A study on the generation of GIS based Pervious/Impervious Map to Secure Funds for Implementing Green Infrastructure Policy

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ABSTRACT: Green infrastructure policies have been introduced recently to solve various pollutant-related problems in the cities. In order to expand policies of green infrastructure, securing sustainable financial resources should be the first priority. One of the feasible ways is to estimate the impervious area of the individual households and levy the pollutant-tax based on the size of the impervious area. For that, the most basic and important step would be the generation of Pervious/Impervious map with relatively higher accuracy. Hence, this study aims to establish a methodology for producing a Pervious/Impervious Map based on a GIS in order to estimate the new green infrastructure resources required to reduce the water pollution and furthermore to install such infrastructure.

It is necessary to update the landcover map to reflect status quo of the landuse to be used as the basis to generate the Pervious/Impervious Map. The landcover map has been updated with irregular interval such as 4-5 years, which makes it difficult to detect the up-to-dated landuse changes. Therefore, it is necessary to update the landcover maps on the yearly basis using various spatial data, and to produce a Pervious/Impervious Map using property information from the updated landcover maps.

Sejong city was selected as the study area since it has been expected that landcover changes will be relatively higher due to the recent relocation of administrative capital and intensive urban development plan. A landcover map produced on a small-scale classification of level 3 in 2015 has been available for the Sejong city from the Ministry of Environment. Considering active landuse changes for the area, however, it is imperative to update the landuse map using recent spatial data such as cadastral map, and airphoto, etc.

The procedure for updating the landuse map consists of preprocessing, updating primary and secondary landuse information, and quality inspection process. The preprocessing includes collection of the data and performing coordinate transformation for overlay analysis among various layers. The primary landuse changes accompanies updating landcover information for the detailed areas requiring precise classification based on the generation guide of the small scale landcover map. The secondary updating includes change-detection for the areas covered by shadows and buildings through the field investigation and road-view function provided by the internet portal service. Using the updated landcover map, the generation process for the Pervious/Impervious map has been proposed as the two stages such as attribute reclassification and quality inspection stages. Attribute reclassification provides classification of the pervious and impervious areas and adds pervious areas for the small sized grassland using the overlay of airphotos.

In this study, a methodology to generate the relative higher accuracy of Pervious/Impervious map has been proposed to secure the fund to install green infrastructure. Furthermore, this has been used as the basis for utilizing green infrastructure policy. Further research for delineating more detailed landcover boundaries will activate the usage of the Pervious/Impervious map as the basic data for building green infrastructure.

1. Introduction

As cities in South Korea underwent rapid urbanization over the past years, safety was not fully applied in the urban development and provoked distortion of natural water circulation that leads to rain, infiltration, and leakage as impervious layer augments due to the development. Nowadays industrialized countries make efforts to improve urban water circulation system and enhance the effects of reducing flood by utilizing green infrastructure (Kang et al., 2014) . South Korea introduced this policy in order to solve urban problems. However, the introduction of current policy remains significantly trivial compared to developed countries due to different norms and the lack of association.

The assurance of sustainable finance is immediately needed to extend this infrastructure policy. Impervious calculation method, which is one of the new financing methods, is required for calculating exact costs. However, there is little research on the production method of highly accurate and standardized pervious/impervious map. Thus, this study attempted to establish the production method of GIS-based highly accurate pervious/impervious map and create basic documents for utilizing this green infrastructure policy. 3rd landcover map should be updated and produce accurate pervious/impervious maps in order to calculate new green infrastructure resource and to reflect the current status of landuse.

In addition, it is difficult to detect the change of the recent landuse since landcover map is irregularly updated in every four or five years. It is important to renew annual landcover map by using various spatial data and produce pervious/impervious maps by using its attribute information (Kwak et al., 2014).

2. Methods and Materials

2.1 Previous research

Studies on renewal methods of the change of middle classification landcover use and output method of impervious percentage by lots by producing pervious/impervious maps were implemented (Kim, 2015). Previous studies used GIS-based pervious/impervious maps to support the assurance of efficient and scientific nonpoint pollution source by considering current status in South Korea and developed impervious percentage statistics calculating technique.

Furthermore, this study proposed an improvement for public sewerage rate system in consideration of rainwater runoff due to impervious surface. 2nd landcover map was developed into 3rd landcover map by using naked eye screen digitizing technique through collection of various spatial data for renewing landcover maps, preprocessing, and overlap analysis. Furthermore, field investigation was conducted to update the latest information of land use and review accuracy as well as utilization. Figure 1 presented the process of updating landcover map and producing pervious/impervious map in a study project on imposing method of sewerage cost by considering landcover map and rainwater runoff. Figure 2 show results from previous research.

