Supplementary Materials

Table S1. Input flows calculation for maize crop in Table 1.

Local renewable resources (R)

1 Sunlight

Land area	10,000	m^2	
Average of insolation	2.17×10^7	$J/m^2/day$	[44]
Albedo	0.13		[44]
Length of cropping cycle	180	days	
Proportion of plant population density	0.993		

Sunlight = (Land area) x (Average of insolation) x (1-Albedo) x (Length of cropping cycle) x (Proportion of plant population density)

Sunlight = ($10,000\ m^2$) x ($2.17 \times 10^7\ J/m^2/day$) x (1-0.13) x (180 days) x (0.993)

= 3.38×10^{13} J

2 Kinetic energy of wind

Land area	10,000	m^2	
Density of air	1.23	kg/m^3	[12]
Land drag coefficient	0.002		[71]
Average wind speed (10 m)	2.66	m/s	[44]
Ratio of surface wind speed to geostrophic wind speed	0.6		[72]
Geostrophic wind speed	(2.66) / (0.6)	m/s	
Length of cropping cycle	1.56×10^7	s	
Proportion of plant population density	0.993		

Kinetic energy of wind = (Land area) x (Density of air) x (Land drag coefficient) x (Geostrophic wind speed)^3 x (Length of cropping cycle) x (Proportion of plant population density)

Kinetic energy of wind = ($10,000\ m^2$) x ($1.23\ kg/m^3$) x (0.002) x ($4.43\ m/s$)^3 x (1.56×10^7 s) x (0.993)

= 3.31×10^{10} J

3 Chemical potential energy in rain

Land area	10,000	m^2	
Average annual rainfall	2.59×10^{-3}	m/day	[44]
Water density	1.00×10^6	g/m^3	
Length of cropping cycle	180	days	
Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.993		

Chemical potential energy in rain = (Land area) x (Average annual rainfall) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Chemical potential energy in rain = (10,000 m^2) x (2.59 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (180 days) x (4.74 J/g) x (0.993)

= 2.20 × 10^{10} J

4 Evapotranspiration energy

Land area	10,000	m^2	
Evapotranspiration	1.68 × 10^{-3}	m/day	
Water density	1.00 × 10^6	g/m^3	
Length of cropping cycle	180	days	
Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.993		

Evapotranspiration energy = (Land area) x (Evapotranspiration) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Evapotranspiration energy = (10,000 m^2) x (1.68 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (180 days) x (4.74 J/g) x (0.993)

= 1.42 × 10^{10} J

Reinforcing feedbacks:

6 Maize forage for animal power

Land area	10,000	m^2	
Dry weight	1.56 × 10^{-1}	$g/m^2/y$	
Time	1	y	
Energy per gram dry wt.	1.47 × 10^4	J/g	[15]

Maize forage for animal power = (Land area) x (Dry weight) x (Time) x (Energy per gram dry wt.)

Maize forage for animal power = (10,000 m^2) x (1.56 × 10^{-1} $g/m^2/y$) x (1 y) x (1.47 × 10^4 J/g)

= 2.29 × 10^7 J

8 Maize seed

Land area	10,000	m^2	
Wet weight	7.20 × 10^{-1}	$g/m^2/y$	
Time	1	y	
Fraction of average moisture	0.26		
Energy per gram wet wt.	3.65	Kcal/g	[74]
Energy per gram dry wt.	1.70 × 10^4	J/g	

Maize seed = (Land area) x (Wet weight) x (Time) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Maize seed = (10,000 m^2) x (7.20 × 10^{-1} $g/m^2/y$) x (1 y) x (1-0.26) x (1.70 × 10^4 J/g)

= 9.04 × 10^7 J

11 Renewable field labor

Planting:

Land area	10,000	m^2

Workdays	1.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 2.40×10^1 h

Fertilization:

Land area	10,000	m^2
Workdays	1.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	2	persons

Fertilization = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Fertilization = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (8 h/day/person) x (2 persons)

= 1.60×10^1 h

Hilling:

Land area	10,000	m^2
Workdays	3.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Hilling = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Hilling = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 7.20×10^1 h

Detasseling:

Land area	10,000	m^2
Workdays	2.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Detasseling = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Detasseling = (10,000 m^2) x (2.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 4.80×10^1 h

Harvest:

Land area	10,000	m^2
Workdays	3.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 7.20×10^1 h

