Supplementary material A

The units of the following results were the inputs of per kilogram live pig (IKG).

Note: The mean final live weight of pigs in EPRS A, B and C was 114.25 kg, 115.00 kg and 88.63 kg, respectively. The whole pigpen could hold 80 pigs at once. Each year this pigpen produced 2 groups. In this study,4 pigs were fed in one small pen which was 20m^2. Average quantity showed the data per pig. Meteorological data came from the database of the Yucheng Comprehension Experiment Station (YCES).

1. Sun (pig rearing): Insolation =4.936E+9 J/m^2/year. Land area =20m^2/pen÷4 pigs/pen=5 m^2. Albedo of the land= 20 % (Hu et al. 2010). Energy (J) = 4.936E+9 J/m^2/year × (1-20 %) × 5 m^2×168/365.25 = 9.09E+9 J. IKG of EPRS A =9.09E+9 J/114.25=7.95E+7 J; IKG of EPRS B=9.09E+9 J/115.00=7.90E+7 J; IKG of EPRS C =9.09E+9 J/88.63=1.05E+8 J.
2. Wind, kinetic energy (pig rearing): Air density =1.23 kg/m3. Land area =5 m^2. Drag coefficient = 0.002 (Chen, B., 2009). Wind speed =2.413 m/s. Energy (J) =5 m^2 × 0.002 × 1.23 kg/m^3 × (2.413 m/s)^3 × (168 × 24 × 3600) s =2.51E+06 J. IKG of EPRS A= 2.20E+04 J; IKG of EPRS B= 2.18E+04 J; IKG of EPRS C = 2.90E+04 J.
3. Rain (pig rearing): Rainfall =0.451 m. Land area = 5 m^2. Gibbs free energy of the water = 4900 J/kg. Energy (J) = 0.451 m×5 m^2 ×1000 kg/m^3 × 4900 J/kg ×168/365.25 = 5.09E+06 J. IKG of EPRS A= 4.46E+04 J; IKG of EPRS B= 4.43E+04 J; IKG of EPRS C = 5.88E+04 J.
4. Ground water: Average quantity =9.14E+02 kg. Gibbs free energy of the water = 4900 J/kg. Energy (J) = 9.14E+02 kg × 4900 J/kg = 4.48E+06 J. IKG of EPRS A= 3.92E+04 J; IKG of EPRS B= 3.89E+04 J; IKG of EPRS C = 5.17E+04 J.
5. Piglet: Tuhe black piglet average weight =10.65 kg; Three-breed crossbred piglet average weight =26.21 kg. IKG of EPRS A= 2.29E-01 kg; IKG of EPRS B= 2.28E-01 kg; IKG of EPRS C = 1.23E-01 kg.
6. Maize silage: IKG of EPRS A = 0/114.25 kg=0 kg. IKG of EPRS B = 136.10/115 kg= 1.18E+03 kg. IKG of EPRS C = 124.45 /88.63 kg= 1.44E+03 kg.
7. Maize grain: IKG of EPRS A =272.41 /114.25 kg= 2.38E+03 g. IKG of EPRS B = 136.78 /115 kg= 1.19E+03 g. IKG of EPRS C = 124.52 /88.63 kg= 1.44E+03 g.
8. Wheat bran: IKG of EPRS A =38.10 /114.25 kg= 3.33E+02 g. IKG of EPRS B = 37.86 /115 kg= 3.29E+02 g. IKG of EPRS C = 34.55 /88.63 kg= 3.99E+02 g.
9. Soya bean meal: IKG of EPRS A =70.51 /114.25 kg= 6.17E+02 g. IKG of EPRS B =67.83 /115 kg= 5.90E+02 g. IKG of EPRS C = 38.10 /88.63 kg= 7.15E+02 g.
10. Disinfectants: Disinfectants used only once before purchased piglets entered the pigpens. Average quantity = 27.78 g. IKG of EPRS A =27.78 g/114.25= 2.43E-01 g. IKG of EPRS B =27.78 g /115 = 2.42E-01 g. IKG of EPRS C = 27.78 g /88.63= 3.21E-01 g.
11. Micro-biological additives：Materials which is a kind of fermentation materials used for in the daily disinfection instead of the disinfectants. Given uncertainty in the production process, the UEV and RNF came from the bio-alcohol process. Average quantity =¥34.97. IKG of EPRS A =¥34.97 /114.25= ¥3.06E-01. IKG of EPRS B=¥34.97 /115 = ¥3.04E-01. IKG of EPRS C =¥34.97 /88.63=¥4.04E-02.
12. Vaccine: The three-breed crossbred piglets from EPRS A developed foot and mouth disease

firstly and had to be injected with additional vaccines. IKG of EPRS A =1.75E-02 g; IKG of EPRS B = 8.70E-03 g; IKG of EPRS C = 1.15E-02 g.

