# COASTAL MAPPING OF JINU-DO WITH UAV FOR BUSAN SMART CITY, KOREA

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**Commission IV, WG IV/7**

**KEY WORDS:** Coastal Topographic Change, Vegetation, Sustainable Development Goals

**ABSTRACT:**

For illustrating estuarine and coastal morphology, UAV has proved its effectiveness in providing accurate and diverse information, but unfortunately, no such application have been undertaken for Nakdong River Estuary for ecosystem-based coastal mapping. In this study an attempt has been made to coastal mapping of Jinu-do in Nakdong River Estuary, and to identify beach volume change and vegetation area migration caused by wave and current from 2017 to 2018 with UAV. Unmanned aerial vehicle used for mapping was M600 hexa-copter drone (DJI, china). To create UAV point clouds a standard digital camera can provide imagery with Sony A7 mirror-less camera. Total 34 Ground Control Points (GCPs) accurately surveyed with a RTK-VRS, network use real-time kinematic solutions to provide high-accuracy. Stereo-matching using Agisoft PhotoScan obtained DEM. Using GCPS the vertical accuracy of the DSMs were found to be 5cm or better. Using the PhotoScan, the area of Jinu-do orthophotos were calculated and the area of vegetation calculated using QGIS. As a result, the vegetation area was increased about 5% more than the topography. This study of coastal mapping at Jinu-do demonstrate that the integration of UAV techniques and photogrammetric software and analysis tools can provide new concepts into the estuarine.

## 1. INTRODUCTION

### 1.1 General Instructions

Urban areas need to manage their development, supporting economic competitiveness, while enhancing social cohesion, environmental sustainability and an increased quality of life of their citizens. Cities in developing countries, in particular, can have an impact on the surrounding sensitive ecosystems, such as wetlands, forests, mountain ecosystems, and need increasing amounts of resources, which could result in over-exploitation.

However, it is a fact that various spatial information about these influences can not be constructed in various ways, and information about the area of vegetation disappearing due to urbanization is also unknown.

Recently, UAV systems receive high demands in business, research institutes and industries since UAV is one of the simple and cheapest equipment in image acquisition. Indeed, it can fly at low altitude and provides very high resolution images of the ground surface. UAV also promised a low-cost flight mission alternative to the classical manned aircraft (Marzolff and Poesen, 2009).

This paper provides a brief presentation of the evolution between topographic change and vegetation migration of Jinu-do in Nakodng River Estuary, Korea. The Nakdong river estuary, a representative estuary of South Korea, can be divided into three tidelands that connect two islands (i.e. Myungji-do, Eulsook-do) formed by the changes in the course of the water and seven sand barriers of sand bars formed by shoals in front of these islands. Furthermore, eco-friendly factors to describe the multiple characteristics of the ‘smart city’ are analysed. A connection between eco-friendly factors and smart city is also presented.

## 2. ECO-FREIDNLY SMART CITY

### 2.1 ENVIRONMENTAL PARAMETERS

The effective implementation of the smart cities requires an integrated and interdisciplinary approach to sustainable development. To ensure a low carbon, a low water and low ecological footprint with infrastructure designed to adapt to the present and future impacts of climate change, developers need to consider the following at the very design and planning stage of the project.

**2.1.1 Disaster Risk Reduction:** The key point is to ensure that sites and development take into consideration the typhoon (i.e. cyclone) and flood risk and appropriate measures to mitigate the risk of flooding on adjacent areas of land and all areas lower down or higher up the watershed. The risk of flash flooding may be taken into account in drainage arrangements for development.

**2.1.2 Greening and Biodiversity:** Biodiversity provides us with life-sustaining systems such as clean and ecosystems. The residents of smart cities must be provide with the opportunity to experience greenery, nature at their door steps. These green area help to reduce heat islands effect, provide carbon offset, conserve biodiversity and enhance the aesthetics of development. The overall objective would be to ensure that there is no reduction in biodiversity due to development and wherever possible, a net gain.

In order to create a smart city, it is more important to build an eco-friendly ecosystem. It is very important to increase the area of vegetation so that greening and biodiversity can be expanded. Therefore, vegetation is more likely to increase in areas where natural terrain increases, such as estuaries, and this is the best way to naturally develop eco-friendly smart cities.

