LAND SUBSIDENCE ANALYSIS AND INUNDATION PREDICTION BASED ON MULTI-TEMPORAL DIGITAL ELEVATION MODEL DATA

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1. INTRODUCTION

Because of the over capacity use of the ground water within the lowlands, the land subsidence along the southwestern coast of Taiwan is a serious problem [1]. For example, the overall amount of subsidence in Yunlin county in the past 30 years reaches about 2 meters, and the total affected area of subsidence is about 516 km^2. Land subsidence has increased the vulnerability in this area, and a large portion of which lies below the mean sea level. The consequence is the arising of the flood hazards during the periods of typhoon and heavy rainfall, and property damages and life losses could be caused by the poor drainage. Therefore, how to monitor the land subsidence effectively and forecast the flood hazards caused by subsidence will be an important study issue for well planning and construction of the proper drainage to minimize the flood hazard impacts. Traditional methods to monitor land subsidence are usually based on height observations using direct leveling or GPS surveying [2]. Such the ground-based methods have high precise results of height measurements, however only a little point-observations of height in small area are obtained. For the land subsidence monitoring in large area, the interpolations from point-observations cannot appeal the overall trend and variations caused by subsidence. On the other hand, the DEM (Digital Elevation Model) obtained by the photogrammetry and remote sensing technologies provides more extensive height information on regular grids than ground-based methods. In addition, most of the processes in photogrammetric or remote sensing technique have already been automated and more efficient nowadays. Compared to the points-observations of heights, the DEM with regular grid is more suitable to present the phenomena on the medium- and large-size terrain, especially favorable for the monitoring of land subsidence. However, it is not easy to perform the analysis of land subsidence when using the different DEM data sets with different resolution and accuracy. In our pervious study, the least squares collocation (LSC) was proposed to adjust the low-precise DEM data to high-precise leveling observations. The experimental results showed that the systematic errors of DEM data can be reduced using LSC, than the corrected DEM data can reveal more information of land subsidence in local areas. In this study, the statistics hypothesis test is applied to verify the significant of the land subsidence. Furthermore, some geomorphometric terrain parameters, such as the slope, aspect, break lines and roads features etc., are extracted from the multi-temporal DEM data sets. Then the change of these features locations can be analyzed along the horizontal direction. Finally, many kinds of 3D geo-information including the multi-temporal DEMs, the types of land use/land cove, and 3D building models in the study area were collected, then the HEC-RAS and SOBEK model which are the powerful 1D and 2D instrument for flood forecasting and simulation are used for the inundation simulation.

2. METHODOLOGIES

There are many geomatics technologies that can be used to acquire DEM data [3]. In term of the accuracy of measurement, a centimeter-level can be reached by photogrammetry and LiDAR (Light Detection and Ranging) technologies. InSAR (Interferometric Synthetic Aperture Radar) is another good technique for deformation measurement and with it an accuracy of 1 cm can be reached [4]. Therefore, the performance and effective of the multi-source DEM data sets for land subsidence analysis were compared firstly in this study. In addition, multi-temporal DEM data sets covering the same test area (Yunlin county, Taiwan) were also collected. In our pervious study, the analysis of the land subsidence was only performed along the vertical directions which the height differences and variances can be revealed. In order to perform the analysis of land subsidence when using the different DEM data sets with different resolution and accuracy, the least squares collocation, which is a kind of generalized statistic adjustment methods [5], was proposed to adjust the low-precise DEM data to high-precise leveling observations. In this study, the statistics hypothesis test is applied to verify the significant of the land subsidence using the LSC-corrected DEMs. In addition, some geomorphometric terrain parameters, such as the slope, aspect, break lines and roads features etc., are extracted from the multi-temporal DEM data sets. Then the change of these features locations can be analyzed along the horizontal direction. The flow chart of the analysis of land subsidence is illustrated in Figure 1. Once the systematic errors of DEMs data are adjusted, the land subsidence can be analyzed by simply differencing of multi-temporal DEMs. Furthermore, many kinds of 3D geo-information including the types of land use/land cove, and 3D building models etc. can be integrated into an inundation model for flood forecasting and simulation [6]. In this study, the HEC-RAS and SOBEK models which are the powerful 1D and 2D instrument for flood forecasting and simulation are used for the inundation simulation[7, 8, 9]. The flow chart of flood simulation is illustrated in Figure 2.