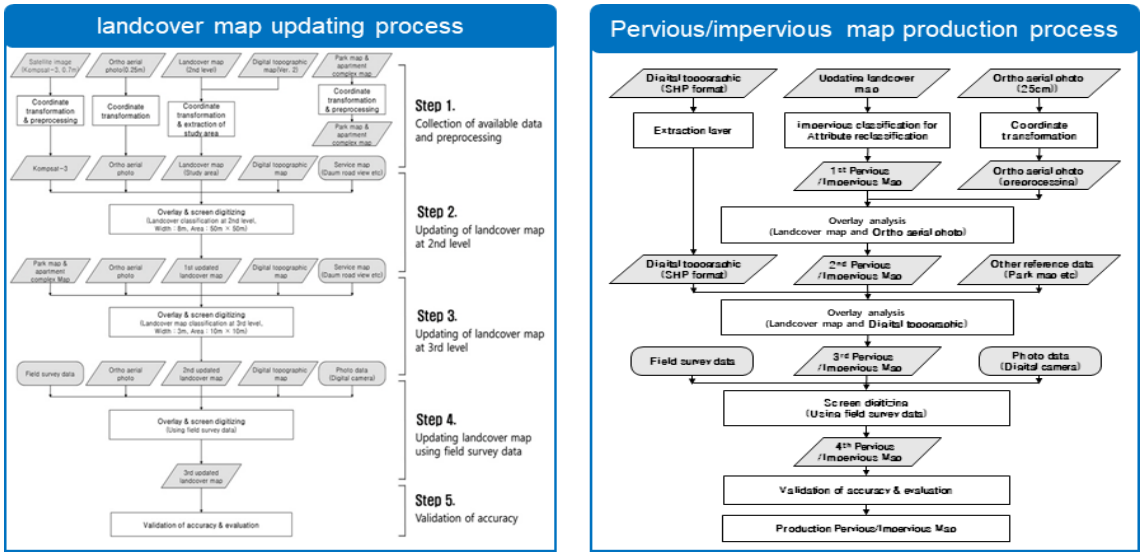

Figure 1. landcover map updating & Pervious/impervious map production process

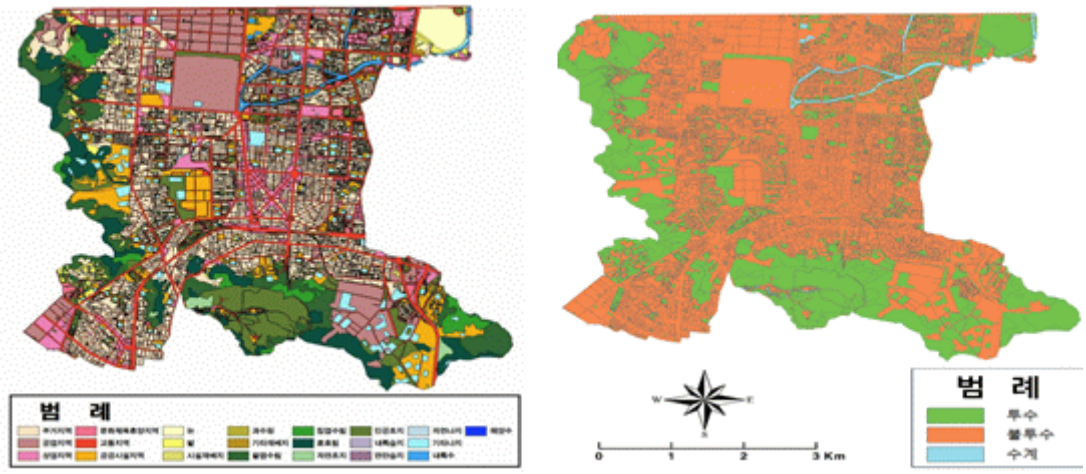

Figure 2. landcover map & Pervious/impervious map result

2.2 Review of Previous Methods for Producing Pervious/Impervious Maps

Renewal of landcover maps and the process of producing pervious/impervious maps were selected as previous methods among study projects on improvement of imposing sewerage costs by considering landcoverage and rainwater runoff (Kim, 2015). In this study, numerous latest spatial data such as aerial photos and artificial satellite video were overlapped with middle classification landcover maps, current status of landcoverage was updated through

field investigation, and pervious/impervious maps were produced.