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https://doi.org/10.5194/isprs-archives-XLII-4-725-2018 

### 2.2 Nakdong River Estuary

The Nakdong River in Figure 1, a representative estuary of South Korea, can be divided into three tidelands that connect two islands (i.e. Myungji-do, Eulsook-do) formed by the changes in the course of the water and seven sand barriers (Daema-deung, Jangja-do, Sinja-do, Baehab-deung, Namutsit-deung, Maenggeummeori-deung, Doyo-deung) formed by shoals in front of these islands (Oh, 2001). After the construction of the Nakdong estuary bank, the sand barriers in the estuary changed greatly, and they are continuously developing their directions towards the open sea (Busan Metropolitan City, 2004). Accordingly, the artificial development of the coastal area changes the hydraulic characteristics of the Nakdong River and Jinhae bay, which is near the Nakdong estuary. Hence, it is expected that the sedimentary environment will be greatly changed (kim et al., 2001). When studying the results from past researches related to the topographical changes of the Nakdong River Estuary, it is clear that many studies from various disciples were conducted. The sand barrier of the Nakdong River Estuary expands toward the open sea by 7.4~33m in annual average, maintain a fixed distance of 1.74~1.64 km, and its area is expected to increase about 28,800 m$^2$ annually (Yoo, 2006).

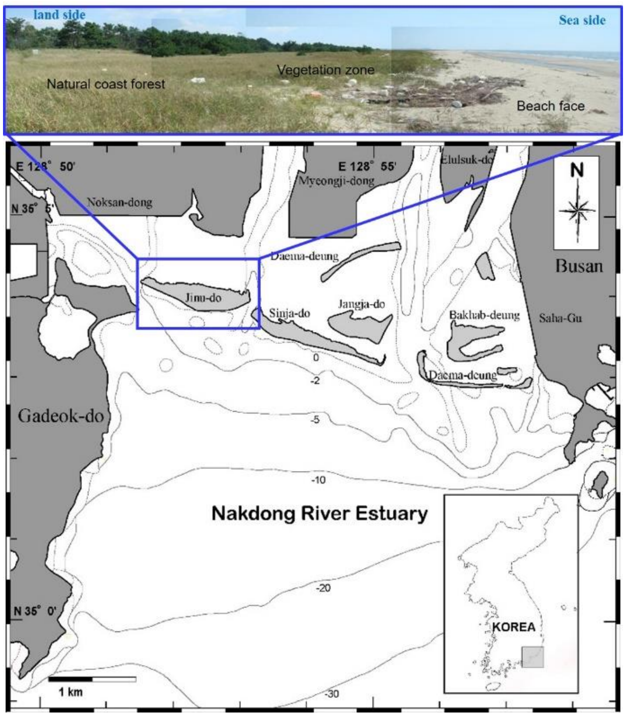


Figure 1. Panoramic view and location of Jinu-do in Nakdong River Estuary, Korea

## 3. DATA ACQUISITION

### 3.1 Sensor platform

The unmanned aerial vehicle used for mapping was M600 hexa-copter drone (DJI, China) in Figure 2. Digital camera was used as a tool to capture image from the air at the study area. High resolution digital camera with 36 megapixel resolution was used in this study.

### 3.2 Flight Planning

Before flight plan an operator needs to identify the coverage of the study area in sequence to design flight plan. The flight plan requires an approximate coordinates as an input to design the flight route.

Site Preparation involves developing a layout for ground control points, checking the accuracy of the camera image used for flight planning, ensuring no obstacles are in the path of the UAV, and evaluating environmental conditions to determine if a flight can be safety undertaken. Several flight tracks were flown with high overlap and sidelap, up to 80% and 60% along the track in Figure 2. Surveys were conducted in 16 January, 26 May 2017 and 15 May 2018.

### 3.3 GCP Surveying

For ground survey work, the imagery needs to be geo-corrected. A network of Ground Control Points (GCP) accurately surveyed with a RTK-VRS, which is provides instant access to Real-Time Kinematic (RTK) corrections utilizing a network of permanent (fixed) continuously operating reference stations, or identified in precise map source are necessary for accurate location. GCP are usually markers placed in a regular network on the ground and may comprise a post plus a cross (and number) visible on the aerial photograph. Each aerial image acquired has to be corrected to a true position on the Earth’s surface with the aid of digital image processing software. The creation of each GCP should follow certain guidelines. Most importantly, the GCP needs to be identifiable in the images taken by the UAV. This requires each GCP to be large enough to be seen by the image equipment.

