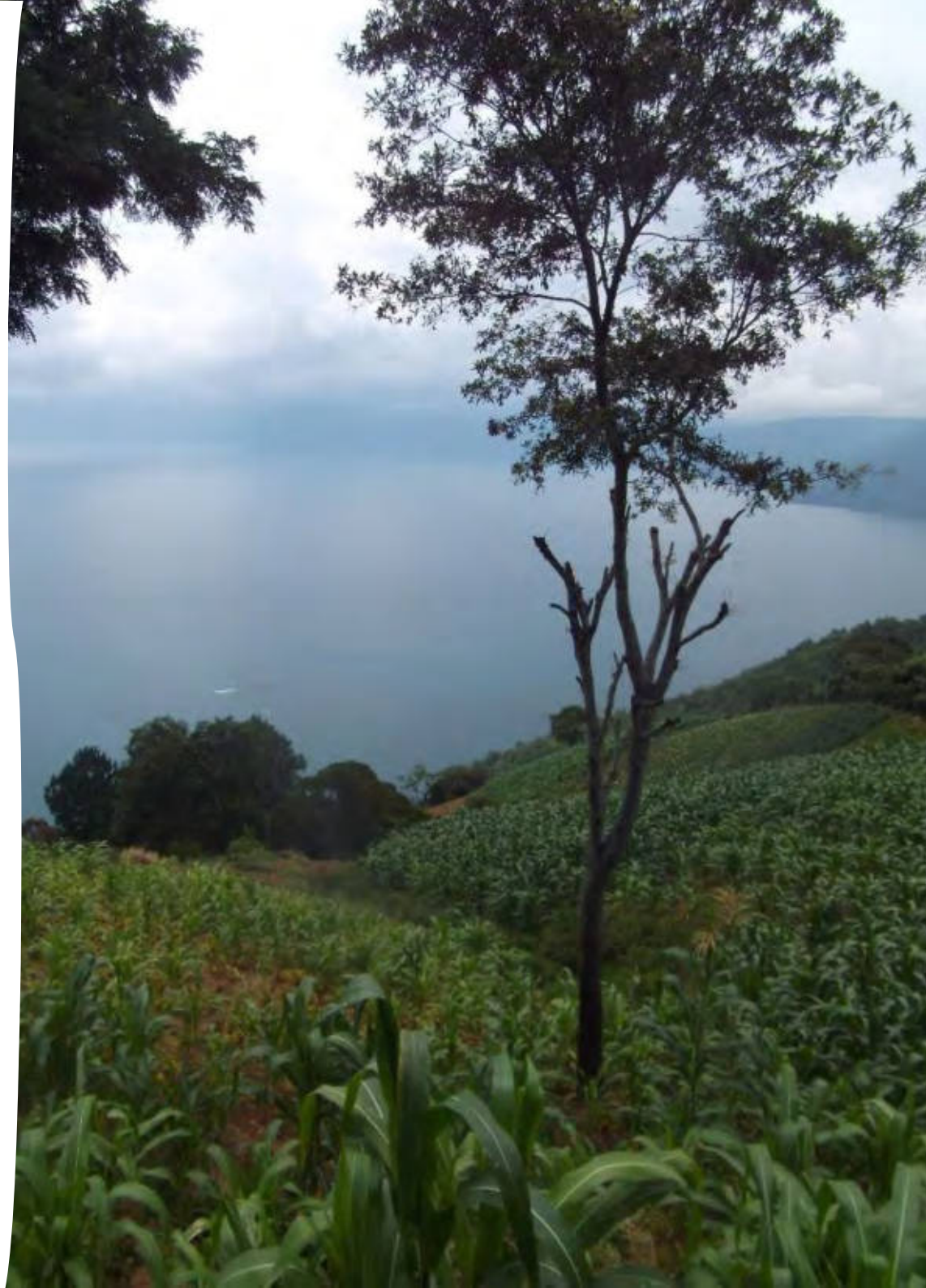


Modélisation hydrologique participative et inclusive

Tz'olöj Ya', Iximulew
(Guatemala)

*Julien Malard
CentrEau, 23 juin 2020*

Julien.malard@mail.mcgill.ca



Contexte écologique Ecological context

- Lac endoréique, le plus profond en Amérique centrale
Endorheic lake; deepest in Central America
- Pollution :
 - Ruissellement agricole
Agricultural runoff
 - Eaux usées
Wastewater
 - Érosion des sols
Erosion
- 2009 : Explosion massive d'algues
Massive bloom in 2009



