US-Costa Rica Collaboration to Quantify the Holistic Benefits of Resource Recovery in Small-Scale Communities

Grant #: 2246348

A six-week experience in Monteverde, Costa Rica supported by the National Science Foundation International Research Experience for Students

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Informational Session: November 13 at 1:30pm ET

https://wvu.zoom.us/j/5887448299?pwd=YSs5MUg5dEpnL3U0MWJrbUJOd1huZz09

Applications are now open!

Due by February 9, 2024

Apply and find more info at this link:
https://kevinorner.faculty.wvu.edu/costa-rica
Questions to kevin.orner@mail.wvu.edu

U.S. Faculty – Principal Investigators

Dr. Kevin Orner
Department of Civil and Environmental Engineering
West Virginia University

Dr. Pablo K. Cornejo
Department of Civil Engineering
California State University, Chico

Dr. Nancy Romero-Daza
Department of Anthropology
University of South Florida

Dr. David Himmelgreen
Department of Anthropology
University of South Florida

U.S. Faculty – Evaluator

Dr. Allan Feldman
Professor Emeritus
University of South Florida

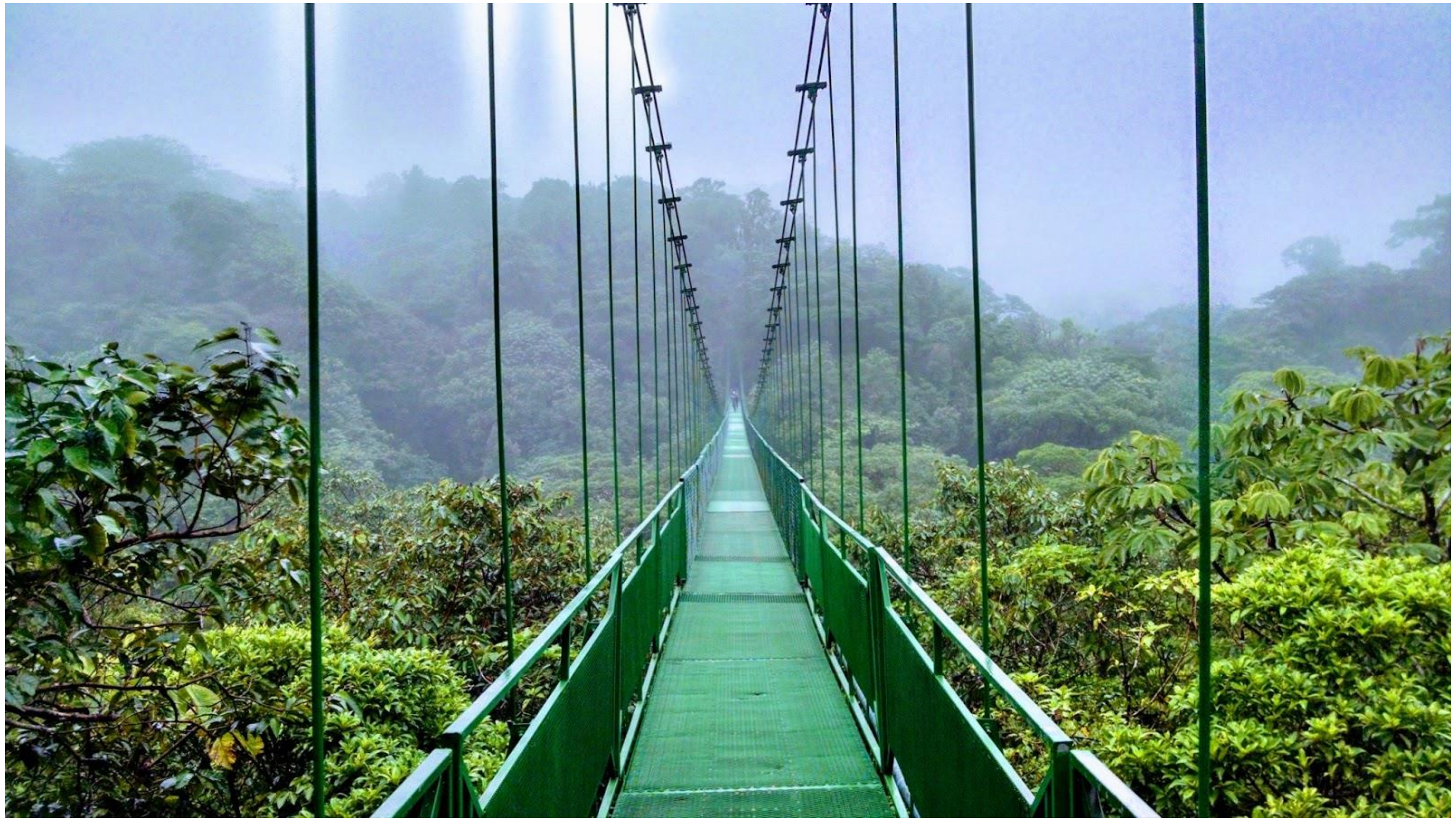
Monteverde Institute

Alexandra Paniagua
Academic Director

Purpose

Info meeting to:

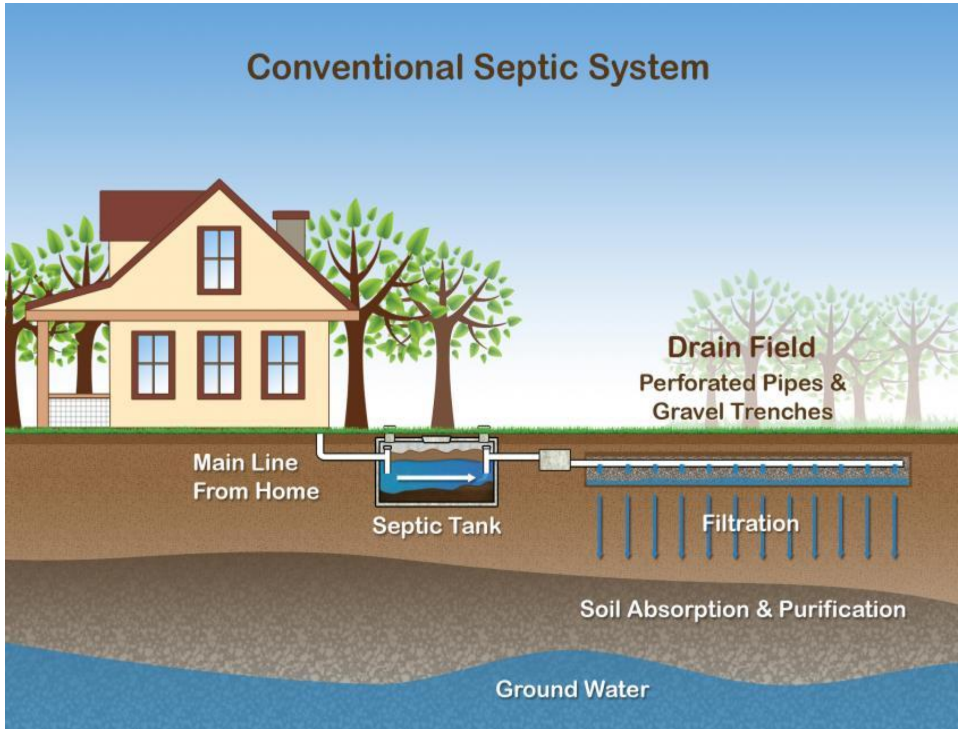
- Introduce NSF-IRES goals and objectives
- Answer your questions
- Encourage you to apply!