The RTK-VRS survey, performed by a dual frequency GSX2 (Sokkia) for the mentioned dataset (GCPs), resulted in RMS values of less than 0.02 m and 0.03 m for horizontal and vertical accuracies respectively, for 98% of the sampled points. Horizontal coordinates were referenced to UTM zone 52N, while the vertical values were referred to the mean sea level using the geoid model KNGeoid13 provided by the National Geographic Information Institute (NGII).

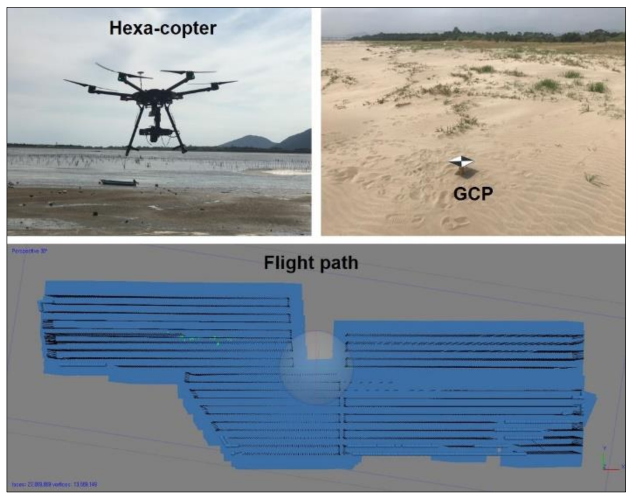


Figure 2. UAV, GCP and flight path for data acquisition


Figure 3. Aerial images acquired by M600 in Jinu-do

### 3.4 Photogrammetric Processing and Software

The processing of original image collection was performed by the software package called PhotoScan, available at a moderate coast for research institutions from the Russian manufacturer AgiSoft LLC. The SfM algorithm implemented by PhotoScan was used in this work to generate the dense DSM of the study area to be successively validated with the GNSS GCPs and compared with the DSM produced by the more familiar TLS survey technique. The reconstruction of ground surface and objects by PhotoScan is a three-step process. For a good reconstruction, at least two photographs representing a single point must be available.

In the first step the alignment of the acquired images was performed. The SfM algorithm comes into play by the detection of image feature points and reconstruction of their movement along the sequence of images. In the second step a pixel-based dense stereo reconstruction was performed starting from the aligned dataset.

## 4. ANALYSIS AND RESULTS

### 4.1 Topographic change of JINU-DO

The UAV performed 3 times (16 January, 26 May 2017 and 15 May 2018) of flights, gathering approximately 80 gigabytes of aerial imagery. The initial processing over 1800 images (ground resolution of 0.003 m/pixel at 100m flying height). By Knowledge of the GCPs coordinates, after processing by the SfM approach, bundle adjustment was performed to register the model in the UTM reference system camera locations and attitude were considered as unknowns.

The accuracy of the RTK-VRS survey is within ±15~25 mm in both horizontal and vertical components with respected to fixed control.

Successively, for further investigations on the absolute accuracy of 3D surface from the point cloud, a linear interpolator was used to produce a DSM. The pixel spacing was selected on the basis of the average distance between points of the dense cloud.


Figure 4. Orthophotos of Jinu-do


Figure 5. Contour maps of Jinu-do

Three orthophotos obtained through UAV aerial photographs show that the shoreline in the downward direction (toward open sea) is changed drastically (Figure 4). In particular, the vegetation of May 2018 was found to increase slightly more than May 2017. When the contour lines 2017 and 2018 are compared from -1 m to 3 m, the topographic change is more evident near the coastline and focused on intertidal zone (Figure 5).

Figure 6. 3D photo of Jinu-do using RealityCapture.

To clarify the result of the orthophoto, 3D model was created using RealityCapture. As a result, it was confirmed that the wood, grass and sand were clearly distinguished (Figure 6).

### 4.2 QGIS Analysis

QGIS is based on the Qt framework, a cross-platform application and UI framework, and leverages many libraries to achieve its full functionality. QGIS also can be used as a library to build other applications or to add GIS capabilities to an already existing application. Each capture had to be performed in one time, using the QGIS software (QGIS Development Team, 2009). To classifying vegetation and ground (sand) using raster calculator tool in PhotoScan. The vegetation figure is shown in green color of Figure 7 are between 0.8 to 0.86, and generated contour. Open topographic contours attribute table and execute filtering tool for select elevation that is larger than 1m. After select out boundary 1m contour, using field calculator’s area tool for obtain topographic area.