13. Electricity: Average quantity = 0.31 kWh per live pig. Electricity (J) = 0.31 kWh × 1.25E+07 J/kWh = 3.89E+06 J. IKG of EPRS A = 3.40E+04 J; IKG of EPRS B = 3.38E+04 J; IKG of EPRS C = 4.49E+04 J.
14. Steel: Total pigpen used 2.88t steel with 25-year working life(GB50352-2005). This pigpen can hold 80 pigs at once. Each year this pigpen produced 2 groups. Average quantity per live pig=7.2E+2 g. IKG of EPRS A = 6.30 g; IKG of EPRS B = 6.26 g; IKG of EPRS C = 8.31 g.
15. Glass: Total weight=105 kg with 25-year working life (GB50352-2005). This pigpen can hold 80 pigs at once. Each year this pigpen produced 2 groups. Average quantity per live pig=26.25 g. IKG of EPRS A = 0.23 g; IKG of EPRS B =0.228 g; IKG of EPRS C = 3.03 g.
16. Concrete: Total weight=20.5t with 25-year working life (GB50352-2005). This pigpen can hold 80 pigs at once. Each year this pigpen produced 2 groups. Average quantity per live pig=5.13E+03 g. IKG of EPRS A =44.90 g; IKG of EPRS B = 44.61 g; IKG of EPRS C = 59.22 g.
17. Labor: Conversion of the labor = 1.26E+07 J/day (Chen et al. 2011).This pigpen needs 1.5 h labor/day，and each worker works 8 hours per day. Average quantity =1.5h/day*168 days÷8h/day÷80 pigs= 0.391 days/pig. Labor (J) = 0.391 days × 1.26E+07 J/day = 4.93E+06 J. IKG of EPRS A =4.30E+04 J; IKG of EPRS B = 4.26E+04 J; IKG of EPRS C =5.66E+04 J.
18. Building investment: Total assets input= ¥5000. Such pigpens with 25-year working life (GB50352-2005)，This pigpen can hold 80 pigs at once. Each year this pigpen produced 2 groups. Average quantity = ¥5000/(80pigs/batch*2batchs/year*25year)=¥1.25. IKG of EPRS A = ¥1.09E-02. IKG of EPRS B=¥1.09E-02. IKG of EPRS C = ¥1.44E-02.
19. Facilities investment: Total assets input=10000 CNY，Such pigpens with 10 years' working life(Wang et al. 2014)，This pigpen can hold 80 pigs at once. Each year this pigpen produced 2 groups. Average quantity = ¥10000/(80pigs/batch*2batchs/year*10year)= ¥6.25 per pig, IKG of EPRS A = ¥5.46E-02. IKG of EPRS B= ¥5.42E-02. IKG of EPRS C = ¥7.20E-02.
20. Medicine: EPRS A consumed ¥98，EPRS B consumed ¥30; EPRS C consumed ¥20. IKG of EPRS A =¥8.58E-01. IKG of EPRS B=¥2.61E-01. IKG of EPRS C = ¥3.24E-01

Supplementary material B

This part shows UEVs and RNFs calculated details of maize planting system, maize silage planting system, wheat planting system and wheat bran production system in this study.

Table S1 Emergy input and output details of the planting systems (ha^{-1})

Items	Unit	RNF	UEV [a]	Wheat		Grain Maize		Silage maize	
				Raw data	Emergy	Raw data	Emergy	Raw data	Emergy
Natural environmental inputs									
Sun [b]	J	1	1.00E+00	2.52E+13	2.52E+13	1.67E+13	1.67E+13	1.42E+13	1.42E+13
Wind [b]	J	1	1.86E+03	8.19E+09	1.53E+13	2.40E+09	4.47E+12	2.04E+09	3.80E+12
Rain [b]	J	1	2.36E+04	1.49E+10	3.50E+14	7.25E+09	1.71E+14	6.17E+09	1.45E+14
River water	J	1	1.86E+05	3.68E+09	6.84E+14	1.47E+09	2.73E+14	1.47E+09	2.73E+14
Purchased materials									

