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学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Studies on subsidence-related issues under paddy land use in boreal peatlands
（水田利用のなされた泥炭地の地盤沈下に伴う諸課題に関する研究）

Amongst various types of lands on the earth, peatlands are wetland areas with naturally accumulated layers of dead plant bodies (peat) at the surface under saturated or water-rich environments. Reclamation and drainage for agricultural use of peatlands inevitably cause land surface subsidence. Several agricultural management methods to mitigate subsidence have been proposed, such as rewetting and paludiculture. In Hokkaido, northern Japan, peatlands cover approximately up to 270,000 ha. Nearly 70 % of the peatland area has been drained and converted to agricultural farmlands during the past century. The most remarkable point in the agricultural use of peatlands in Hokkaido is that peatlands have been used as paddy fields for rice production, which is a rare case if compared to other countries in the world. To investigate peat subsidence related issues in paddy use peatlands in Hokkaido will provide important insights for future land use in peatlands not only in Hokkaido but also in countries with peatlands around the world.

In this study, issues related to peat subsidence in Hokkaido, where peatlands have been uniquely cultivated as paddies for rice production, were investigated to get knowledge about how paddy use affects peat subsidence and what is needed for sustainable paddy agriculture in peatlands. Following the circumstances mentioned above, the objectives of this study are to clarify the effect of paddy use of peatland on subsidence, to understand the impacts of mineral soil dressing of paddy fields on peat subsidence, and to grasp the actual situation of subsidence of irrigation faculties on peatland, which have been poorly understood.

In advance to the investigation of peat subsidence in the paddy fields, the current agricultural use of peatland in Hokkaido and its impacts on greenhouse gas emission were assessed. The assessment on the land use of peatlands in Hokkaido with satellite image remote sensing was carried out, and CO_2 emission was estimated based on the land use assessment. The value of estimated CO_2 emission was compared to the official report of the Japanese government. The contribution of the emissions from the peatlands to the total anthropogenic emission from Hokkaido was discussed based on our estimates. The results showed that the total emission from the entire agricultural peatlands in Hokkaido was estimated to be 1,919,000 t CO_2 yr^{-1}. Based on this result, the emission from organic soils reported in Japan's greenhouse gas inventory was obviously underestimated. The contribution of the emission from peatlands based on this study was estimated to be 2.6 % of the total anthropogenic CO_2 emission from Hokkaido, and it could have the largest contribution to the emission from the agricultural sector in Hokkaido.

Following the assessment of the land use, the effect of paddy use of peatlands on land subsidence was discussed. The subsidence rates of peatland in rice paddy use were measured and compared with the rates in peatland under upland crop cultivation. The subsidence was observed broadly enough to get as many samples as possible with digital elevation models constructed based on airborne laser surveys. The average subsidence between 2006 and 2017 for the paddy plots was almost zero and significantly less than that of the upland plots. The subsidence reduced linearly as the period of paddy use increased. These results suggest that paddy use of peatlands can effectively reduce subsidence. Our results will encourage the use of peatlands with a wet environment as one of the valid options for future peatland management in terms of mitigation of land subsidence and peat loss.

In addition to the impact of paddy use on peat subsidence, the effect of mineral soil dressing on peat subsidence is evaluated. The relationship between land surface subsidence and thickness of the dressed mineral soil layer was examined with 53 field plots that have been used as multipurpose paddy for the production of wheat, soybean, and vegetables as well as rice. In the plots with paddy land use, the subsidence was very small, and there was no significant correlation between the subsidence and the dressed layer thickness. In contrast, subsidence in upland plots had a significant negative correlation with the thickness. This suggested that thicker soil dressing can effectively reduce surface subsidence. The thick layer of dressed soil may reduce the oxidative decomposition of peat by relatively deepening the peat layers from the surface.

The subsidence of irrigation pipelines in peatlands is also assessed. The subsidence of pipelines was relatively uniform in the section without any special construction conditions such as intersection with road or junction to aqueduct bridge. On the other hand, the subsidence of the pipelines occurred unevenly at the intersection with the road where the vertical load was high and at the junction to the aqueduct bridge where the pipeline was fixed to a firm pile foundation. Uneven subsidence may damage the joints of the pipes and some of the observed misalignment excessed the allowance designated by the design criteria. Thus, the risk of incidence such as leakage may increase at those sections. Therefore, continuous observation and measures against uneven subsidence of pipelines are strongly required.

Despite more than 50 years since the reclamation, the subsidence continues in peatlands. Subsidence is a crucial problem accompanying agricultural use of peatlands, and thus future decision-making on land use must consider this continued subsidence and environmental consequences. The result of this study implied agricultural practice with paddy cultivation could possibly reduce subsidence. However, the socio-economic condition conflicts with this as the demand and price of rice has been decreasing. Therefore, a combination of technical and socio-economic implementation is necessary to make the best future land use and management on peatlands to mitigate further subsidence, cost to maintain agronomic production, and related environmental problems.