Contexte humain Human context

- 96% Mayab' :
 - Kaqchikel
 - K'iche'
 - Tz'utujil
- 3% Ladino

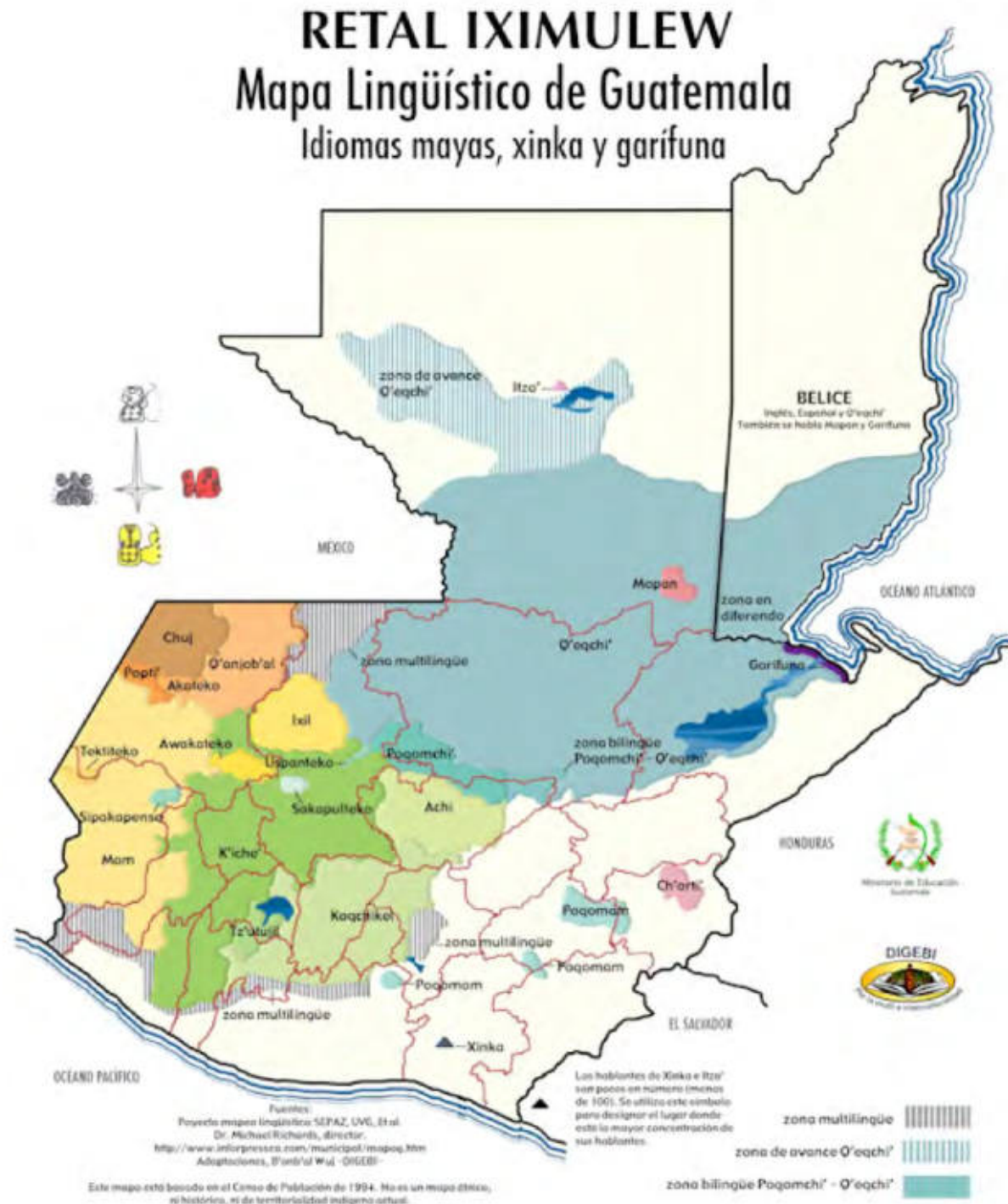


Langues du Guatemala

Languages of Guatemala

> 25 total

- 22 Mayab'
- Xinka
- Garífuna
- Español



Eaux usées | Wastewater – Pan Ajache'l

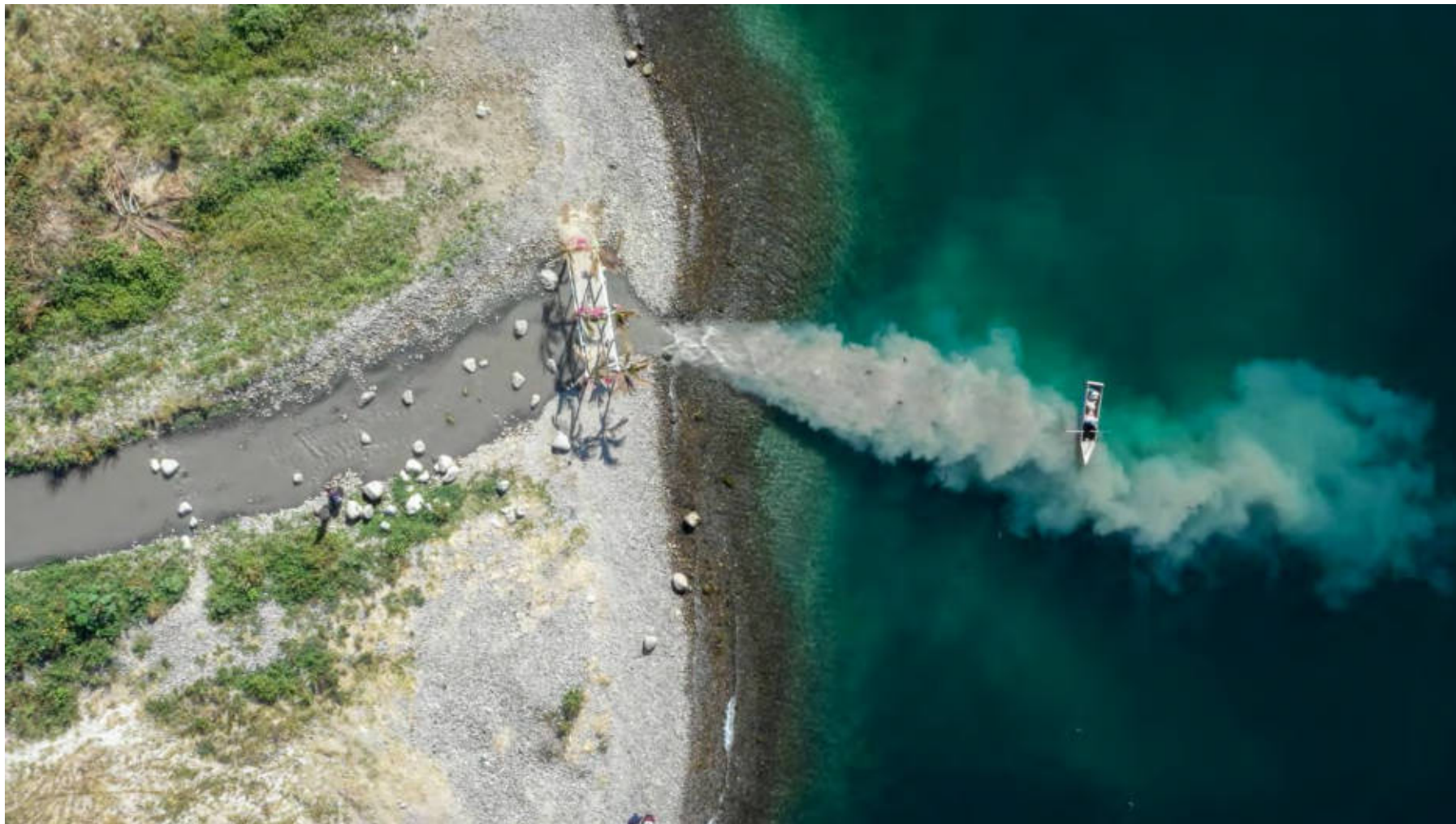


Photo : El País