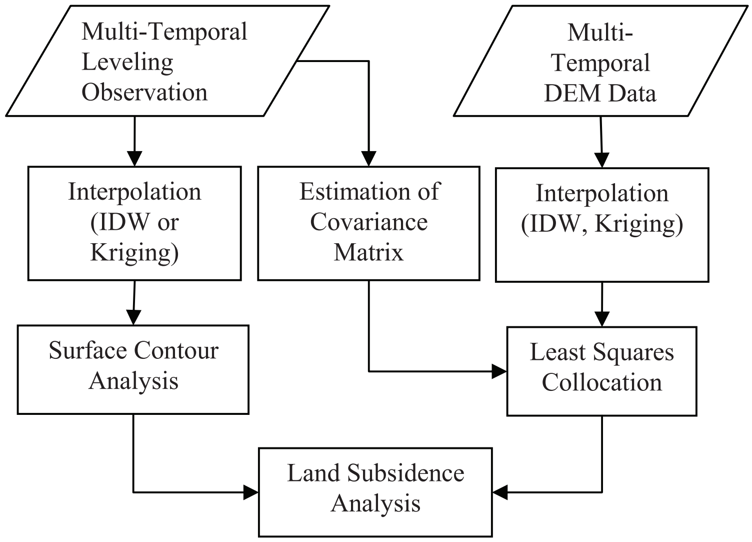

Figure 1. The flow chart for the land subsidence analysis

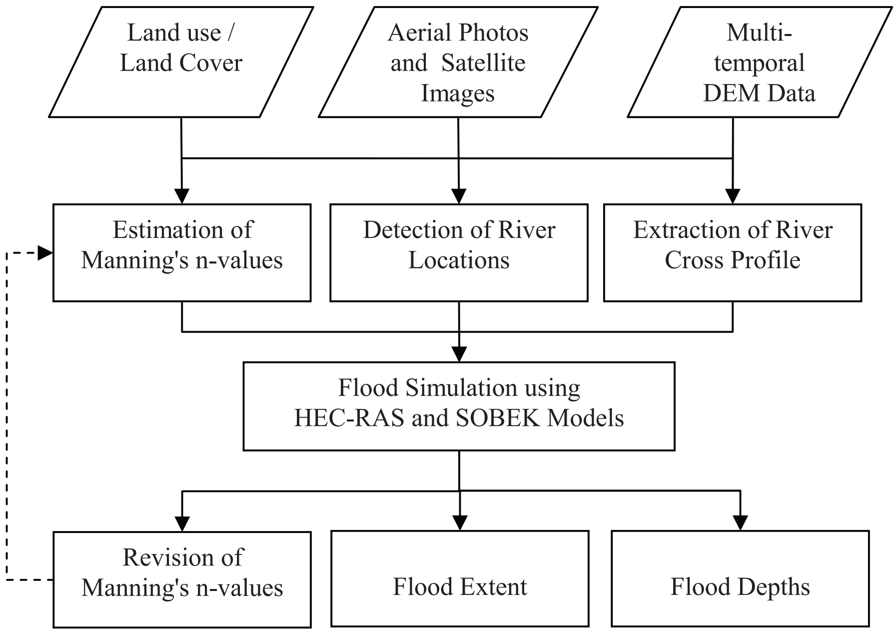

Figure 2. The flow chart for flood simulation

3. RESULTS AND CONCLUSIONS

The experiment results of this study showed that the extensive DEM data exactly provides more complete and reliable height information for land subsidence than traditional ground-based methods. The least squares collocation we proposed can exactly reduce the system errors of DEMs data and reveal more detail variances of land subsidence in local areas. The change detention of multi-temporal and multi-source DEM also reveals the important trend and variances of the land subsidence and flood prediction. Once land subsidence is identified and mapped, subsidence-monitoring and flood simulation programs can be implemented and scientific studies can be launched to improve our understanding of the subsidence and flood processes. A combination of scientific understanding and careful management can minimize the subsidence that results from developing our land and water resources, and then reduce the impact of flood hazards. The results of this study can serve as guidelines for design and planning of the infrastructures for the prevention of flooding hazards. In future, automated tracking of extracted features is needed for more efficient measurement of change of land subsidence, and the results will be used to improve the results of forecasting and simulation of the land subsidence and flood simulation. In addition, the visualization of the DEMs and measurements of subsidence will be developed for planning and decision making to reduce the impact of flood impacts.

4. REFERENCES

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