Predictive Modelling of Land Subsidence and its Impacts in The Netherlands

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Research problem & goal

- The economic and environmental costs associated with the land subsidence (Kok and Angelova, 2020) and GHG emissions in the Netherlands (Schouten, 2020) were recently recognized. Although costs are recognized, there is no comprehensive land subsidence adaptation/mitigation strategy in place.
- Research Problem: Land subsidence and peat oxidation causes irreperable damage to the Dutch landscape, causing societal and economic harm. Without proper management, the Netherlands with soft soil is at risk of becoming inhabitable.
- Research Question: Can we evaluate the impact of specific mitigation and adaptation strategies against land subsidence in the Netherlands using 3D predictive modeling over a 100-year timeframe?
- Research Goal: Assess the long-term impact of innovative mitigation and adaptation strategies on land subsidence and peat oxidation in the Netherlands through 3D predictive modeling. By the end of this study, we aim to provide valuable insights and recommendations for sustainable land management practices and policies that can help mitigate the adverse effects of subsidence in this vulnerable area.

Land Subsidence: A complex problem

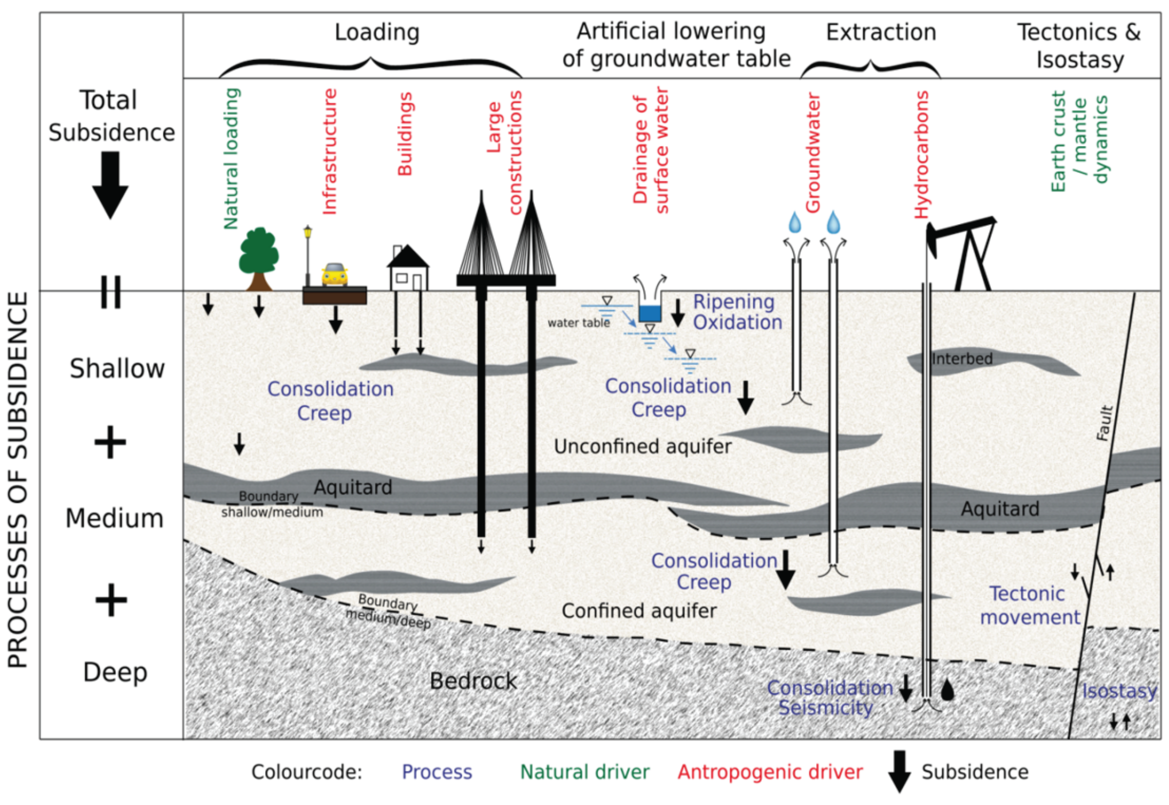

Figure 1: Subsidence processes and their drivers at shallow, medium, and deep horizons. (Minderhoud et al., 2015)