Hanging bridge in the Monteverde Cloud Forest

In Costa Rica…

- 75.4% of its five million residents use septic tanks[1]
- 66% of the septic tank sludge is not treated before disposal
- Many septic systems are not properly treating wastewater
- National goal to have wastewater treatment for[2]:
  - 100% of urban areas by 2030
  - 100% of rural areas by 2050



[1]Mora Alvarado, D. y Portuguez B., C. F. (2019). *Agua para consumo humano por provincias y saneamiento por regiones manejados en forma segura en zonas urbanas y rurales de Costa Rica al 2018*. San José, Costa Rica.
[2]Acueductos y Alcantarillados (AyA), Ministerio de Ambiente y Energía (MINAE) y Ministe- rio de Salud (MS). (2016). *Política Nacional de Saneamiento en Aguas Residuales 2016-2045*. San José.

Where Are We Locally?

Sustainable Futures (2012)

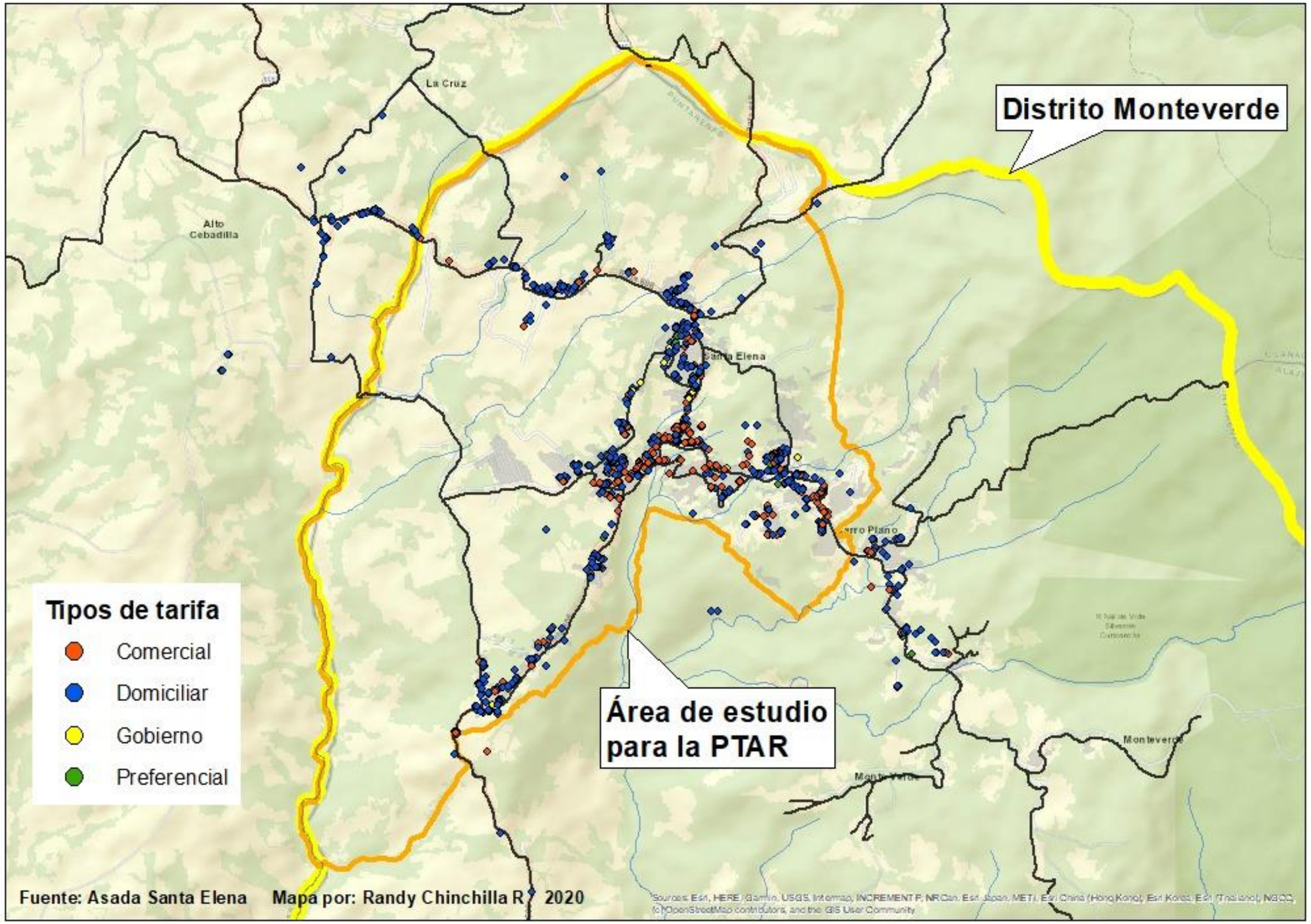
Monteverde Region

Characteristics of critical area[1]:

- Urban and semi-rural
- Tourist destination
- ~6,500 residents
- ~250,000 visitors/year
- Average wastewater flow: 1,184 m^3/day

Problems identified:

- Challenges with septic systems
- Limited greywater treatment
- Aesthetic concerns
- Public health risks



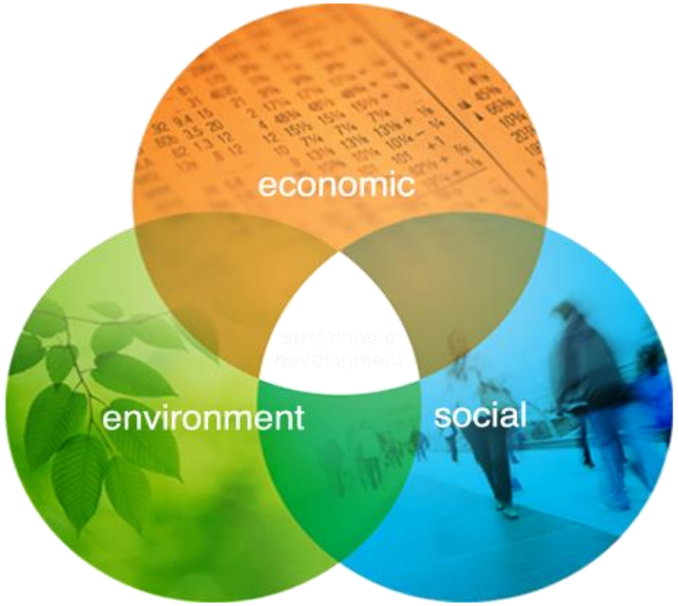
Study area in Monteverde

[1]Sanchez Vega, C. y Vindas Ruiz, R. (2022). *Analisis socioeconomico y propuesta para la implementacion del Sistema de tratamiento de las aguas residuales de la ASADA de Santa Elena de Monteverde*. Unversidad Tecnica Nacional, Alajuela, Costa Rica.
[2]CEHIREH (2017). Enfoques Estrategicos del Plan Municipal para la Gestion Integral de Aguas Residuales en el Districto Municipal de Monteverde. Comision especial para la gestion integral de recursos hidricos de Monteverde. Monteverde, Costa Rica

