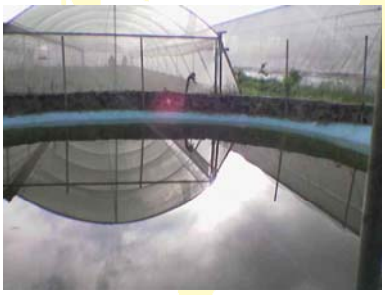
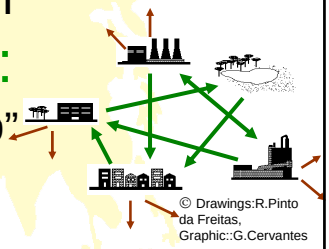
INDUSTRIAL ECOLOGY

"Measuring Sustainability in Industrial Ecosystems: Farming systems in México"





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INDUSTRIAL ECOLOGY

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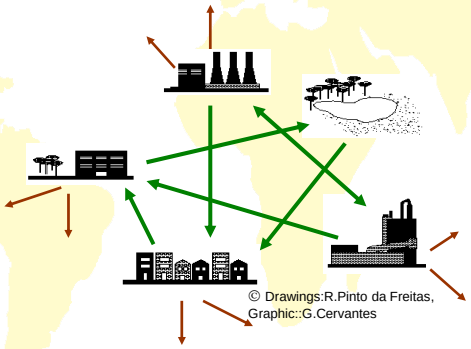
1. What is Industrial Ecology



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Industrial and Ecology??

A multidisciplinary approach the ultimate goal of which is to have **industrial systems operate like natural ecosystems** by having industries, society and nature interact mutually in cycling matter and by increasing process efficiency*.

*** Cervantes (2007) Ecología Industrial.**

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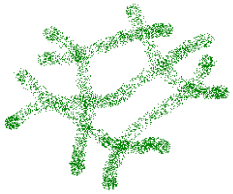

Sinergies **Networks**

Industrial systems tend towards **sustainable systems**

MODEL: Natural ecosystems

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Industrial Ecology Criteria

Material (water)

Dematerialization
Resources optimization
Reusing, Recycling
Closed loop systems
New technologies

Energy

Ecoeficiency
Renewable Energies

Social

Resource distribution
Creating new jobs
Increasing quality of jobs
Giving value to diversity
Decentralising technology
Increasing local social capital
Promoting networks

Economy

Internalizing Externalities
Economy Diversification
Efficient Technologies

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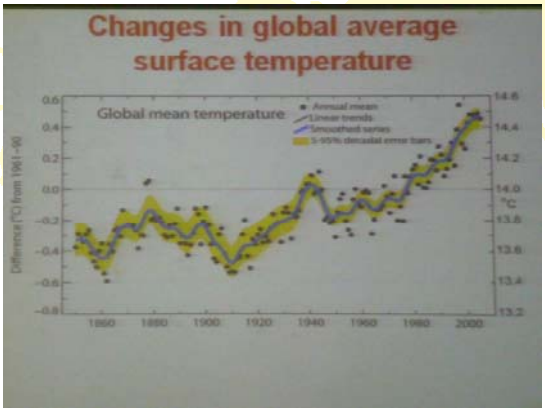
2. México and Climate Change



Rachauri, IPCC 2009

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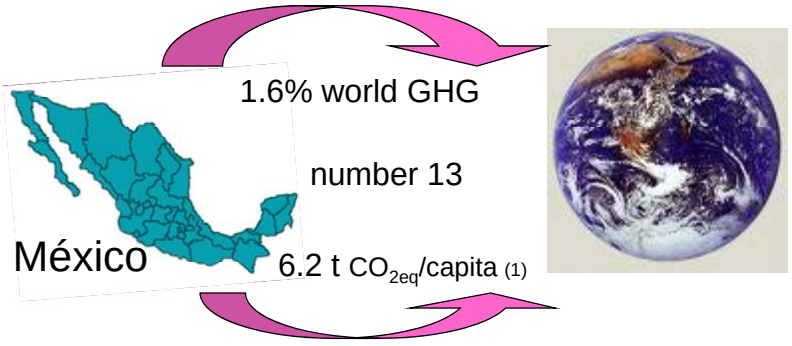