Energy used per hour	3.50×10^2	Kcal/h	[75]
Energy used per hour	1.47×10^6	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable field labor = (Planting + Fertilization + Hilling + Detasseling + Harvest) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable field labor = (2.40×10^1 h + 1.60×10^1 h + 7.20×10^1 h + 4.80×10^1 h + 7.20×10^1 h) x (1.47×10^6 J/h) x {1-[(0.24) x (0.89]}

= 2.69×10^8 J

12 Renewable post-harvest labor

Land area	10,000	m^2	
Workdays	8.00×10^{-4}	day/m^2	
Work hours per day per person	7	h/day/person	
Number of persons	4	persons	
Energy used per hour	3.50×10^2	Kcal/h	[75]
Energy used per hour	1.47×10^6	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable post-harvest labor = (10,000 m^2) x (8.00×10^{-4} day/m^2) x (7 h/day/person) x (4 persons) x (1.47×10^6 J/h) x {1-[(0.24) x (0.89)]}

= 2.59×10^8 J

Local non-renewable resources (N)

13 Net loss of topsoil

Land area	10,000	m^2	
Fraction of organic matter	0.024		
Total annual soil erosion	5.00×10^{-1}	kg/m^2/y	
Energy of organic matter	2.26×10^7	J/kg	[14]
Time	1	y	
Proportion of plant population density	0.993		

Net loss of topsoil = (Land area) x (Fraction of organic matter) x (Total annual soil erosion) x (Energy of organic matter) x (Time) x (Proportion of plant population density)

Net loss of topsoil = (10,000 m^2) x (0.024) x (5.00×10^{-1} kg/m^2/y) x (2.26×10^7 J/kg) x (1 y) x (0.993)

= 2.72×10^9 J

Purchased resources (F)

14 Liquid motor fuel

Land area	10,000	m^2	
Volume of fuel	8.45×10^{-5}	L/m^2	
Energy of fuel	1.32×10^8	J/gal	[51]
Energy of fuel	3.49×10^7	J/L	

Liquid motor fuel = (Land area) x (Volume of fuel) x (Energy of fuel)

Liquid motor fuel = (10,000 m^2) x (8.45×10^{-5} L/m^2) x (3.49×10^7 J/L)

= 2.95×10^7 J

15 Nitrogen (urea)

Land area	10,000	m^2
Quantity of fertilizer	16	g/m^2/y
Molecular weight of N_2	28	g/mol
Molecular weight of fertilizer	60.06	g/mol
Time	1	y

Nitrogen (urea) = (Land area) x (Quantity of fertilizer) x (Molecular weight of N_2 / Molecular weight of fertilizer) x (Time)

Nitrogen (urea) = (10,000 m^2) x (16 g/m^2/y) x (28 g/mol / 60.06 g/mol) x (1 y)

= 7.46×10^4 g

16 Phosphorus (DAP)

Land area	10,000	m^2
Quantity of fertilizer	4	g/m^2/y
Molecular weight of P	30.97	g/mol
Molecular weight of fertilizer	132	g/mol
Time	1	y

Phosphorus (DAP) = (Land area) x (Quantity of fertilizer) x (Molecular weight of P / Molecular weight of fertilizer) x (Time)

Phosphorus (DAP) = (10,000 m^2) x (4 g/m^2/y) x (30.97 g/mol / 132 g/mol) x (1 y)

= 9.39×10^3 g

17 Nitrogen (DAP)

Land area	10,000	m^2
Quantity of fertilizer	4	g/m^2/y
Molecular weight of $(NH_4)_2$	36.08	g/mol
Molecular weight of fertilizer	132	g/mol
Time	1	y

Nitrogen (DAP) = (Land area) x (Quantity of fertilizer) x (Molecular weight of $(NH_4)_2$ / Molecular weight of fertilizer) x (Time)

Nitrogen (DAP) = (10,000 m^2) x (4 $g/m^2/y$) x (36.08 g/mol / 132 g/mol) x (1 y)

= 1.09×10^4 g

18 Non-renewable field labor

Planting:

Land area	10,000	m^2
Workdays	1.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 2.40×10^1 h

Fertilization:

Land area	10,000	m^2
Workdays	1.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	2	persons

Fertilization = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Fertilization = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (8 h/day/person) x (2 persons)

= 1.60×10^1 h

Hilling:

Land area	10,000	m^2
Workdays	3.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Hilling = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Hilling = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 7.20×10^1 h

Detasseling:

Land area	10,000	m^2
Workdays	2.00×10^{-4}	day/m^2
Work hours per day per person	8	h/day/person
Number of persons	3	persons

Detasseling = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Detasseling = (10,000 m^2) x (2.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 4.80×10^1 h

Harvest:

Land area	10,000	m^2	
Workdays	3.00×10^{-4}	day/m^2	
Work hours per day per person	8	h/day/person	
Number of persons	3	persons	

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (8 h/day/person) x (3 persons)

= 7.20×10^{1} h

Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable field labor = (Planting + Fertilization + Hilling + Detasseling + Harvest) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable field labor = (2.40×10^{1} h + 1.60×10^{1} h + 7.20×10^{1} h + 4.80×10^{1} h + 7.20×10^{1} h) x (1.47×10^{6} J/h) x (0.24) x (0.89)

= 7.14×10^{7} J

19 Non-renewable post-harvest labor

Land area	10,000	m^2	
Workdays	8.00×10^{-4}	day/m^2	
Work hours per day per person	7	h/day/person	
Number of persons	4	person	
Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable post-harvest labor = (10,000 m^2) x (8.00×10^{-4} day/m^2) x (7 h/day/person) x (4 persons) x (1.47×10^{6} J/h) x (0.24) x (0.89)

= 6.89×10^{7} J

20 Tractor service

Fallow:

Land area	10,000	m^2
Cost of service	1.20×10^{-1}	MX$/$m^2$

Yearly average currency exchange rate for 2018	19.24	MX$/US$	[48]

Fallow = [(Land area) x (Cost of service)] / (Yearly average currency exchange rate for 2018)

Fallow = [(10,000 m^2) x (1.20 × 10^{-1} MX$/$m^2$)] / (19.24 MX$/US$)

= 6.24 × 10^1 US$

Furrowed:

Land area	10,000	m^2	
Cost of service	8.00 × 10^{-2}	MX$/$m^2$	
Yearly average currency exchange rate for 2018	19.24	MX$/US$	[48]

Furrowed = [(Land area) x (Cost of service)] / (Yearly average currency exchange rate for 2018)

Furrowed = [(10,000 m^2) x (8.00 × 10^{-2} MX$/$m^2$)] / (19.24 MX$/US$)

= 4.16 × 10^1 US$

Tractor service = (Fallow) + (Furrowed)

Tractor service = (6.24 × 10^1 US$) + (4.16 × 10^1 US$)

= 1.04 × 10^2 US$

Table S2. Input flows calculation for bean crop in Table 1.

Local renewable resources (R)

1 Sunlight

Land area	10,000	m^2	
Average of insolation	2.17 × 10^7	J/m^2/day	[44]
Albedo	0.13		[44]
Length of cropping cycle	150	days	
Proportion of plant population density	0.003		

Sunlight = (Land area) x (Average of insolation) x (1-Albedo) x (Length of cropping cycle) x (Proportion of plant population density)

Sunlight = (10,000 m^2) x (2.17 × 10^7 J/m^2/day) x (1-0.13) x (150 days) (0.003)

= 9.15 × 10^{10} J

2 Kinetic energy of wind

Land area	10,000	m^2	
Density of air	1.23	kg/m^3	[12]
Land drag coefficient	0.002		[71]
Average wind speed (10 m)	2.66	m/s	
Ratio of surface wind speed to geostrophic wind speed	0.6		[72]
Geostrophic wind speed	(2.66) / (0.6)	m/s	
Length of cropping cycle	1.30 × 10^7	s	
Proportion of plant population density	0.003		

Kinetic energy of wind = (Land area) x (Density of air) x (Land drag coefficient) x (Geostrophic wind speed)^3 x (Length of cropping cycle) x (Proportion of plant population density)

Kinetic energy of wind = (10,000 m^2) x (1.23 kg/m^3) x (0.002) x (4.43 m/s)^3 x (1.30 × 10^7 s) x (0.003)

= 8.97 × 10^7 J

3 Chemical potential energy in rain

Land area	10,000	m^2	
Average annual rainfall	2.59 × 10^{-3}	m/day	[44]
Water density	1.00 × 10^6	g/m^3	
Length of cropping cycle	150	days	
Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.003		

Chemical potential energy in rain = (Land area) x (Average annual rainfall) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Chemical potential energy in rain = (10,000 m^2) x (2.59 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (150 days) x (4.74 J/g) x (0.003)

= 5.95 × 10^7 J

4 Evapotranspiration energy

Land area	10,000	m^2	
Evapotranspiration	1.67 × 10^{-3}	m/day	
Water density	1.00 × 10^6	g/m^3	
Length of cropping cycle	150	days	
Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.003		

Evapotranspiration energy = (Land area) x (Evapotranspiration) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Evapotranspiration energy = (10,000 m^2) x (1.67 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (150 days) x (4.74 J/g) x (0.003)

= 3.83 × 10^7 J

Reinforcing feedbacks:

7 Bean plant residues

Land area	10,000	m^2	
Dry weight of the plant	2.49 × 10^{-1}	$g/m^2/y$	
Time	1	y	
Energy per gram dry wt.	15.01	MJ/kg	[16]
Energy per gram dry wt.	1.50 × 10^4	J/g	

Bean plant residues = (Land area) x (Dry weight of the plant) x (Time) x (Energy per gram dry wt.)