Goals and Objectives

NSF-IRES Goals and Objectives

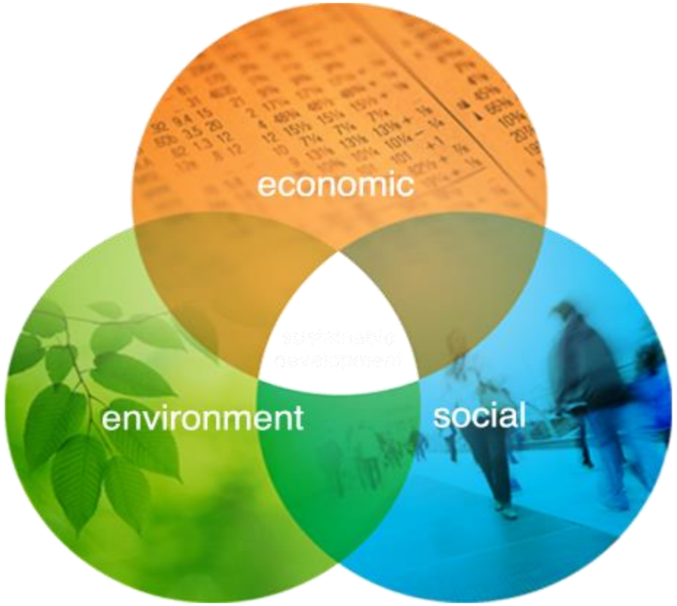
Overall scientific goal: Quantify the social, economic, and environmental impacts and benefits of waste treatment and integrated resource recovery in a small community dependent on ecotourism in Costa Rica



NSF-IRES Goals and Objectives

Scientific objectives:

1. Determine social, environmental, and economic sustainability metrics for wastewater treatment and resource recovery systems – Year 1
2. Collect and analyze data to assess the sustainability of sanitation systems at varying scales of implementation (decentralized, semi-centralized, centralized) – Years 1, 2, 3
3. Utilize a multi-criteria sustainability tool to evaluate the sustainability of varying management strategies and facilitate communication with stakeholders – Year 3



International Research Experience for Students

- Open to engineering and anthropology students
- Two students each year from each of the 3 universities

  (WVU, CSU-Chico, USF)
- Six weeks summer research experience (18 students total over 3 years)
- Cultural immersion through home-stays with local families

Participants receive

- Virtual pre-departure training (2 weeks, 4 d/w)
- Airfare to CR
- Room and Board
- Weekly stipend ($530) during six field weeks in Costa Rica

What students will do

- Days 1 and 2 (San Jose): tour of wastewater treatment plant, interact with UCR faculty and students
- Days 3-10 (Monteverde w/ faculty): Orientations, trainings, site visits
- Days 11-42 (Monteverde w/ local advisors): Environmental sampling and analyses, surveys and focus groups
- In Monteverde, live with a host family. Eat breakfast and dinner with host family, received packed lunch.

Typical Day

- 7:30am Breakfast w/ host family
- 9:00-10:20 Anthropology Training at MVI
- 10:40-12 Engineering Training at MVI
- 12-1 Lunch
- 1-2:20 Anthropology Field Work
- 2:40-4 Engineering Field Work
- 4-4:30 Debrief
- 5:30pm Dinner w/ host family

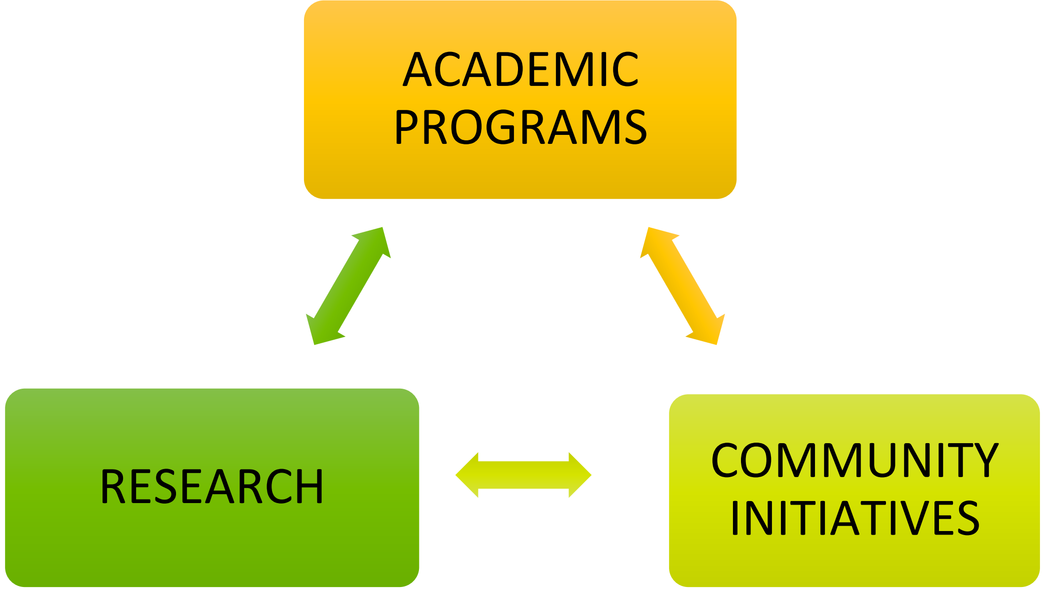
MONTEVERDE INSTITUTE

Our **mission** is to promote social, ecological and economic sustainability by integrating community initiatives with education, research and conservation.

The Monteverde Institute Model

- Place-based education with more than 30 collaborating universities that includes research and service to the community

- Three pillars: place-based education, applied research, and community programs.



Monteverde Institute Orientation

Facilities orientation

Introductory presentation to Monteverde and MVI campus tour

Classes

Health & Safety

Health and safety are shared responsibilities, self-care and group awareness are important

More orientation when you arrive

Consider site-specific risks and contingency plans throughout the program

WFR-certified program staff and MVI emergency response team

911 service

Homestays

An integral part of the program since MVI academic programs began (1987)

Community connections and local context

Cultural immersion

Spanish

Food

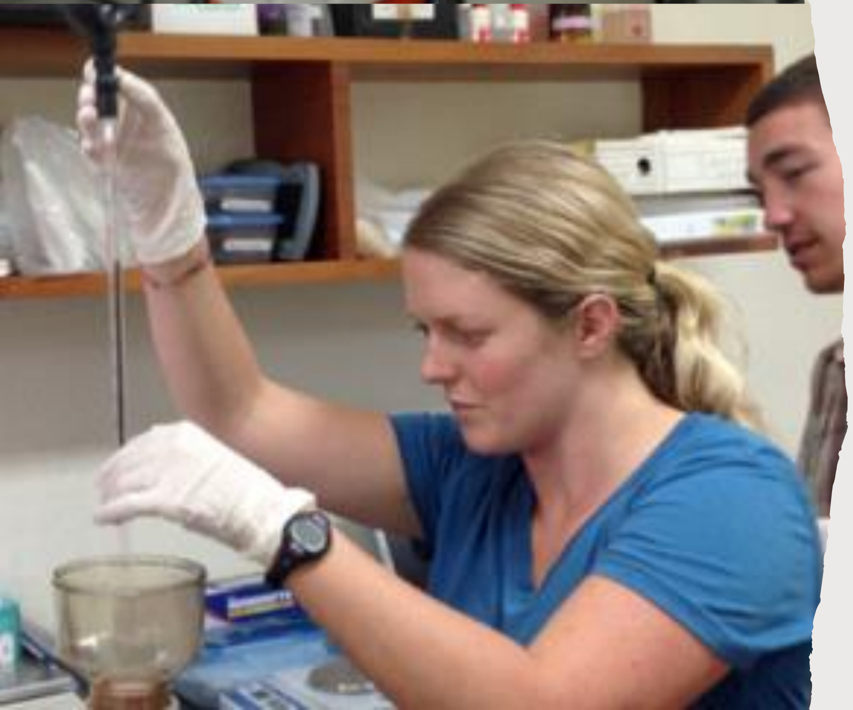
- Rice and beans
- Many carbs, minimal animal protein
- Gallo pinto for breakfast
- Casado for lunch/dinner
- Fruits and vegetables
- Overall vegetarian/vegan-friendly, dietary restrictions accommodated
- All meals included in program cost

