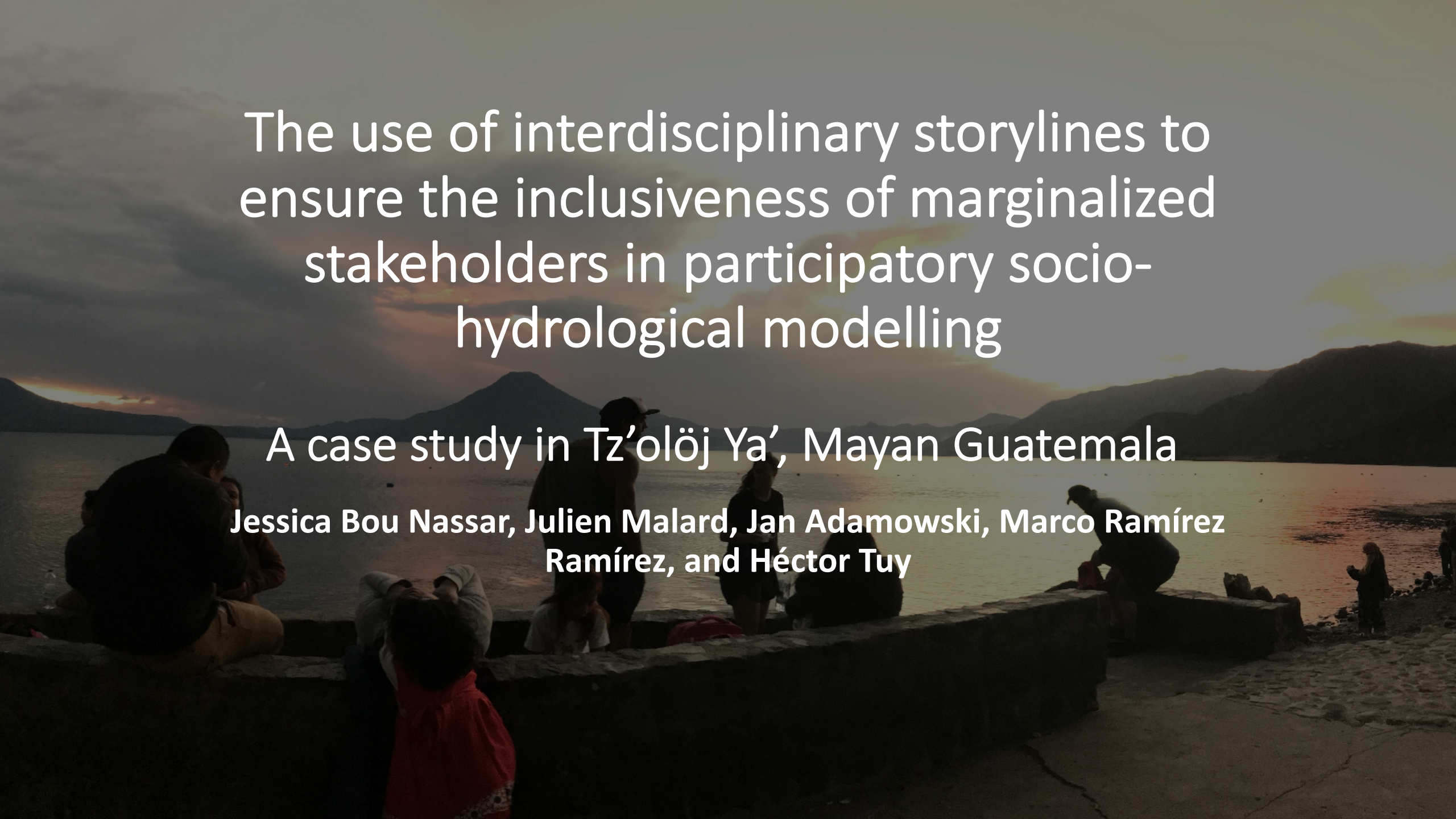

The use of interdisciplinary storylines to ensure the inclusiveness of marginalized stakeholders in participatory socio-hydrological modelling

