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Appendix: Raw data, units, calculations and references for the annual energy and material flows in Table 1. Subsystems are given by Roman numerals from I to VI progressing toward the sea.

Notes	Item	Raw Data	Units (per year unless noted)	References and Assumptions
I. Farm land[1]				
	Area	2.87E+08	m^2	Li et al. 2003
	Mean annual temperature	287	°K	http://forages.oregonstate.edu/organizations/seed/osc/tech-pubs/goat_ch
	Temperature of growing season	296	°K	Li et al. 2003
1	Mean annual solar radiation	1.19E+06	$kcal/m^2$	Zhang,1998
	Albedo	0.3		Zuo et al. 2004
	Formula for energy from the sun	area × average solar radiation×(1-Albedo) ×4186 J/kcal		
	Energy	1.00E+18	J	
2	Wind velocity	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient on land	2.00E-03		Garratt 1977
	Seconds in a year	3.15E+07	s	
	Energy formula	area × density × drag coefficient × (geostrophic wind velocity)^3×sec/y		
	Energy	1.29E+16	J	
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy formula	heat flux × area × seconds/y		
	Energy	6.79E+14	J	
4	Rainfall	1.025	m	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential energy of rain	area × mean elevation × rainfall × density × gravity		
	Energy	5.77E+12	J	
5	Gibbs free energy of rain formula	(8.314J/mole/deg)(287K)/(18g/mole)*ln(999990ppm/965000ppm)		
	Gibbs free energy per gram	4.72	J/g	At mean annual temperature
	Chemical potential energy of rain	area × rainfall × density × Gibbs free energy		
	Energy	1.39E+15	J	
6	River water inflow	4.70E+09	m^3	
	Density	1.00E+06	g/m^3	
	Mineral content	7.50E+02	ppm	Yancheng Reserve Committee,2000
	Gibbs free energy of river water	(8.314J/mole/deg)(287K)/(18g/mole)*ln((1E6-750)ppm/965000ppm)		
	Gibbs free energy at 287°K	4.62	J/g	Avg. annual temperature

	Energy formula	volume flow × density × Gibbs free energy		
	Energy	2.17E+16	J	
7	River water for irrigation	0.61	m^3/m^2	Bai 2006
	Gibbs free energy river water	(8.314J/mole/deg)(296K)/(18g/mole)*ln((1e6-750)ppm/965000ppm)		
	Gibbs free energy at 296°K	4.77	J/g	Avg. temp. growing season
	Energy	8.35E+14	J	For 1.75E+08 m^3
				Bai 2006 converted to 9.26 base
8	Purchased input	1.45E+16	sej/ha	Lan and Odum 1994, for Tr.
				Chinese labor and service.
	Total purchased emergy	Area* purchased emergy density		
	Emergy purchased	4.16E+20	sej	
9	Productivity of rice	4457	kg/ha	Bai 2006
	Rice harvested	1.28E+08	kg	
	Energy value	14230	J/g	Bai 2006
	Energy of rice harvest	1.82E+15	J	
10	Rice left after harvest	50000	kg	Dong et al. 2005
	Energy left	7.12E+11	J	
11	River water outflow	Available energy in river water minus irrigation use		
	Energy	2.09E+16	J	4.52E+09 m^3

II. Aquaculture ponds

	Area	2.51E+08	m^2	
1	Mean annual solar radiation	1.19E+06	$kcal/m^2$	Zuo et al. 2004
	Albedo	0.3		Zuo et al. 2004
	Energy formula	area×average solar radiation×(1-Albedo)×4186J/kcal		
	Energy	8.75E+17	J	
2	Wind velocity (metric)	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient over water	1.00E-03		Garratt 1977
	Seconds in a year	3.15E+07	s	
	Energy formula	area×density×drag coefficient × (geostrophic wind velocity)^3×sec/y		
	Energy	5.64E+15	J	
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy formula	heat flux × area × seconds/y		
	Energy	5.94E+14	J	
4	Rainfall	1.025	m	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential of rain	area × mean elevation × rainfall × density × gravity		