Bean plant residues = (10,000 m^2) x (2.49 × 10^{-1} $g/m^2/y$) x (1 y) x (1.50 × 10^4 J/g)

= 3.74×10^{7} J

9 Bean seed

Land area	10,000	m^2	
Wet weight	2.00×10^{-2}	$g/m^2/y$	
Time	1	y	
Fraction of average moisture	0.12		
Energy per gram wet wt.	3.33	Kcal/g	[74]
Energy per gram dry wt.	1.58×10^{4}	J/g	

Bean seed = (Land area) x (Wet weight) x (Time) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Bean seed = (10,000 m^2) x (2.00×10^{-2} $g/m^2/y$) x (1 y) x (1-0.12) x (1.58×10^{4} J/g)

= 2.79×10^{6} J

11 Renewable field labor

Planting:

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	2.60×10^{-2}	h/day/person	
Number of persons	3	persons	

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (2.60×10^{-2} h/day/person) x (3 persons)

= 7.80×10^{-2} h

Harvest:

Land area	10,000	m^2	
Workdays	3.00×10^{-4}	day/m^2	
Work hours per day per person	2.60×10^{-2}	h/day/person	
Number of persons	3	persons	

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (2.60×10^{-2} h/day/person) x (3 persons)

= 2.34×10^{-1} h

Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable field labor = (Planting + Harvest) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable field labor = (7.80×10^{-2} h + 2.34×10^{-1} h) x (1.47×10^{6} J/h) x {1-[(0.24) x (0.89)]}

= 3.61×10^{5} J

12 Renewable post-harvest labor

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	5.00×10^{-1}	h/day/person	
Number of persons	1	person	
Energy used per hour	3.50×10^2	Kcal/h	[75]
Energy used per hour	1.47×10^6	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable post-harvest labor = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (5.00×10^{-1} h/day/person) x (1 person) x (1.47×10^6 J/h) x {1-[(0.24) x (0.89)]}

= 5.79×10^5 J

Local non-renewable resources (N)

13 Net loss of topsoil

Land area	10,000	m^2	
Fraction of organic matter	0.024		
Total annual soil erosion	5.00×10^{-1}	kg/m^2/y	
Energy of organic matter	2.26×10^7	J/kg	[14]
Time	1	y	
Proportion of plant population density	0.003		

Net loss of topsoil = (Land area) x (Fraction of organic matter) x (Total annual soil erosion) x (Energy of organic matter) x (Time) x (Proportion of plant population density)

Net loss of topsoil = (10,000 m^2) x (0.024) x (5.00×10^{-1} kg/m^2/y) x (2.26×10^7 J/kg) x (1 y) x (0.003)

= 8.83×10^6 J

Purchased resources (F)

14 Liquid motor fuel

Land area	10,000	m^2	
Volume of fuel	2.11×10^{-5}	L/m^2	
Energy of fuel	1.32×10^8	J/gal	[51]
Energy of fuel	3.49×10^7	J/L	

Liquid motor fuel = (Land area) x (Volume of fuel) x (Energy of fuel)

Liquid motor fuel = (10,000 m^2) x (2.11×10^{-5} L/m^2) x (3.49×10^7 J/L)

= 7.37×10^6 J

18 Non-renewable field labor

Planting:

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	2.60×10^{-2}	h/day/person	
Number of persons	3	persons	

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (2.60×10^{-2} h/day/person) x (3 persons)

= 7.80×10^{-2} h

Harvest:

Land area	10,000	m^2	
Workdays	3.00×10^{-4}	day/m^2	
Work hours per day per person	2.60×10^{-2}	h/day/person	
Number of persons	3	persons	

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (2.60×10^{-2} h/day/person) x (3 persons)

= 2.34×10^{-1} h

Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable field labor = (Planting + Harvest) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable field labor = (7.80×10^{-2} h + 2.34×10^{-1} h) x (1.47×10^{6} J/h) x (0.24) x (0.89)

= 9.61×10^{4} J

19 Non-renewable post-harvest labor

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	5.00×10^{-1}	h/day/person	
Number of persons	1	person	
Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable post-harvest labor = (10,000 m^2) x (1.00 × 10^{-4} day/m^2) x (5.00 × 10^{-1} h/day/person) x (1 person) x (1.47 × 10^6 J/h) x (0.24) x (0.89)

= 1.54 × 10^5 J

Table S3. Input flows calculation for squash crop in Table 1.