- Land subsidence is a natural process in deltas that can be overprinted and accelerated by anthropogenic activities (Figure 1). In addition to consolidation and creep, clays and organic rich peats tend to undergo additional processes such as shrinkage/swelling and oxidation based on clay-water interaction or peat-air interaction, respectively.
- Anthropogenically enhanced subsidence originates from human activities that increase the physical loading or change the local or regional hydrogeological state. Modification of the surface (land use/ land cover), the shallow water table (polders, drainage) and/or the subsurface (exploitation of natural resources: groundwater, salt, gas, hydrocarbons) determines the degree of anthropological subsidence.

The 6M Approach to Subsidence

Figure 2: The 6M approach proposed by Erkens and Stouthamer, (2020) to tackle land subsidence. CBA = Cost Benefit analysis. (Erkens and Stouthamer, 2020)

- A key step in the 6M approach is the Predictive Modelling (M3) step (Figure 2). It is possible to link the M3 with M4 via a set of analytical/empirical solutions to quantify the potential land subsidence related damages in urban and rural areas.
- In the Dutch case, a detailed set of measures for against land subsidence (no subsidence, limited subsidence but no emissions fixed water level, water level indexation etc.) could be proposed by quantifying the impact of potential measures at the water management parcel scale via the Predictive Modelling (M3) approach.