	Energy	5.04E+12		
5	Gibbs free energy of rain	4.73	J/g	At avg. annual temperature
	Chemical potential of rain	area × rainfall × density × Gibbs free energy		
	Energy	1.21E+15	J	
6	River water inflow	2.09E+16	J	From I.10 above
7	River water for aquaculture	4.5	m^3/m^2	Liu and Luan 2000
	Energy	5.39E+15	J	1.13E+09 m^3
8	Mean NPP of Phytoplankton	5320	g/m^2	Zuo et al. 2004
	Standard energy value	5	kcal/g	Parsons and Takahashi, 1973
	Energy formula	area ×average NPP of Phytoplankton ×standard energy		
	Energy	2.79E+16	J	
9	N fertilizer	30	kg/ha	Liu and Luan 2000
	Total quantity	7.53E+05	kg	
10	P fertilizer	45	kg/ha	Liu and Luan 2000
	Total quantity	1.13E+06	kg	
11	Forage	7000	kg/ha	Liu and Luan 2000
	Total quantity	1.76E+08	kg	
12	Fry	636	kg/ha	Liu and Luan 2000
	Total quantity	1.60E+07	kg	
13	Electricity and other purchased input	2.73E+15	sej/ha	Lu et al. 2002a
	Total quantity	6.85E+19	sej	
14	Aquaculture productivity	2500	kg wwt. /ha	Liu and Luan 2000
	Energy value for cultured fish	4813	J/g	http://www.seagrant.wisc.edu/greatlakesfish/ctable/html
	Aquaculture output	area×productivity×standard energy		
		3.02E+14	J	
15	Benthic fauna left in pond	194	g wwt. /m^2	Dong et al. 2005
	Standard energy value	3767	J/g wwt.	USDA Nutrient Data Laboratory "Food Composition and Nutrition." http://www.nal.usda.gov/fnic/cgi-bin/nut_search.pl
	Aquaculture output	area×productivity×dry ratio×standard energy		
		1.83E+14	J	
16	Annual increase of organic matter (OM) in mud	170	g dwt. /m^2	Liu and Luan 2000
	Standard energy value	5.00E+00	kcal/g	Gorham and Sanger (1967)
	Energy	8.93E+14	J	
17	River water outflow	available river water-irrigation		
	Energy	1.55E+16	J	3.40E+09 m^3

III. *Phragmites* and *Aeluropus*

	Area[2]	2.47E+08	m^2	
	Area of *Phragmites*	1.07E+08	m^2	Li, 2000
	Area of *Aeluropus* and *Imperata*	1.40E+08	m2	Li, 2000
1	Mean annual solar radiation	1.19E+06	kcal/m^2/y	Zhang, 1998
	Albedo	0.3		Zuo et al. 2004
	Energy	area × average of solar radiation×(1-Albedo) ×4186 J/kcal		
	Energy	8.61E+17	J	
2	Wind velocity (metric)	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient	2.00E-03		Garratt 1977
	Sec/year	3.15E+07	J	
	Energy formula	area × density × drag coefficient × (geostrophic wind velocity)^3×sec/yer		
	Energy	1.11E+16		
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy formula	heat flux × area × seconds/y		
	Energy	5.84E+14	J	
4	Rainfall	1.025	m	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential of rain	area × mean elevation × rainfall × density × gravity		
	Energy	4.96E+12	J	2.41E+8 m^3
5	Gibbs free energy of rain	4.72	J/g	At mean annual temperature
	Chemical potential of rain	area × rainfall × density × Gibbs free energy		
	Energy	1.20E+15	J	
6	River water inflow	1.55E+16	J	From II. 17 above
7	Evapotranspiration of *Phragmites*			
		NPP = 2.72E3	g/m^2	Li et al. 2004
	Water evapotranspired	700×NPP or 1.90E+06	g/m^2	Li et al. 2004
	Gibbs free energy of rain and river	(8.314J/mole/deg)(296K)/(18g/mole)*ln((1E+6-698)/965000ppm)		
	Gibbs free energy at 296°K	4.78	J/g	Temp. growing season
	Energy of evapotranspiration	Area×evapotranspiration per area× Gibbs free energy		
	Evapotranspiration of *Phragmites*	1.07E+8m2×700×2.72E+3g/m^2/y×4.78J/g		
	Energy	9.74E+14	J	2.04E+08 m^3
	Evapotranspiration of *Aeluropus* and *Imperata*	(1-22%)×Pan Evaporation =78%×1.5355m		Xu et al. 2006
	Energy of evapotranspiration	area×evapotranspiration per area×density×Gibbs free energy		