Local renewable resources (R)

1 Sunlight

Land area	10,000	m^2	
Average of insolation	2.17 × 10^7	J/m^2/day	[44]
Albedo	0.13		[44]
Length of cropping cycle	180	days	
Proportion of plant population density	0.003		

Sunlight = (Land area) x (Average of insolation) x (1-Albedo) x (Length of cropping cycle) x (Proportion of plant population density)

Sunlight = (10,000 m^2) x (2.17 × 10^7 J/m^2/day) x (1-0.13) x (180 days) x (0.003)

= 1.16 × 10^{11} J

2 Kinetic energy of wind

Land area	10,000	m^2	
Density of air	1.23	kg/m^3	[12]
Land drag coefficient	0.002		[71]
Average wind speed (10 m)	2.66	m/s	[44]
Ratio of surface wind speed to geostrophic wind speed	0.6		[72]
Geostrophic wind speed	(2.66) / (0.6)	m/s	
Length of cropping cycle	1.56 × 10^7	s	
Proportion of plant population density	0.003		

Kinetic energy of wind = (Land area) x (Density of air) x (Land drag coefficient) x (Geostrophic wind speed)^3 x (Length of cropping cycle) x (Proportion of plant population density)

Kinetic energy of wind = (10,000 m^2) x (1.23 kg/m^3) x (0.002) x (4.43 m/s)^3 x (1.56 × 10^7 s) x (0.003)

= 1.13 × 10^8 J

3 Chemical potential energy in rain

Land area	10,000	m^2	
Average annual rainfall	2.59 × 10^{-3}	m/day	[44]
Water density	1.00 × 10^6	g/m^3	
Length of cropping cycle	180	days	

Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.003		

Chemical potential energy in rain = (Land area) x (Average annual rainfall) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Chemical potential energy in rain = (10,000 m^2) x (2.59 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (180 days) x (4.74 J/g) x (0.003)

= 7.52 × 10^7 J

4 Evapotranspiration energy

Land area	10,000	m^2	
Evapotranspiration	1.67 × 10^{-3}	m/day	
Water density	1.00 × 10^6	g/m^3	
Length of cropping cycle	180	days	
Gibbs free energy	4.74	J/g	[73]
Proportion of plant population density	0.003		

Evapotranspiration energy = (Land area) x (Evapotranspiration) x (Water density) x (Length of cropping cycle) x (Gibbs free energy) x (Proportion of plant population density)

Evapotranspiration energy = (10,000 m^2) x (1.67 × 10^{-3} m/day) x (1.00 × 10^6 g/m^3) x (180 days) x (4.74 J/g) x (0.003)

= 4.83 × 10^7 J

Reinforcing feedbacks:

5 Squash plant residues

Land area	10,000	m^2	
Dry weight of the plant	2.91 × 10^1	g/m^2/y	
Time	1	y	
Energy per gram wet wt.	0.19	Kcal/g	[74]
Energy per gram dry wt.	1.12 × 10^4	J/g	

Squash plant residues = (Land area) x (Dry weight of the plant) x (Time) x (Energy per gram dry wt.)

Squash plant residues = (10,000 m^2) x (2.91 × 10^1 g/m^2/y) x (1 y) x (1.12 × 10^4 J/g)

= 3.25 × 10^9 J

10 Squash seed

Land area	10,000	m^2	
Wet weight	1.60 × 10^{-2}	g/m^2/y	
Time	1	y	
Fraction of average moisture	0.07		[74]
Energy per gram wet wt.	5.41	Kcal/g	[74]
Energy per gram dry wt.	2.43 × 10^4	J/g	

Squash seed = (Land area) x (Wet weight) x (Time) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Squash seed = (10,000 m^2) x (1.60×10^{-2} $g/m^2/y$) x (1 y) x (1-0.07) x (2.43×10^4 J/g)

= 3.62×10^6 J

11 Renewable field labor

Planting:

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	2.74×10^{-2}	h/day/person	
Number of persons	3	persons	

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (2.74×10^{-2} h/day/person) x (3 persons)

= 8.22×10^{-2} h

Harvest:

Land area	10,000	m^2	
Workdays	3.00×10^{-4}	day/m^2	
Work hours per day per person	2.74×10^{-2}	h/day/person	
Number of persons	3	persons	

