

Research Statement

Roman Eric Sieler · romaneric.sielер@unibas.ch · romansieler.com

We live in an era of widespread ecosystem collapse (Bergstrom et al., 2021) and of biodiversity loss the Earth has not seen in 65 million years (Ceballos et al., 2015). Despite the scale of this challenge, the economic and distributional consequences for the people who depend, directly or indirectly, on the nature around them are only starting to be understood. Economists have long worked on valuing ecosystem services, but we are now at a point where the impacts of climate change and other anthropogenic stressors are materializing in ways we can directly observe, and where we finally have the tools to observe them.

In this context, my research asks a simple question: what does the degradation of the environment actually cost the people and firms who depend on it? Answering this question credibly requires two things: large-scale data that capture the regional and global dimension of environmental loss, and a solid econometric approach to estimate its impacts in specific settings. This is my **primary line of work**, which I pursue in two settings: coral reefs, where degradation reaches households through their livelihoods and their children’s health, and air quality, where it reaches firms through the productivity of their workers. A **secondary strand**, using the same toolkit on administrative firm data, studies the other side of the same coin: how firms respond to climate policy, particularly the EU Emissions Trading System, and how global climate policy is shaped. Understanding the impacts is not enough; we also need to understand how to address their causes without imposing unnecessary welfare losses elsewhere. Both lines require working across disciplinary boundaries, and interdisciplinary collaboration is one of the main strengths I bring to this agenda.

Primary Agenda: The Economic Costs of Environmental Degradation

Coral reefs are among the first ecosystems to suffer large-scale degradation from climate change. They are, in some sense, the canary in the coal mine for climate-induced ecosystem loss, which is why understanding the impacts of reef loss also helps us understand the dynamics that matter for ecosystems at large. Yet quantitative ex-post evidence on what coral bleaching costs is largely absent from the literature. The reason, and here coral reefs are again representative of ecosystem research in general, is missing data. Outside the Great Barrier Reef and small-scale surveys of individual sites, there is no consistent record of where and when reefs have bleached. Researchers therefore substitute thermal stress indices for bleaching itself, even though temperature affects fish, tourists, and coastal economies through other channels and does not map closely to bleaching; or rely on very few, and likely biased, in-situ observations. Solving this measurement problem, and using the solution to estimate economic effects, is the core of my research.

A causal analysis and the foundation for more. In my **single-authored** job market paper, *Coral bleaching reduces child growth through nutritional pathways* (under review at *Nature Climate Change*), I built a satellite-based coral bleaching dataset for East Africa from Sentinel-2 reflectance, normalized against non-coral benthic cover in the same pixel and classified using a deep recurrent neural network trained on global survey and Australian aerial-survey data. The model reliably separates bleached from non-bleached reef cells it has never seen (F1 of 0.73 on held-out cells; 0.70 on an external holdout of new locations), which makes the data dense and consistent enough to serve as a source of identifying variation rather than being confined to unevenly sampled survey sites. To identify causal effects, I instrument observed bleaching with accumulated heat stress while controlling flexibly for current sea surface temperatures. This exploits the fact that corals respond to long-run thermal accumulation, while reef fish respond to, and relocate with, contemporaneous temperature. A falsification test supports the design directly: past heat stress predicts catch in bleached areas but not in unbleached ones, conditional on my controls. Studying every link from a climate-driven ecosystem shock to child health, I find that a one-standard-deviation increase in bleaching reduces fish catch per fisher-day by about 26% of the mean in Kenya, that strongly affected households in Tanzania consume about 21% less fresh fish, and that children across four countries who are exposed to bleaching in utero or in their first two years are significantly shorter for their age: a one-standard-deviation increase in cumulative exposure lowers height-for-age by about 11%. Households,

moreover, do not appear to adapt through assets, labor, or migration. The current version of this paper shows that I am able to combine a rigorous econometric design with the interdisciplinary understanding and collaboration that makes my work appealing to a broader scientific audience. However, I had to cut some aspects to make it compatible with a nature journal; an earlier version with more robustness tests is available under the same DOI. Using the same data, I am currently working with Bryan Galligan on the impacts on micronutrient intake.