Cyanobactéries | Cyanobacteria

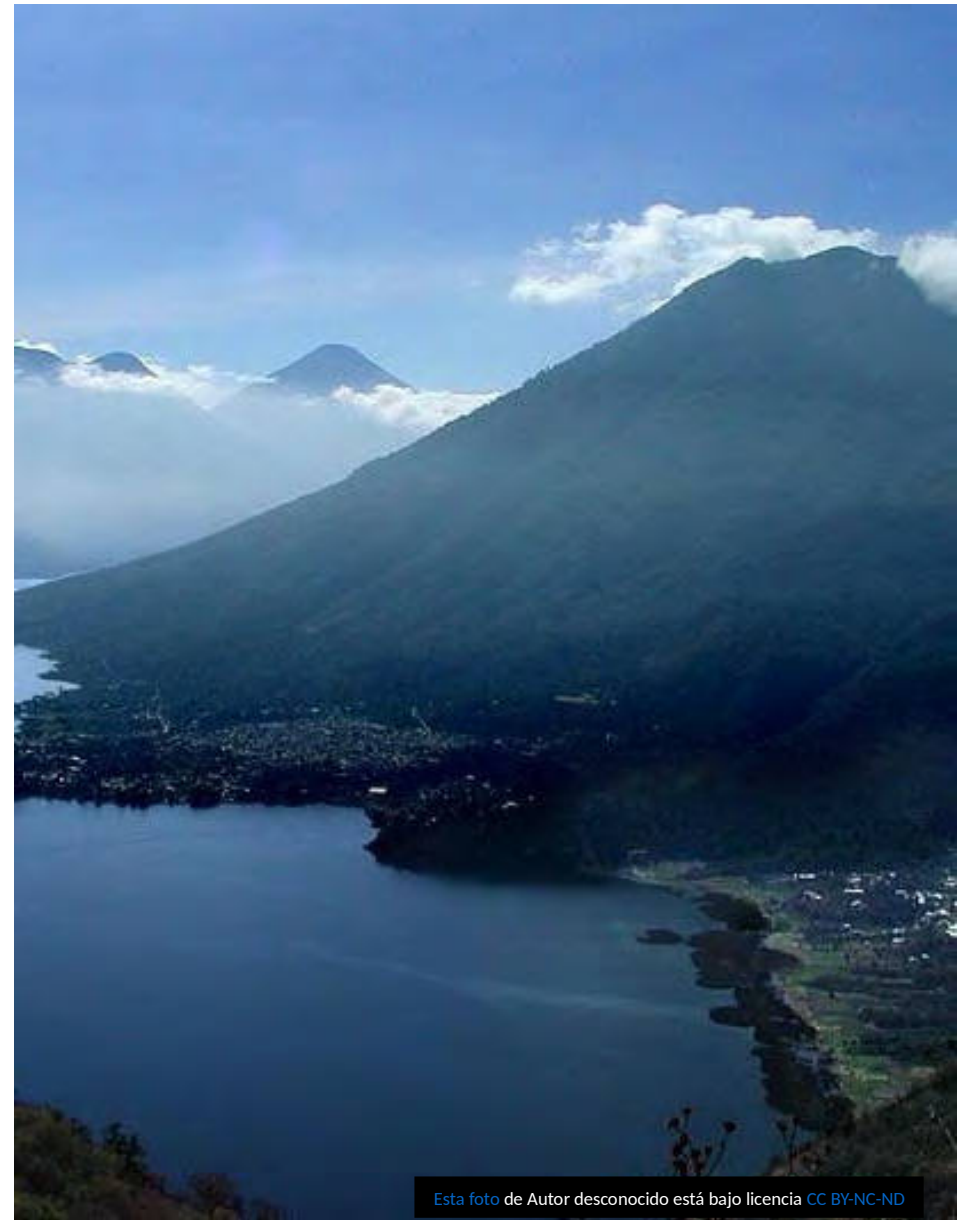


Photo : Plaza Pública

Méthodes

Methodology

- **Inclusive**
- Dynamiques des systèmes
System dynamics
 - Entrevues individuelles
Individual interviews
 - 3 ateliers (à date)
3 workshops (to date)
- Parties prenantes:
Stakeholders
 - ONGs | NGOs