Transportation in Monteverde

Sidewalks

Local public bus and taxi service

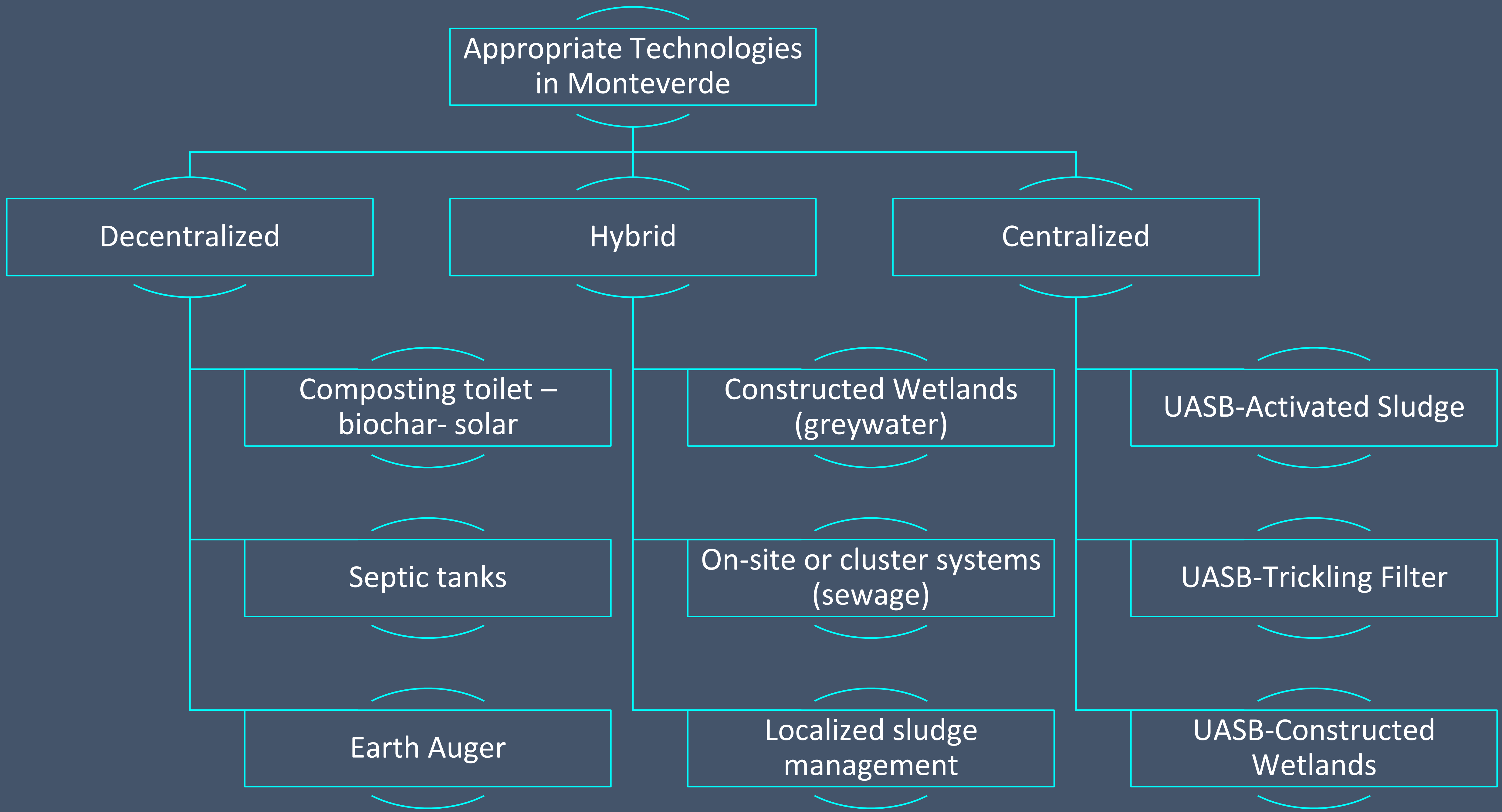
Plenty of walking



Professional development goals

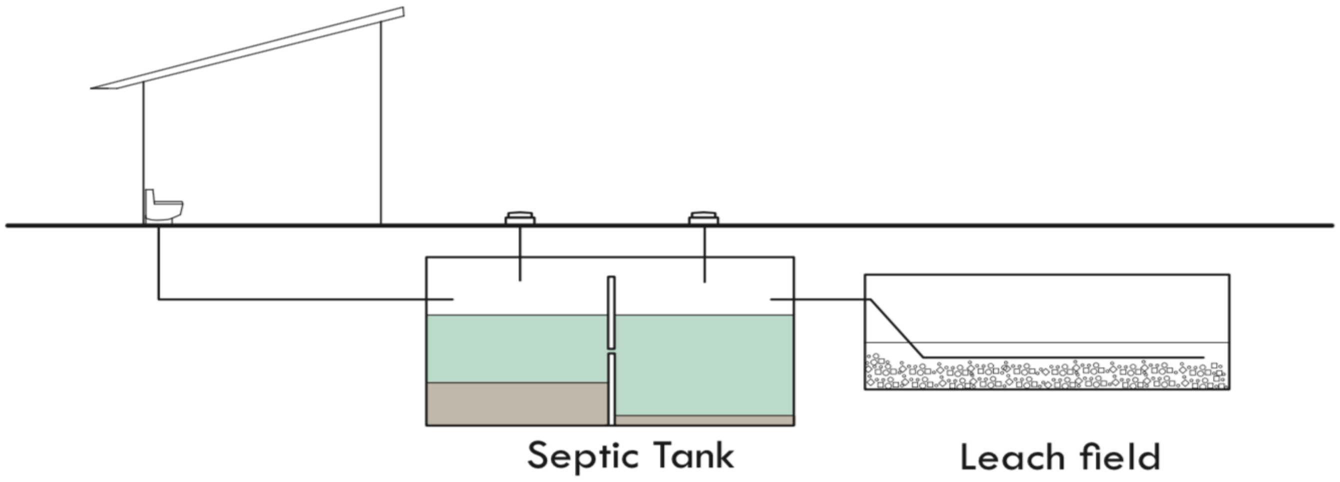
- Develop global and interdisciplinary skills and competencies through cross-training and multidisciplinary field work
- Increase the number of U.S. students from underrepresented groups participating in international research experiences that combine STEM and Social Sciences
- Strengthen and expand the partnership between Costa Rican stakeholders and U.S. institutions