A case study in Tz'olöj Ya', Mayan Guatemala

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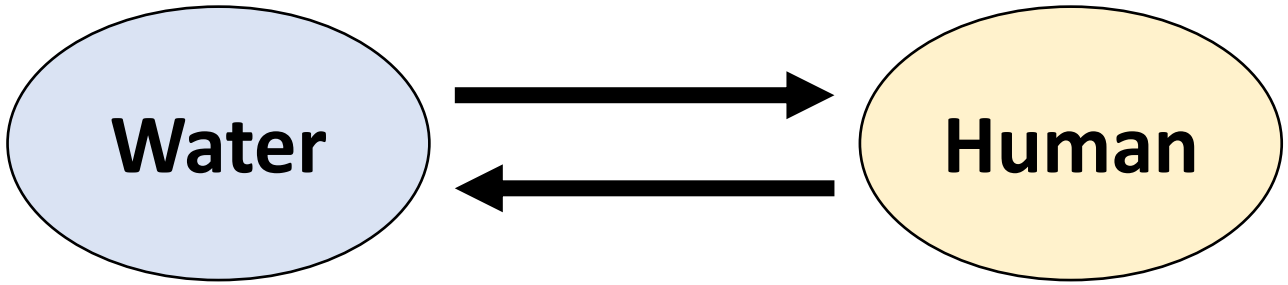
Relevance to the “23 Unsolved Problems of Hydrology”

Problem 18

How can we extract information from available data on human and water systems in order to inform the building process of socio-hydrological models and conceptualizations?



Multi-level storylines to conceptualize socio-hydrological system dynamics models

- Storylines visualize and describe conditions using narrative texts, in order to provide information and insight
- Why storylines?
  - Consider multi-causality and nonlinearity
  - Consider complex interactions – i.e. can reframe the observed complexity of socio-hydrological systems in ways that surpass capabilities of more science-ordered approaches
  - Accommodate interdisciplinary participation
  - Capable of ensuring inclusiveness (e.g. can accommodate participants with low literacy since they do not require reading or writing skills)

Multi-level storylines to conceptualize socio-hydrological system dynamics models

- Step 1: conceptualization - conceptualizing a participatory storyline development method that accommodates system dynamics (SD) models
  - Literature: emphasis on storyline construction techniques that are well-suited for linear models but not SD models
- Step 2: implementation – suggesting a process that can accommodate a multilingual environment and ensure the inclusiveness of marginalized stakeholders (less literate and relatively powerless)
  - Literature: lack of participatory modelling processes that accommodate multilingual environments and marginalized stakeholders

STEP 1 – Conceptual Framework

- Underpinned by Multi-level Perspective (MLP) framework developed by Geels et al. (2002).
- The development of three main storylines on three different levels: Macro, Meso, and Micro.

STEP 1 – Conceptual Framework

Storyline	Description
Macrolevel	Provides the gradient (context) for Meso-level and Micro-level storylines and characterizes the system boundaries in which the modeled problem and policy-based scenarios are contained
Mesolevel	Delineates the state of the modelled problem yielded by dynamic interactions between causes and consequences of the investigated problem, situated within previously-identified boundaries
Microlevel	Identifies (1) BMPs or policies – preferably associated with the system's leverage points – that lie within the boundaries and context of the modelled problem but are not yet embedded within the system nor interacting with it and (2) outcomes of applying them on the dominant state of the system