 - Gouvernements | Governments
 - Mayab' et jeunesse | Mayab' and youth
 - Pêcheurs et agricultrices.eurs
Fishers and farmers
- Langues Mayas
Mayan languages



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Diagrammes de boucles causales

Causal loop diagram

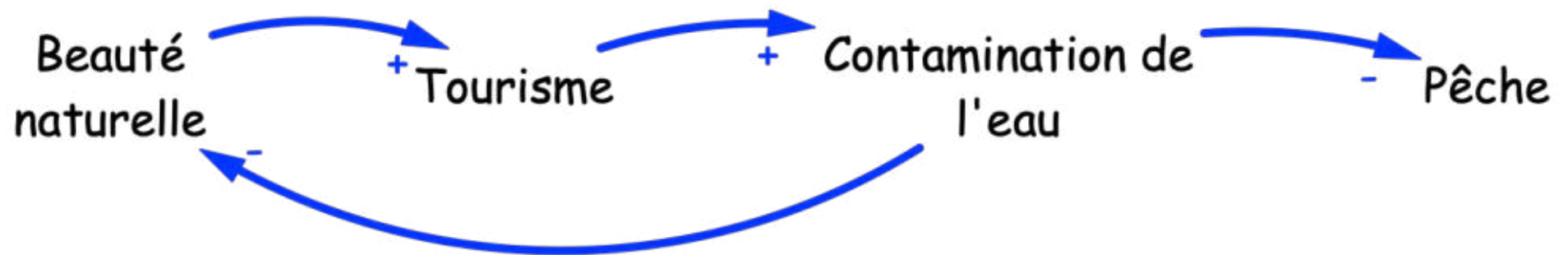


Diagramme de boucles causales (DBC)

