

Energy Balances and Greenhouse Gas Emissions of Agriculture in the Shihezi Oasis of China

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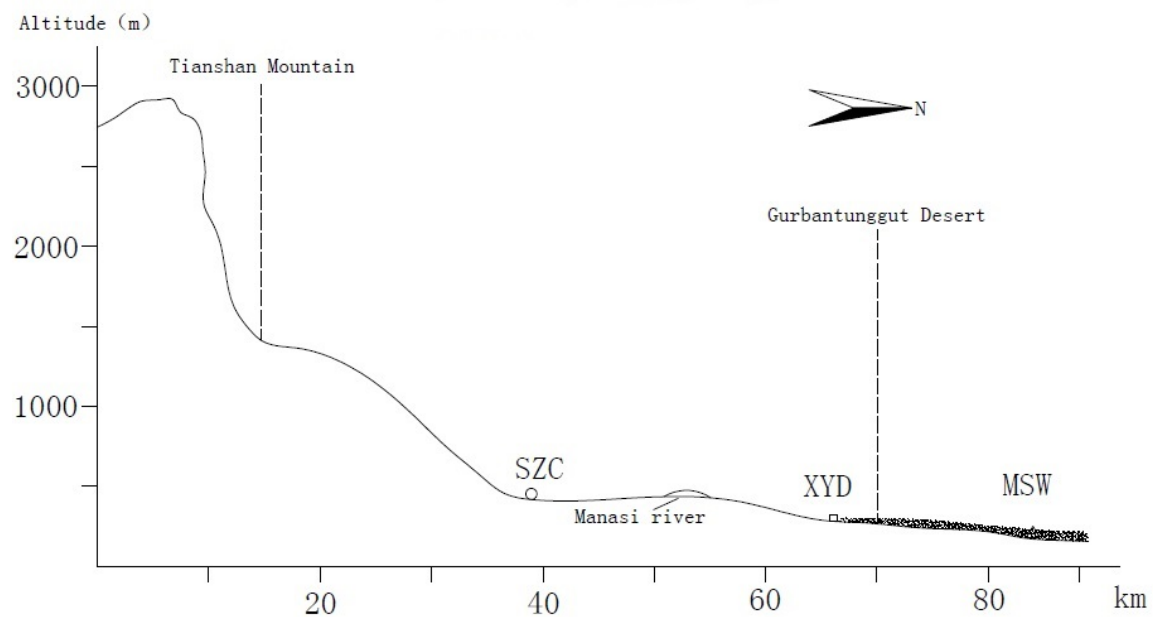


Figure S1: Longitudinal section of Shihezi study site to show Mountain-Oasis-Desert coupling ecological system (84°58'-86°64'E)

Table S1. Average data of climate, crop, and livestock of the three sub-oases in the Shihezi Oasis (2015-2016).

	SZC ¹	XYD ²	MSW ³
No. of farm surveys	57	194	103
Climate condition			
Annual mean temperature (°C)	9.1	8.8	8.3
Annual rainfall (mm)	211.5	123.6	91.5
Elevation (m)	429	353	362
Groundwater level (m)	17	21	23
Cropland (ha)			
Wheat (Spring)	40.93	30.67	8.13
Maize	12.00	28.00	61.67
Cotton	73.0	124.90	43.77
Alfalfa	0.00	82.93	27.20
Grape	0.00	27.87	66.40
Tomato	53.80	0.00	0.00
Livestock (sheep units ⁴ : head)			
Sheep	29400	163900	117200
Dairy cattle	384	872	648

Beef cattle

1632

4032

2784

¹SZC: Shizongchang; ²SZC: Xiayedi; ³SZC: Mosuowan; ⁴sheep: 1.0 sheep unit (SU); dairy cattle: 4.5 SU; beef cattle: 4.0 SU.

Table S2. The structured questionnaire of farm survey.