Components of multi-level storylines

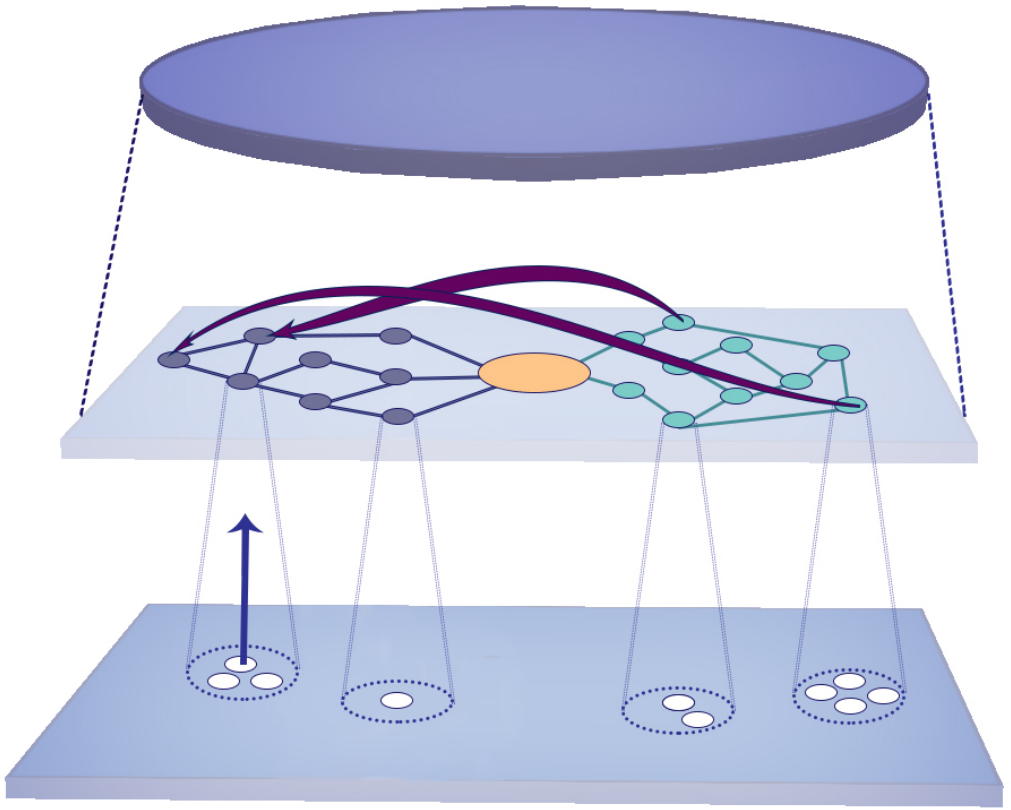
Macro-level

- Problem framing
- Economic, social, cultural, and political factors
- Social context
- Geographic context
- Historical events

Micro-level*

- Candidate policies and BMPs ○
- Expected impacts of policies and BMPs ↑

**Aligning with leverage points and/or zones of undesired outcomes*



Meso-level*

- Causes ●
- Relationships between causes —
- Consequences ●
- Relationships between consequences —
- Feedbacks ←

**Reflecting the state of the problem* ●

STEP 2 – Implementation

- Accommodates multilingual environments
- Ensures the inclusiveness of marginalized stakeholders:
  - Less literate: participation does not require reading or writing
  - Relatively powerless: the process takes power dynamics into account at every stage of the implementation
- Incorporates interviews, focus groups, causal loop diagrams, workshops, and feedback surveys

STEP 2 – Implementation

Please scan the QR code or click on the link below to view the flowchart of the process.

https://qrcgcustomers.s3-eu-west-1.amazonaws.com/account8324209/6954359_1.pdf?0.6896418365127122

SCAN ME

Case Study – Lake Atitlán, Tz'olöj Ya’, Guatemala

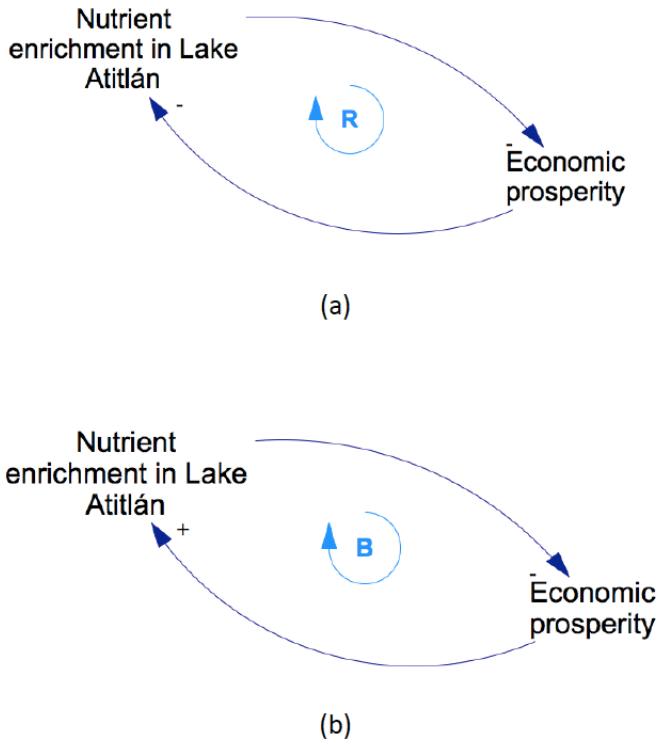
- Atitlán is the deepest lake in Central America.
- It witnessed major cyanobacterial blooms in 2009 (covered 40% of the lake’s surface).
- The ongoing processes of eutrophication have recently shifted the lake from oligotrophic to mesotrophic.