The East Africa dataset, however, was a proof of concept. Its global version is now complete: *A Global Satellite-Derived Coral Bleaching Dataset (2016–2025)*, monthly and at 5-kilometer resolution, covering every reef mapped by the Allen Coral Atlas with Sentinel-2 coverage. I am currently writing the accompanying paper, which documents global bleaching patterns since 2016 and which I plan to submit at the turn of 2026/2027. It fills an important gap: there are no published large-scale analyses yet of the fourth global bleaching event, likely the most damaging so far. With the release of the dataset, any question that currently substitutes temperature for bleaching, in ecology, fisheries, conservation, or economics, can be revisited with a direct observational measure. In parallel, I am developing the model further, toward continuous bleaching intensity and distinguishing coral mortality from recovery. Because dead coral is progressively colonized by algae and shifts toward a spectrally distinct reflectance, while recovering coral returns toward its pre-event signature, the temporal structure of the data should allow the model to separate the two. Building on the dataset, I am working on the impacts on fish biomass with Christopher Golden and Jessica Zamborain-Mason (at an early stage), with an extension to long-term projections planned with Christina Dräger, and on the impacts on human–wildlife conflict with Francesco Cenerini. I aim to make two follow-up projects my next major papers: one on the economic impacts of bleaching in Australia, with Ben Henley and Neal Cantin, and one on its global nutrition dimension, with Jonas Stehl. The first asks what mass bleaching has actually cost reef-dependent industries in Australia. We will combine an event-study design around the Great Barrier Reef’s mass bleaching events with the instrumental-variable strategy from my dissertation, applied to Queensland commercial fisheries logbooks and Reef Authority visitor data, to separate the ecological channel from a perception channel operating through undifferentiated media coverage of a reef system 2,300 kilometers long. This distinction has direct policy implications, since existing Australian damage estimates so far vary widely and are drawn almost entirely from stated-preference methods rather than realized outcomes. To the best of my knowledge, this paper will produce the first ex-post, causally identified cost estimate for bleaching in a high-income economy. The second project extends my identification strategy globally, using Demographic and Health Survey data for more than twenty countries to ask whether the East African fisheries-to-nutrition effects generalize across income levels and ecologies, a question the existing literature cannot answer.

From households to firms: air quality as a production input. Reef loss reaches households through their livelihoods and their children’s health. My second main paper, *Bad for Business? The Impact of Air Quality on Firm Outcomes in Germany* (with Beat Hintermann and Corrado Di Maria), asks the same question on the production side of the economy, for a form of degradation that is far less visible but almost universal: fine particulate matter. Combining satellite-derived PM_{2.5} with administrative plant-level data covering German manufacturing from 2003 to 2018, we face an identification problem similar to my coral work: economic activity itself generates pollution. We therefore instrument pollution with the strength of temperature inversions, which trap pollutants near the surface, while controlling flexibly for temperature, wind, and other weather conditions. As with coral bleaching, a falsification test supports the design: pollution on weekdays reduces output, while pollution on weekends, when most plants do not operate, does not. A one-standard-deviation increase in PM_{2.5} (0.9 $\mu\text{g}/\text{m}^3$) reduces the value of production by 1.6% and hours worked by 1.1%. Because we observe output and hours within the same plants, a production framework allows us to separate the two channels: most of the loss comes from lower labor productivity for any plausible output elasticity of labor. We also show that aggregating to the firm level, as most of the literature has to, masks the effect on hours entirely. Even at Germany’s comparatively low pollution levels, our estimates imply that a reduction of 1 $\mu\text{g}/\text{m}^3$ would have raised manufacturing value added by roughly EUR 12 billion in 2018, well above the cost of policies such as low-emission zones. The paper was reviewed at the *American Economic Review*, and we are currently revising it in response to the referee reports for a new submission in JEEM.

Interdisciplinary by design. None of these projects could be done within economics alone. Measuring bleaching requires remote sensing and machine learning; interpreting it requires coral biology and marine ecology; and tracing its consequences for people requires nutrition and public health. My collaborations reflect this: with nutrition and public health researchers at Harvard University, with marine scientists at KAUST and the Australian Institute of Marine Science, and with climate scientists at RMIT University and Harvard. In each of these collaborations, I bring the economic question and causal design, while my coauthors bring the domain knowledge that makes the measurement credible and the results relevant beyond economics. This is how I intend to keep working: an economist who has the econometric knowledge our profession requires, but who can also speak the language of the natural and health sciences is well placed to answer questions that neither side could answer alone, and to publish the results both in the economics literature as well as in outlets where they reach a broader audience.