In contrast, Bupyeong-gu Incheon, a small target region, was limited to certain types of land use and the classification of pervious/impervious regions on various types of urban land use are insufficient as much as its regional division. As preprocessing and complex production process were constituted for utilizing various spatial data, it demanded relatively long work hours and reduced the efficiency. Advantages, disadvantages, and improvement were accordingly summarized on previous methods.

Table 1 summarized renewal of previous landcover maps, production of pervious/impervious maps, advantages and disadvantages, and improvements as presented in Figure 1.

Table 1. Renewal of Previous landcover Maps, Production of Pervious/Impervious Maps, Advantage and Disadvantage, and Improvements

	Production Method of updating Previous landcover Maps	**Production Method of Previous Pervious/Impervious Maps**
Advatage	- Capable of updating landcover maps with the latest information on land use by utilizing the latest spatial data such as satellite video and aerial photos and by identifying misclassified regions as well as time series changed areas - Capable of updating middle classification unit landcover maps into subdivided units by using various spatial data such as aerial photos and digital maps in addition to landcover maps. - Classify detailed items that facilitate the classification of pervious regions within impervious regions by updating subdivided units. - Enhance the accuracy of updated landcover maps by identifying time series changed regions as well as blocked areas through a field investigation	- Elicit the method of producing pervious/impervious maps by conducting an overlap analysis of single spatial data such as digital maps, aerial photos, and updated landcover maps and producing trial pervious/impervious maps - Capable of producing highly accurate pervious/impervious maps by using digital maps and aerial photos in updated landcover maps, by revising margin information of pervious/impervious surface, and by identifying the accurate insertion of attribute information - Enhance the accuracy of pervious/impervious maps by updating time series changed regions and specific regions within impervious regions (artificial grass, playground made of urethane materials) through the field investigation
Disadvatage	- Slightly complex process as complicated preprocessing and middle classification landcover maps are updated through each step as much as using various spatial data. - Long work hours and reduced efficiency as it involves manual works such as revising margins and changing landcover classification items by utilizing screen digitizing methods by deciphering with naked eyes. - Problem in obtaining the latest data as other spatial data should always be obtained for updating landcover maps	- Long work hours as it involves manual works such as revising margins and identifying attributes by utilizing digital maps and aerial photos in the course of producing pervious/ impervious maps - Reduced Work efficiency by reusing overlap process for elevating the accuracy in the course of updating landcover maps (margin revision and identifying attribute information) as well as previously used spatial data - Additional classification of pervious aspect in a small garden is likely less accurate due to naked eye inspection
Improvement	- Simplify the renewal process of landcover maps, reduces work hours and elevates efficiency by obtaining subdivided landcover maps on target regions - For subdivided landcover maps, update it into the new one with the latest information on land use through overlap analysis of various spatial data and identifying time series changed areas since there is a difference in the period of offer (2015) and the current period (2016) - Simplify the preprocessing by removing the redundant spatial data (satellite), yet using various spatial documents	- Present the optimal pervious/impervious production method by producing pervious/impervious maps through reclassification of updated subdivided landcover maps and by updating pervious regions within impervious regions (artificial grass, playground made of urethane) through a field investigation - Simplify the process of producing the optimal pervious/impervious maps and enhance the efficiency by reducing work hours and workforce - Compare production methods of pervious/impervious maps by using updated subdivided landcover maps with those provided by the Ministry of Environment in the former administration and test the accuracy.

3. Result and Consideration

3.1 Study Area

Sejong City that urgently needed the management of impervious surface due to the recent relocation of administrative capital and constant urbanization was selected as a research target region for the renewal of landcover map development of pervious/impervious map production method (Fig. 5).

Its size is 465.23km2, which is 77% of Seoul area. For populations, approximately 0.24 million people are estimated to live in this city on October 2016. Immigrating people are expected to rise due to the urban development plan. In other words, Sejong city can handle various types of urban land use since there are many variations of landcover use, many development demands are on the rise in this city and it was considered as an appropriate region to be applied with the method developed in this study.