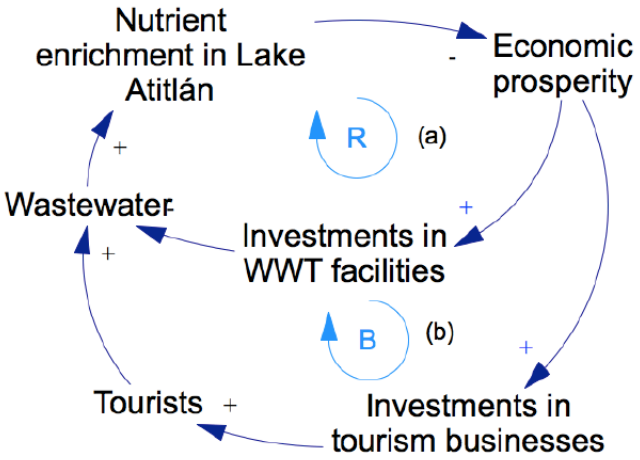
Case Study – Lake Atitlán, Tz'olöj Ya’, Guatemala

- **Highlights of demographics**
  - 96% indigenous
  - 81% indigenous language speakers
  - 30% illiterate
- **Languages**
  - Mayan Kaqchikel
  - Mayan Tz’utujil
  - Mayan K’iche
  - Spanish
- **Major economic sectors**
  - Tourism
  - Agriculture
  - Aquaculture

- **Stakeholders**
  - Indigenous and non-indigenous municipalities
  - Local indigenous authorities
  - Governmental institutions (the lake’s authorities, environmental institutions, and agricultural institutions)
  - Farmers’ associations
  - Fishermen’s associations
  - Academic institutions
  - NGOs
  - Owners of tourism businesses

Highlights of research findings





- This figure shows one example of elicited relationships between nutrient enrichment and economic prosperity.
- The balancing loop between nutrient enrichment and economic prosperity: explicit contribution of indigenous stakeholders
- The identification of both loops and the socioculturally-specific mechanisms that govern them aid decisionmakers to act on leverage points of the system:
  - intensify the impact of the reinforcing loop (e.g. optimize the allocation of resources reduce nutrient enrichment)
  - abate the impact of the balancing loop (e.g. ensure that economic prosperity is driven by environmentally-sustainable economic practices having no or minimal adverse effects on the lake)

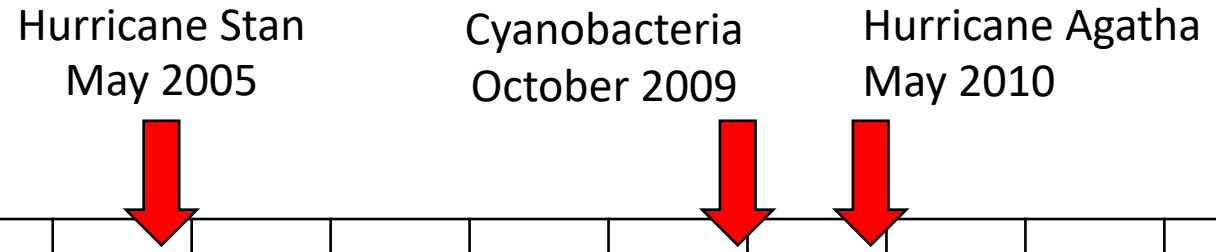
Highlights of research findings

- **The Pendulum Swing:**
  - Defined by Di Baldassare et al. (2019) as a socio-hydrological phenomena described as the change of priorities from immediate economic prosperity to environmental protection or vice versa
  - Delineated by several stakeholders and represented in two different balancing loops (B6 and B7 in the environmental awareness module - slide 17).
  - Environmental awareness:
    - Central to the representation of the phenomena
    - Mentioned exclusively by members of NGOs in the case study
    - Emphasized and modelled by van Emmerik et al. (2014)
- Stakeholders stated that the major cyanobacterial blooms occurring year 2009 (and other environmental crises such as hurricanes) have increased environmental awareness in the area.
- Example:
  - Prior to the blooms, practices encouraged the expansion of agricultural areas by replacing forest areas.
  - After the appearance of blooms, extensive reforestation campaigns have been held to prevent soil erosion, prioritizing forest areas over agricultural areas.