N fertiliser [c]	g	0	4.85E+09	1.53E+05	7.42E+14	2.34E+05	1.13E+15	1.64E+05	7.95E+14
P fertiliser [c]	g	0	4.98E+09	1.80E+05	8.96E+14	1.08E+05	5.38E+14	8.64E+04	4.30E+14
K fertiliser [c]	g	0	1.41E+09	4.50E+04	6.35E+13	9.00E+04	1.27E+14	8.10E+04	1.14E+14
Herbicide	g	0	1.89E+10	3.00E-01	5.67E+09	1.50E+03	2.84E+13	1.50E+03	2.84E+13
Pesticides	g	0	1.89E+10	8.45E+01	1.60E+12	9.00E+01	1.70E+12	0.00E+00	0.00E+00
Micro-biological additives	¥	0.2	3.31E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-01	1.21E+11
Diesel(harvest)	J	0	8.44E+04	1.65E+09	1.39E+14	1.65E+09	1.39E+14	1.80E+09	1.52E+14
Diesel(sowing)	J	0	8.44E+04	6.38E+08	5.38E+13	6.38E+08	5.38E+13	6.38E+08	5.38E+13
Plastic film	g	0	4.83E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.01E+04	1.94E+13
Electricity	J	0.09	2.18E+05	2.09E+09	4.56E+14	2.09E+09	4.56E+14	2.09E+09	4.56E+14
Seed	J	1	8.44E+04	4.89E+09	4.13E+14	3.53E+08	2.98E+13	3.53E+08	2.98E+13
Facilities	¥	0.05	3.31E+11	2.01E+01	6.65E+12	2.01E+01	6.65E+12	2.21E+01	7.32E+12
Labor	J	0.6	5.75E+06	8.99E+07	5.17E+14	8.99E+07	5.17E+14	5.43E+07	3.12E+14
Total inputs	seJ			4.32E+15		3.48E+15		2.82E+15	
Outputs									
Production	g			5.63E+06		6.00E+06		1.74E+07	
UEV	SeJ/g			7.68E+08		5.79E+08		1.62E+08	
Note：	[a]:The baseline used in this study is12.00E+24seJ/year standard.								
	[b]: Only the highest value of wind and rain was considered.								
	[c]: Compound fertiliser was calculated by its composition of N,P,K.								

Table S2 Emergy flows of the planting systems (ha^{-1})

Emergy flows	Wheat		Grain maize		Silage maize	
Total emergy inputs(U)	4.32E+15		3.48E+15		2.82E+15	
Total renewable emergy flows(R)	1.80E+15	41.63%	8.26E+14	23.76%	6.78E+14	24.05%
Total nonrenewable emergy flows(N)	2.52E+15	58.37%	2.65E+15	76.24%	2.14E+15	75.95%
UEV(seJ/g)	7.68E+08		5.79E+08		1.62E+08	
RNF	0.416		0.238		0.241	

Table S3 Details for UEV and RNF calculated for the wheat bran production system (per kg wheat bran)

Items	Unit	RNF	UEV	Raw data	Emergy
Ground water	J	0.00	1.86E+05	9.80E+02	2.40E+08
Wheat	g	0.40	7.68E+08	5.00E+03	3.84E+12
Electricity	J	0.09	2.18E+05	4.32E+05	1.24E+11
Plastic bags	g	0.00	4.83E+08	2.00E+00	1.27E+09
Labor	J	0.60	5.75E+06	3.15E+04	2.38E+11
Building	¥	0.05	3.31E+11	5.69E-04	1.88E+08
Facilities	¥	0.05	3.31E+11	3.99E-03	1.32E+09

Total inputs	seJ	4.21E+12
Total nonrenewable emergy flows	seJ	2.50E+12
Total renewable emergy flows	seJ	1.71E+12
UEV	seJ/g	8.41E+8
RNF		0.406
Note:	The baseline used in this study is12.00E+24seJ/year standard.	

Supplementary material C

This section shows economic costs of the pig raising and planting systems

Table S4 Cost details of the pig raising system

Item	Unit	EPRS A	EPRS B	EPRS C
Piglets	¥	4.57E+00	4.54E+00	7.38E+00
Maize silage	¥	0.00E+00	3.04E-01	3.69E-01
Maize grain	¥	1.78E+00	8.35E-01	1.07E+00
Wheat bran	¥	6.33E-02	6.24E-02	6.24E-02
Soya bean meal	¥	1.80E+00	1.72E+00	2.09E+00
Vaccine	¥	5.95E-03	2.96E-02	3.92E-02
Disinfectants	¥	9.73E-04	9.66E-04	1.28E-03
Micro-biological additives	¥	3.06E-01	3.04E-01	4.04E-01
Electricity	¥	5.17E-03	5.14E-03	6.82E-03
Steel	¥	3.28E-02	3.26E-02	4.33E-02
Concrete	¥	8.32E-03	8.26E-03	1.10E-02
Glass	¥	4.90E-04	4.87E-04	6.46E-04
Building	¥	1.09E-02	1.09E-02	1.44E-02
Facilities	¥	5.47E-02	5.43E-02	7.22E-02
Medicine	¥	8.58E-01	2.61E-01	2.31E-01
Labor	¥	8.11E-04	8.05E-04	1.07E-03
Total cost	¥	9.50E+00	8.18E+00	1.18E+01
outputs				
pig	¥/Kg	1.14E+02	1.15E+02	8.66E+01