Causal loop diagram (CLD)



El Megacolector ("Popoférico")

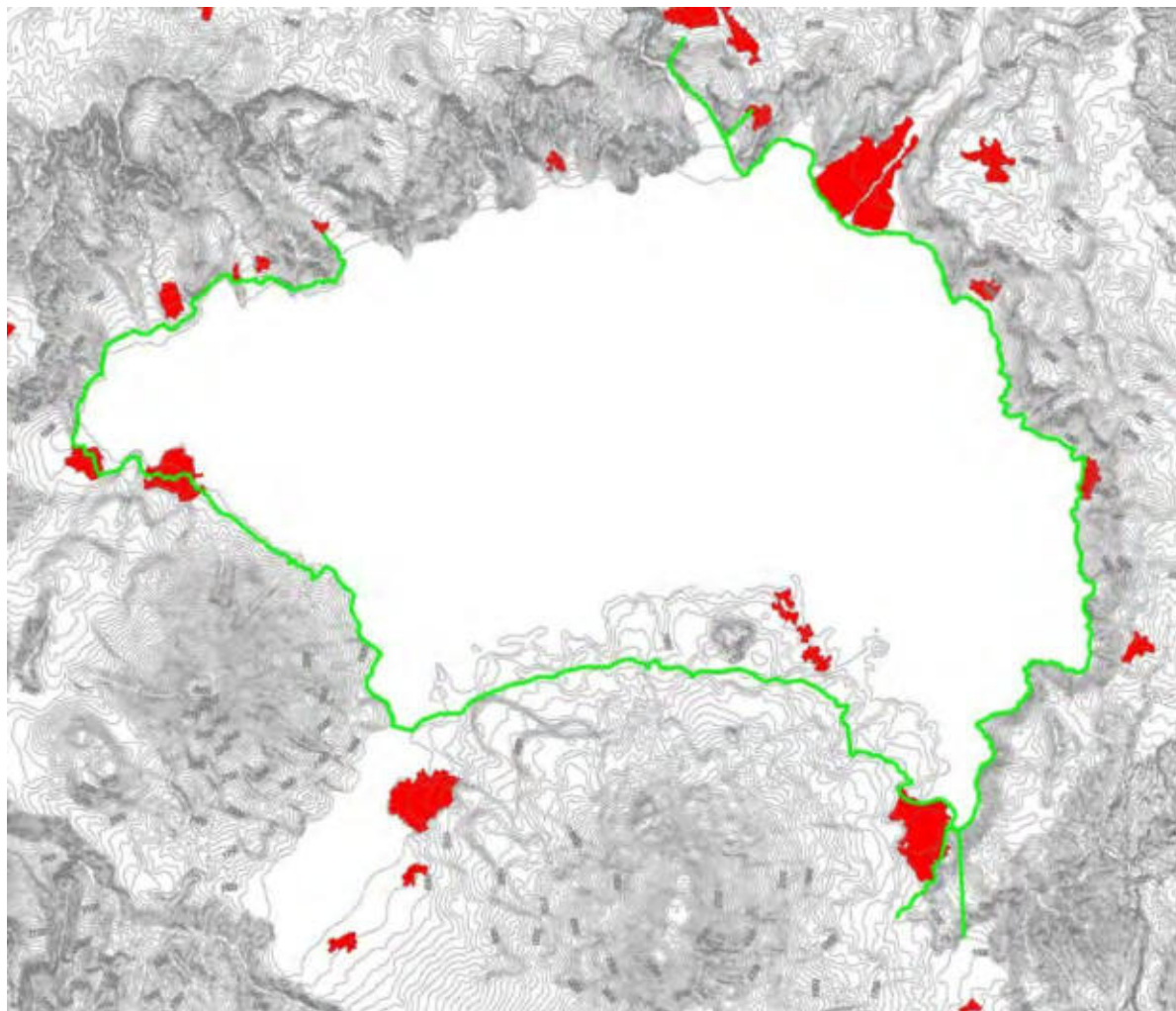


Photo : AMSCLAE

El Megacolector ("Popoférico")