Highlights of research findings

- The concept of environmental awareness in that case can be used to model changing dynamics in land use
- While land use in the area is typically governed by relationships between agricultural areas and agricultural demand, the concept of environmental awareness and its impacts on forest areas might introduce different dynamics
- For example, the following table shows how areas reforested by reforestation initiatives increased abruptly following environmental damage

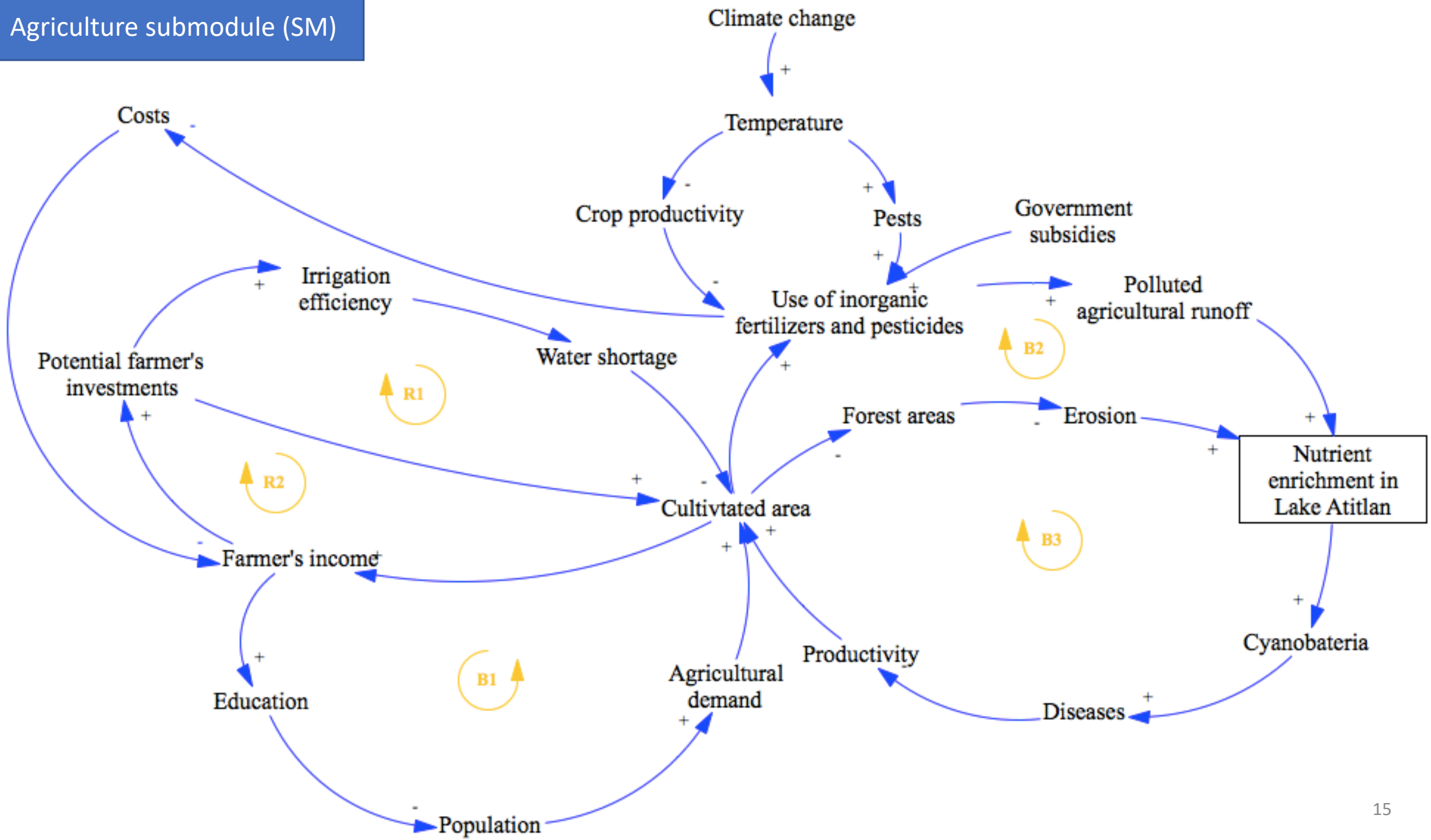
Area reforested by reforestation initiatives in Tz'olöj Ya', Guatemala