Data	Units	Source
Crop production		
labor type	-	farmer interview
labor input	hours/year	farmer interview
crop type	(e. g. maize)	farmer interview
sowing area	ha	farmer interview
seed source	-	farmer interview
amount of seeds used	kg/ha	farmer interview
rate of fertilizers used	kg/ha	farmer interview
rate of pesticide used	kg/ha	farmer interview
fuel consumption for production	kg/ha	farmer interview
amount of plastic film	kg/ha	farmer interview
farm machine type	-	farmer interview
farm machine (life and working hours)	hours/year	farmer interview
electricity consumption for irrigation	kWh/year	farmer interview
yield of crop product	kg/ha	farmer interview
yield of crop straw	kg/ha	farmer interview
market price of inputs	¥/kg	farmer interview, local government officials
market price of outputs	¥/kg	farmer interview, local government officials
net income	1,000¥/farm	farmer interview
Livestock production		
labor type	-	farmer interview
labor input	hours/year	farmer interview
category	(e.g. sheep)	farmer interview
numbers classified livestock	head/farm	farmer interview
age classified livestock	month/head	farmer interview
weight classified livestock	kg/head	farmer interview
carcass weight classified livestock	kg/head	farmer interview
milk	kg/head	farmer interview
wool	kg/head	farmer interview
feed source	-	farmer interview
feed type	(e.g. hay, forage)	farmer interview
feed usage	kg/head	farmer interview
veterinary drug usage	kg/head	farmer interview
lighting of housing structures	kWh/farm	farmer interview
coal consumption of housing structures	kg/farm	farmer interview
market price of inputs	¥/kg	farmer interview, local government officials
market price of outputs	¥/kg	farmer interview, local government officials
net income	1,000¥/farm	farmer interview

Table S3. Average market price of inputs and outputs for agricultural production (2015-2016).

Inputs	Price	Outputs	Price
Seeds (¥/kg)		Crop products (¥/kg)	
Wheat (spring)	3.00	Wheat(spring)	1.00
Maize	16.00	Maize	1.90
Cotton	6.80	Cotton	6.00
Alfalfa	40.00	Grape	2.50
Grape	3.00	Tomato	3.00
Tomato	20.00	Wheat hay	0.70
Fertilizers (¥/kg)		Maize hay	1.96
Urea	2.00	Alfalfa hay	1.50
Monoammonium phosphate	2.60	Livestock products (¥/kg)	

Phosphate fertilizers	0.50	Lamb	38.00
Compound fertilizers	1.60	Beef	60.00
Potassium	2.00	Milk	4.00
Manure	1.00	Wool	650.00
Pesticide (¥/kg)			
Herbicides	28.00		
Insecticides	22.00		
Fungicides	25.00		
Mulch (¥/kg)	0.77		
Fuel (¥/kg)	12.86		
Electricity (¥/kwh)	0.80		
Forage feed (¥/kg)			
Wheat hay	0.70		
Maize hay	1.96		
Alfalfa hay	1.50		
Concentrate feed (¥/kg)			
Maize	1.96		
Soybean	4.53		
Wheat husk	1.67		
Veterinary vaccine (¥/dose)			
Sheep	0.20		
Cattle	1.30		

Table S4. Energy balances, carbon balances, carbon economic efficiency, water use, and water use efficiency of crop grown in the Shihezi Oasis.