Figure 5-1: View of Lake Atitlán Model and Proposed Pipeline Network, Looking North

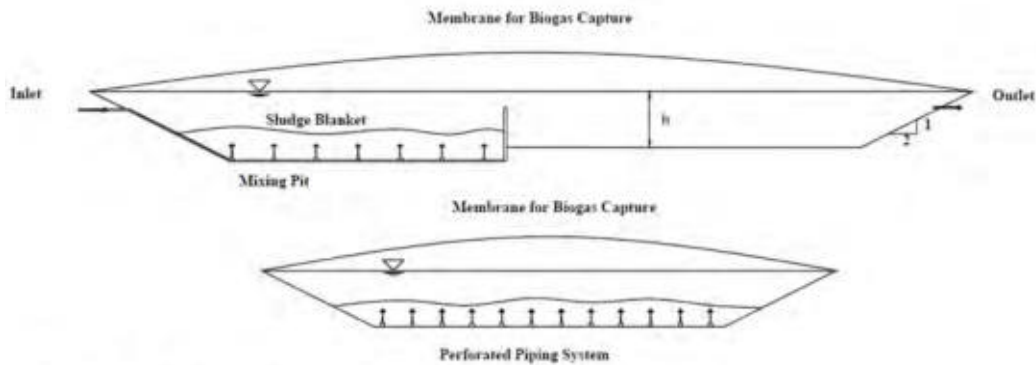


Figure 4-5: Profile and Section View of Upflow Anaerobic Pond

Hinds *et al.*, 2015



Démographies Demographics

Démographie	Participant.e.s (%)	Population Générale (%)
Femmes Women	24.1	52
Hommes Men	75.9	48
Mayab'	62.1	96
Espagnol	37.9	3
Langue indigène Mayab' language	58.6	81
Hispanophones Hispanophone	41.4	18
Lettres Literate	86.2	70
Illettrés Illiterate	13.8	30

Définition du problème

Problem definition

- Services écosystémiques :
 - Eau potable | Drinking
 - Irrigation
 - Pêche | Fishing
 - Beauté | Beauty
- Usages différents
Different uses
- Quantité, qualité, distribution
Quantity, quality, distribution



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Des publications scientifiques | In the literature

Integrated Wastewater Management in the Lake Atitlán Basin: An Ecological Engineering Challenge

GREGORY HINDS¹, KELLY VANNOY¹, ELIZABETH JACHENS², STEWART OAKLEY^{2*}

¹University of South Florida, Tampa, Florida, USA

²California State University, Chico, California, USA

*Corresponding author: email: soakley@csuchico.edu, Tel: 1-530-898-4976

agriculture and the recovery of energy through anaerobic pretreatment. A life cycle cost analysis (LCCA) approach was taken in comparing the alternatives. Capital costs, projected operation and maintenance costs, and wastewater valorization potential over the 20 year design life, ranging from 2016 to 2036, were included in the LCCA. The results of the analysis indicate that the export/reuse alternative is the economically and environmentally superior option and is therefore the most appropriate solution for integrated wastewater management within the Lake Atitlán basin.

Des publications scientifiques | In the literature

Table 5-1: Life Cycle Cost Analysis of Lake Atilán Wastewater Management Alternatives