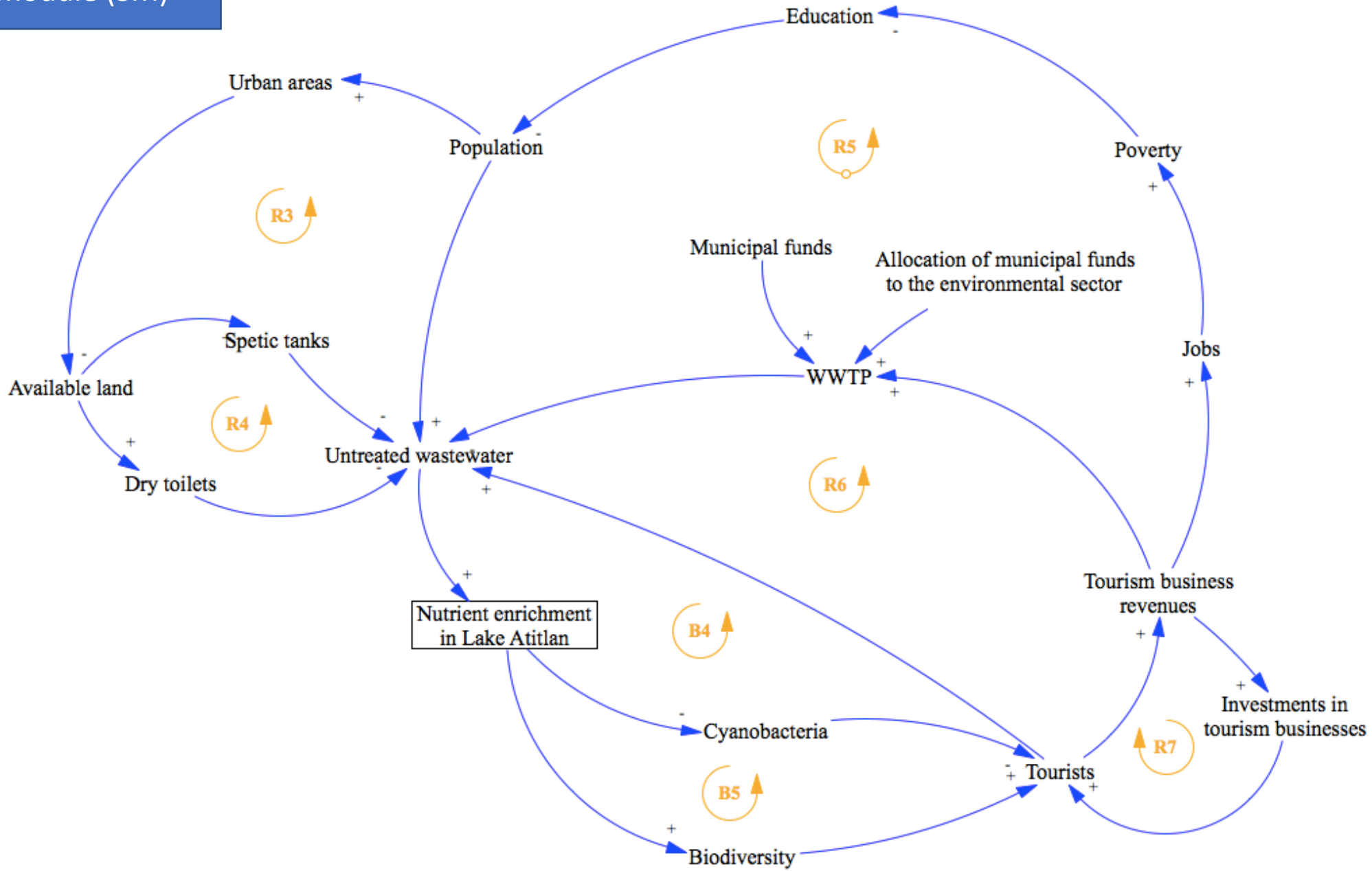
Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Area (ha)	43.7	55.7	89.3	22.3	50.0	39.3	45.0	46.3	**1,446.2**	-	282.3	243.1	**1,083.5**	**2,224.8**	1,244.5	426.1

Source: Institu Nacional de Estadística Guatemala (INE)