	Calculation	1.40E+8m^2×78%×1.5355m×1E+6g/m^3×4.78J/g		
	Energy	8.01E+14	J	1.68E+08 m^3
	Subtotal ET[2*]	1.78E+15	J	3.71+08 m^3
	ET from rain 0.072 by energy[3*]	1.27E+14	J	2.65E+07 m^3
	ET from river 0.928 by energy[3*].	1.65E+15	J	3.51E+08 m^3
8	Water stored in peaty sediment			
	Depth addition of peat	0.04	m	Yangcheng Reserve Committee, 2000
	Water content ratio	0.57		Zuo et al. 2004
	Density	1.00E+06	g/m^3	
	Gibbs free energy of rain & river	4.63	J/g	At avg. annual temperature
	Energy	Vol. of rain water× Gibbs free energy of rain water+ vol. of river water× Gibbs free energy of river water		
	Subtotal water stored[2]	2.61E+13	J	5.63E+06 m^3
	Fraction from rain 0.066 by vol.[4*]	1.76E+12	J	3.72E+05 m^3
	From river water 0.934 by vol. [4*]	2.43E+13	J	5.26E+06 m^3
9	Cost for harvest per MT *Phragmites*	100	RMB/MT	
	Exchange Ratio	8.3	$ /RMB in 2000	
	Harvest quantity of *Phragmites*	20000	MT/y	
	Formulation of Purchased input for harvest *Phragmites*	Cost for harvest per MT *Phragmites*/Exchange Ratio× quantity harvested		
	Purchased input	2.41E+05	$ in 2001	
10	*NPP of *Phragmites*	1.07E+08m^2×2.72E+03g/m^2/y		Zuo et al. 2004
		2.91E+11	g	
	*NPP of *Aeluropus* and *Imperata*	1.40E+08m^2×2.45E+03g/m^2		Zuo et al. 2004
		3.43E+11	g	
	Subtotal	6.34E+11	g	
	Standard energy value	4.00E+00	kcal/g	
	Energy[2]	1.06E+16	J	
	*Energy of *Phragmites* harvested	3.35E+14	J	
	*Energy of left NPP	1.03E+16	J	
11	Depth of peaty sediment	0.85	m	Yancheng Reserve Committee, 2000
	Density	0.7	g/cm^3	Odum, 1996
	Organic C content ratio	0.105		Odum,1996
	Standard energy value of C	11	kcal/g	Coultas and Calhoun 1976
	Turn over time	188	a	
	Energy formula	deposition area ×depth ×density × C content ratio ×Gibbs free energy of the C /turn over time		
	Energy	3.78E+15	J	
12	Annual production of benthic fauna	378	g wwt./m^2	Dong et al. 2005
	Standard energy value	3767	J/g	USDA Nutrient Data Laboratory

