Death by a Thousand Cuts — Assessing the Cumulative Impact of Humans on the Landscape

Presented by
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Momentum is building to officially declare the Anthropocene a new geological epoch. Humans are changing the Earth's biophysical system — atmospheric and ocean climatology and chemistry, extent of snow cover, permafrost and sea-ice, glacier, ice-sheet and ocean volume, and indeed the hydrological cycle. Some changes are truly global, represented by similar temporal trends — atmospheric greenhouse gases, global surface temperatures, nitrogen fluxes to the coastal zone, and species extinctions.

Striking is the extent and rate at which humans have modified Earth's land surface. Humans are now the largest force in the movement of sediment — greater than ice, wind and water. There are 568,000 abandoned mines in the U.S. alone, and millions more throughout the world. We mine 8 to 9 Gt/y of coal and by 2030 the rate may reach 13 Gt/y. This equals the total sediment delivery to the global ocean by all rivers. In the U.S. crushed stone production is 1.7 Gt/y, and sand and gravel mining exceeds 1.3 Gt/y. Globally, aggregate production is 13 Gt/y. Global hydraulic cement production is 2.2 Gt/y, and global iron ore production is 2.2 Gt/y. The Palm Islands of Dubai required 3 Gt of sand; the Hong Kong airport island required 0.6 Gt of sediment. How large is a Gt? The Great Wall of China is ~6,250,000m x 7m x 5m or ~0.4 Gt of bricks & stone.

The traces of humanity (e.g. petroleum wells, geotechnical boreholes, mining-exploration holes, and deep-water wells) will last millions of years. Since 1950, 2.6 million oil and natural gas wells have been drilled in the U.S. with a length of over 5 million kilometers — Worldwide the borehole-length might exceed 50 million kilometers, with truly global drilling locations.

Historical deforestation and land clearing have greatly impacted soil erosion, hill slope failure and downstream sedimentation. And climate often amplifies our human footprint — during the Great American Dust Bowl a combination of poor tilling practice and a prolonged drought caused 94,000 km2 or agricultural land to lose 12.5 Gt of topsoil. Human activities have led five Asian Rivers alone to carry an extra 2000 Gt to the coastal ocean over the last millennium. As humans have spatially-fixed rivers with engineered

levee systems, some such as the Yellow River have become unnaturally super-elevated 5 to 20 m above their floodplain for over a thousand kilometers.

On average, one large (>45m high) dam has been built every day for the last 130 years. This has delayed the flow of freshwater to the ocean by weeks to months and trapped Gt/y of sediment within their reservoirs. Deltas are thus starved of sediment, and in combination with the mining of water, oil and gas, large deltas are sinking four times the rate sea level is rising due to climate change. Subsidence rates can exceed 240 mm/y on many deltas.

By any unbiased and quantitative measure, we have entered a new geological era, unique to the history of our planet. Some of these changes have crept up on us; others have gone unrecognized until recently. Global sustainability involves facing our risks both global and local and aligning governance with stewardship.

Professor J (Jai) PM Syvitski

After receiving doctorate degrees (Oceanography & Geological Science) from the U of British Columbia in 1978, Professor Syvitski held various appointments within Canadian universities (1978-95) while principally working as a Senior Research Scientist within the Bedford Institute of Oceanography (1981-95). Jai was Director of CU's Institute of Arctic and Alpine Research (1995-07), and holds CU faculty appointments in Geological Sciences, Applied Mathematics, Atmosphere & Ocean Sciences, Hydrological Sciences, and Geophysics. Professor Syvitski is presently Executive Director of the Community Surface Dynamics Modeling System, an international effort in 68 countries to develop, support, and disseminate computer models to the broader Geoscience community. Between 2011-16, Jai chaired ICSU's International Geosphere-Biosphere Programme to provide essential scientific leadership and knowledge of the Earth system and help guide society onto a sustainable pathway during rapid global change. Professor Syvitski received the Royal Society of Canada's Huntsman Medal for Outstanding Achievements in Marine Science (2009), is a Fellow of the American Geophysical Union (2010), the SEPM Francis Shepard Medal for outstanding contributions to Marine Geology (2016), and an Honorary Doctor of Science in Sustainability and Earth-System Science from Newcastle University (2016). Professor Syvitski has authored 170 peer-reviewed Journal papers, 61 peer-reviewed books and book chapters, and hundreds of other technical publications.