as mean ± standard deviation (sample number)

SOC contents in most counties in Taiwan were increase with time

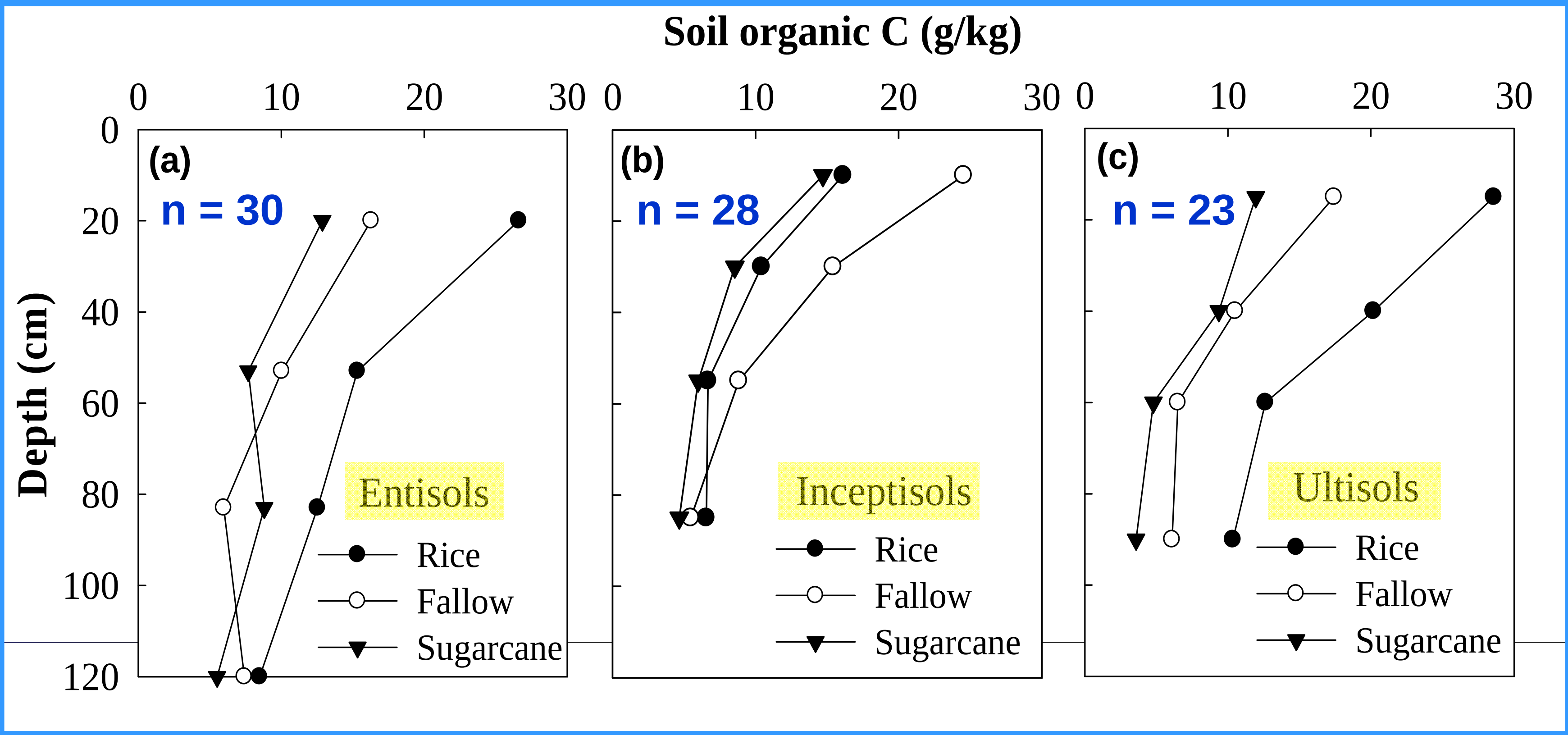

Soil D
Soil C
Soil B
Soil A
Soil property
A
B
C
D
A
B
C
D
Age

SOC accumulation rate in Taiwan



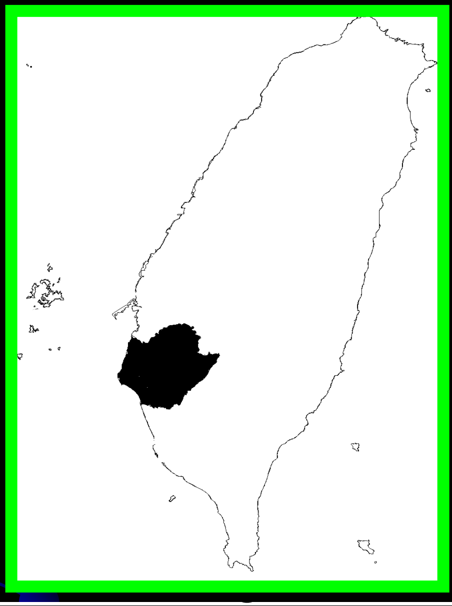
The points in grey zone are SOC accumulation rate at marine terraces; others in white zone are SOC accumulation rate at river terraces

Vertical distribution of SOC content in selected croplands with different land uses in Taiwan