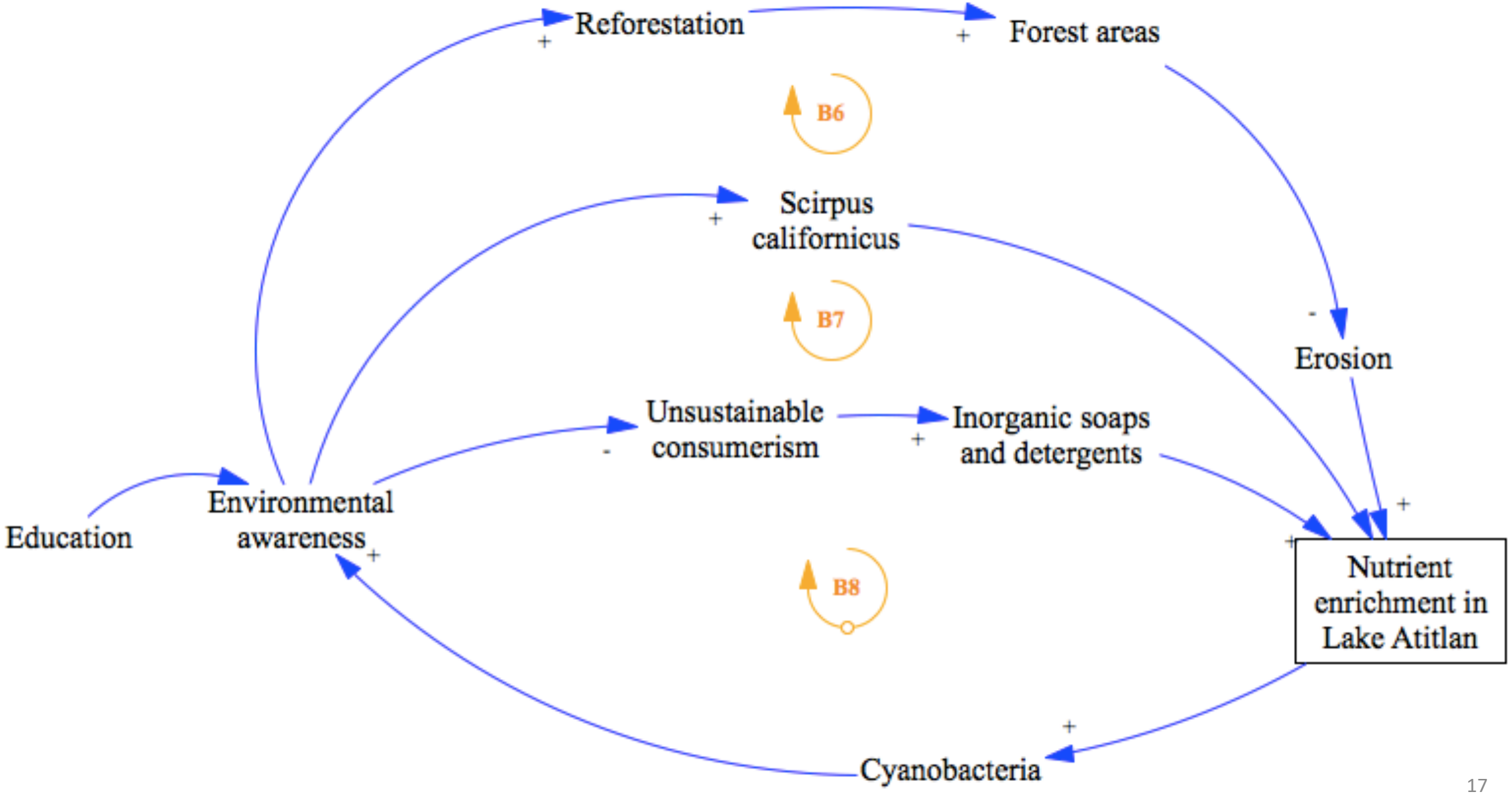
Agriculture submodule (SM)



Tourism submodule (SM)



