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The relative contribution of peat compaction and oxidation to total subsidence in built-up areas in the Rhine-Meuse delta, The Netherlands

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Inhabitants of many deltas worldwide are confronted with high rates of land subsidence, which causes increased flood risks and damage to buildings and infrastructure. Highest amounts and rates of land subsidence are usually caused by human activities, including extraction of groundwater and hydrocarbons, groundwater table lowering, and subsurface loading.

Holocene delta sequences often contain substantial amounts of peat. Compaction and oxidation of peat, caused by loading and drainage, are important contributors to land subsidence, and hence relative sea-level rise, in peat-rich deltas. Especially built-up areas, having densely-spaced urban assets, are heavily impacted by land subsidence, in terms of livelihoods and damage-related costs. However, so far, built-up areas have been largely avoided in peat compaction and oxidation field studies. Consequently, essential information on the relative contributions of both processes to total subsidence and underlying mechanisms, which is required for developing effective land use planning and construction strategies, is lacking. Therefore, we quantified subsidence due to peat compaction and oxidation in built-up areas in the Rhine-Meuse delta, the Netherlands, using detailed lithological data and laboratory analyzes. We reconstructed subsidence due to peat compaction and oxidation over the last 1000 years of up to ∼4 m, and recent subsidence rates of up to ∼140 mm/yr, averaged over an 11-year time span. The amount and rate of subsidence due to peat compaction and oxidation is variable in time and space, depending on the Holocene sequence composition, overburden thickness, loading time, organic-matter content, and groundwater-table depth. In our study area, the potential for future subsidence due to peat compaction and oxidation is still substantial, especially where the peat layer occurs at shallow depth and is relatively uncompacted. We expect this is the case for many peat-rich deltas worldwide. We propose to use subsurface-based spatial planning in these areas, using specific subsurface information, to inform land use planners about the most optimal building sites.