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Greenhouse gas flux from tropical peatlands: context and controls

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Peatlands play a key role within the global carbon cycle by storing a disproportionately large amount of soil carbon relative to other terrestrial ecosystems. Peatland systems have accumulated carbon through an imbalance between the uptake and release of CO2 from and to the atmosphere. In a pristine condition, tropical peat swamp forest is one of the world's most efficient carbon sequestering ecosystems as a result of substantial biomass production and the waterlogged condition of the peat, which reduces significantly the rate of organic matter decomposition. Tropical peat deposits have acted as sinks of atmospheric carbon since at least the beginning of the Holocene and, in some cases, the Late Pleistocene. They currently store $\sim$ 65 Gt C, most of which is located in thick deposits in Southeast Asia. Tropical peatlands are, however, vulnerable to destabilisation through both human and climate induced changes. The former include poor forest and land management practices, drainage, large-scale conversion to plantation agriculture, and fire; these lead to degradation and reduction of the peatland carbon store and contribute to greenhouse gas emissions, whilst compromising other valuable ecosystem services. Climate induced changes include susceptibility to drought-impacts, particularly during ENSO-events; there are also initial indications that regional climates in areas with extensive peatlands are experiencing reduced rainfall, which threatens longer term peatland sustainability. This paper reviews the current understanding of carbon-climate-human interactions on tropical peatlands. It focuses on the main causes of peatland degradation, in particular natural and anthropogenic changes in peatland hydrology; considers the risks that hydrological change, especially water-table drawdown, poses to the peatland carbon pool; and assesses the scale of peatland drainage-associated CO2 emissions, which are currently of the order of $\sim$250 Mt C yr-1 for Southeast Asian peatlands. It discusses likely responses of tropical peatlands to a changing climate and considers the scope for mitigation to reduce greenhouse gas emissions, including hydrological rehabilitation and reforestation. This information is highly relevant to current tropical peatland carbon emission reduction programmes, which aim to re-wet the peat in order to reduce the CO2 flux from peat decomposition as well as from fire. There is an urgent requirement to develop simulation tools (models) capable of predicting the dynamic response of peatland ecosystem-atmosphere CO2exchange to environmental change and landuse (e.g. hydrological) management.