DRIVERS OF DELTA SUBSIDENCE

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The world's fertile delta regions, that are supporting large human populations, are subject to significant and irreversible changes due to massive urbanization, climate and land-use change, and land subsidence. Delta subsidence causes a range of problems, including flooding, fresh water and land scarcity, salt water intrusion, damage to buildings and infrastructure, loss of cultivated land, wetlands and biodiversity, degradation of fishing areas, and rapid shoreline retreat. Combined with future sea level rise, submergence of deltaic areas is projected to increase by 50% by the end of this century (Syvitski et al., 2009).

Addressing the challenge of land subsidence deltas world-wide face requires a sound knowledge of the subsidence drivers. A distinction can be made between natural and human-induced drivers. Natural drivers are: basin and local tectonics, isostasy, sediment compaction due to loading by e.g. sediment, and oxidation of organic matter due to natural groundwater level fluctuations and (bio)geochemical processes .

Human-induced drivers are: extraction of hydrocarbons and groundwater, drainage and loading by e.g. buildings and roads. Natural subsidence rates are in general relatively low (up to a few mm/yr) compared to human-induced subsidence rates that are relatively high (up to 10's of cm's/year). To influence and reduce especially human-induced subsidence rates and hence the negative impacts, it is essential to quantify the relative contribution of the single drivers to total subsidence (Fig. 1).

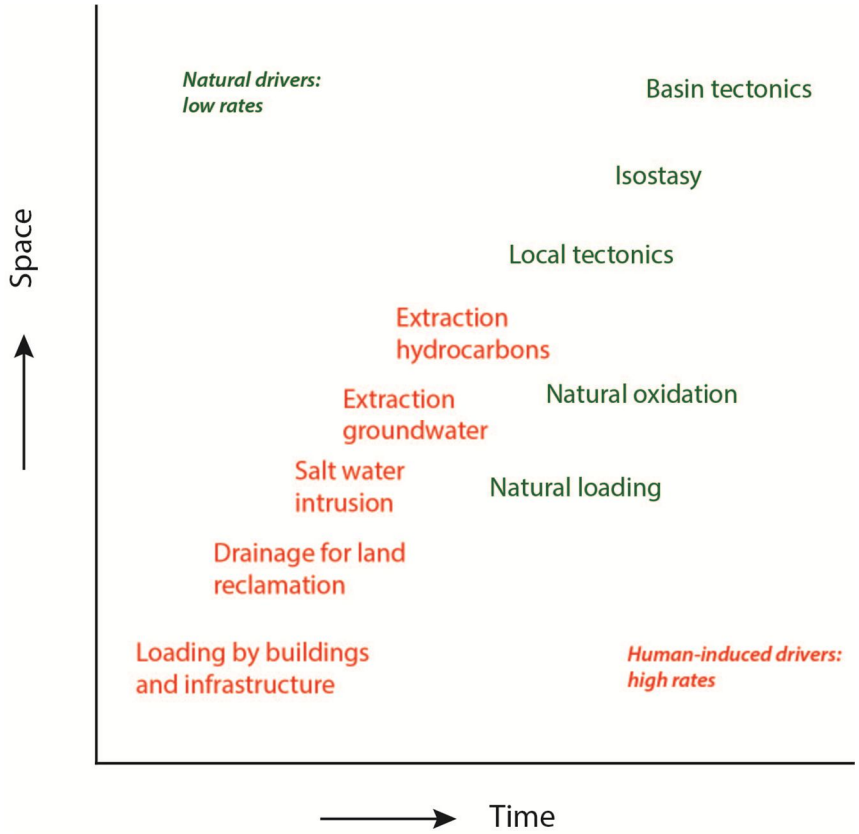

Figure 1. Time-space diagram showing the relative contribution of drivers of delta subsidence. Natural subsidence occurs at relatively long temporal scales and large spatial scales. Human-induced subsidence occurs at relatively short temporal and smaller spatial scales.

The expectations are that climate change will lead to further acceleration of subsidence due to peat oxidation under prolonged periods of drought and higher temperatures. Peat oxidation leads to considerable greenhouse gas emissions thereby generating a positive feedback on climate change.

Subsidence has a direct impact on the dynamics of water, sediment, nutrients and vegetation, and hence on the boundary conditions of ecosystem functioning. These impacts not only affect livability in deltas but also potentially reduce a delta's capability to adapt to and recover from external and internal forcing of change. If thresholds are crossed a delta system may collapse, thereby losing its valuable services.

Sustainable delta management strategies are needed to ensure that future delta societies benefit from vital services provided by deltas while not exhausting or destroying them. It is important to realize that delta managers aiming to restore or mitigate subsidence not only need fundamental knowledge concerning processes that drive changes in deltas and associated impacts, but also must take into account the socio-economic and governance system and legislative frameworks operating in the area. This involves regulatory and policy approaches that support or hamper change in different deltas, awareness building, financing the prevention or restoration of subsidence, issues related to burden sharing and diverse and fragmented public and private responsibilities such as water management, land use, nature conservation, drinking water supply, urban and rural development and agriculture to prevent and restore damages.

To enable bringing together the expertise that is essential for the development of sustainable and resilient management strategies to reduce subsidence rates and its negative impacts, thereby improving the livability in future deltas, Utrecht University has established a new research focus area: Future Deltas. Future Deltas follows an interdisciplinary approach by bringing together expertise on natural processes, spatial planning, land and water governance and legislative frameworks. We focus on understanding drivers, predicting impacts and optimizing solutions related to subsidence and associated loss of ecosystem services.

For more information on the research focus area Future Deltas of Utrecht University see: http://www.uu.nl/en/futuredeltas.

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