Upland farming will decrease SOC contents regardless of Soil Orders

The SOC storages in the croplands with different land uses in Tainan county in 1969 and 2002

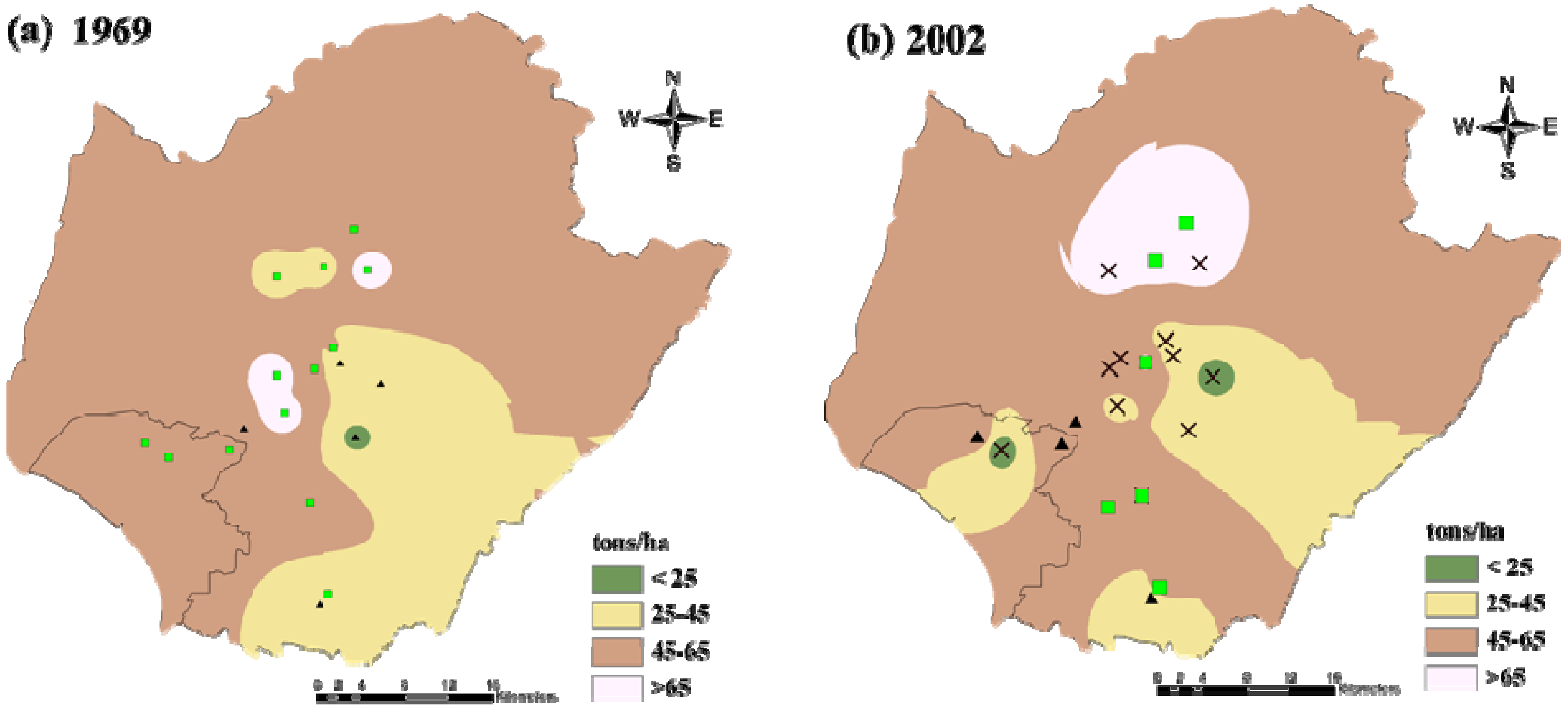


- Permanent rice-growing increased SOC storage from 4.92 to 7.74 kg/m^2 in 30 cm depth.
- Chang rice-growing to fallow decreased SOC storage from 6.36 to 4.87 kg/m^2 in 30 cm depth.
- Chang rice-growing to sugarcane decreased SOC storage from 5.92 to 5.75 kg/m^2 in 30 cm depth.

