Belmont Forum Collaborative Research Action (CRA) Soil & Groundwater

Draft concept note

This draft concept note was developed by the participants of the scoping workshop organised on 5-7 April 2019 in Vienna, Austria and hosted by the Austrian Environment Agency. This document will be updated based on the continued scoping consultation (see section 4 – next steps). This process is led for the Belmont Forum by AllEnvi (France) and the French National Research Agency (ANR) with the support of an international steering committee including the National Science Foundation (NSF), USA, the Sao Paulo Research Foundation (FAPESP), Brazil, and the Qatar National Research Fund (QNRF). Finalisation of this concept note is planned for mid September 2019 to be presented at the Belmont Forum Plenary (23-25 October 2019).

1. Content of the call

Title: Towards sustainability of soils and groundwater for societal benefit

Theme: Identify pathways towards sustainability of critical zone and ecosystem dynamics and related services to ensure support of societies and sustainability of human activities

Context

Human impact on the biosphere is such that humanity has entered the "Anthropocene", a new geological period in which human activities are the main driver of global environmental changes. This "great acceleration" has global manifestations, the most evident being the increasing concentrations of atmospheric greenhouse gases that drive climate change. At a local scale, changes in land management and cover, and urbanization exert an increasing and unprecedented pressure on terrestrial ecosystems and related resources. Terrestrial ecosystems, above and below ground biodiversity, soils, rocks, and water are natural resources that interact to provide sustainable life support systems and essential benefits to societies such as food production and water quality and quantity. At the heart of the dynamics of these socio-ecological systems are decisions and actions taken by a multitude of socio-economic actors. Rather than being independent, all these human and non-human components interact constantly along trajectories that remain to be characterized, especially when accounting for conflicts, synergies and trade-offs.

Initially defined as the zone from the top of the lower atmosphere to the bottom of the fresh bedrock in which freely circulating groundwater is found (NRC 2001; Brantley et al. 2006), the Critical Zone is a complex socio-ecological system in which water, rocks, soils living organisms, and societies interact at different timescales. The Critical Zone concept promotes a holistic, systems approach to better understand how this system responds to human activities, to ensure the identification of pathways and transitions to its sustainable management for the benefit of current and future generations. This "whole system approach" must include all scales of space and time since, for example land use change due to agricultural practices, which lead to soil erosion affecting both agricultural practices and flood risk.– Another example of ecosystem processes not fully taken into account in decision-making relates to the accelerating rate of soil degradation, which largely exceeds its rate of formation by long-term biogeochemical processes. This issue of rate have not frequently been considered in relation to societal needs nor have they been integrated into management actions.

Understanding changes and potentially reversing on-going degradation in the Critical Zones requires:

- Engagement of scientists from many disciplines to assess and understand interactions between above and below ground components, including ecosystems, soils, landforms, bedrock, surface and groundwater, which combined are responsible for the storage and fluxes of matter and energy needed to sustain the water cycle and biogeochemical cycles. As well, multiple disciplines are needed to understand the impacts of local and more distant socio-economic factors on these systems;
- Integration of the many facets of this socio-ecological system into predictive models, including the social, political and economic drivers and processes leading to pressures on this system;
- Consideration and engagement the different socio-economic actors, as the processes of their actions and their feedbacks on the system use different pathways. Consideration should include:

1) How decisions, individual as well as economic, political and planning, impact the Critical Zone (and how they could be modified towards more sustainable management);
2) How the Critical Zone's deterioration feeds back - through the reduced delivery of ecosystem services - on the different societal actors, and how these actors might respond to a new situation.

Figure 1 presents the multiple interactions that must be accounted for to develop solutions for sustainable management of the Critical Zone.

