学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Geospatial analysis on multiscale geomorphic processes and sediment connectivity in the Brahmaputra River basin
（ブラマプトラ川流域における地形プロセスと土砂接続性の地理空間情報解析）

Geomorphological knowledge is critical in understanding watershed-scale surface processes both in steep mountainous areas and flat lowlands, particularly if the mid- and downstream areas are densely populated and hazard assessments are highly required. The upper basin morphodynamics, hydrology, and sediment flux highly influence the repeated sediment disasters in the downstream areas, and our understanding of the large-scale fluvial geomorphic processes and basin-scale sustainable river management is crutial. However, our knowledge about such surface processes has relatively been limited in some areas in South Asia (particularly Bangladesh) due likely to the lack of comprehensive studies of geomorphology and related fields. In this study, the author first undertakes an overview of the geomorphological processes of the disaster-prone deltaic landscape of the Ganges–Brahmaputra–Meghna (GBM) focusing on fluvial processes (Chapter 2). The review of previous studies found that most of the geomorphic researches in Bangladesh are exploring landslide inventory and susceptibility mapping in hilly areas; river channel or riverbank shifting, riverbank erosion and accretion in fluvial environments; watershed morphometric analysis and geomorphic unit identification in plain land; and coastline shifting or coastal erosion and accretion in coastal environments at a small scale. Then, the author discusses the fluvial dynamics and sediment transport of the GBM river system to address the knowledge gap in the context of deltaic plain land in Bangladesh, where upstream fluvial sedimentation processes impact the geomorphic connectivity from Himalayan to the Bay of Bengal. Although some studies on the fluvial dynamics and sediment dispersal in the upstream GBM river basin are present, the fluvial processes in the downstream domain of Bangladesh are not fully understood with a limited number of research with field-based approaches. Hence, some future perspectives of geomorphic research in Bangladesh are then mentioned to understand better the complex geomorphological settings in the entire GBM watershed and to strengthen the existing research capacity.

Following these reviews, in Chapter 3, the author attempts to characterize the morphometric and topographic features along with the spatial sediment connectivity pattern of the middle Brahmaputra River basin (Teesta, Torsa, and Manas basins) covering ~75,000 km2 that influences the hydro-geomorphic response of the deltaic landscape of lowland Bangladesh. This work considers a set of morphometric and topographic parameters including the stream network, longitudinal profiles, stream power index (SPI), and topographic wetness index (TWI) for geomorphometric characterization. The linkage between the sediment sources to downstream areas also has been evaluated with the sediment connectivity index (IC) to understand better the sediment dynamics of the middle Brahmaputra River basin, draining towards lowland Bangladesh from the basin's upstream countries of India and

Bhutan. The result of this study demonstrates a highly potential hydro-geomorphic response of the downstream areas attributed to steep topography, steep channel longitudinal profiles, high rainfall, and high sediment connectivity in upstream regions. However, the low topography, presence of anthropogenic stressors, almost flat longitudinal channel profiles with limited change in elevation, and lowered sediment connectivity potential in the mid-to-downstream areas depicts sensitivity to the depositional processes therein, impacting the basin-scale geomorphic connectivity from the upstream to the downstream region. These results will be the basic information for exploring the large-scale hydro-geomorphic response and structural sediment dynamics to understand the complex geomorphological processes in the South Asia region.

Furthermore, for a widespread understanding of the upstream's hydro-geomorphic response as well as assessing geomorphological dynamics and protecting floodplain areas in downstream, the topographical changes in disaster-prone riverine floodplains at the local-scale need to be measured, which has been limited in South Asia due to the lack of multitemporal, high-definition digital elevation models (DEMs) derived from modern techniques including airborne laser scanning, structure-from-motion (SfM) photogrammetry accompanied with Unmanned Aerial Vehicle (UAV), and field-based mapping approaches. Hence, as a local-scale case, the author carried out a preliminary study at two locations of the Teesta River (Brahmaputra's tributary) in Bangladesh using the UAV-SfM techniques and generated high-resolution DEMs (Chapter 4). The selected locations represent dynamic changes of sediment and water on the floodplain over years, and the UAV-SfM approach can be an effective method for monitoring those changes, but an archive of the past data has been unavailable. Here the author evaluated the topographic changes by comparing the UAV-SfM-derived DEMs of 2022 with global DEM products (NASADEM of 1999), which are often the only available choice of DEMs in this river floodplain. The elevation differences of these two sets of DEMs were in the range of −5.23 to −84.66 m, and volumetric changes of −4.11±0.15 to −86.25±0.20 million m3, likely dominated by erosional processes towards the left side bank where the elevation errors are supposed to be several meters for UAV-DEM and ca. 5-12 m for NASADEM. Although it is not easy to accurately evaluate the absolute values of the changes, these changes may be associated with the upper basin's hydrology, sediment flux, and anthropogenic stressors along the floodplain. The considerable changes in topography, including cross-sectional profiles, elevation, and sediment volume, indicate the importance of continuous river topographic monitoring that can be facilitated from the present workflow, which can optimize river management strategies in South Asia, particularly Bangladesh.

Hereafter, the author believe that this study will develop a holistic understanding of basin-wide fluvial geomorphic processes and sediment dynamics of the Brahmaputra River to the policymakers considering the key determinants (excessive sediment sequestering, riverbed aggradation, river hydrology, hydro-engineering structures etc.) of geomorphic connectivity and may be helpful to improve the transboundary river basin management policies or strategies focusing on restoring the geomorphic connectivity, monitoring river floodplain, joint research initiatives, cross-boundary cooperation, and sustainable development among the basin-sharing countries.