Land use change 1969	2002	Sample number	1969 SOC storages (kg/m^2) 0-30	0-50	0-100	2002 SOC storages (kg/m^2) 0-30	0-50	0-100
			----- cm					-----
Rice	Rice	5	4.92 ± 0.74	8.26 ± 1.93	17.3 ± 6.98	6.74 ± 0.91	9.13 ± 1.78	13.5 ± 3.84
Rice	Fallow	6	6.36 ± 1.64	10.0 ± 2.27	16.1 ± 4.35	4.87 ± 2.44	6.88 ± 4.42	11.9 ± 5.41
Rice	Sugarcane	2	5.92 ± 0.80	9.38 ± 1.44	15.5 ± 1.15	5.75 ± 0.01	9.05 ± 0.69	16.2 ± 0.28
Sugarcane	Sugarcane	1	3.09 ± -[a]	3.66 ± -	4.89 ± -	3.02 ± -	4.77 ± -	6.58 ± -
Sugarcane	Fallow	3	2.55 ± 0.55	4.29 ± 0.67	7.19 ± 1.53	2.79 ± 1.39	3.82 ± 1.70	6.09 ± 1.49

[a] Not available.

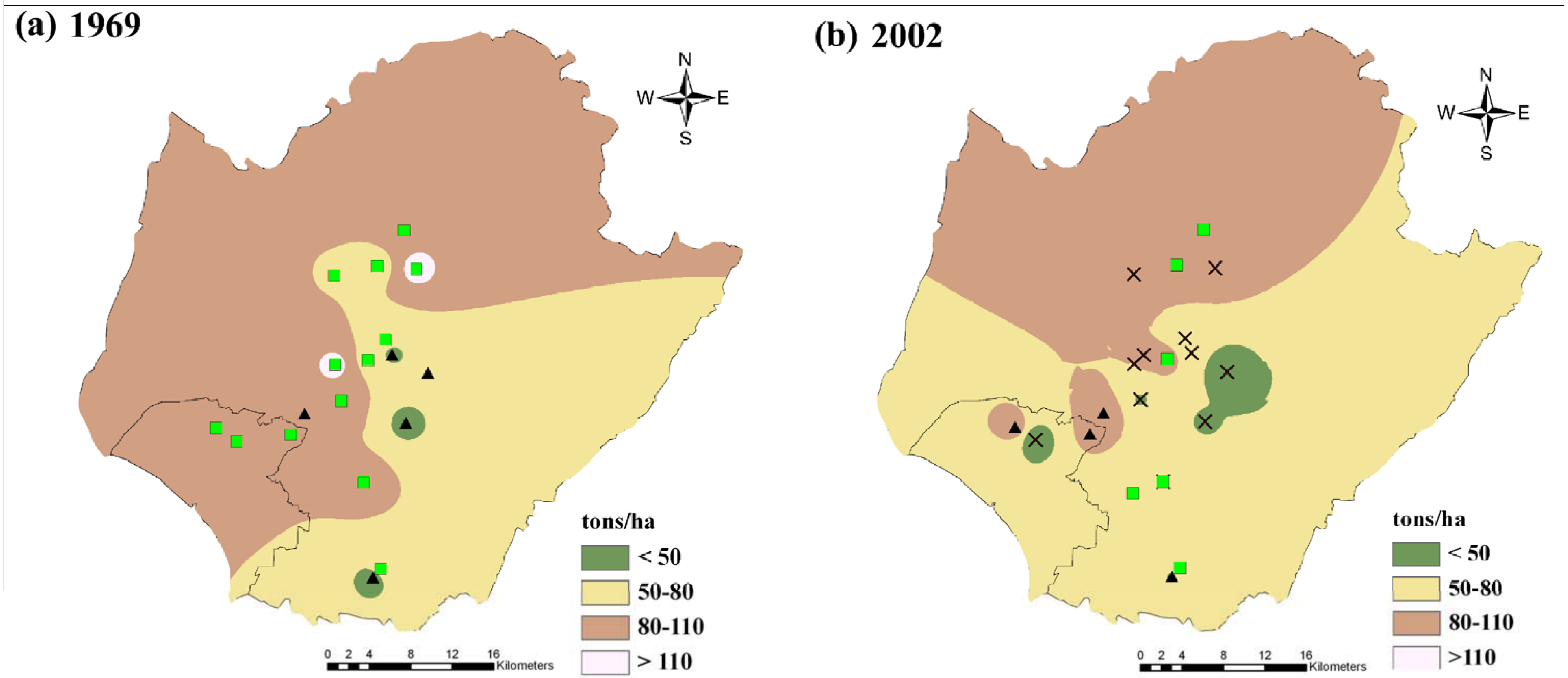
The change of SOC storage (Mg/ha) for depth of 0-30 cm with different land uses in Tainan County of Taiwan in 1969 and 2002