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (2.74×10^{-2} h/day/person) x (3 persons)

= 2.47×10^{-1} h

Energy used per hour	3.50×10^2	Kcal/h	[75]
Energy used per hour	1.47×10^6	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable field labor = (Planting + Harvest) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable field labor = (8.22×10^{-2} h + 2.47×10^{-1} h) x (1.47×10^6 J/h) x {1-[(0.24) x (0.89)]}

= 3.80×10^5 J

12 Renewable post-harvest labor

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	5.00×10^{-1}	h/day/person	
Number of persons	1	person	
Energy used per hour	3.50×10^2	Kcal/h	[75]
Energy used per hour	1.47×10^6	J/h	

Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x {1-[(Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)]}

Renewable post-harvest labor = (10,000 m^2) x (1.00 × 10^{-4} day/m^2) x (5.00 × 10^{-1} h/day/person) x (1 person) x (1.47 × 10^6 J/h) x {1-[(0.24) x (0.89)]}

= 5.79 × 10^5 J

Local non-renewable resources (N)

13 Net loss of topsoil

Land area	10,000	m^2	
Fraction of organic matter	0.024		
Total annual soil erosion	5.00 × 10^{-1}	kg/m^2/y	
Energy of organic matter	2.26 × 10^7	J/kg	[14]
Time	1	y	
Proportion of plant population density	0.003		

Net loss of topsoil = (Land area) x (Fraction of organic matter) x (Total annual soil erosion) x (Energy of organic matter) x (Time) x (Proportion of plant population density)

Net loss of topsoil = (10,000 m^2) x (0.024) x (5.00 × 10^{-1} kg/m^2/y) x (2.26 × 10^7 J/kg) x (1 y) x (0.003)

= 9.30 × 10^6 J

Purchased resources (F)

14 Liquid motor fuel

Land area	10,000	m^2	
Volume of fuel	2.11 × 10^{-5}	L/m^2	
Energy of fuel	1.32 × 10^8	J/gal	[51]
Energy of fuel	3.49 × 10^7	J/L	

Liquid motor fuel = (Land area) x (Volume of fuel) x (Energy of fuel)

Liquid motor fuel = (10,000 m^2) x (2.11 × 10^{-5} L/m^2) x (3.49 × 10^7 J/L)

= 7.37 × 10^6 J

18 Non-renewable field labor

Planting:

Land area	10,000	m^2
Workdays	1.00 × 10^{-4}	day/m^2
Work hours per day per person	2.74 × 10^{-2}	h/day/person
Number of persons	3	persons

Planting = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Planting = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (2.74×10^{-2} h/day/person) x (3 persons)

= 8.22×10^{-2} h

Harvest:

Land area	10,000	m^2	
Workdays	3.00×10^{-4}	day/m^2	
Work hours per day per person	2.74×10^{-2}	h/day/person	
Number of persons	3	persons	

Harvest = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons)

Harvest = (10,000 m^2) x (3.00×10^{-4} day/m^2) x (2.74×10^{-2} h/day/person) x (3 persons)

= 2.47×10^{-1} h

Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable field labor = (Planting + Harvest) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable field labor = (8.22×10^{-2} h + 2.47×10^{-1} h) x (1.47×10^{6} J/h) x (0.24) x (0.89)

= 1.01×10^{5} J

19 Non-renewable post-harvest labor

Land area	10,000	m^2	
Workdays	1.00×10^{-4}	day/m^2	
Work hours per day per person	5.00×10^{-1}	h/day/person	
Number of persons	1	person	
Energy used per hour	3.50×10^{2}	Kcal/h	[75]
Energy used per hour	1.47×10^{6}	J/h	
Fraction of persons who work in the milpa and outside in the regional economy	0.24		
Average non-renewable fraction	0.89		[60]

Non-renewable post-harvest labor = (Land area) x (Workdays) x (Work hours per day per person) x (Number of persons) x (Energy used per hour) x (Fraction of persons who work in the milpa and outside in the regional economy) x (Average non-renewable fraction)

Non-renewable post-harvest labor = (10,000 m^2) x (1.00×10^{-4} day/m^2) x (5.00×10^{-1} h/day/person) x (1 person) x (1.47×10^{6} J/h) x (0.24) x (0.89)

= 1.54×10^{5} J

Table S4. Calculations of annual production of the co-products and splits in Table 2.

a Squash plant residues

Land area	10,000	m^2

Squash fruit units	8.64×10^{-3}	U/m²	This study
Average weight per squash fruit wet wt.	1743.58	g/U	[76–78]
Average dry weight of squash biomass (from reference)	1.20×10^{4}	g/m²	[79]
Average wet weight of squash fruit (from reference)	6.20×10^{3}	g/m²	[79]
Biomass to fruit reference ratio	(1.20×10^{4}) / (6.20×10^{3})		
Energy per gram wet wt.	0.19	Kcal/g	[74]
Energy per gram dry wt.	1.12×10^{4}	J/g	

Squash plant residues = (Land area) x (Squash fruit units) x (Average weight per squash fruit wet wt.) x (Biomass to fruit reference ratio) x (Energy per gram dry wt.)