Table S5 Cost details of the planting systems

Item	Unit	Wheat (ha^{-1})	maize(ha^{-1})	Maize silage(ha^{-1})	Flour milling (kg wheat $bran^{-1}$)
Compound fertiliser	¥	2.04E+03	2.04E+03	1.43E+03	0.00E+00
Herbicide	¥	2.25E+02	2.25E+02	2.25E+02	0.00E+00
Pesticide	¥	5.63E+00	6.00E+00	0.00E+00	0.00E+00
Micro-biological additives	¥	0.00E+00	0.00E+00	1.50E+02	0.00E+00

Diesel(harvest)	¥	2.18E+02	2.18E+02	2.37E+01	0.00E+00
Diesel(sowing)	¥	8.37E+01	8.37E+01	8.37E+01	0.00E+00
Plastic film/bags	¥	0.00E+00	0.00E+00	7.50E+02	1.00E-01
Electricity	¥	2.70E+02	2.70E+02	2.70E+02	1.31E-02
Seeds	¥	1.20E+03	1.05E+03	1.05E+03	0.00E+00
Facilities & building	¥	3.00E+02	3.00E+02	3.27E+02	4.56E-03
Labor	¥	2.85E+02	2.85E+02	1.73E+02	1.00E-02
Total cost	¥	4.62E+03	4.47E+03	4.49E+03	1.26E-01
Outputs					
Dry weight	kg	5.63E+03	6.00E+03	1.74E+04	5.00E+00
Cost	¥/kg	8.22E-01	7.46E-01	2.57E-01	1.26E-01

Note: 5 kg wheat could produce 4kg flour and 1kg wheat bran. So in this study we calculated the cost of the wheat bran =1/5(wheat cost + milling cost) =1.89E-1 ¥/kg,

Supplementary material D

This section shows data for soil organic carbon for the past 3 years from the database of the Yucheng Comprehension Experiment Station. This data is support materials to 2.4 part to clarity the reason why we delete the item of soil erosion.

Table S6. Soil organic carbon (SOC, g/kg) data for fields planted without and with fertiliser from 2012-2014

Date	Without fertiliser	With fertiliser
12 Jun 2012	17.26	17.26
12 Oct 2012	16.70	16.70
13 Jun 2013	16.52	16.52
13 Oct 2013	16.63	17.15
14 Jun 2014	16.96	16.96
14 Oct 2014	17.51	16.92

Supplementary material E

This section shows the basic principle of the L1 and L2 calculative processes (Fig. S1). Though the purpose of two calculative processes is both to get the maximum ping raised number supported by 1 ha land per year. The calculative processes are entirely different.

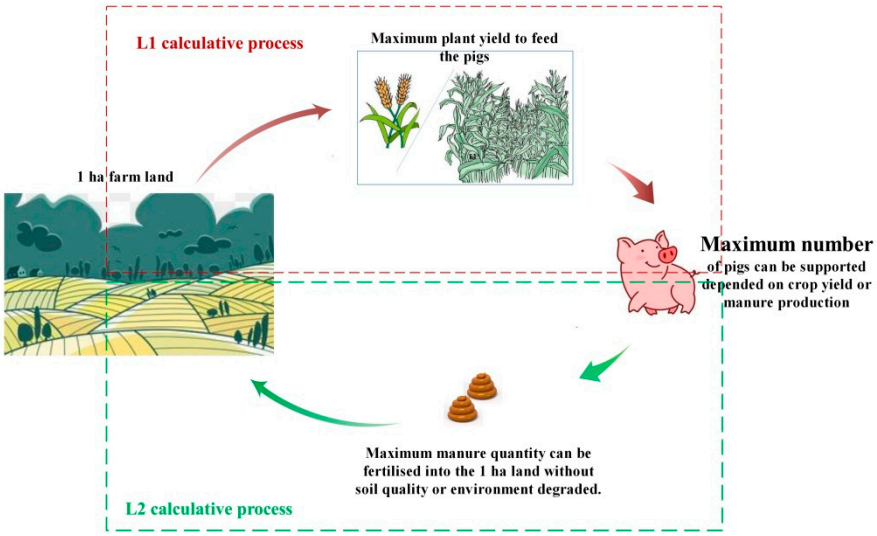

Fig. S1 basic principle of the L1 and L2 calculative processes

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