(1) Gay, 2006

Mexican target:

reducing 50% GHG emissions in 2050 (2000 levels)

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CC: Impacts (1)

(1) Rachauri, IPCC 2009

- Increase in frequency and strength of huracans in the mexican coast
- 30% yield reduction in agriculture in Latin America by 2080
- 12-81 million people in LA will suffer water stress by 2020
- Significant biodiversity loss

CC: Costs (2)

(2) SEMARNAT 2009

4% GDP México — Paying for CC consequences

0,65% GDP México — MITIGATION ACTIONS

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3. Farming systems in México

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México

More than 4 million small production units (agricultural + forestry) (1)

35.2% area of México

(1) Censo agropecuario de México, 2007

Farming systems in México: area

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Agricultural sector GHG emissions	Transport sector GHG emissions	
13,5%	13,1%	WORLD (1)
8,3%	20,8%	MÉXICO (2)

1. FAO, WWI, 2004 2. Inventario de Emisiones de México 2002

Farming systems in México: GHG emissions

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4. Justification and objectives

IE may contribute to increasing sustainability in agricultural systems

Reducing GHG emissions in all sectors. Agriculture is one of the main productive sectors in Mexico

GHG emissions must be measured in order to know the amount of GHG emissions reduction

Applying Industrial Ecology criteria to farming systems in México and measuring their sustainability (including GHG emissions)

Importance of developing sustainability measuring systems

Importance of applying sustainability tools to industrial ecosystems

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5. Systems studied

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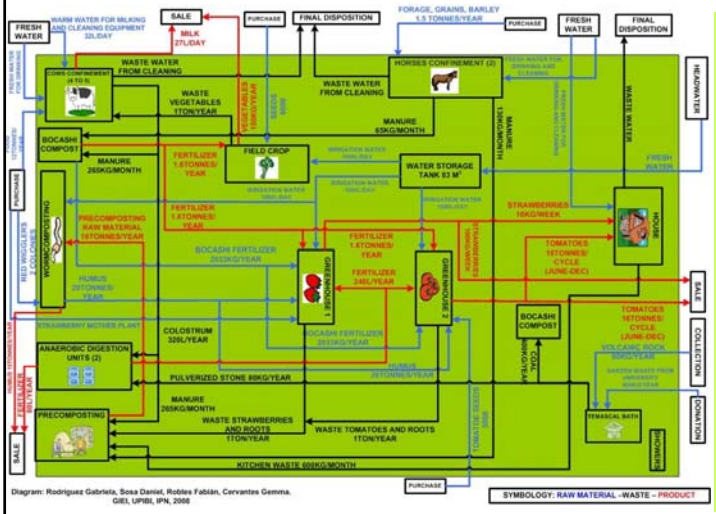
Xochimancas farm



Total Area = 2000 m²
Crops Area = 900 m²
Workers = 4
Horses = 2
Cows =5
Crops = organic vegetables
Temascal (traditional steam bath)
Waste valuation = Biofertilizers: vermicomposting, Bocashi type composting anaerobic decomposition

Proyecto IPN SIP2008 "Aplicación de *Criterios de Ecología Industrial en un Sistema Agrario*"