Parameter	Discharge to Lake	Wastewater Export with Valorization	
	Activated Sludge	With Borehole	Without Borehole
I. Construction Cost, US\$			
Treatment Plants	-\$44,134,000	-\$11,891,000	-\$11,891,000
Pipeline Materials	-	-\$8,374,000	-\$8,409,000
Borehole	-	-\$600,000	-
Pump Houses	-	-\$1,821,000	-\$1,821,000
Hydroelectric Facilities	-	-\$3,608,000	-\$3,608,000
Reservoir	-	-\$3,320,000	-\$3,320,000
Total Cost	\$44,134,000	-\$29,690,000	-\$29,048,000
II. Operation and Maintenance			
Average Energy Consumption, kWh/day	-28,239	-7,569	-9,696
Average Energy Production, kWh/day			
4 Turbines Inside Basin	-	7,255	7,255
1 Turbine Outside Basin	-	11,986	11,986
Energy from Methane Produced in Anaerobic Lagoons	-	7,024	7,024
Net Energy = Production - Consumption, kWh/day	-28,239	18,696	16,569
Net Energy = Production - Consumption, kWh/year	-10,307,333	6,824,189	6,047,753
Net Cost of Energy, US\$/year (US\$0.20/kWh)	-\$2,061,467	-\$553,000	-\$708,000
Net Value of Energy, US\$/year (US\$0.20/kWh)	\$0	\$1,917,000	\$1,917,000
Net Worth of Energy, US\$/year (US\$0.20/kWh)	-\$2,061,000	\$1,365,000	\$1,210,000
Present Net Cost of Energy, 2016-2036	-\$23,266,000	-\$6,242,000	-\$7,988,000
Present Net Value of Energy, 2016-2036	\$0	\$21,639,000	\$21,639,000
Total Net Present Worth, 2016-2036	-\$23,266,000	\$15,398,000	\$13,651,000
III. Valorization of Effluent for Agricultural Reuse			
Value of Water for Reuse, US\$/m ³	\$0	\$0.015	\$0.015
Value of Water for Reuse, US\$/yr @ 9,633,021 m ³ /yr	\$0	\$186,000	\$186,000
Value of Nitrogen, US\$/year (NT = 30 mg/L)	\$0	\$517,000	\$517,000
Value of Phosphorus, US\$/year (FT = 10 mg/L)	\$0	\$472,000	\$472,000
Total Value of Water and Nutrients, US\$/year		\$1,176,000	\$1,176,000
Net Present Worth of Water & Nutrients, 2016-2036	\$0	\$13,268,000	\$13,268,000
IV. Life Cycle Cost, 2016-2036, US\$	-\$67,399,000	-\$657,000	-\$2,130,000

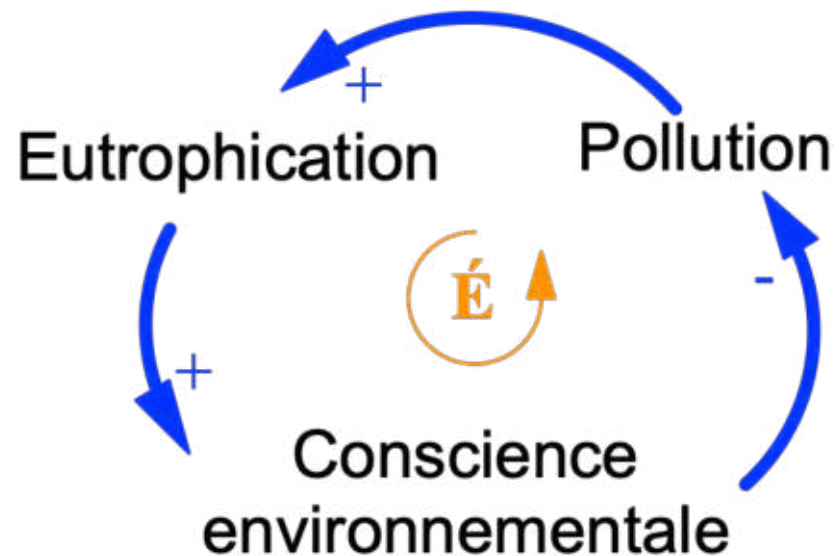
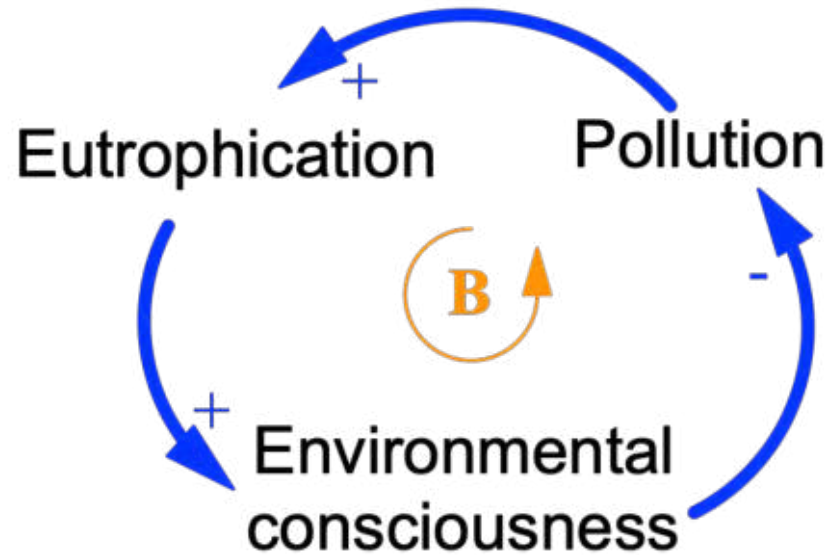
Hinds *et al.*, 2015

Une petite surprise | A small surprise

Maggie García tiene 28 años, es periodista, activista y, desde hace poco, se convirtió en madre. Teléfono móvil en mano, saluda a los asistentes y exclama: "Yo soy 80% de agua y la leche que produzco para mi bebé es agua también". Para ella, el megaproyecto no representa una solución, sino un problema mayor. "No estamos de acuerdo con que nos quiten el agua". Desde que empezó a manifestarse en contra del megacolector ha recibido varias amenazas de muerte.