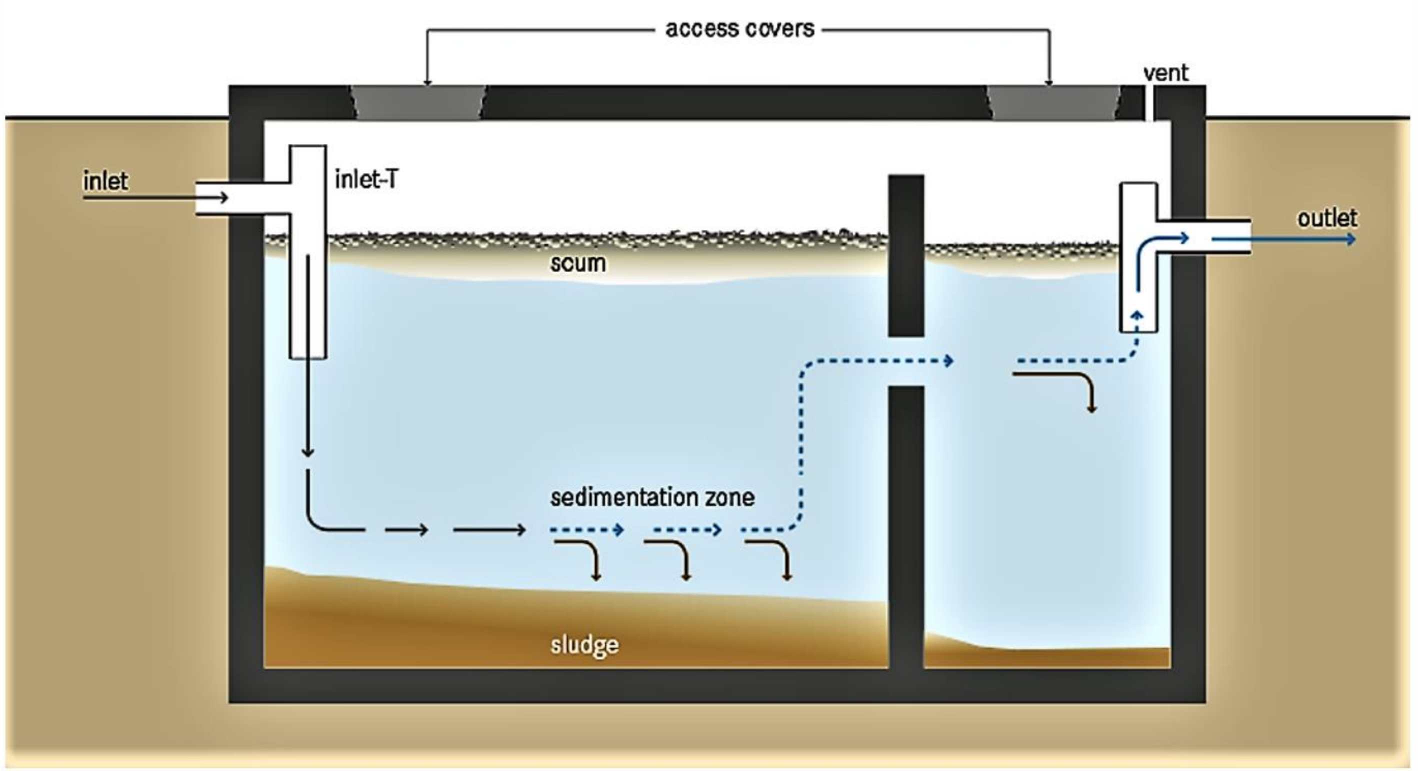
Sanitation Technologies


Appropriate Technologies in Monteverde
Decentralized
Hybrid
Centralized
Composting toilet – biochar- solar
Septic tanks
Earth Auger
Constructed Wetlands (greywater)
On-site or cluster systems (sewage)
Localized sludge management
UASB-Activated Sludge
UASB-Trickling Filter
UASB-Constructed Wetlands

Septic Systems

- Passive technology
- Low energy usage
- Routine maintenance
- Low population density
- Can be designed for water and nutrient reuse





Source: https://sswm.info/factsheet/septic-tank

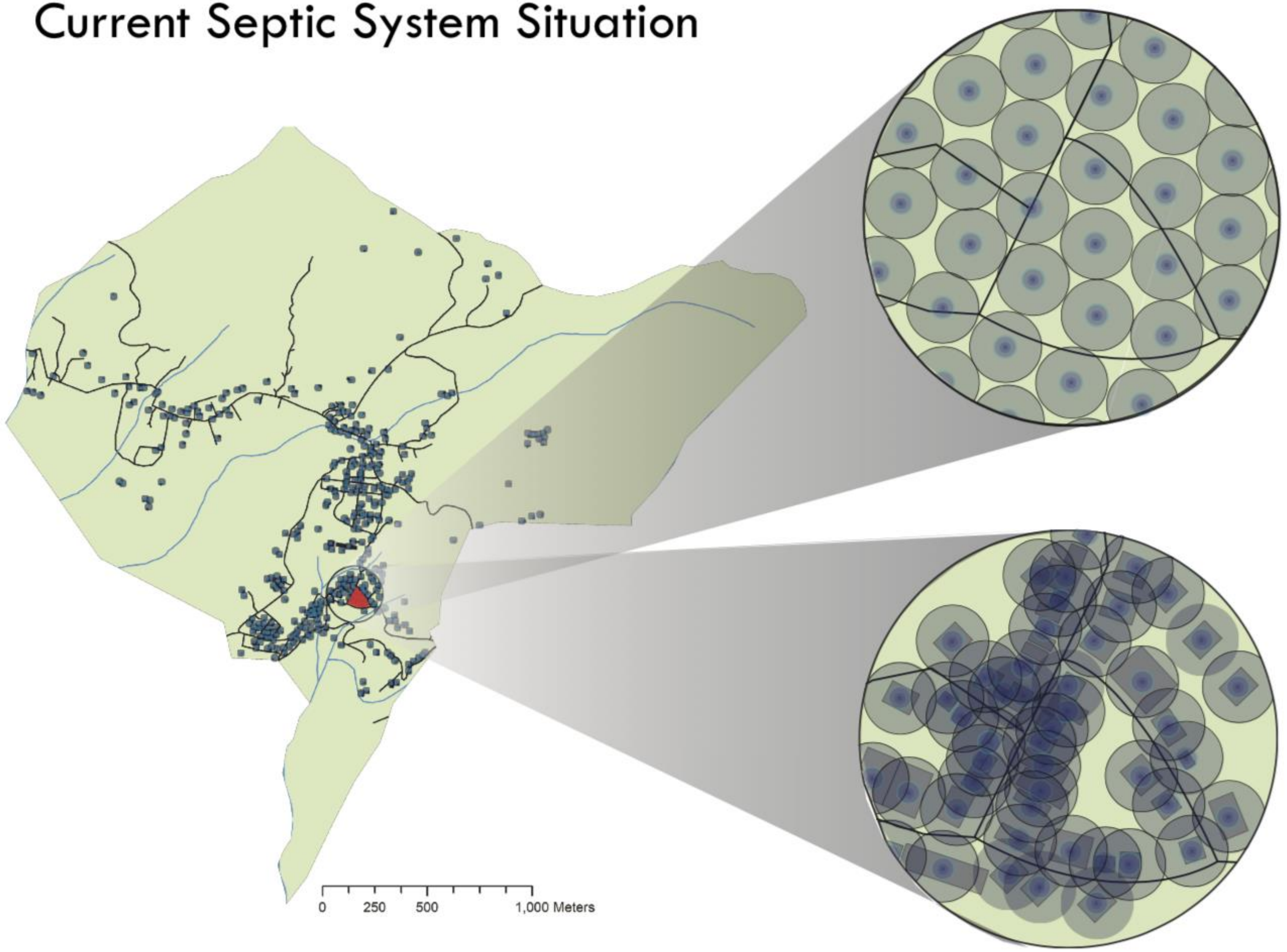
Septic systems

- Design concerns
- Space limitations for leach field
- Leading to groundwater pollution

Inside of a septic tank

Modified septic tank using car tires

Current Septic System Situation



Sustainable Futures (2012)

Composting Toilets

- Conserve water
- Reduce carbon footprint
- Recycle nutrients
- Public perception issues