	Wheat (Spring)	Maize	Cotton	Alfalfa	Grape	Tomato	SED ⁶	p-value
Energy balances (GJ/ha. year)								
Input	59.53*	49.71**	58.80*	21.35	36.56	49.55**	26.127	<0.001
Output	233.01	341.21	110.54	267.23	101.59	204.15	108.338	<0.001
Balance	173.47	291.50	51.74	245.88	65.03	154.60	176.112	<0.001
NER ¹	3.95*	6.27	1.91	12.71	2.56	4.17*	9.743	<0.001
Carbon balances (Mg CO ₂ -eq/ha. year)								
Emissions ²	8.59	12.10	17.72	8.09	12.22	10.35	6.765	<0.001
Stock ³	10.41	22.87	13.11	23.76	11.01	16.99	12.891	<0.001
Balance ⁴	1.80	11.75	-4.25	15.97	-1.60	-7.28	1.865	<0.001
Carbon economic efficiency (¥/kg CO ₂ -eq)								
	0.17	1.14*	0.70	1.18*	0.41	0.31	0.232	<0.001
Water use (1000 m ³ /ha)								
	6.25	8.09	7.65	4.59	6.67*	6.56*	0.313	<0.001
Water use efficiency ⁵ (MJ/m ³)								
	27.50**	11.24	7.17*	25.67**	24.94**	23.58**	2.811	<0.001

¹NER: net energy ratio = output energy/input energy; ²GHG emissions from crop production input; ³carbon stock of the net deposition of photosynthesis from crop products, such as grain, stem, and root; ⁴carbon balances of crop production, Balance = stock-emissions; ⁵water use based on energy balances; ⁶SED: standard error of differences; (*) and (**): significant difference only exists between values with different asterisk number – i.e. there is significant difference between single (*) and double (**) asterisk values; no significant difference exists between values with the same asterisk number –i.e. there is no significant difference between (**) and (**) values.

Table S5. The standardized direct, indirect and total effects between dependent variables and predict variables.

No. of Figure 3	Dependent Variables	Predict Variables	Direct Effects	Indirect Effects	Total Effects
Figure 3 (a)	OtoD ¹	ECO ⁶	0.000	-0.969	-0.969
	SPD ²	ECO	-0.290	0.131	-0.159
	PS ³	ECO	-0.399	-0.348	-0.747
	WUE ⁴	ECO	0.034	0.196	0.230
	BS ⁵	ECO	0.647	0.000	0.647

Figure 3 (b)	OtoD	EB ⁷	0.000	-0.840	-0.840
	SPD	EB	0.224	0.272	0.521
	PS	EB	0.073	-0.471	-0.398
	WUE	EB	0.024	0.297	0.296
	BS	EB	0.898	0.000	0.898
Figure 3 (c)	OtoD	CB ⁸	0.000	-0.503	-0.503
	SPD	CB	0.435	0.330	0.864
	PS	CB	0.563	-0.571	0.046
	WUE	CB	-0.068	0.430	0.262
	BS	CB	1.091	0.000	1.091
Figure 3 (d)	OtoM ⁹	ECO	0.000	0.647	0.647
	SPD	ECO	-0.290	0.182	-0.108
	PS	ECO	-0.399	-0.318	-0.717
	WUE	ECO	0.034	0.208	0.242
	BS	ECO	0.980	0.000	0.980
Figure 3 (e)	OtoM	EB	0.000	0.815	0.815
	SPD	EB	0.224	0.335	0.559
	PS	EB	0.073	-0.430	-0.358
	WUE	EB	0.024	0.289	0.313
	BS	EB	0.898	0.000	0.898
Figure 3 (f)	OtoM	CB	0.000	0.457	0.457
	SPD	CB	0.435	0.448	0.882
	PS	CB	0.563	-0.475	0.088
	WUE	CB	-0.068	0.351	0.282
	BS	CB	1.091	0.000	1.091

¹OtoD: the distance from the oasis to the desert (km); ²SPD: soil particle diameter (μm); ³PS: planting structure (planting crop type); ⁴WUE: water use efficiency (MJ/m^3); ⁵BS: livestock breeding structure (breeding livestock category); ⁶ECO: net income ($1000\text{¥}/\text{ha}$); ⁷EB: Energy balance (GJ/ha); ⁸CB: the difference value of carbon stock minus GHG emissions from agricultural production input ($\text{Tonne CO}_2\text{-eq}/\text{ha}$); ⁹OtoM: the distance from the oasis to the desert (km). Shading indicates the greatest positive direct effect, indirect effect, and total effect between dependent and independent variables.