1. **Change from rice-growing to sugarcane planting and fallow will decrease SOC storages.**
2. **Although land uses were changed from 1969 to 2002, total SOC storage was increase in 0-30 cm soil depth.**

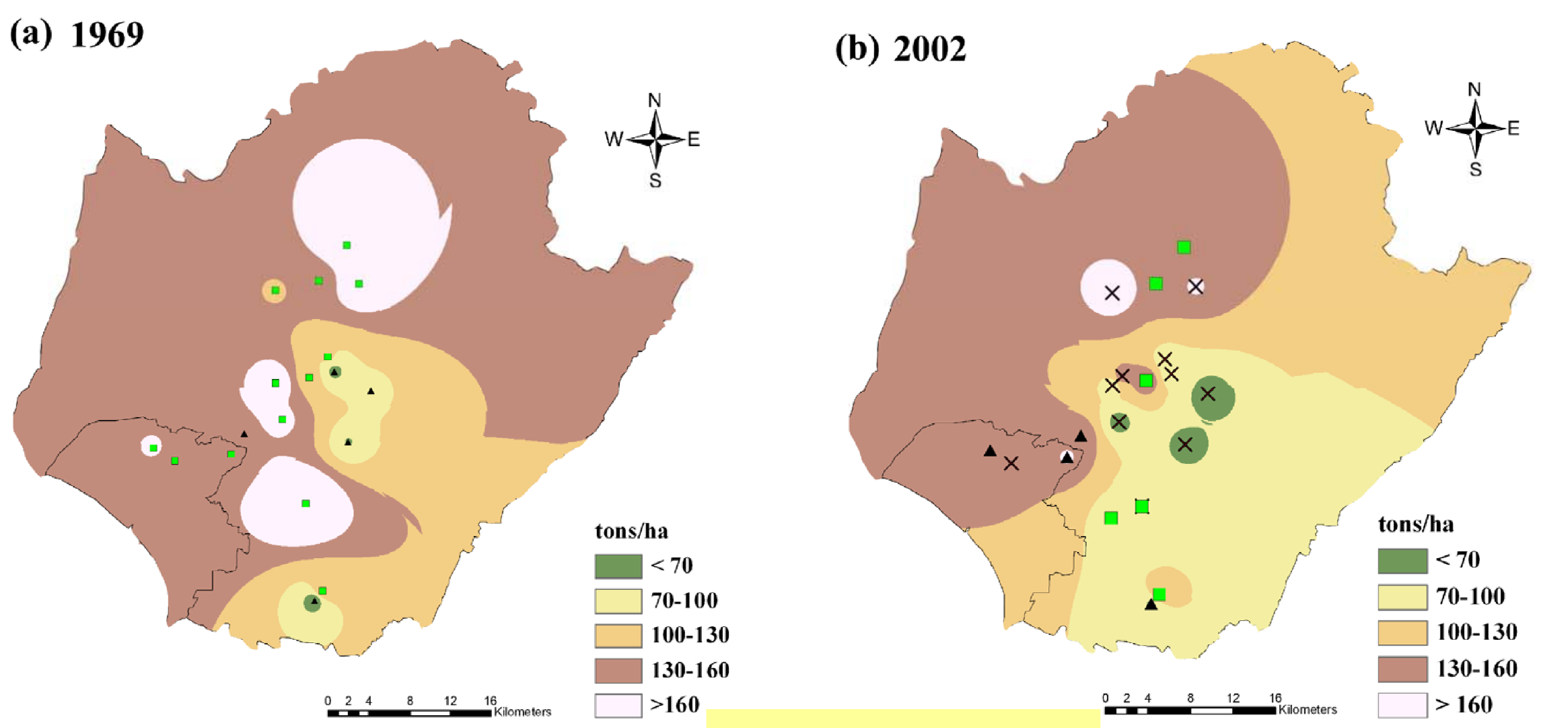
■ Rice-growing
▲ Sugarcane
× Fallow

The change of SOC storage (Mg/ha) for depth of 0-50 cm with different land uses in Tainan County of Taiwan in 1969 and 2002



1. Different from SOC storage in 30 cm, SOC decreases with time in 50 and 100 cm soil depth.

The change of SOC storage (Mg/ha) for depth of 0-100 cm with different land uses in Tainan County of Taiwan in 1969 and 2002