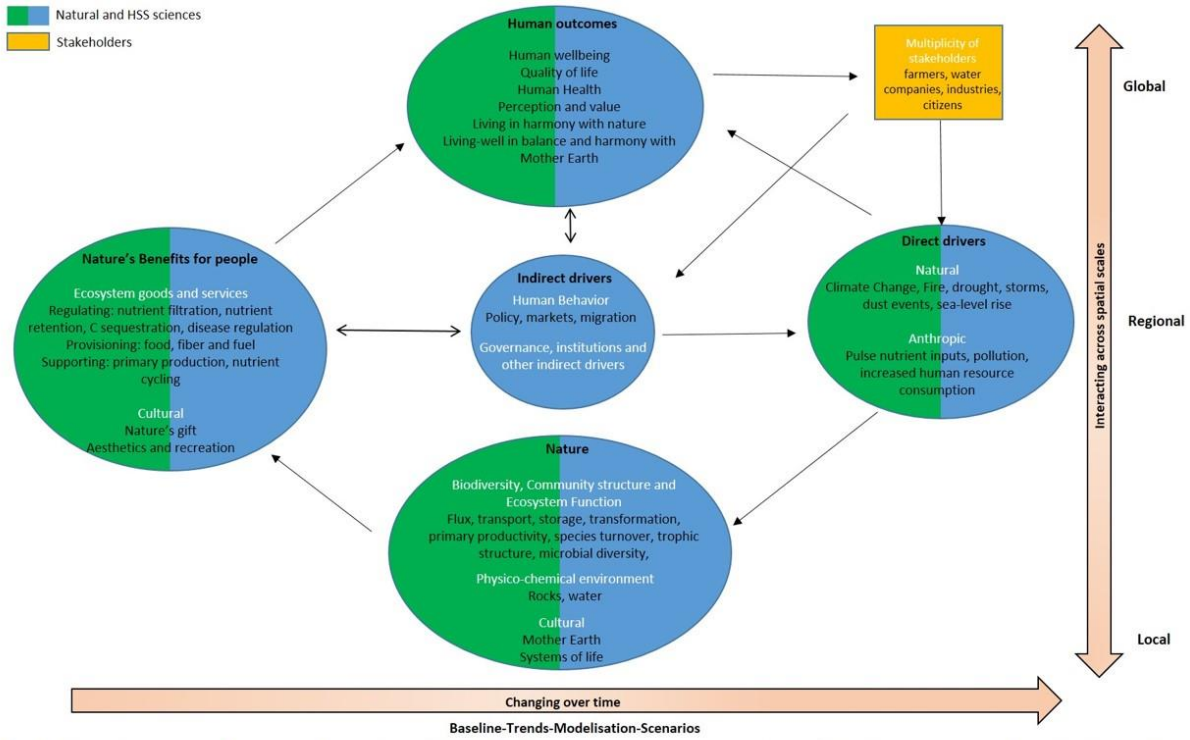

Fig.1 This CRA Conceptual Framework provides the basis for long-term, integrated, socio–ecological research. In each of the boxes, the headlines in black are inclusive categories that should be relevant to all stakeholders involved in the CRA. Examples are illustrative, not exhaustive. Arrows describe influence between elements. The anthropocentric values of nature are embedded in the nature, nature's benefits to people and Human outcomes boxes, and in the arrows connecting them. The thick coloured arrows below and to the right of figure indicate that the interactions between the elements change over time (horizontal bottom arrow) and occur at various scales in space (vertical arrow).
This figure was adapted from the following publications: Collins, S. L., *et al.* 2011. *An integrated conceptual framework for long-term social–ecological research*. Frontiers in Ecology and the Environment 9:351–357; S. Díaz, *et al.* 2015. *The IPBES Conceptual Framework—Connecting nature and people. Curr. Op. Environ. Sust.* 14, 1–16

Goal and objectives

The goal of this CRA is to produce the necessary knowledge and propose solutions to maintain a well-functioning Critical Zone, or rehabilitate it where degraded, through:

1) Better understanding of the dynamics and functions of the Critical Zone, impacts from societal (including economics) decisions, management practices, public policies, and how these systems have been transformed; and,

2) Providing avenues, pathways, and narratives toward transformation of management practices of the Critical Zone through a fundamental shift of socio-economic actors' practices and related-decisions making processes.

