Development of Carbon Spatial Map for Spatial Planning

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Abstract. Existing greenhouse gas statistics make it difficult to establish a spatial unit reduction plan for individual regions. In addition, there are limitations in analyzing carbon emission reduction effects reflecting spatial characteristics and establishing spatial plans. Therefore, the purpose of this study is to improve greenhouse gas spatial information and statistics, develop technology, and establish a system to support carbon-neutral urban planning. Research builds carbon spatial maps and develops platforms to support carbon-neutral urban planning. This shortens the basic survey period, improves the explanation of predictive models, and supports the establishment of carbon neutral plans in demonstration cities. The results of the study can be used in various fields such as carbon neutral monitoring and carbon neutral policy establishment and are expected to be effective in urban planning such as narrowing the technology gap and establishing a foundation for Spatial management.

Keywords. Carbon Neutral City, Carbon Spatial Map, Urban Planning, Planning Support, Demonstration

1. Research background

According to the "Basic Act on Carbon Neutrality" enacted in September 2021 and the "2050 Carbon Neutral Scenario" announced in October 2021, local governments are obliged to establish and implement carbon neutral basic plans to promote carbon neutrality. Accordingly, the government and local governments have an obligation to establish GHG reduction targets and implementation plans and to check the progress.

Existing greenhouse gas statistics were written centering on emission sources, making it difficult to use them to establish spatial unit reduction plans for individual regions. In addition, the greenhouse gas inventory is currently provided at the local government level, and there is a two-year lag between collection and publication. Because of this, spatial-level data is

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needed for beneficial carbon emission reductions within a city. It is difficult to analyze the emission reduction effect that reflects spatial characteristics such as spatial structure, urban form, land use, and infrastructure of the city with only the existing (metropolitan) administrative district unit emission information, and there are limitations in establishing spatial planning.

Therefore, in order to establish a carbon-neutral city plan, local governments need to revise the basic planning guidelines for cities and counties. To this end, it is necessary to develop technology that supports spatial planning, which analyzes carbon emission and absorption status information based on spatial maps. In addition, to support the establishment of spatial policies, a separate system establishment and utilization basis must be prepared.

The purpose of this study is to improve greenhouse gas spatial information and statistics, develop technology, and build a system for carbon-neutral city planning, build a carbon Spatial map that can be used for spatial planning, and a platform that supports carbon-neutral city planning.

2. Research content

2.1. Conceptual diagram of research object

The carbon-neutral city Spatial planning support platform includes a carbon Spatial map system and is composed of various modules to support carbon-neutral city planning. This platform is designed to share and connect the functions necessary for city planning in connection with the big data-based artificial intelligence city planning establishment support system. In addition, it has been implemented so that the platform can operate smoothly by utilizing the latest information such as KLIP and greenhouse gas information system in connection with information systems in land transportation and related fields.

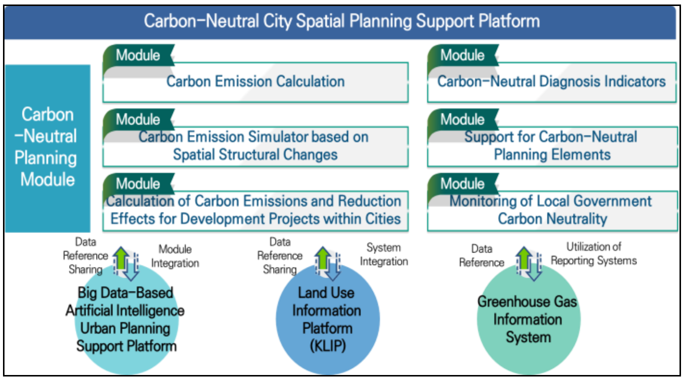

Figure 1. Carbon Neutral City Spatial Planning Support Platform Concept

2.2. Establishment and Verification of Data Acquisition Plan for Advancement of Carbon Spatial Map

In order to upgrade the carbon Spatial map, we have established a plan to secure and link source data to calculate energy use in buildings and carbon emissions in the transportation sector. This increases spatial resolution from the traditional minimum grating of 100 m to 10 m, providing more granular carbon emissions and absorption data.