NWA-LOSS Program

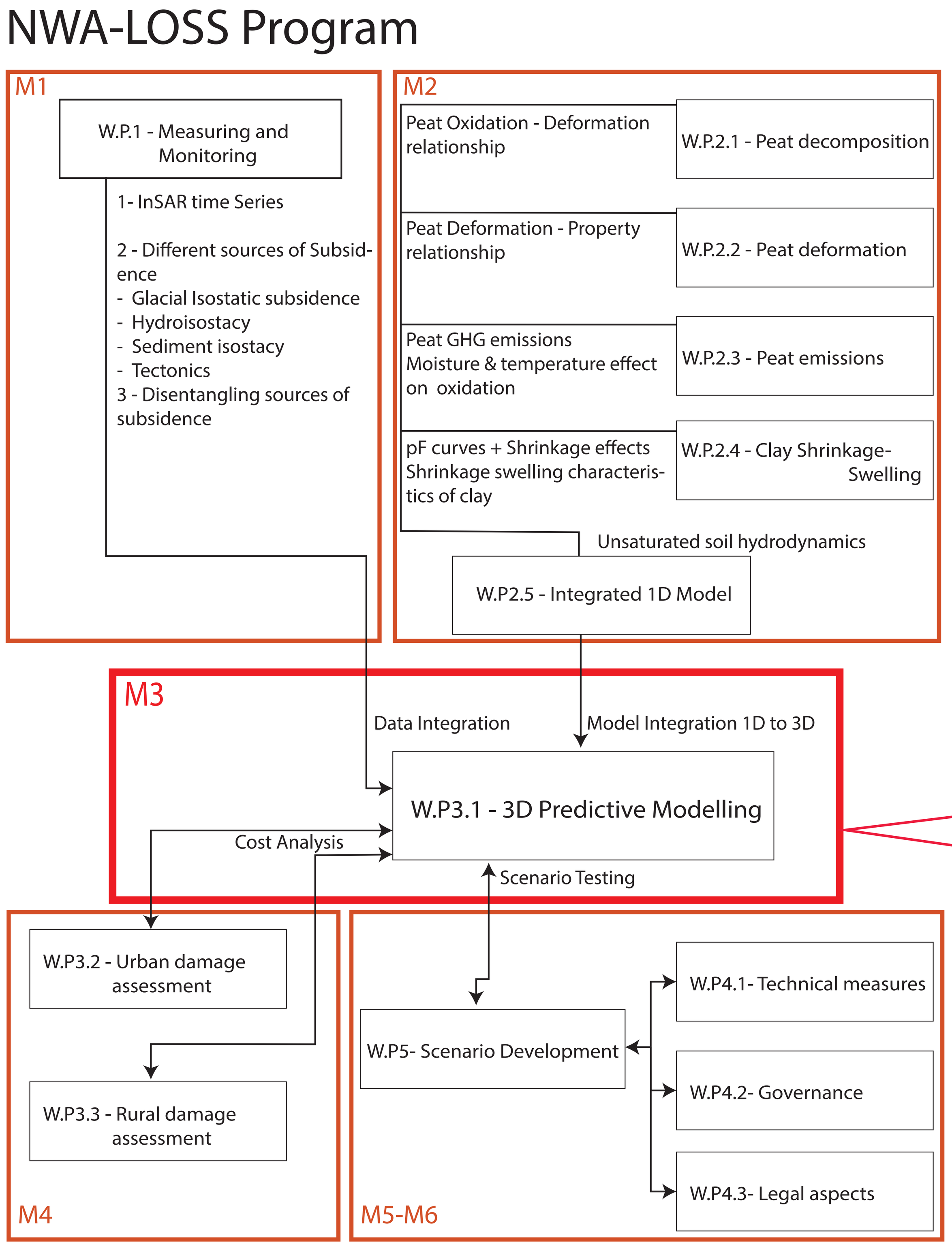

Figure 3: The NWA-LOSS program shown in a diagram. Arrows indicate the flow of data between work packages. Orange and red boxes indicate the link between the 6M approach (Figure 2) and NWA-LOSS work packages. Between M3 and M4, M3 and M5-M6, an information feedback loop exists.

Integrated Spatial Data/Modelling Framework (The Work Package 3.1 - M3)