Improved management style that embraces the concept of the Critical Zone is at the core of this call, and especially the evolution of management practices from stationary to adaptive systems i.e. evolving under anthropogenic and natural pressures. The design and implementation of novel solutions will help to address global societal issues such as poverty and migration, as these are related to factors such as soil degradation and the loss of ecosystem services such as soil fertility, water quality and quantity.

Developing improved management practices requires projects that address the whole socio-ecological system and that are grounded in a solid transdisciplinary scientific understanding of the Critical Zone. This will necessitate a strong engagement of socio-economic actors in developing and conducting research projects with interdisciplinary research teams (environmental science, biogeochemistry, sociology, political sciences, economics, etc.). It also requires consideration of side effects, trade-offs, synergies and co-benefits between decisions, policies, regulations and management practices.

Focus

Given the environmental urgency facing Earth's surface and socio-ecological systems, the focus of this CRA should be on better understanding mechanisms of long-term change and retroactions to improve our predictive capacity through integrated models development and scenario building (what ifs, narratives), including how institutions and governance affect management practices. Attention should also be paid to differentiating and linking between local and global scales. The critical zone is typically a local system, where most impacts are local but it is a system influenced by global processes such as climate change and socio-economic drivers.

Proponents can address any topic related to ongoing or predicted future degradation of Critical Zone resources and functioning through societal actions. They should also address measures to restore and rehabilitate these resources and functions, and make them more resilient. Projects may include regional or inter-regional comparisons, or address environmental or land-use gradients. The focus should be on management within this socio-ecological system, identifying solutions that can be tested or implemented. Projects must address the multiple dimensions of the Critical Zone including the physical, biological and socio-ecological factors. Examples of research questions follow:

- Understanding the dynamics and functioning of the socio-ecological system of the Critical Zone: interactions of natural and socio-economic processes that govern, for example, the formation and evolution of the CZ, the rate of soil formation and degradation, to provide options for more sustainable management practices

    - What are the processes within the Critical Zone responsible for export of dissolved and/or particulate organic matter to rivers and oceans, which has greatly increased during the last decades, including how are the biogeochemical processes modified/accelerated by socio-economic changes (land use change, water extraction, etc.).
    - What are the processes that maintain functioning of other nutrient cycles, and what are the socio-economic drivers of change in those cycles? How can those drivers be managed to sustain functioning for the benefit of nature and humanity?
- Development of management options to achieve environmental standards quantity, quality, and functioning of all compartments of the CZ.
- Understanding the impact of management practices and decisions on the relationships between carbon erosion and carbon sequestration including inorganic carbon.
- Understanding processes and factors of salinization of ground water and soils (irrigation, coastal saline intrusion, continental subsidence of the deltas.
- Questions about adaptive governance
- Questions about unexpected consequences of management and actions
- Questions about contamination in the view of rehabilitation
- Research question addressing policy challenges of establishing and maintaining groundwater safeguard zones
    - Demonstrating that the Critical Zone generates a number of ecosystem services other than groundwater protection (co-benefits), and all of them should be accounting when developing management or policy schemes
    - Value those ecosystem services in economic terms
    - Develop scenarios of land use in the Critical Zone that maximizes societal support and economic benefit
    - Design economic instruments of cost sharing (e.g. payment for ecosystem services-PES)
- Research question addressing policy challenge of regulating groundwater extraction
    - Understand factors driving (non-)compliance by users (legal, social and economic dimensions)
    - Design and test participatory approaches that help design rules, which reconcile diverging interests and visions of social justice (participatory engineering)
    - Design and test experiments that favour economic instruments of compliance (i.e. Payment and Penality-P&P)
- Research question addressing policy challenge of planning groundwater use through citizen participative science, aimed at improving users' perception of critical zone resources and management issues, and increasing acceptance of changes
    - Investigating incentives that involve citizens in data collection
    - Designing new governance models that use new information derived from citizen involvement
    - Incorporating citizen data into models (quality assurance issues)

- Developing multi-objective hydro-economic models to optimize conjunctive use of surface and groundwater to maximize water supply reliability and ecosystem protection in a context of increasing variability (options for insurance against drought)
- Designing socio-economic models to develop a form of agriculture and forestry that incorporates soil conservation measures to reduce and limit erosion and potentially reduce flood risk.