Squash plant residues = (10,000 m²) x (8.64×10^{-3} U/m²) x (1743.58 g/U) x (1.93) x (1.12×10^{4} J/g)

= 3.25×10^{9} J

b Maize forage

Land area	10,000	m²	
Dry maize grain yield	1.08×10^{2}	g/m²	This study
Average dry weight of biomass (from reference)	375.63	g/m²	[80]
Average maize grain yield (from reference)	288.33	g/m²	[80]
Biomass to maize grain yield reference ratio	(375.63) / (288.33)		
Energy per gram dry wt.	1.47×10^{4}	J/g	[15]

Maize forage = (Land area) x (Dry maize grain yield) x (Biomass to maize grain yield reference ratio) x (Energy per gram dry wt.)

Maize forage = (10,000 m²) x (1.08×10^{2} g/m²) x (1.30) x (1.47×10^{4} J/g)

= 2.06×10^{10} J

b1 Maize forage for animal power

Land area	10,000	m²	
Dry weight	1.56×10^{-1}	g/m²	This study
Energy per gram dry wt.	1.47×10^{4}	J/g	[15]

Maize forage for animal power = (Land area) x (Dry weight) x (Energy per gram dry wt.)

Maize forage for animal power = (10,000 m²) x (1.56×10^{-1} g/m²) x (1.47×10^{4} J/g)

= 2.29×10^{7} J

b2 Maize forage (animal feed)

Total maize forage	2.06×10^{10}	J
Maize forage for animal power	2.29×10^{7}	J

Maize forage (animal feed) = (Total maize forage) - (Maize forage for animal power)

Maize forage (animal feed) = (2.06×10^{10} J) - (2.29×10^{7} J)

= 2.06×10^{10} J

c Bean plant residues

Land area	10,000	m^2	
Dry bean yield	0.16	g/m^2	This study
Average dry weight of biomass (from reference)	281.53	g/m^2	[16,81,82]
Average bean yield (from reference)	180.87	g/m^2	[16,81,82]
Biomass to bean yield reference ratio	(281.53) / (180.87)		
Energy per gram dry wt.	15.01	MJ/kg	[16]
Energy per gram dry wt.	1.50×10^4	J/g	

Bean plant residues = (Land area) x (Dry bean yield) x (Biomass to bean yield reference ratio) x (Energy per gram dry wt)

Bean plant residues = (10,000 m^2) x (0.16 g/m^2) x (1.56) x (1.50×10^4 J/g)

= 3.74×10^{7} J

d Maize grain

Land area	10,000	m^2	
Wet weight	146.28	g/m^2	This study
Fraction of average moisture	0.26		This study
Energy per gram wet wt.	3.65	Kcal/g	[74]
Energy per gram dry wt.	1.70×10^4	J/g	

Maize grain = (Land area) x (Wet weight) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Maize grain = (10,000 m^2) x (146.28 g/m^2) x (1-0.26) x (1.70×10^4 J/g)

= 1.84×10^{10} J

d1 Maize seed for planting

Land area	10,000	m^2	
Wet weight	0.72	g/m^2	This study
Fraction of average moisture	0.26		This study
Energy per gram wet wt.	3.65	Kcal/g	[74]
Energy per gram dry wt.	1.70×10^4	J/g	

Maize seed for planting = (Land area) x (Wet weight) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Maize seed for planting = (10,000 m^2) x (0.72 g/m^2) x (1-0.26) x (1.70×10^4 J/g)

= 9.04×10^{7} J

d2 Maize grain for family consumption

Total maize grain	1.84×10^{10}	J

Maize seed for planting	9.04×10^{7}	J	

maize grain for family consumption = (Total maize grain) - (Maize seed for planting)

maize grain for family consumption = (1.84×10^{10} J) - (9.04×10^{7} J)