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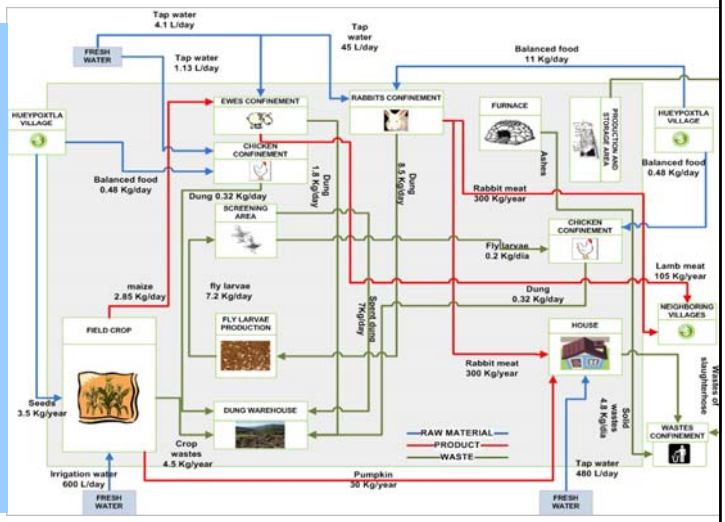
Tochtli farm

Total Area = 2500 m²
Crops Area = 100 m²
Workers = 3
Rabbits = 24
Chicken =13
Ewes= 3
Crops: corn, pumkins
Wood oven
Waste valuation: fly larvae from manure as chicken feed



Proyecto IPN SIP2009 069 "*Valorización de Residuos Agropecuarios según los Criterios de la Ecología Industrial*"

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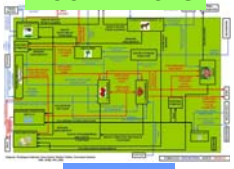
Actions developed in farms

- Data systematization
- Flow diagrams: raw material, wastes, products, water, social aspects
- Proposals for new sinergies and waste valuation
- Design and calculation of a set of sustainable indicators
- GHG emissions calculation

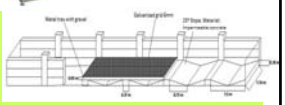
XOCHIMANCAS



Composting Analyses: vermicomposting, anaerobic digestion unit

Solar thermal energy proposal

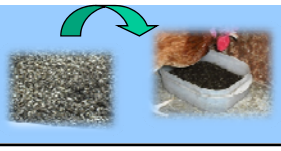
Design of a new vessel for the recovery of humic and fulvic acids in the vermicomposting unit



TOCHTLI

Fly larvae nutritional analysis

Improving use of fly larvae as chicken feed



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6 . Sustainability indicators

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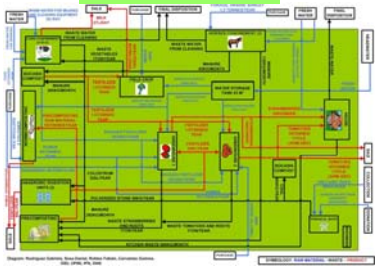
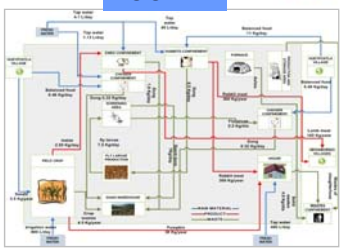
XOCHIMANCAS