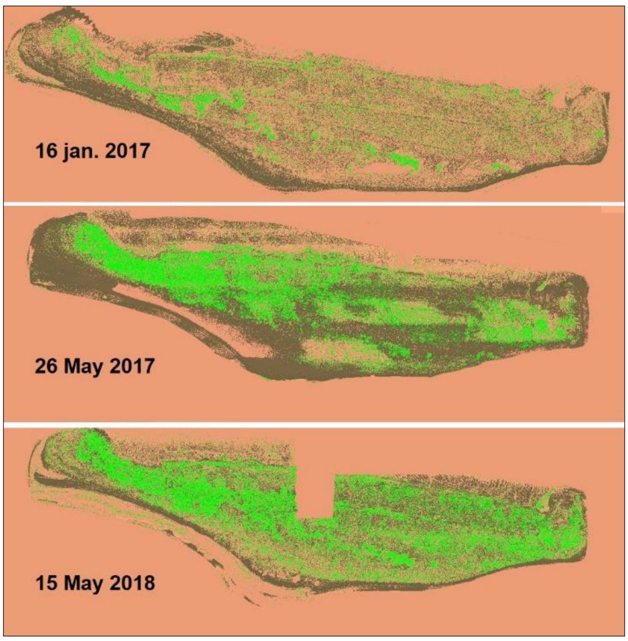


Figure 7. Representation of vegetation image of Jinu-do displayed in QGIS on digital orthophoto

Table 1 is shown the analysis results of Jinu-do using PhotoScan and QGIS tools. During the study period, the topographic variation of Jinu-do above 1 m was not changed much but the vegetation area was increased about 45%. The area of vegetation in which the plant can be inhabited compared to the total area increased about 5% based on the area of 1 m.

| Contents | 2017 | | 2018 |
|---|---|---|---|
| | 16 January | 26 May | 15 May |
| Topographic area over elevation 1.0m ($m^2$) | 943,245 | 945,460 | 929,954 |
| Vegetation area ($m^2$) | 106,674 | 123,920 | 155,331 |
| Vegetation /Topographic area (%) | 11.31 | 13.11 | 16.70 |

Table 1. Variation of topographic change area and semi-auto classification of Jinu-do between 2017 and 2018.

This results in an extremely detailed record of the surface at the different times A major limitation of the process is that the point clouds generated by the UAV do not represent areas where vegetation is dense and complex (such as dead or dry reed with many overlapping bushes) and when the surface has a homogeneous texture (e.g. water). Estuary environments indicate a range of complexities, including variable vegetation cover, strong topographic relief and variability in texture. Future studies will need to monitor migration and growth of vegetation on the accuracy of the generated point clouds using UAV photogrammetry.

## 5. CONCLUSION

Coastal ecosystems provide not only essential ecological services but also protect our coastal region from damaging floods and storms. In addition, Coastal wetlands provide critical habitat for migratory birds and mammals and serve to help keep our waters clean. Despite the critical importance of coastal areas to our health, coasts a wide range of threats from human activities, such as pollution, coastal development, reducing biological diversity.

In order to quantify this importance, a technique of mapping a target area by a time is required, and a technique using unmanned aerial system (UAS) is typical, An UAS including a UAV and a photo camera could be a good alternative for high resolution, relatively low cost photo-analysing information on elevation data of estuarine morphology, i.e. sand barrier and spit, by DEMs difference.

Using the PhotoScan, the area of Jinu-do orthophotos were calculated and the area of vegetation was calculated using QGIS. As a result, the area of vegetation was increased about 5% more than the topography.

This study of coastal mapping at Jinu-do demonstrate that the integration of UAV techniques and photogrammetric software and GIS analysis tools can provide new concepts into the estuarine and coastal morphologic by coastal mapping and quantifying topographic change and migration vegetation at high levels of spatial and temporal detail. These results can provide important information for critical factors of Sustainable Development Goals (SDGs) making as well as methodologies and tools that can be applied to other coastal city.

## ACKNOWLEDGEMENTS

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education. (NRF-2015R1D1A1A01060446).

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*Revised May 2018*