				"Food Composition and Nutrition." http://www.nal.usda.gov/fnic/cgi-bin/nut_search.pl
	Energy formula	Area×biomass per area×standard energy value		
	Energy	3.52E+14	J	
13	River water outflow	1.38E+16	J	3.04E+09 m^3
14	Rain infiltration†	1.07E+15	J	
IV. *Spartina* and *Suaeda*				
	Area[2]	5.17E+08	m^2	
	Area of *Spartina*	2.51E+08	m^2	
	Area of *Suaeda*	2.66E+08	m^2	
1	Mean annual solar radiation	1.19E+06	$kcal/m^2$	Zhang,1998
	Albedo	0.3		Zuo et al. 2004
	Energy formula	area× average of solar radiation×(1-Albedo) ×4186 J/kcal		
	Energy	1.80E+18	J	
2	Wind velocity (metric)	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient	2.00E-03		Garratt 1977
	Sec/year	3.15E+07	s	
	Energy of Wind	area × density × drag coefficient × (geostrophic wind velocity)^3×sec/yer		
	Energy	2.32E+16	J	
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy	heat flux ×area× seconds/y		
	Energy	1.22E+15	J	
4	Rainfall	1.025	m	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential of rain	area× mean elevation × rainfall × density × gravity		
	Energy	1.04E+13		
5	Gibbs free energy of rain	4.72	J/g	At mean annual temperature
	Chemical potential of rain	(area+0.5 prograded area) × rainfall × density × Gibbs free energy		
	Energy	2.50E+15	J/y	5.30E+08 m3
6	River water inflow	1.38E+16	J/y	From III.13
7	Evapotranspiration	3.5	L/m2/growth day	Hussey and Odum,1992
	Growth days (without frost)	210	day	
	Density	1.00E+03	g/l	
	Subtotal energy ET[2*]	1.85E+15	J	3.80E+08 m3
	From rain fraction 0.155 by energy[3*]	2.83E+14	J	5.81E+07 m^3
	From river water 0.845 by energy[3*]	1.57E+15	J	3.28E+08 m^3

8	Water stored in peaty sediment			
	Depth addition of peat	0.04	m	Yancheng Reserve Committee, 2000
	Water content ratio	0.57		Zuo et al. 2004
	Density	1.00E+06	g/m^3	
	Energy formula	Vol. Of rain water× Gibbs free energy of rain water+ vol. Of river water× Gibbs free energy of river water		
	Subtotal energy of water stored[2]	5.47E+13	J	1.18E+07 m^3
	From rain fraction 0.153 by vol.[4]	8.25E+12	J	1.75E+06 m^3
	From river water 0.847 by vol.[4]	4.65E+13	J	1.00E+07 m^3
9	Tides per year	707		
	Mean height	1.7	m	Li et al., 2005
	Density	1.025E+03	kg/m^3	
	Gravity	9.800E+00	m/s^2	
	Formula for energy of tide	area× 0.5 ×(tides/y)× $(height)^2$ × density × gravity		
	Energy	5.50E+15	J	
10	NPP of *Spartina*	area×2.60E3g/m^2		Zuo et al. 2004
		6.53E+11	g	
	NPP *Suaeda*	2.66E+08m^2×5.59E+02g/m^2		Zuo et al. 2004
		1.49E+11	g	
	Subtotal salt marsh NPP[2]	8.01E+11	g	
	Standard energy value	4.00E+00	kcal/g	
	Energy	1.34E+16	J	
11	Annual depth of peaty sediment	0.85	m	Chen, 1994
	Density	0.7	g/cm^3	Odum, 1996
	Organic C content ratio	0.105		Odum, 1996
	Standard energy value	11	kcal/g C	Coultas and Calhoun, 1976
	Energy of peat deposited	area ×depth × density × organic content ratio ×Gibbs free energy of the organic matter		
	Energy	1.40E+16	J/y	
12	Annual production of benthic fauna	378	g wwt./m^2	Dong et al. 2005
	Standard energy value	3767	J/g wwt.	
	Formula for energy of benthos	(area+0.5 prograded area)×biomass per area×standard energy value		
		7.36E+14	J/y	
13	River water outflow	1.22E+16	J/y	2.71E+09 m3
14	Rain infiltration†	2.21E+15	J/y	4.62E+08 m3
V. Saltpans				
	Area	3.25E+08	m^2	
1	Mean annual solar radiation	1.19E+06	$kcal/m^2/y$	Zhang,1998
	Albedo	0.3		Zuo et al. 2004
	Formula for energy from the sun	area×average solar radiation× (1-Albedo) ×4186 J/kcal		

