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学 位 論 文 内 容 の 要 旨

博士（環境科学）

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学 位 論 文 題 名

Assessing the effects of dike protection systems on rice cropping patterns and water quality in An Giang province, Vietnam

(ベトナム、An Giang省における稲作パターンと水質に対する堤防保護システムの影響の評価)

The Vietnamese Mekong Delta (VMD) is one of the largest rice-growing areas in Vietnam, and exports a huge amount of rice products to the world. The dike protection systems have been built to prevent flooding, and have supported agricultural intensification since the early 1990s. Semi-dike and full-dike systems have been used to grow double and triple rice cropping, respectively. Furthermore, the uses of pesticide and herbicide chemicals have swelled dramatically in many parts of the region, and the local government has been seeking solutions to reduce the use of the chemicals to improve water quality, especially in inside the dike systems. An Giang province, a prominent area in the VMD, with sufficient impact of farming, was chosen as the study area. The main purpose of this study was to analyze the relationship between water quality parameters inside and outside dike and the rice cropping system. To this end we conducted (1) monitoring and mapping rice cropping system distribution under dike system development, and (2) monitoring spatial and seasonal variation in surface water quality at different rice cropping system.

Sentinel-1A data with C-band (5.4 GHz) SAR were acquired from March 2017 to March 2018. We used the IW model dual-polarization data acquired in Ground Range Detected (GRD) Level-1. The repeat cycle of Sentinel-1A data is 12 days with dual-polarization (VV+VH). Sentinel-1A data were processed using the open source Sentinel-1 toolbox in Sentinel Application Platform (SNAP) software. The fieldwork was carried out on the dates close to the Sentinel-1A acquisition. The results showed that the backscattering behavior of Sentinel-1A SAR shows a good relationship with rice phenological changes at three rice cropping patterns. The σ^0 VH polarization showed better information about rice growth than σ^0 VV. The Sentinel-1A data showed the trajectory of rice growth stages, and the trajectory also matched well with the crop calendar in the area. Thus, this feature of SAR data can be used for discriminating between rice crop and other objects. Interesting, the mean of maximal values of σ^0 VH were found to be higher in winter-spring season than other seasons. Based on the

mapping of LULC, we detected most of the triple-rice crop was distributed close to main rivers as compared to double-rice crop. Many of the areas were areas that adopted the full-dike system.

Spatial and temporal variations in water quality inside and outside dike-protected areas were examined in the study area by using of multivariate statistical analysis during the dry and wet seasons in 2017. Water quality parameters showed clear seasonal variations in the study area. Water samples from inside the full-dike protected area were characterized by high pollution loads when compared to water samples from semi-dike systems and from outside the dike systems. Also, we used water quality index to classify the level of water pollution. The main sources of pollution in the study area were combination of elements originating in local and upstream Mekong River resources. Therefore, the variation in surface water quality parameters during the wet season was higher than that during the dry season. The HCA method was used to divide the sample sites into 4 clusters. Cluster 1 (water samples from inside the full-dike system) showed “poor” water quality levels with reference to WQIal grades in both the dry and wet seasons. Cluster 1 (inside the full-dike area) was designated as being a water quality hot-spot. Water in cluster 1 had high concentrations of nitrate and phosphate in the dry season, and NH_4^+ and COD in the wet season. Our study suggests that water quality in areas inside full dike-protected systems should be continuously monitored in both seasons. There is also a need to monitor water quality in the region using a real-time remote data acquisition system that is able to provide data in a timely fashion at a large scale. Dike protection systems have been useful in reducing flood hazards and supporting the intensification of rice cropping; however, it has had an adverse effect on the maintenance of water quality within the region. In recent years, the area devoted to triple-rice crops in An Giang has decreased, which might be beneficial in terms of restoring water and soil quality. It is expected that the government of An Giang will either adopt strategies to enhance water quality by reducing triple-rice crops or reconsider the construction and operation of full-dike protection areas.

In conclusion, many of triple-rice crops area located in the area close to the full-dike system; however, in recent years, triple rice cropping system has tended to decrease. The water quality might be improved in the future, considering that the water quality in the full-dike system has deteriorated. In the future, it is necessary to monitor changes in rice cropping styles and water quality in this area to maintain the good environment.