In addition, we have established a plan to standardize carbon Spatial map data for each spatial unit in consideration of areas for use such as residential, commercial, industrial, and green areas. This provides carbon spatial map data in a consistent format.

By accurately calculating the energy usage and carbon emissions of the building unit and transportation sector and providing detailed carbon emission and absorption data, the quality of carbon Spatial maps is enhanced and standardized data reflecting various use areas is secured

Categories		Existing Carbon Spatial Map System	Approach for Applying Enhanced Carbon Spatial Map Model
Resolution	Grid	Minimum 100m grid	Minimum 10m grid
	Buildings	Representation using grids	Representation using grids, building forms
	Transportation	Administrative areas, linear features	Representation using grids, road linear features
	Absorption sources	Representation using grids	Representation using grids, boundaries of absorption sources
Utilization information	Buildings	Utilization of building energy usage information	Incorporation of additional characteristics at the global level, addition of variables for simulation purposes
	Transportation	Utilization of major road network traffic volume (vehicle type/fuel type/speed) information, applying emission conversion factors	Precise calculation of traffic volume up to detailed road network + addition of variables for new transportation modes, validation using private data
	Absorption sources	Calculation of forest absorption using forest area (provided by Korea Forest Service) and emission factors	Precise calculation of traffic volume up to detailed road network + addition of variables for new transportation modes, validation using private data
Inventory		Confirmation of emission quantities by administrative areas and land use zones	Creation of spatial unit inventories incorporating residential, commercial, industrial, and green areas

Table 1. Carbon Spatial map advancement model application plan

2.3. Establishment and verification of data acquisition plan

The following tasks were performed to secure basic data necessary for upgrading carbon spatial maps. First, we established statements about data sources, data refresh cycles, data types, and structures to clearly define the sources and characteristics of the data. Through this, the reliability and consistency of the data were secured.

The National Building Energy Integrated Management System collects basic information on buildings, areas of use, and road networks as well as electricity, gas, and energy usage data every month. The data collected in this way is used to calculate the building's carbon emissions.

We also measured carbon absorption in green areas using clinical maps and land cover map data from the Korea Forest Service. Based on these basic data, we design a model and data linkage structure for calculating carbon emissions and absorption.

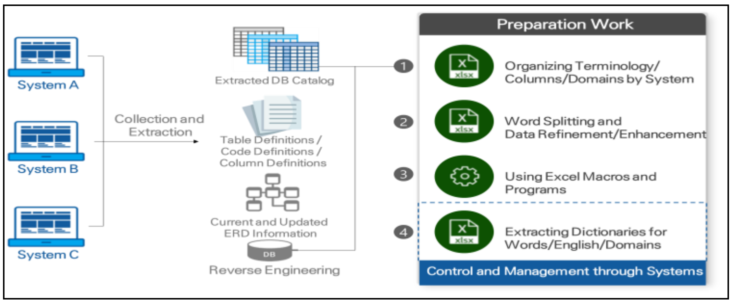

Figure 2. Metadata-related artifacts

2.4. Application of Carbon Emission and Absorption Calculation Model by Spatial Unit

In order to calculate carbon emissions and absorption, various spatial data such as buildings, road networks, use areas, and administrative areas were considered. To this end, we selected standard spatial units and developed conversion algorithms to maintain consistency and interoperability between data.

In relation to the energy usage of buildings (electricity, gas, district heating, etc.), we have developed a data set of carbon emission conversion by building units combined with various attributes such as location, use, and construction year of buildings. This creates a dataset that can be represented in the form of a building, and also takes into account the scalability of future.

This allows you to standardize various spatial data and develop conversion algorithms to accurately calculate carbon emissions and absorption. In addition, a building-level dataset can be developed and expressed according to the shape of the building, which also takes into account future scalability.