42 indicators:
21 environmental
11 economic
10 social

TOCHTLI



65 indicators:
38 environmental
12 economic
15 social

63%
created for the projects

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OBJECTIVE	THEME	INDICATOR	TOCHTLI	XOCHIM.
Closure of material cycles	wastes as raw material.	Use of manure as raw material (Kg/year)	3100.0	
		Use of crop wastes as raw material (Kg/year)	9.0	
		Use of fly larvae as fowl feed (Kg/year)	73.0	----
		Use of organic wastes as fertilizers (Kg/year)	3109.0	
		Total solid wastes produced (Kg/year)	613.2	----
		Quantity of wastes used as raw material/Quantity of total wastes produced. (%)	56.0	100
		Quantity of manure used as raw material/Quantity of total manure produced. (%)	80.0	100
Reduction in material and natural resource use	Fertilizer use.	Use of chemical fertilizers (Kg/year)	0	0
		Quantity of wastes sold as fertilizers (Kg/year)	0	4.8
		Quantity of waste used as fertilizer/Quantity of total fertilizer used (%)	100.0	100
	Water use	Use of tap water (m3/year)	239.0	812
		Use of water for irrigation (m3/year)	219.0	576
		Use of reused water (m3/year)	0	0
	Food consumption for birds.	Quantity of fly larvae used as a fowl feed/ Quantity of total fowl feed (%)	30.0	---
Reduction in the use of hazardous substances	Chemical substances use	Use of pesticides (L/year)	0	0
	Reduction in the use of chemicals	Percentage of non-hazardous substances used in substitution of chemicals	100.0	100
Reduction in energy use and/or in the use of energy from non-renewable sources.	Energy consumption	Energy consumption (Kwh/year)	6230.4	7115
	Use of non-renewable energy sources	Use of gas (Kg/year)	720.0	1600
		Use of non-renewable energy sources (Kwh/year)	6230.4	7115
Increase in the use of alternative energies	Use of renewable energy sources	Use of renewable energy sources (Kwh/year)	0	0

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ECONOMIC

OBJECTIVE	THEME	INDICATOR	TOCHTLI	XOCHIM.
Reduction of environmental costs	Water use	Water fees (USD/year)	144	435
	Reduction of raw material costs	money saved by using fly larvae as fowl feed (USD/year)	44	---
		money saved by using manure as fertilizer (USD/year)	1434	3100
Obtaining profits by using wastes	Obtaining profits by using wastes	Money earned by fertilizer sold (USD/year)	0	6000
Investment in quality improvement and in corporate social responsibility	quality improvement	invested money in quality improvement (USD/year)	1000	2000
	corporate social responsibility	invested money in corporate social responsibility (USD/year)	1000	0

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SOCIAL

OBJECTIVE	THEME	INDICATOR	TOCHTLI	XOCHIM.
Network creation and Information dissemination	Information dissemination	Number of dissemination activities	3	5
		Assistants to dissemination activities	150	117
		Number of information exchanges	3	3
Increasing local social capital	Social cohesion	Increase of number of productive relations after the project	20	60
	Enterprise relations	Increase of number of new stakeholders after the project	1	1
Promotion of R&D activities	R&D activities	Number of R&D projects developed in the farm.	1	1
		Number of new technologies developed.	3	2
		number of researchers working in the project	3	4
		Number of new activities/projects that could be started	5	3
Promotion of the education	development of academic works	Number of students working in the project	3	4
Creation of new jobs or major quality jobs	Capacity to create new jobs	Number of New jobs that could be created	1	1
		Number of major quality jobs.	1	2

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7. GHG Emissions

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2006 IPCC Guidelines for National Greenhouse Gas Inventories
Volume 4
Agriculture, Forestry and Other Land Use