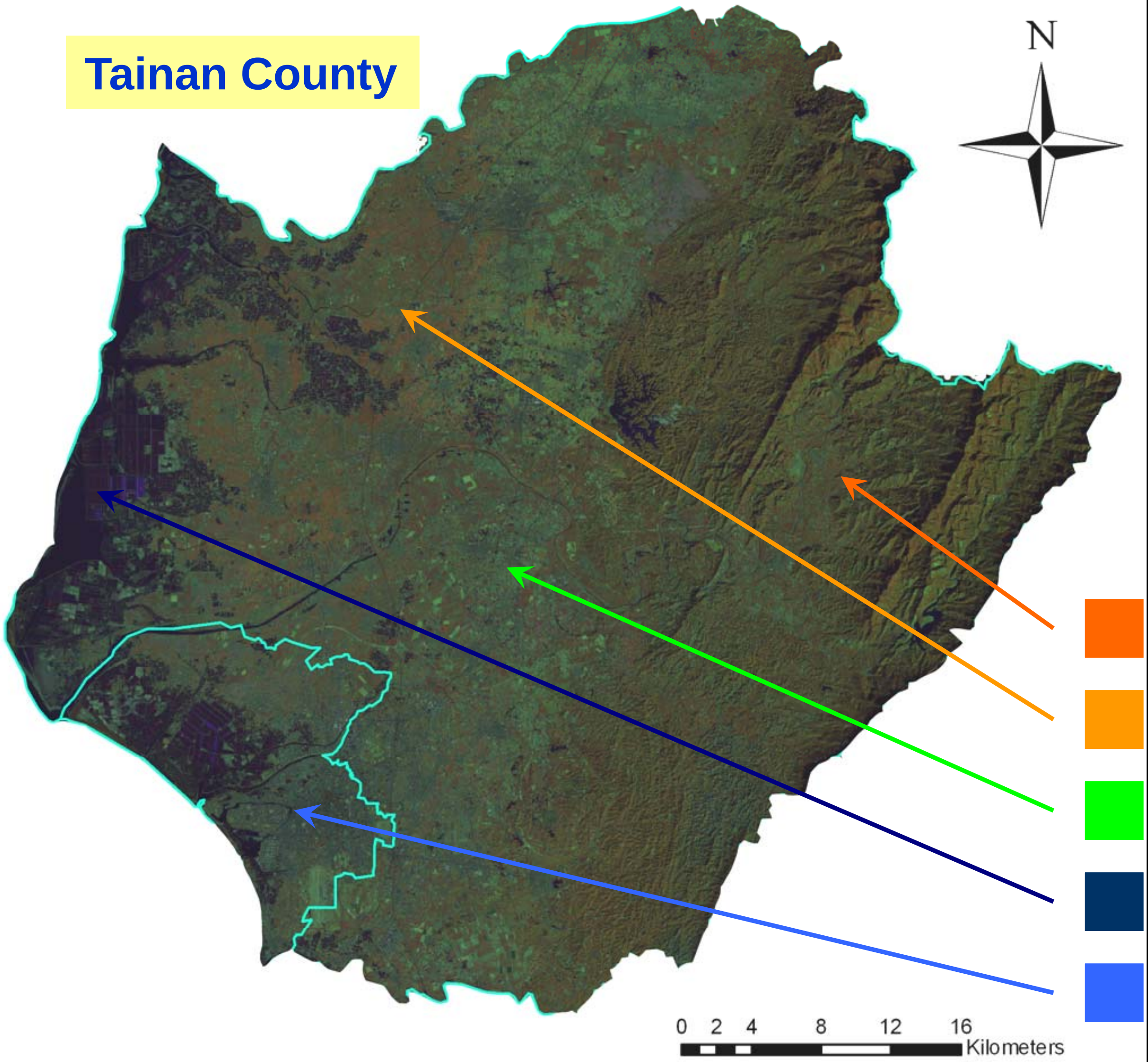


Rice-growing
Sugarcane
Fallow

Strategies of SOC sequestration in the rural soils in Taiwan (1)

- In this study, permanent rice-growing increased SOC storage and the sequestrated rate was 0.55 ± 0.35 Mg/ha per year from 1969 to 2002.
- To change land use from rice-growing to fallow or upland cultivation decreased the SOC storage in rates of –0.45±0.87 Mg/ha and – 0.02±0.17 Mg/ha per year, respectively. Consequently, long-term fallow will decrease the SOC storage in the rural soils.
- Prolonging waterlogged duration of paddy soils and efficiently reusing crop residues for all rural soils were proposed as good ways to sequester SOC in Taiwan based on our results.

Strategies of SOC sequestration in the rural soils in Taiwan (2) : <u>Remote sensing application</u>



- Landset 5 (photographed in 1985)
- Red:4; Green:5; Blue:3
- The area of different land uses could be estimated by image analysis tool (ERDAS IMAGINE 8.4)

Forest (41% in area in Tainan)