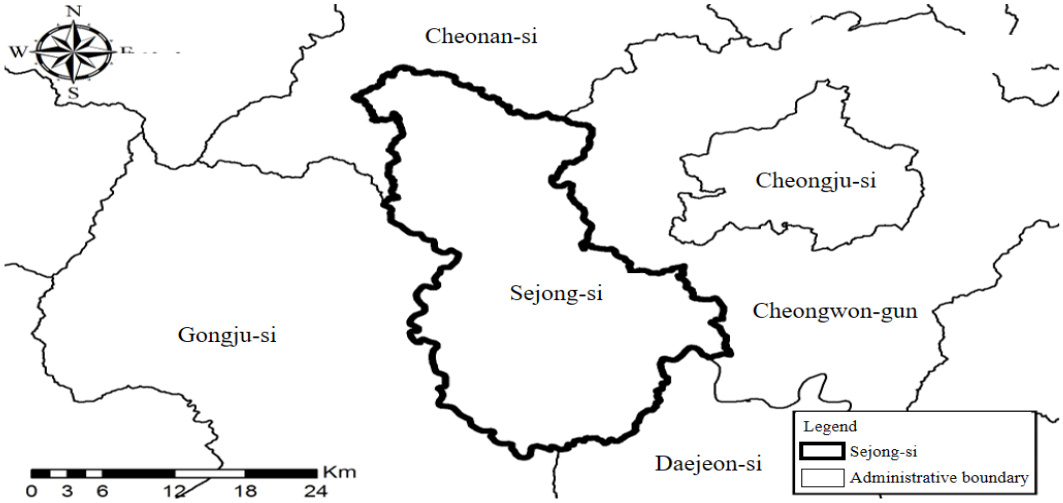

Figure 3. Study area – sejong

3.2 Establishment of updating landcoverage and Production Method of Pervious/Impervious Maps Based on Revised Previous Methods

Hence, this study obtains accurate subdivided items by using subdivided landcover maps and highlighted the application of the recent landcover information through the latest aerial photos. Furthermore, it intended to renew landcoverage information as well as landcover maps through various spatial data such as creating parks in the city and aerial photos on impervious as well as pervious regions and overlap analysis. It further attempted to improve the accuracy of pervious/impervious maps. In addition, it attempted to classify the types of pervious/impervious maps on numerous types of landcoverage based on extensive urban areas instead of previous research target regions and further apply it into the entire city. In addition, it intended to propose a method of producing pervious/impervious maps, which were more efficiently systematized outcomes from the previous complex work process.

Revision on the renewal of landcover maps and production of pervious/impervious maps was defined by analyzing advantages and disadvantages as well as improvement of previous methods. Renewal process of revised landcover maps and methods of producing pervious/impervious maps were established. As a result, eight-step renewal process of landcover maps and methods of producing pervious/impervious maps were set up with eight steps (Figure 4, 5). ① and ② processes refer to the preprocessing of available spatial data, ③ process refers to confirmation and revision of road margin of digital map and landcover maps, and renewal and revision process by overlapping aerial photo according to misclassified regions and time change. ④ process refers to reflecting field investigation and renewal on unidentifiable regions by using various spatial documents. ⑤ process wrote quality inspection card on the lately updated landcover maps, classified pervious/impervious regions into non-classified, misclassified, and margin revision-needed regions, and tested accuracy. ⑥ process refers to classifying pervious/impervious by reclassifying features by using updated landcover maps. ⑦ process conducts a field investigation for identifying pervious/impervious surface, checks and revises pervious regions and impervious regions within pervious regions. ⑧ process wrote quality inspection card on the latest produced pervious/impervious maps, classified pervious/impervious regions into non-classified, misclassified, and margin revision-needed regions, and tested accuracy.