Current Greywater Management

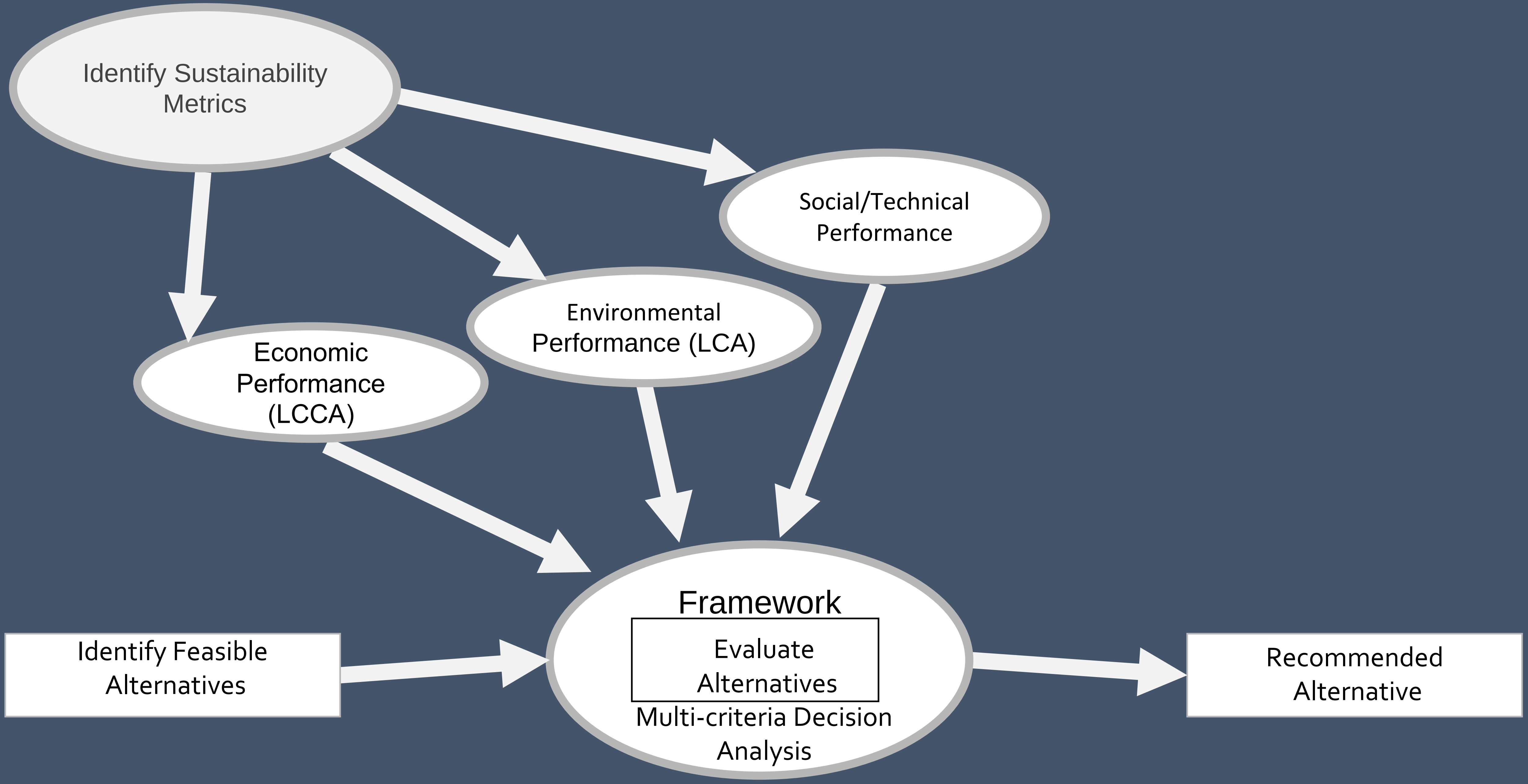
- Contamination of surface waters
- Direct discharge to streets or groundwater
- Untreated greywater, aesthetic issues