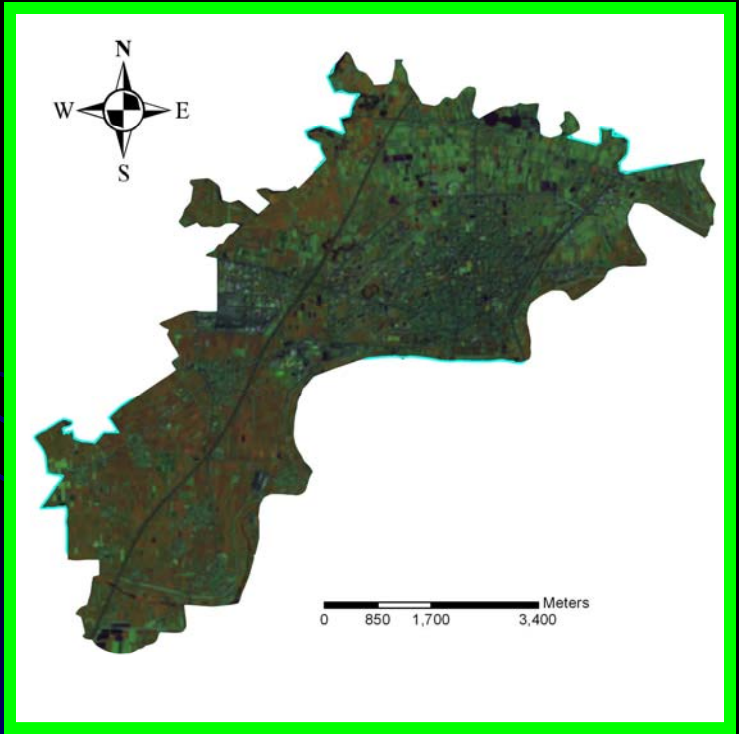
Cropland (25%)

Fallow (18%)

Water (5%)

Urban (11%)

- Land cover will be discerned by the remote sensing techniques to screen its land use for calculating and monitoring the soil carbon sequestration potential with a regional or national scale.



Conclusions

- The average SOC stocks with 0-30 cm, 0-50 cm, and 0-100 cm depths were about 5.97, 8.06, and 11.0 kg/m^2, respectively.
- The major SOC stocks were concentrated in 0-30 cm, which was more than 43-63% of the total stocks in 100 cm depth.
- Over than 60% SOC are held in Inceptiosols in rurals in Taiwan.
- Prolonging waterlogged duration of paddy soils and efficiently reusing crop residues for all rural soils were proposed as good ways to sequester SOC in Taiwan
- Remote sensing techniques could be applied to determine the area of each land use in Taiwan and approximate SOC storages of different land uses or whole SOC storage in Taiwan could be therefore estimated.

Thank you for your attention