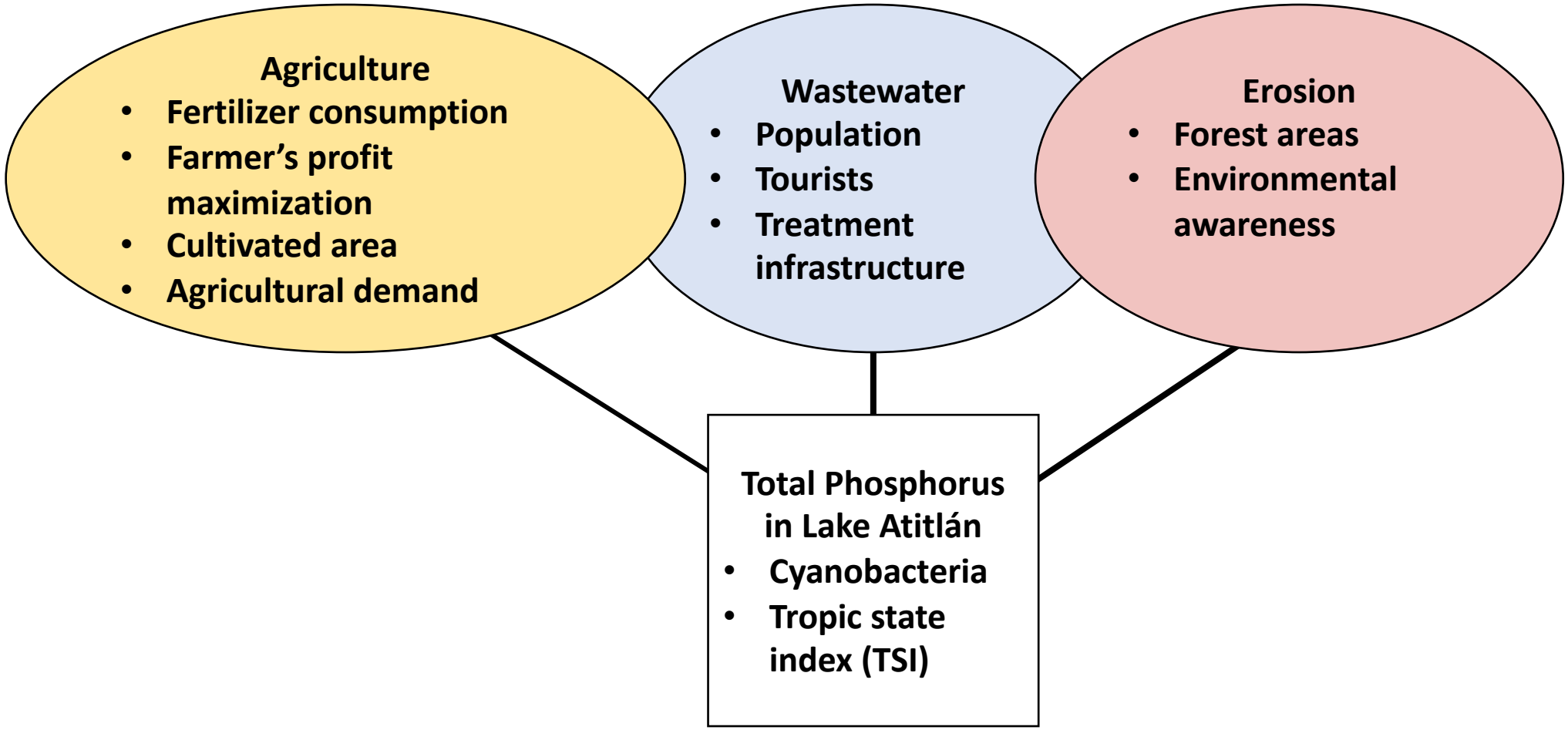
Environmental awareness submodule (SM)



Added value of inclusiveness

Contribution	Reference	Contributors
'WWTP' variable	R6 in Tourism SM	Mix of indigenous and non-indigenous stakeholders
'Dry latrines' and 'Septic tanks' variables	R4 and R3 in Tourism SM	Indigenous stakeholders
Reinforcing feedbacks between nutrient enrichment in Lake Atitlan and economic prosperity	B1 in Agriculture SM; R5 and R6 in Tourism SM	Mix of indigenous and non-indigenous stakeholders
Balancing feedbacks between nutrient enrichment in Lake Atitlan and economic prosperity	R2 and R1 in Agriculture SM; B4 and B5 in Tourism SM	Indigenous stakeholders
Balancing feedbacks between nutrient enrichment in Lake Atitlan and environmental awareness	B6, B7, and B8 in Environmental awareness SM	NGOs
Positive correlation between crop productivity and the use of inorganic fertilizers	Excluded (misunderstood relationship)	Decision-makers
Negative correlation between crop productivity and the use of inorganic fertilizers	Agriculture SM	Agriculturists/farmers

Work in progress: quantification



Takeaway

- Storylines provided leeway for narrating more nuanced versions of connections between variables.
  - Prevented participants from making reductionist assumptions (typically resulting from the restrictive nature of CLDs)
  - Allowed for the extraction of contextualized socio-hydrological phenomena
- Not only is inclusiveness important to endorse equitable community-based decision-making, but also:
  - To foster the inputs that marginalized stakeholders could provide
  - To induce needed collaboration for the successful implementation of solutions
- Socioculturally explicit perspectives of generalized relationships might be needed for developing well-targeted recommendations in water resources management