2. Expected outcomes

Proponent should justify the breadth of impact and expected outcomes.

There is a large range of potential outcomes (see below), but they will be specific for each project. Categories of potential outcomes include:

- Strategies towards sustainable Critical Zone management to support human societies and nature.
- Knowledge based decision-support tool kit for managers:
    - Addressing past, current and future aspects of CZ function
    - Unified non-stationary models of Critical Zone function
    - Scenario development tools and outcomes
    - Management of uncertainty
    - Best practices in management
- Support of policy agenda:
    - Development of national environment legislation and policy, such as UK in the context of Brexit
    - Migration policies in relation to local development
    - U.N. Sustainable Development Goals, such as water quality, land degradation, biodiversity, climate change
    - Addressing knowledge gaps identified in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment on land degradation and restoration (2018)
    - Addressing knowledge gaps identified in the Intergovernmental Panel on Climate Change (IPCC) Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SR2)
- Evidence of science in decision making as well as potential citizen science (Evidence of money well spent – value of demonstrators – improve social welfare)
- Vibrant transdisciplinary community of researchers in the field of Critical Zone science
- Expand knowledge of:
    - How society makes decisions on land use to achieve Critical Zone sustainability
    - Processes within the Critical Zone
    - Processes impacting the Critical Zone

    - Mitigation and adaptation to climate change especially in relation to the carbon cycle
    - Thresholds/tipping points that affect Critical Zone function
    - Improved predictive capacity through improved integrative models and data
    - Improved scenario building for sustainable management of the Critical Zone
    - Data to ground truth remote sensing of the CZ
    - Etc.
- Development of observation systems (social, natural, etc.), novel monitoring devices/instrumentation (such as technologies, probes, monitoring stations), and global data sets provided by these instrumentations
- Outreach and communication aimed towards the public at large and other audiences to raise awareness of soil, the critical zone concept, and threats related to their degradation.

3. Design of the call – aspects, which request discussions among the funding agencies

Development of proposals

Announcement of the call as soon as possible after the Belmont Forum plenary (October 2019) – if approved.

Propose to set up a long ingress window (5-6 months) to be used to support activities of networking especially with various societal actors and disciplines, capacity building, transdisciplinary training or series of workshops. This is to address the challenge of this CRA been focused on transformation of management practices (transdisciplinary) using an holistic system approach (interdisciplinary).

Potential supporting activities during the proposal development phase:

- Workshops and other supporting activities could be organised regionally with the objective to build community gathering Natural Scientists, Humanities and Social Scientists, and Societal actors from different countries.
- Participation in this workshop should not be mandatory but should be considered as great opportunities for applicants to develop the transdisciplinary community and their networks. A key aspect for the success of these activities will be working with good knowledge brokers and mechanisms. These activities should have a regional focus.

Conduct of selected projects

There is a proposition to organise "coordination and valorisation" activities for funded projects/consortium.

Specific mechanism(s) and/or appropriate budget in projects proposal to conduct and engage in these activities should be designed.

Once projects are selected for funding, NERC suggests organising a competitive call for these projects to get some extra-funds to conduct coordination and valorisation activities. This would request projects' partners realise the need to work together and promote data sharing. This additional funding opportunities should be described in the main call text to ensure projects are 1) aware of this requirement of collaboration, and 2) start preparing themselves in terms of budget and potential application for this extra-funding.

Other aspects

Participants proposed project durations of 5 years due to the following characteristics of the CRA:

- Inter- and trans-disciplinary work
- Development of dynamic models may require better characterisation of processes (socio and/or natural process and their interactions)
- Allow completion of PhDs
- Include some time for publication and outreach activities.

4. Glossary

To be completed – please suggest terms to be included

Critical Zone: The zone from the top of the lower atmosphere to the bottom of the fresh bedrock in which freely circulating groundwater is found (NRC 2001; Brantley et al. 2006)