Greywater often goes untreated into the street

Greywater effluent discharging into the street

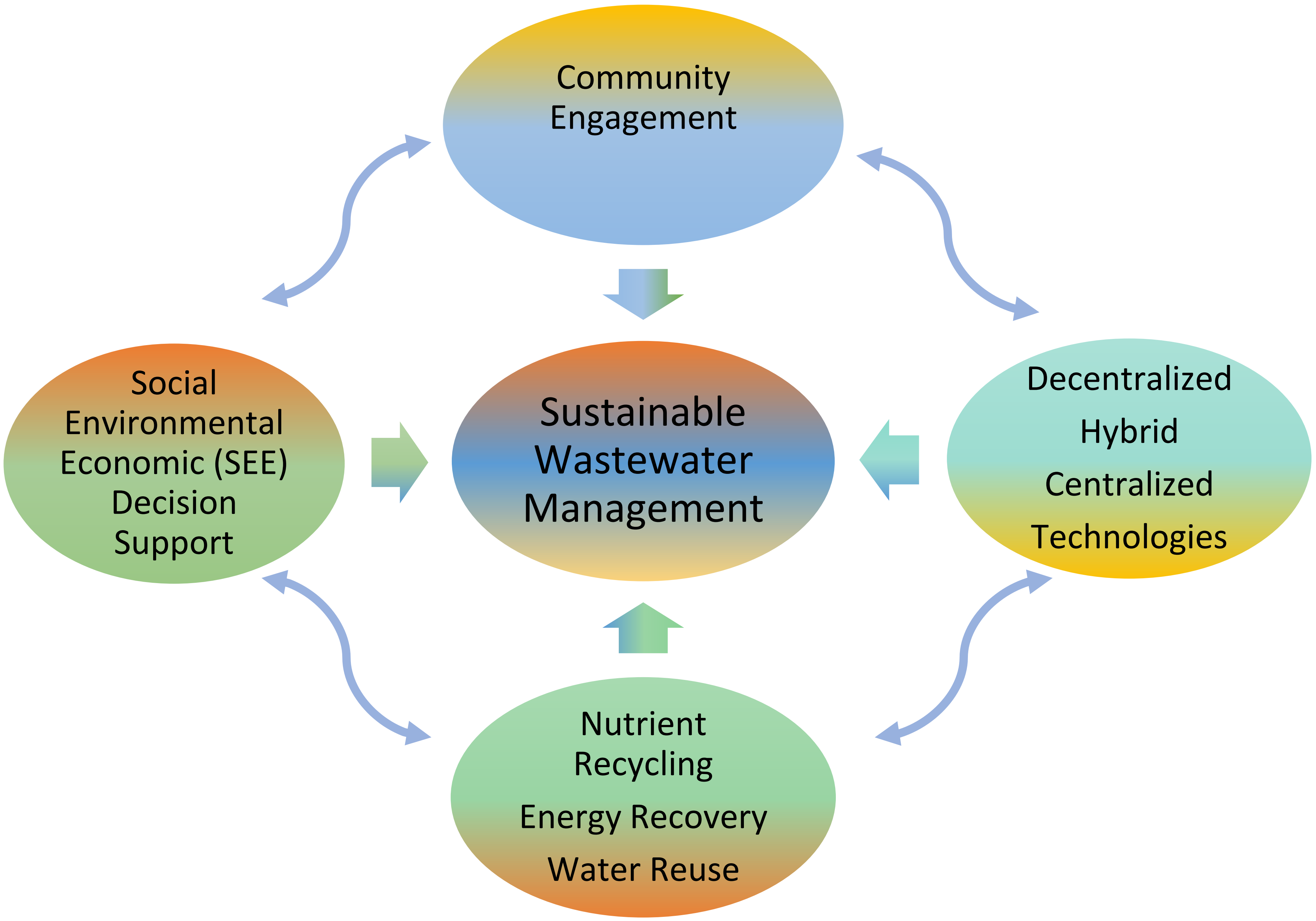
Methodology

SEE Wastewater Decision Support Tool



In-country Collaborators

Technologies	Mentor	Organization	Roles and Responsibilities
Septic systems, composting toilets	Gabriela McAdam, Katy Van Dusen, Mark Fabian	CORCLIMA (Monteverde Commission for Resilience and Climate Change)	Provide research mentorship septic systems and composting toilets. Support with carbon footprint analysis and guest lectures.
Centralized WWTP	Justin Welch, Eric Centeno	ASADA (local water authority), University of Costa Rica (UCR), Environmental Engineering	Provide research mentorship for centralized wastewater systems. UCR will provide research expertise. The ASADA will facilitate research mentorships, contact key stakeholders, and provide access to key data.
Biojardineras	Anibal Torres, Ronald Aguilar	Monteverde Institute (MVI), UCR), Biosystems Engineering	Provide research mentorship and laboratory support for water quality analysis. MVI will provide logistical support for lodging, meals, transportation, tours, and MVI facilities.
Sludge management	Dr. Mauricio Bustamante, Dr. Juan Pablo Rojas Sossa	University of Costa Rica (UCR), Biosystems Engineering	Provide research mentorship, laboratory support for water quality analysis, and guest lectures.


Community Engagement
Social Environmental Economic (SEE) Decision Support
Sustainable Wastewater Management
Decentralized
Hybrid
Centralized
Technologies
Nutrient Recycling
Energy Recovery
Water Reuse

Acknowledgement

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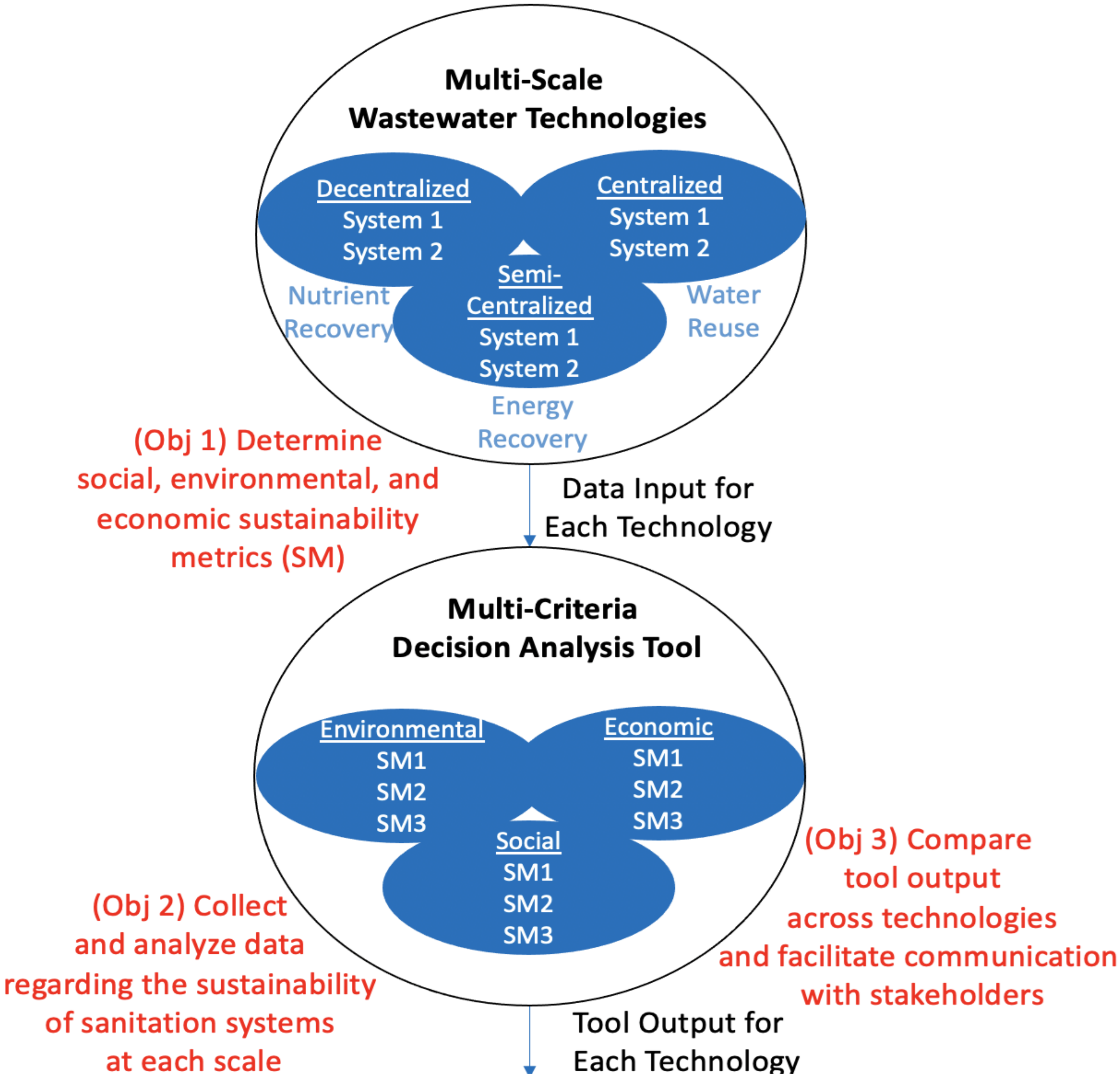
Icebreaker

- Name
- Where you call home
- Why you are interested in this international research experience
- Questions you have about the program


Multi-Scale
Wastewater Technologies
Decentralized
System 1
System 2
Centralized
System 1
System 2
Semi-Centralized
System 1
System 2
Nutrient Recovery
Water Reuse
Energy Recovery
(Obj 1) Determine social, environmental, and economic sustainability metrics (SM)
Data Input for Each Technology
Multi-Criteria
Decision Analysis Tool
Environmental
SM1
SM2
SM3
Economic
SM1
SM2
SM3
Social
SM1
SM2
SM3
(Obj 2) Collect and analyze data regarding the sustainability of sanitation systems at each scale
(Obj 3) Compare tool output across technologies and facilitate communication with stakeholders
Tool Output for Each Technology

Objective 1: Determine social, environmental, and economic sustainability metrics for wastewater treatment and resource recovery systems

- Key questions: what sustainability metrics are important wastewater management? What are community perceptions of varying strategies?

Stakeholder Engagement

- Residents
- Regulators
- Engineers
- NGOs
- Water authority
- Academics

Methodology

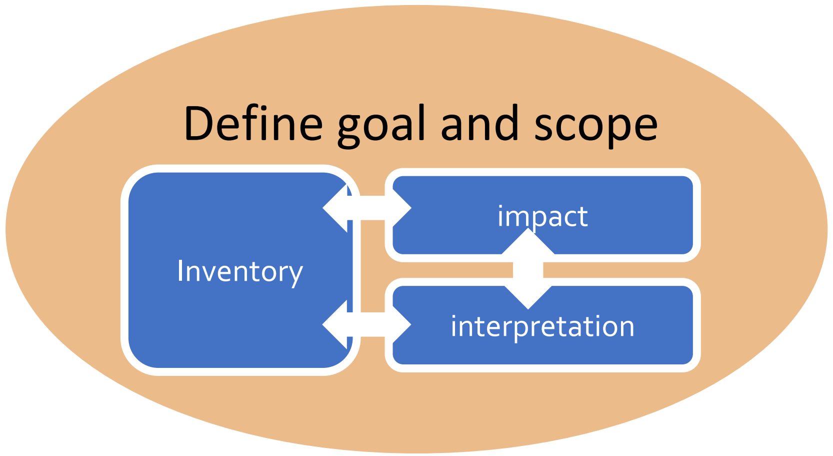
- IRB-approved short surveys
- Systematic observations
- Individual semi-structured interviews
- Focus group discussion