= 1.83×10^{10} J

e Bean

Land area	10,000	m^2	
Wet weight	0.16	g/m^2	This study
Fraction of average moisture	0.12		[74]
Energy per gram wet wt.	3.33	Kcal/g	[74]
Energy per gram dry wt.	1.58×10^{4}	J/g	

Bean = (Land area) x (Wet weight) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Bean = (10,000 m^2) x (0.16 g/m^2) x (1-0.12) x (1.58×10^{4} J/g)

= 2.23×10^{7} J

e1 Bean seed for planting

Land area	10,000	m^2	
Wet weight	0.02	g/m^2	This study
Fraction of average moisture	0.12		[74]
Energy per gram wet wt.	3.33	Kcal/g	[74]
Energy per gram dry wt.	1.58×10^{4}	J/g	

Bean seed for planting = (Land area) x (Wet weight) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Bean seed for planting = (10,000 m^2) x (0.02 g/m^2) x (1-0.12) x (1.58×10^{4} J/g)

= 2.79×10^{6} J

e2 Bean for family consumption

Total bean	2.23×10^{7}	J	
Been seed for planting	2.79×10^{6}	J	

Bean for family consumption = (Total bean) - (Bean seed for planting)

Bean for family consumption = (2.23×10^{7} J) - (2.79×10^{6} J)

= 1.95×10^{7} J

f Squash seed

Land area	10,000	m^2	
Squash fruit units	8.64×10^{-3}	U/m^2	This study
Average weight per squash fruit wet wt.	1743.58	g/U	[76–78]
Fraction of seed	0.03		[76–78]
Fraction of average moisture	0.07		[74]
Energy per gram wet wt.	5.41	Kcal/g	[74]
Energy per gram dry wt.	2.43×10^{4}	J/g	

Squash seed = (Land area) x (Squash fruit units) x (Average weight per squash fruit wet wt.) x (Fraction of seed) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Squash seed = (10,000 m^2) x (8.64×10^{-3} U/m^2) x (1743.58 g/U) x (0.03) x (1-0.07) x (2.43×10^4 J/g)

= 1.05×10^8 J

f1 Squash seed for planting

Land area	10,000	m^2	
Wet weight	1.60×10^{-2}	g/m^2	This study
Fraction of average moisture	0.07		[74]
Energy per gram wet wt.	5.41	Kcal/g	[74]
Energy per gram dry wt.	2.43E+04	J/g	

Squash seed for planting = (Land area) x (Wet weight) x (1-Fraction of average moisture) x (Energy per gram dry wt.)

Squash seed for planting = (10,000 m^2) x (1.60×10^{-2} g/m^2) x (1-0.07) x (2.43×10^4 J/g)

= 3.62×10^6 J

f2 Squash seed for family consumption

Total squash seed	1.05×10^8	J
Squash seed for planting	3.62×10^6	J

Squash seed for family consumption = (Total squash seed) - (Squash seed for planting)

squash seed for family consumption = (1.05×10^8 J) - (3.62×10^6 J)

= 1.01×10^8 J

g Squash pulp

Land area	10,000	m^2	
Squash fruit units	8.64×10^{-3}	U/m^2	This study
Average weight per squash fruit wet wt.	1743.58	g/U	[76–78]
Edible fraction of squash	0.53		[74]
Fraction of seed	0.03		[76–78]
Fraction of average moisture (edible fraction)	0.91		[74]
Fraction of average moisture (seed fraction)	0.07		[74]
Energy per gram wet wt.	0.30	Kcal/g	[74]
Energy per gram dry wt.	1.39×10^4	J/g	

Squash pulp = (Land area) x (Squash fruit units) x {[(Average weight per squash fruit wet wt.) x (Edible fraction of squash) x (1-Fraction of average moisture of edible fraction of squash)] - [(Average weight per squash fruit wet wt.) x (Fraction of seed) x (1-Fraction of average moisture of seed fraction)]} x (Energy per gram dry wt.)

Squash pulp = (10,000 m^2) x (8.64×10^{-3} U/m^2) x {[(1743.58 g/U) x (0.53) x (1-0.91)] - [(1743.58 g/U) x (0.03) x (1-0.07)]} x (1.39×10^4 J/g)

= 3.99×10^7 J

Table S5. GEBs and their respective equivalency factor for adjusting the UEVs to a reference GEB of 12.00 × 10^{24} seJ y^{-1}.

GEB (× 10^{24}) (seJ y^{-1})	Reference	Equivalency factor
09.44	[12]	1.2711
09.26	[83]	1.2958
15.83	[84]	0.7581
09.26	[85,86]	1.2958
15.20	[87]	0.7895
12.00	[50]	1