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System dynamics modelling of linked land-coast-sea systems for water quality management under different RCP-SSP scenarios

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The human-nature interactions driving water quality deterioration in linked land-coast-sea systems are complex, including numerous components across different water environments. This complexity has led to many unsuccessful or insufficient efforts for water quality improvement, as seen, for example, in the Baltic Sea and its coasts that suffer from severe eutrophication long after several policies and measures have been repeatedly taken for mitigating excess nutrient loads. Considering the Swedish water management district of Northern Baltic Proper and its surrounding coastal areas and associated marine waters of the Baltic Sea, this study has used a system dynamics (SD) modelling approach to investigate possible future shifts in regional water availability and quality under different regional change scenarios. The SD model is developed based on a stakeholder-identified problem-oriented system network diagram that includes key land-coast-sea system interactions. The scenarios are developed based on scenarios of Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs), complemented with insights from the IPCC report 'Global warming of 1.5°C' to reflect possible future changes in human pressures and hydro-climatic conditions. Relevant RCPs and SSPs are downscaled to region-specific change scenarios for associated model input variables, and their combined impacts on system behavior are evaluated using various key performance indicators defined for socioeconomic sectors, natural water systems, and policy and management aspects. Results show that further investment and development are needed for urban storm water handling and wastewater treatment from both water quantity and quality perspectives. Water quality management strategies also need to account for and target long-lived nutrient legacy sources to mitigate their further contribution to water quality problems in the study region. Furthermore, policy targets defined for water quality improvement, for example, in the Baltic Sea Action Plan, need to be updated based on regional water-related impacts of projected hydro-climatic changes and expected future socioeconomic conditions. The updated targets, however, can only be achieved if synergistic management measures are taken across the land-coast-sea continuum. SD modelling and scenario analysis, as established, applied and will be further developed in this study, can support identification of efficient policy and management strategies for water quality improvement by assessing their performance and exploring possible sustainable

solutions under different future development scenarios.