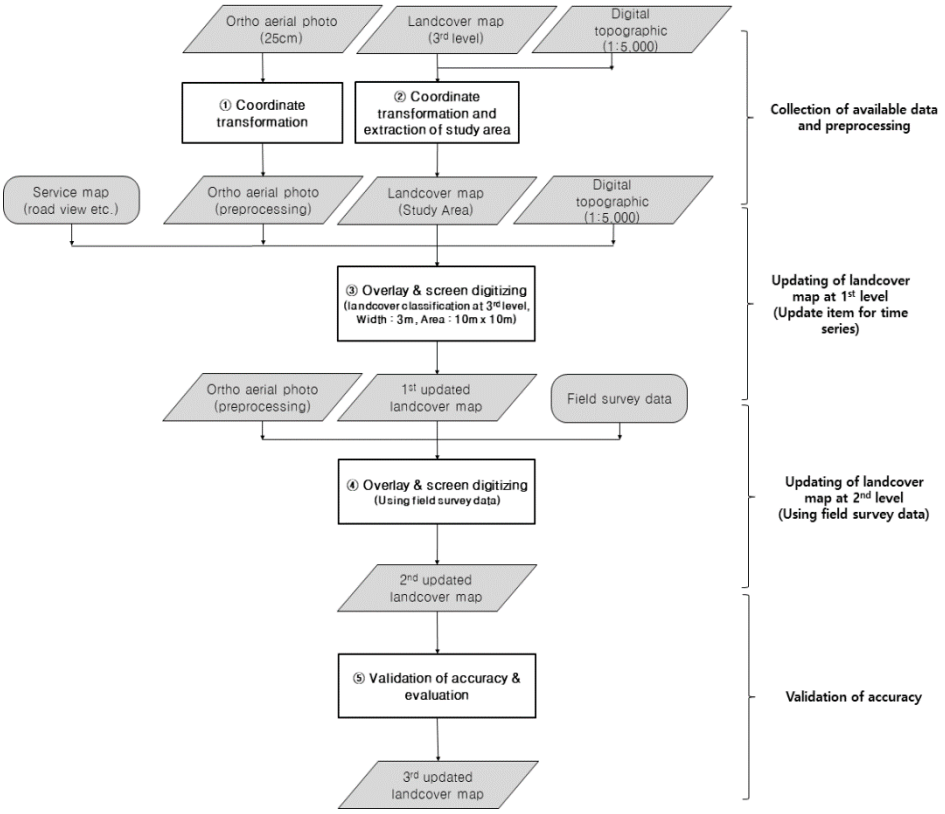

Figure 4. landcover map Updating Methodology

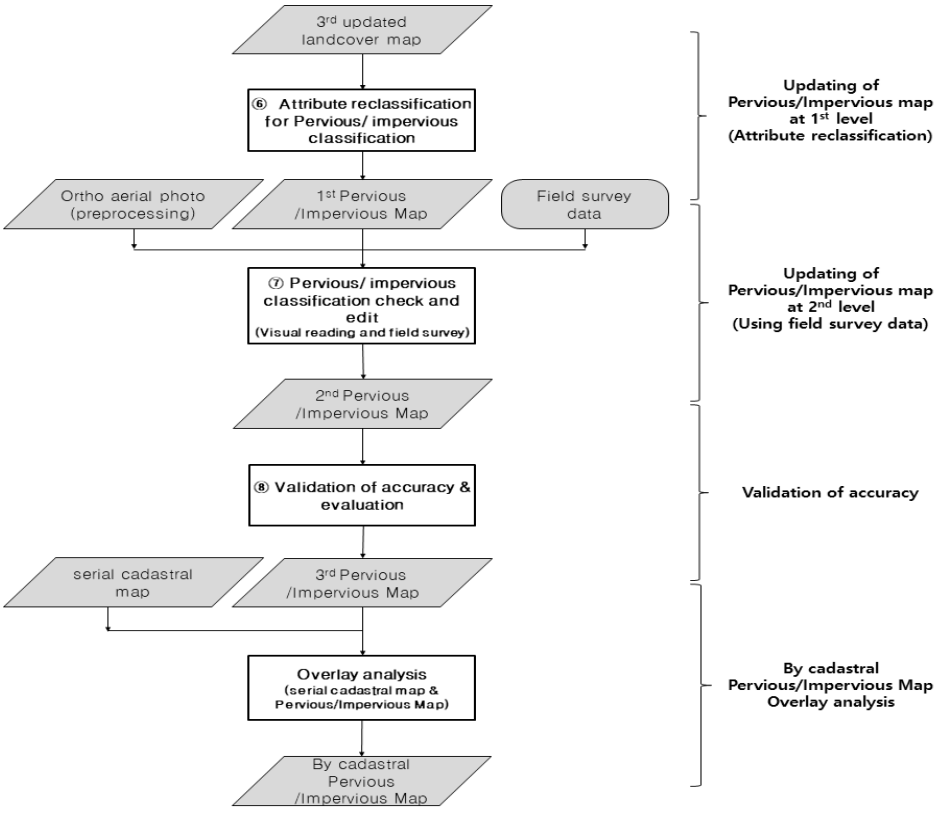

Figure 5. Pervious/ impervious map production Methodology

4. Conclusion

Regarding the management of impervious surface, developed countries actively use low impact development and green stormwater infrastructure to limit the extension of impervious surface and to minimize side-effects from the ruin of water circulation. Therefore, this study presented the production process establishment of GIS-based accurate pervious/impervious in order to calculate new green infrastructure resource. As there are many variations of previous landcover map due to lots of the current development demands, the presented method will be applied in this city where various types of urban land use. Regarding the final results from this study, the author attempted to lay foundations for utilizing this green infrastructure policy like developed countries. Basic documents for establishing this policy will be available by classifying more detailed landcover maps.

Further research on the production guideline of pervious/impervious maps for the sake of standardization should be performed and local pervious/impervious maps should be produced based on established guidelines. Furthermore, research on automatic methods for annual renewal should be further conducted. Results from this study will contribute to the effective management of urban impervious surface.

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