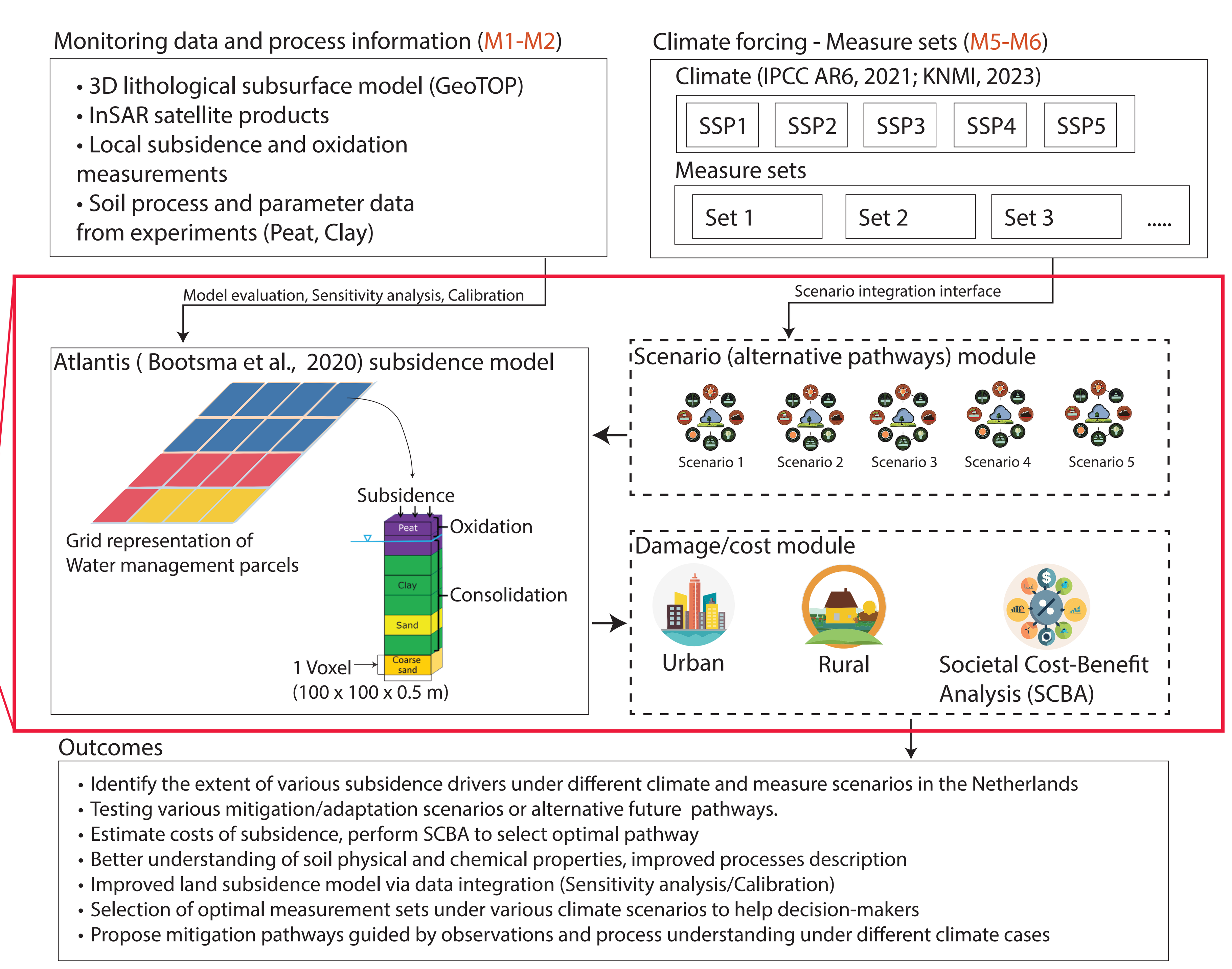

Figure 4: The modelling framework of W.P.3.1, Boxes indicate the modules of the framework. Dashed boxes show the modules that will be developed by W.P.3.1, including the model integrations. Arrows show the flow of the data in the modelling framework. The Atlantis model will be futher improved by sensitivity analysis-calibration work that will be carried out by W.P.3.1.