	Energy	1.13E+18	J/y	
2	Wind velocity (metric)	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient	1.00E-03		Garratt 1977
	Sec/year	3.15E+07	J	
	Formula for energy from the wind	area × density × drag coefficient × (geostrophic wind velocity)^3×sec/y		
	Energy	7.30E+15	J/y	
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy formula	heat flux ×area × seconds/y		
	Energy	7.69E+14	J	
4	Rainfall	1.025	m/y	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential of rain	area × mean elevation × rainfall × density × gravity		
	Energy	6.53E+12		
5	Formula for weight of rain water	Area×rainfall×density		
	Mass	3.33E+14	g	
	Salt yield	9.36E+11	g	Wang et al. 2001
	Waste salt	9.36E+10	g	
	Salts in waste brine	6.32E+11	g	
	Salt required	1.66E+12	g	
	Mean salinity of seawater	3.09E+04	g/m^3	
6	Formula for seawater required	salt dissolved in seawater/mean salinity of seawater		
	Volume	5.38E+07	m^3	
7	Evaporation	1.5355	m/y	Yancheng Reserve Committee,2000
	Density	1.00E+06	g/m^3	
	Gibbs free energy rain	4.87	J/g	In the warm seasons
	Energy	area×evaporation×density×Gibbs free energy		
		2.43E+15 J		
8	Fuels and goods required per g salt	5.09E+07	sej/g salt yield	Babic 2005, adjusted to 9.26 baseline
	Total fuels and goods	4.77E+19	sej/yr	
9	Labor	22.4	J/g salt yield	Babic 2005, adjusted to 9.26 baseline
	Labor cost	2.09E+13	J/yr	
10	Salt yield	9.36E+11	g	Wang et al. 2001
11	Annual production of benthic fauna	241	g wwt./m^2	Dong et al. 2005
	Standard energy value	3767	J/g	USDA Nutrient Data Laboratory "Food Composition and Nutrition." http://www.nal.usda.gov/fnic/cgi-bin/nut_search.pl

	Formula for energy of benthos	area×biomass per area×dry ratio×standard energy value		
	Energy	2.95E+14	J	
VI. Mud flats				
	Area	2.06E+09	m^2	
1	Mean annual solar radiation	1.19E+06	$kcal/m^2/y$	Zhang,1998
	Albedo	0.3		Zuo et al. 2004
	Energy	area×average of solar radiation×(1-Albedo) ×4186 J/kcal		
		7.19E+18	J/y	
2	Wind velocity (metric)	5	m/s	Zhu et al. 2004
	Geostrophic wind	8.34	m/s	Reiter 1969
	Air density	1.23	kg/m^3	
	Drag coefficient	1.00E-03		Garratt 1977
	Sec/year	3.15E+07	J	
		area×density×drag coefficient×(geostrophic wind velocity)^3×sec/yr		
	Energy	4.64E+16	J	
3	Earth heat flux	75	mW/m2	http://www.heatflow.und.edu
	Energy	heat flux ×area× seconds/y		
	Energy	4.88E+15	J	
4	Rainfall	1.025	m	
	Mean elevation	2	m	
	Density	1.00E+03	kg/m^3	
	Gravity	9.8	m/s^2	
	Geopotential of rain	area× mean elevation × rainfall × density × gravity		
	Energy	4.14E+13		
5	Gibbs free energy of rain	4.72	J/g	At mean annual temperature
	Formula for rain chemical potential	area× rainfall × density × Gibbs free energy		
	Energy	9.98E+15	J	2.11E+09 m3
6	River water inflow	2.71E+15	g	From IV.13 above
	Salinity of mixed water near beach	2.20E+04	g/m^3	Yancheng Reserve Committee,2000
	Formula for Gibbs free energy	(8.314/mole/deg)(287K)/(18g/mole)*ln((1E+06-750)ppm/(1E+06-22000ppm)		
	Gibbs free energy river water	2.85	J/g	
	Energy	7.71E+15	J	
7	Wave			
	Shore length	5.82E+05	m	
	Absorption ratio	0.125		Odum 1996, Qin et al. 2000
	Density	1.025E+03	kg/m^3	
	Mean wave height	1	m	Li, 2000
	Gravity	9.8	m/s	
	Velocity	2.6	m/s	