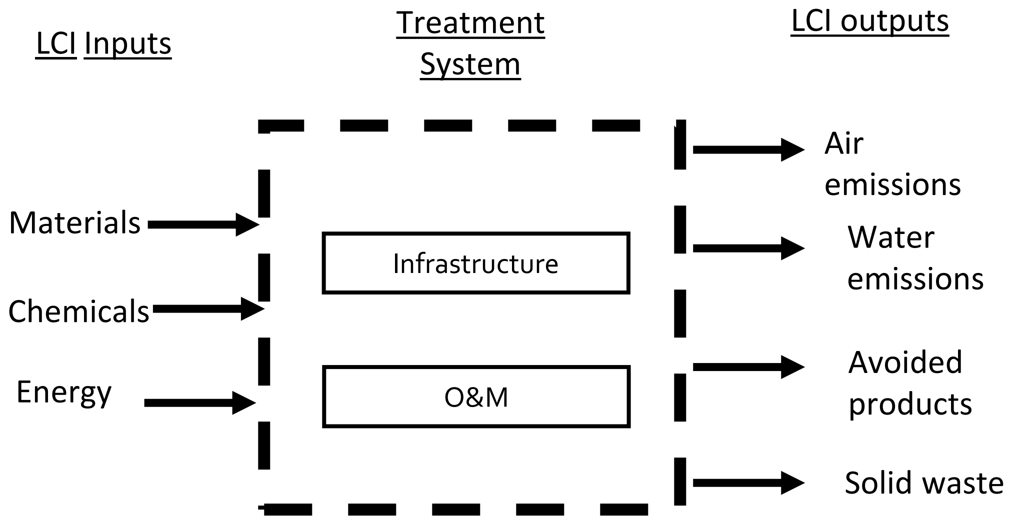
Outputs

- Inform sustainability metrics important to region
- Improve understanding of public perceptions of alternative strategies

Objective 2. Environmental Performance

Life cycle assessment (LCA) will be used to quantify environmental impacts of systems over their useful lifespan





LCIA Results

ReCiPe Midpoint Indicators

Carbon footprint
Eutrophication potential
Water depletion

Endpoint Indicators

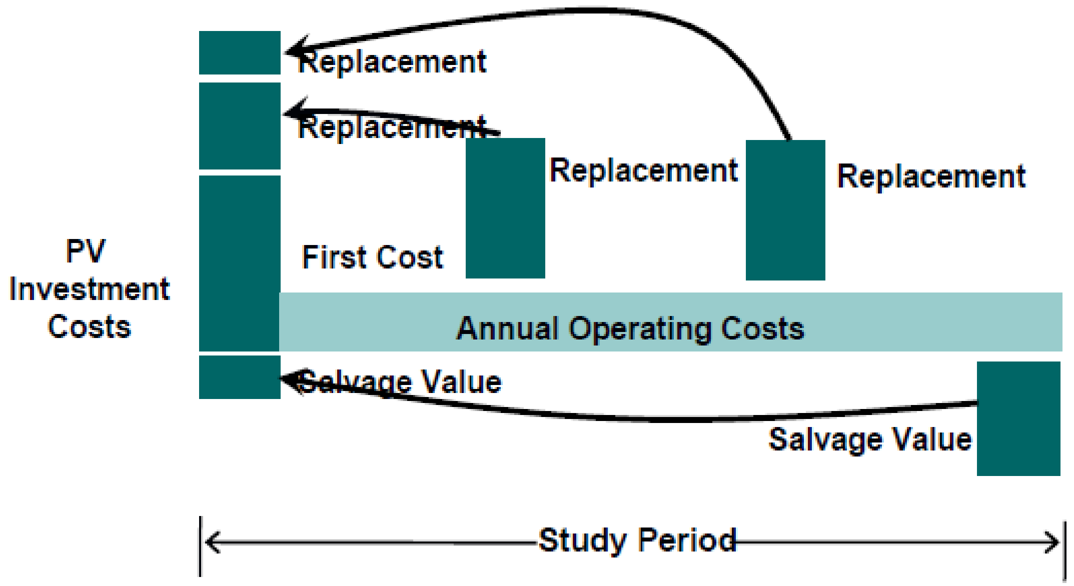
Damage to human health
Damage to ecosystems
Damage to resources

Interpretation

Monte-Carlo uncertainty analysis
Sensitivity Analysis

Objective 2: Economic Performance

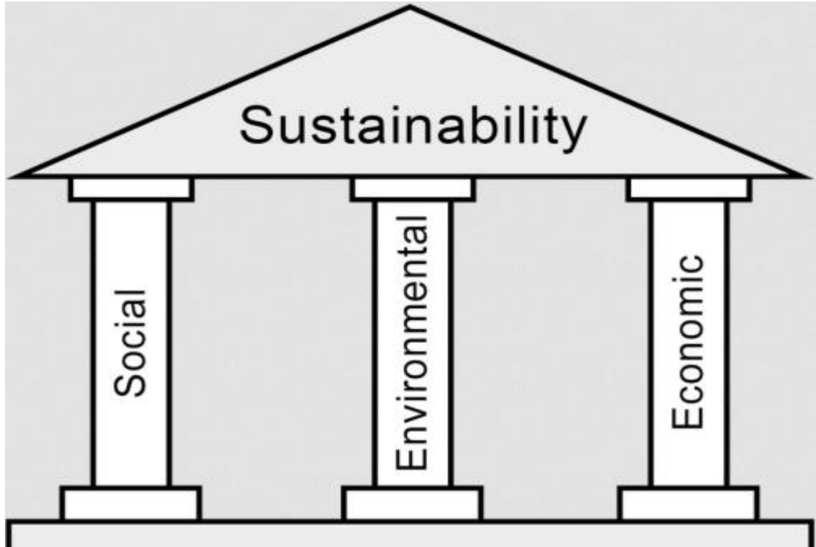
Life cycle cost analysis (LCCA) will be used to quantify economic impacts over each system's useful life



Capital cost: land, infrastructure, equipment, and installation.
O&M cost: electricity, fuel, chemical, labor, sludge management, and overhead costs
Major replacement costs: cost and frequency of replacement
End-of-life costs: salvage values and decommission costs
Benefits: savings associated with environmental protection and resource recovery, revenues
Expected Results: net present worth, benefit/cost ratio, payback period, sensitivity analysis

Objective 3: Triple Bottom Line Decision Support

- Conventional decision making:
  - Focuses primarily on economics
  - Lacks community participation
  - Excludes key aspects of sustainability
- Triple bottom line decision making
  - Considers holistic sustainability metrics
  - Incorporates community input
  - Identifies trade-offs



Input Data for SEE wastewater decision support tool

Category	Description
Location	Location of system investigated
Water Quality	Influent and effluent quality (flow, BOD5, TSS,TN,TP, pathogens)
Recovery of resources	Amount of water saved or reused, nutrients recycled, and energy recovered
Biosolids	Total N and total P in biosolids
Energy	Electricity, diesel, and other fuel usage
Chemicals/Additives	Chemical or additive type and cost
Infrastructure	Capital cost, material type, amount of materials
O&M costs	Operation and maintenance costs, replacement costs, benefits
Social and technical factors	Maintenance time, system intrusiveness, resilience, operational complexity, capacity building