CH_4 N_2O

ANIMALS

N_2O

CROPS

CO_2

WOOD, FURNNACE

CO_2

HOUSE

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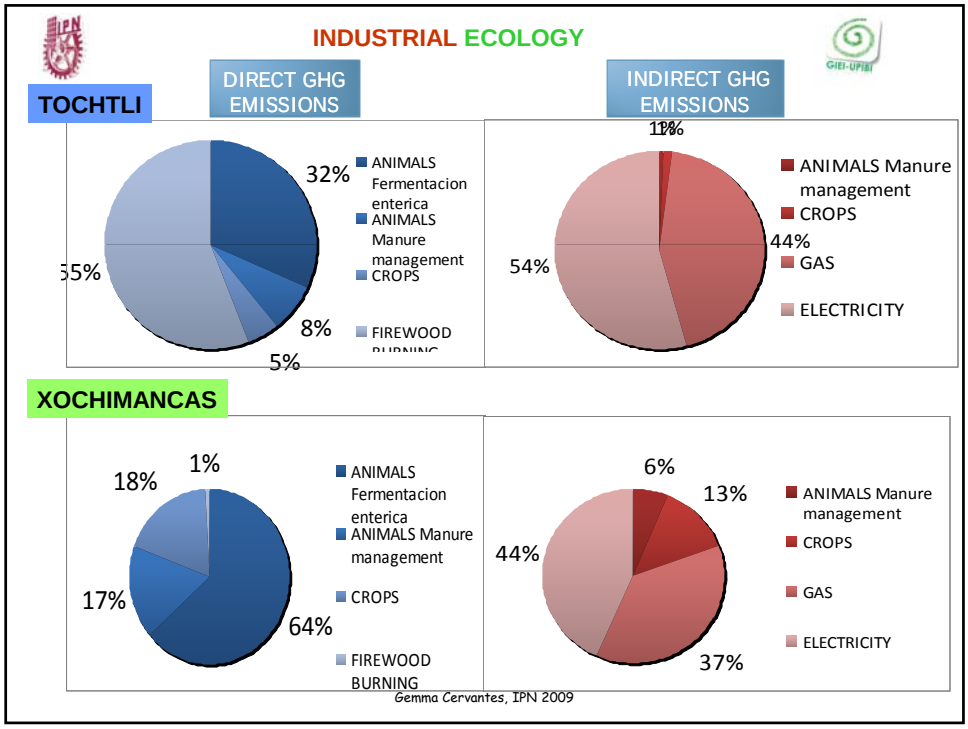
INDUSTRIAL ECOLOGY
TOCHTLI
DIRECT GHG EMISSIONS
INDIRECT GHG EMISSIONS
32%
55%
8%
5%
ANIMALS Fermentacion enterica
ANIMALS Manure management
CROPS
FIREWOOD BURNING
1%
54%
44%
ANIMALS Manure management
CROPS
GAS
ELECTRICITY
XOCHIMANCAS
1%
18%
17%
64%
ANIMALS Fermentacion enterica
ANIMALS Manure management
CROPS
FIREWOOD BURNING
6%
13%
44%
37%
ANIMALS Manure management
CROPS
GAS
ELECTRICITY
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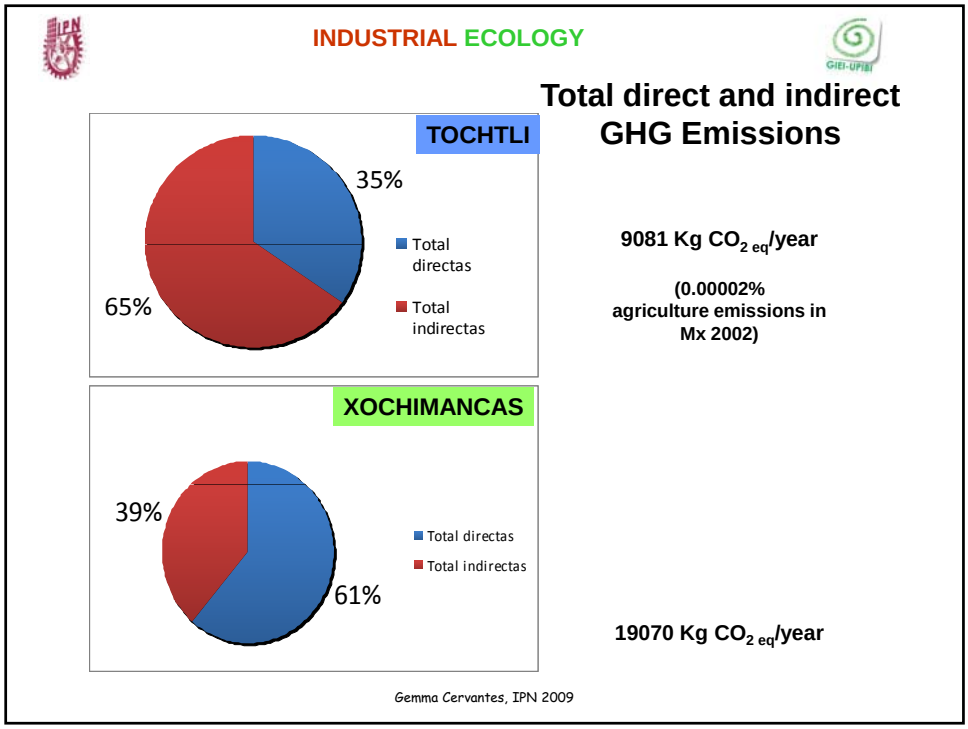
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Total direct and indirect GHG Emissions
TOCHTLI
35%
65%
Total directas
Total indirectas
9081 Kg $CO_{2\ eq}$/year
(0.00002% agriculture emissions in Mx 2002)
XOCHIMANCAS
39%
61%
Total directas
Total indirectas
19070 Kg $CO_{2\ eq}$/year
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EMISSIONS MITIGATION ACTIONS