	Formula for wave energy	shore length×absorption ratio×density×gravity×(height)^2 ×velocity×3.15×107 s/y		
	Energy	5.99E+16	J/y	
8	Tides per year	707		
	Mean height	1.7	m	
	Density	1.025E+03	kg/m^3	
	Gravity	9.800E+00	m/s^2	
		area elevated × 0.5 ×(tides/y)× (height)^2 × density × gravity		
	Energy	2.12E+16	J/y	
9	NPP of Phytoplankton	5320	g/m^2	Zuo et al. 2004
	Standard energy value	5	kcal/g	
		area×average NPP of Phytoplankton ×standard energy		
	Energy	2.30E+17	J	
10	Annual production of Benthic fauna	365	g/m^2	Dong et al. 2005
	Standard energy value	3767	J/g	USDA Nutrient Data Laboratory "Food Composition and Nutrition." http://www.nal.usda.gov/fnic/cgi-bin/nut_search.pl
		area×biomass per area×standard energy value		
	Energy	2.84E+15	J/y	
Waterfowls				
1	Purchased forage for waterfowl (mainly corn)	5.00E+06	g/y	Dong et al. 2005
	Energy per weight	19736	J/g	Campbell et al. 2005
	Energy	9.87E+10	J	
2	Estimated number of birds	7.54E+06	ind.	Yancheng Reserve Committee,2000
	Mean weight	800	g/ind.	Qin et al. 2000
	Time of stay (years)	0.5		Yancheng Reserve Committee,2000
	Dry weight ratio	0.2		
	Standard energy value	4.04	kcal/g	Typical value for duck
		Number×avg. weight×time of stay×dry wwt ratio×standard energy value		
	Energy	1.02E+13	J	
3	Daily food requirement of waterfowl	food weight/average biomass of waterfowl/day		
	Daily ration	8/45	g/g.day	Loesch et al. 2002,
	Benthic fauna eaten by waterfowl	Number×avg. weight×Stay in days×daily ration-artificial forage-rice		
	Weight Fauna consumed[5]	1.96E+11	g	
	Fraction of benthic fauna eaten by waterfowl	16.79%		

[1]Assumes all of the farmland is used for rice planting and is irrigated.

[2]Sub-items included.

[3] Take the available energy of river water and rain water as the weighting factor.

[4] Take the available volume of river water and rain water as the weighting factor.

[5] 2.25E+11 g food required and 1.52E+12 g produced.

[*]Assume the chance that a parcel of river or rain water would be used for evaporatio, evapotranspiration or absorption into the peat was dependent only on the quantities of each that were available.

[†]Assume all of the rain water left after evapotranspiration was assumed to infiltrate into the ground water in the relatively flat

References:

Babic, J. 2005. Emergy analysis of the salt production process at the Secovlje saltpans, Slovenia. Pages 519-534 in M. T. Brown and E. Bardi, editors. Emergy Synthesis 3: Theory and Application of the Emergy Methodology. Center for Environmental Ploicy, University of Florida, Gainesville.

Bai, Y. 2006. Emergy evaluation on the sustainability of different production modes in alluvial paddy field at Huiyang District. Master dissertation. South China Botanical Garden, Chinese Academy of Sciences. (In Chinese)

Campbell, D. E., S. L. Brandt-Williams, M E. A. Meisch. 2005. Environmental accounting using: evaluation of the state of West Virginia. USEPA/600R-05/006. 116pp.

Chen, C.J., 1994. Effect of increasing deposition and defending seashore by planting spartina anglic on beach in Jiangsu Province. Marince Science Bulletin 13(2), 55-61.

Coultas, C. L., F. G. Calhoun. 1976. Properties of some tidal marsh soils of Florida. Soil Science Society of America Journal. 40: 72-76.