Beyond coral reefs. Going forward, I plan to extend my work to other ecosystems where the same measurement gap exists. For forests, satellite records capture outright clearing well, but much less so gradual degradation, such as drought-induced dieback, fire damage, or selective logging, even though degradation can erode the services forests provide long before any tree-cover loss is recorded. Among marine and coastal habitats, the loss of mangroves, seagrass meadows, and kelp forests threatens the same fisheries and coastal livelihoods my current work studies, but is rarely measured consistently over time. In each case, the combination I have developed for reefs and air quality carries over: models trained on ground-truth observations to detect environmental change from space, an identification strategy that separates environmental loss from the climatic and economic shocks that cause it, and collaborators from the relevant natural sciences.

I have also built a track record of securing the resources this agenda requires. I co-developed the SNSF grant that funds the East Africa project (CHF 100,425) with Beat Hintermann, and separately secured a grant from the Supporters' Association of the Faculty of Business and Economics, a Burckhardt-Bürgin travel grant, and a competitive, university-wide Doc.Mobility fellowship of the University of Basel. Together, these have funded the data work, analysis, and international collaboration this agenda runs on, and I expect to build on this record as the agenda scales globally.

Secondary Strand: Addressing the Problem through Climate Policy

A smaller second line of research turns from the costs of degradation to the policies that address its causes. My air-quality paper is the bridge between the two: fine particulates are largely produced by the same combustion processes that emit greenhouse gases, so its estimates speak directly to the local co-benefits of carbon pricing, and it builds on the same administrative firm data I use to study climate policy. This strand also keeps me connected to the policy questions of my work in energy and climate policy consulting and of my work in the UNFCCC process. With Francisco J. André, Corrado Di Maria, and Beat Hintermann, I study whether firms regulated under the EU Emissions Trading System adjust their product mix in response to carbon pricing. This margin of adjustment sits between the emissions-reduction and relocation channels usually studied, and it matters for how compliance costs and competitiveness effects are read. A related ongoing project with Paula Castro Pareja draws on my experience in the UN climate space and asks how submissions by non-state actors shape global climate policy outcomes.

I plan to extend this strand as the EU ETS enters a phase materially different from the one my current paper studies: a steeply declining cap, an actively binding Market Stability Reserve, and the phase-out of free allocation for sectors coming under the Carbon Border Adjustment Mechanism. With firm-level data of the kind I already use for Germany, I plan to identify how regulated firms adjust production, sourcing, and product mix as CBAM phases in, and to use the growing set of comparable carbon markets, among them China's national ETS and the UK ETS, to ask which design features actually drive firm behavior, rather than relying on within-EU variation alone. Combined with my air-quality estimates, the same data will also allow me to quantify what the resulting emission reductions are worth to firms in the surrounding region through cleaner air, a benefit that evaluations of carbon pricing usually leave out. I intend this to remain a secondary strand, pursued in parallel with the primary agenda rather than competing with it.

Looking Ahead

Across both lines, the approach is the same: find or build the data that lets a real economic shock be measured precisely, use a design that isolates its effect from the obvious confounds, and work with whichever disciplines the question requires. Over the next five years, I will pursue three goals. First, I will establish the global bleaching dataset as durable, openly available research infrastructure, and use it to produce the field's first systematic, ex-post account of what reef loss costs, in Australia and globally. Second, I will extend this approach to other ecosystems, starting with forest degradation and coastal habitats, so that the economic costs of environmental loss can be measured from realized outcomes rather than inferred from hypothetical scenarios, for households as well as for firms. Third, I will continue a smaller but active line of work on how firms respond to the climate policies now reshaping their incentives, including the local air-quality benefits these policies bring, and on how climate policy is made. Throughout, I will build on the interdisciplinary network I have established with nutrition, public health, marine, and climate scientists, and I look forward to bringing it to a department where economics engages actively with the questions that matter most for people and the planet.

References

- Bergstrom, Dana M, Barbara C Wienecke, John Van den Hoff, Lesley Hughes, David B Lindenmayer, Tracy D Ainsworth, Christopher M Baker, Lucie Bland, David MJS Bowman, Shaun T Brooks et al., "Combating ecosystem collapse from the tropics to the Antarctic," *Global change biology*, 2021, 27 (9), 1692–1703.
- Ceballos, Gerardo, Paul R Ehrlich, Anthony D Barnosky, Andrés García, Robert M Pringle, and Todd M Palmer, "Accelerated modern human-induced species losses: Entering the sixth mass extinction," *Science advances*, 2015, 1 (5), e1400253.