Manure composting

Substitution of firewood oven

Improving feed quality: reducing dark fermentation

Sustainable wood Management

N fixing plants

Manure in crops: rapid incorporation

Solar thermal E (hot water)
Photovoltaics

ANIMALS

FIREWOOD OVEN

CROPS

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HOUSE

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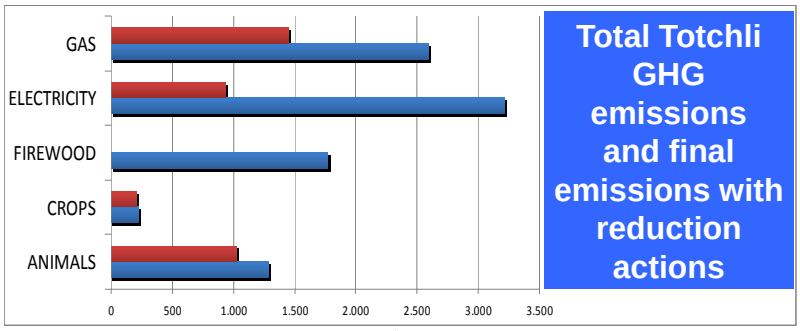
EMISSIONS SOURCE	GHG EMISSIONS Kg CO2eq/year	% reduction proposed	GHG EMISSIONS with mitigation actions (Kg CO2eq/year)
ANIMALS	1.283,11	20	1.026,49
CROPS	228,78	10	205,90
FIREWOOD	1.768,43	100	0,00
ELECTRICITY CONSUMPTION	3.211,58	71	934,50
GAS CONSUMPTION	2.589,35	44	1.446,53
TOTAL	9.081,25	40	3.613,42

Improving manure management

Improving manure management and N fixing plants

Substitution of electricity with photovoltaics

Substitution of gas for hot water with solar thermal



Total Totchli GHG emissions and final emissions with reduction actions

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TREES TO CAPTURE CO_2 EMISSIONS

EMISSION SOURCE	Total Emissions (Kg CO_2eq/year)	Number of trees to capture CO_2	Emissions with reduction scenarios (Kg CO_2eq/year)	Number of trees to capture CO_2 with reduction scenarios
ANIMALS	1.283,11	3,8	1.026,49	3,1
CROPS	228,78	0,7	205,90	0,6
FIREWOOD	1.768,43	5,3	0,00	0,0
ELECTRICITY CONSUMPTION	3.211,58	9,6	934,50	2,8
GAS CONSUMPTION	2.589,35	7,7	1.446,53	4,3
TOTAL	**9.081,25**	27,1	**3.613,42**	10,8

1 Tree =335kg CO_2 eq/year

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8. Concluding remarks

- The data systematization in both systems allowed the development of new waste exchanges and resource optimization.
- Through these projects both agricultural systems exchanged information and expanded their social network.
- Xochimancas shows a bigger tendency to sustainability in environmental and economic aspects and Tochtli in social aspects
- Dark fermentation is one of the main contributions to GHG emissions
- These systems show a tendency towards sustainability and may be a model for implementing IE agricultural systems in Mexico
- Future development: implementing mitigation actions and measuring their effects in sustainability

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