Dong, K., S. C. Lv, T. Healy. 2005. Carrying capacity of red-crowned cranes in the national Yancheng rare birds Natural Reserve, Jiangsu province, China. Acta Ecological Sinica 25(10):2610-2615.

Garratt JR. 1977. Review of drag coefficients over oceans and continents. Monthly Weather Review 105:915-929.

Gorham E, Sanger J. 1967. Caloric values of organic matter in woodland, swamp, and lake soils. Ecology 48(3): 492-494.

Hussey BH, Odum WE. 1992. The global status of peatlands and their role in carbon cycling. A report for friends of the earth by the wetland ecosystem research group. Department of geography, University of exeter. Friends of the Earth, London.

Li, M. L., Y. C. Xu, Q. R. Shen, C. L. Zhou, X. Y. Huang, X. Y. Yin, J. L. Yin, L. Dittert. 2003. Methane and nitrous oxide fluxes in aerobic and waterlogged production systems of rice crop. Soil Sciences. 40(6): 864-869. (In Chinese)

Li, W. J. 2000. The research of Designing of a nature reserve: a case study in Yancheng Biosphere Reserve, China. Beijing: Chinese Environment Press. (In Chinese)

Li, X. R., 2000. Differentiation characteristics of geological environment and its genetic relation to geological hazards in the littoral areas. Geology and Prospecting. 36(1), 65-67, 83. (In Chinese)

Li, Y. F., Zhu, X. D., Zou, X. Q., Gao, J. H., 2005. Study on landscape ecosystem of coastal wetlands in Yancheng, Jiangsu Province. Marine Science Bulletin 24(4), 46-51.

Liu, J. M., J. Y. Luan. 2000. Tide and enter port of tidal boat of Sheyang harbor. Beach Engineering 19(1): 54-58. (In Chinese)

Loesch, C.R., D. J. Twedt, K. Tripp, W. C. Hunter, M. S. Woodrey. 2002. Development of management objectives for waterfowl and shorebirds in the Mississippi alluvial valley. Available online from the Valley Migratory Bird Initiative at http://birds.cornell.edu/pifcapema$_{y}$/loesch.htm.

Lu, H. F., S. F. Lan, F. P. Chen, S. L. Peng. 2002a. Emergy Study on Dike-Pond Eco-agricultural Engineering Modes. Transactions of the CSA, 18(5): 145-150.

Odum, H. T. 1996, Environmental Accounting—Emergy and Decision Making. Wiley John & sons, New York, 110-135.

US EPA ARCHIVE DOCUMENT

Parsons, T. R., M. Takahashii. 1973. Biological Oceanographi Processes. New York: Pergamon Press. p39, 47, 138.

Qin, P., Y. S. Wong, N. F. Tam. 2000. Emergy evaluation of Mai Po mangrove marshes. Ecological Engineering 16(1-4), 271-280.

Reiter, E. R. 1969. Atmospheric Transport processes, Part I. Energy Transformations. U.S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, TN. 253p.

Wang, Z. S., C. J. Ruan, H. P. Zheng. 2001. Features of trial-flat resource of Yancheng and measure of sustainable utilization. Marine Science Bulletin 20(4): 64-69.

Xu MG, Li JM, Li ZJ. 2006. Using salt endure plants to improve the agricultural environment in salt area. Soil and Fertilizer Sciences in China 3: 6-10. (In Chinese)

Yancheng Reserve Committee, 2000, Comprehensive report of Yancheng Reserve Investigation. (In Chinese)

Zhu, H. G., P. Qin, H. Wang. 2004. Functional group classification and target species selection for Yancheng Nature Reserve. Biodiversity and Conservation 7(13): 1335–1353.

Zuo, P., S. W. Wan, P. Qin, J. J. Du, H. Wang. 2004. A comparison of the sustainability of original and constructed wetlands in Yancheng Biosphere Reserve, China: implications from emergy evaluation, Environmental Science & Policy 7: 329–343.

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