Foreseen model outputs: 1) Maps of Subsidence and Damage Estimates

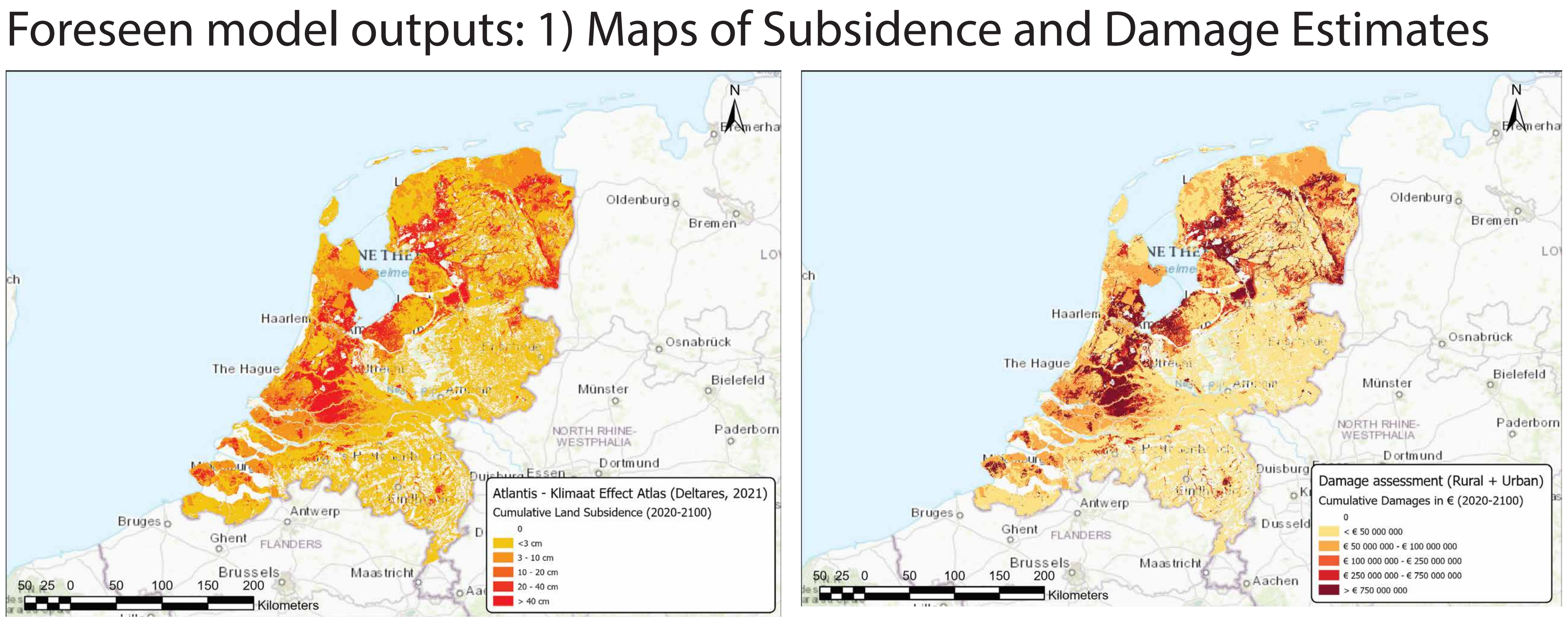

Figure 5: Left: An example of the cumulative land subsidence (in cm) calculated by Atlantis in the period 2020-2100. Right: An example of the cumulative damage assessment in the period 2020-2100 (in EUR). Both figures are for demonstration purposes only.

2) Alternative Adaptation/Mitigation Pathways

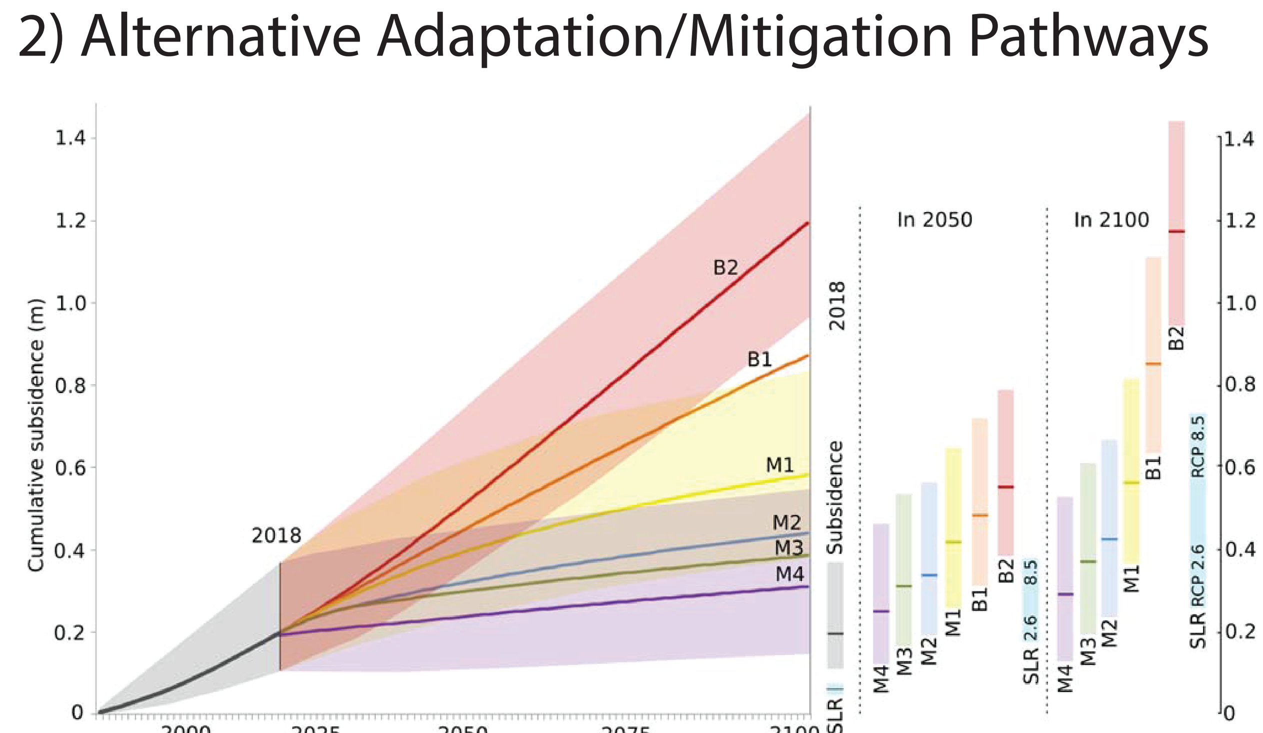

Figure 6: An example of alternative pathways to land subsidence by managing water withdrawal in the case of the Mekong Delta (Source: Minderhoud et al., 2020). In this study, the authors evaluated the average cumulative subsidence of the Mekong delta under various groundwater management pathways since 2018 under no mitigation (B1, B2) and mitigation pathways (M1, M2, M3, M4).

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