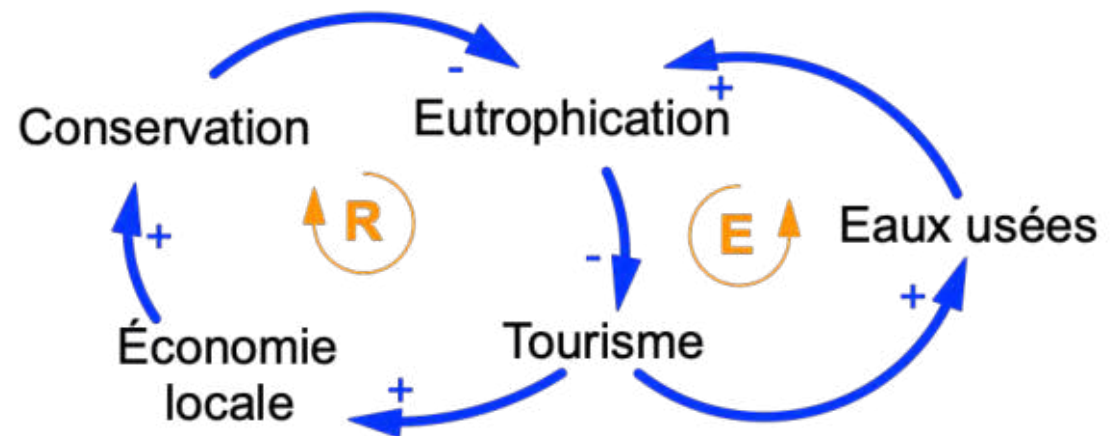
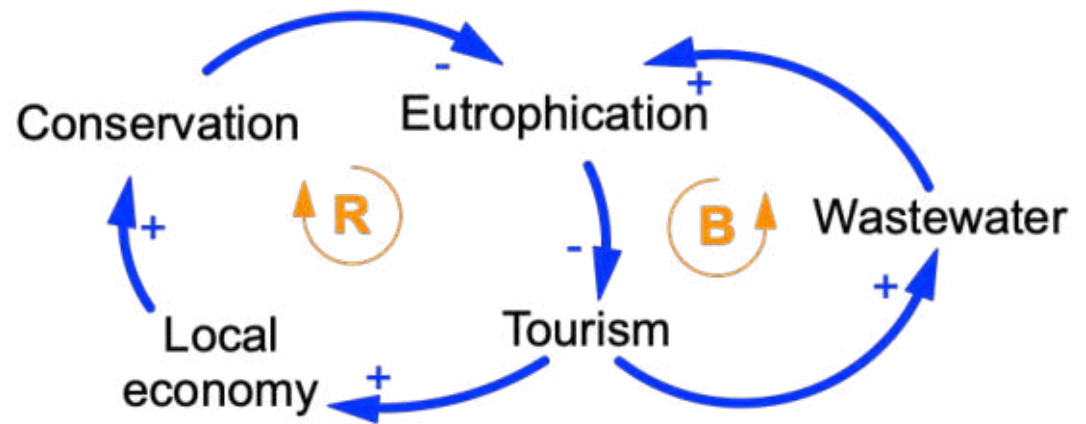
Dynamiques sociohydrologiques Sociohydrological dynamics

- Dynamiques oscillatoires?
Oscillatory dynamics?
- De la part des ONGs
Identified by NGOs



Dynamiques sociohydrologiques Sociohydrological dynamics

- Impacts contradictoires
Contradictory impacts
- Cycle É identifié par les parties prenantes Indigènes
B loop identified by Indigenous stakeholders





Messages de conclusion | Concluding messages

1. Apprenez à parler | Learn to speak

2. Travaillez pour la communauté

Work for the community



3. Soyez sincères, et évitez la politique

Be sincere, and avoid politics



4. Il n'y a pas d'hydrologie sans sociologie
There is no hydrology without sociology





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