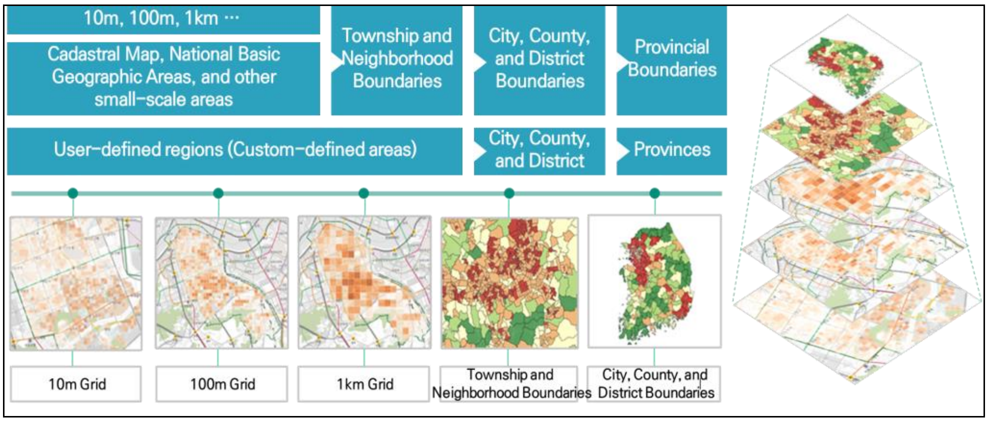

Figure 3. Carbon emission and absorption calculation model application plan by spatial unit

2.5. Implementation of Advanced Carbon Spatial Map

In order to upgrade the carbon space map, we are designing and developing systems to provide various functions and accurate information. In the past, we plan to improve the carbon space system that can only be inquired and provide flexible and accurate information through functions such as point analysis, drawing analysis, SHP file analysis, and carbon reduction modeling analysis.

Develop a methodology for producing grid-unit data used in carbon Spatial maps, and develop guidelines and manuals for users and operators of the system to promote operational and management efficiency. Through this, it is possible to provide more diverse analysis functions and accurate information by realizing the advancement of carbon spatial maps.

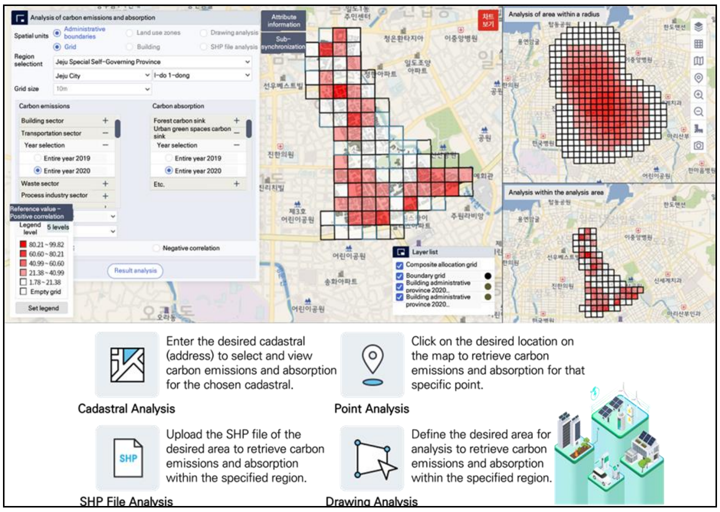

Figure 4. Carbon Spatial Map Advanced Implementation System

2.6. Design of Carbon Spatial Map System Framework

The carbon spatial mapping system framework is designed with a focus on data collection, analysis and visualization, security, and scalability.

Data Collection Module Design: A module was developed to collect source data such as energy use, traffic volume, and land use area. This module collects data in real time and stores it securely on a distributed storage system.

Data Analysis and Visualization Module Design: A module applying an analytical formula that calculates carbon emissions and absorption using stored source data was developed. This module visualizes the analysis results in a variety of ways and provides them as maps, charts, etc. This allows users to intuitively understand carbon emissions and absorption.

Security and scalability module design: Design security features for data including sensitive information covered within the system. Secure features such as data encryption, access control, and logging to ensure data confidentiality and integrity. In addition, a standard framework is established in consideration of the scalability of the system to facilitate the addition of new features and system expansion.

The carbon Spatial mapping system framework designed in this way provides comprehensive capabilities in terms of data collection, analysis, visualization, security, and scalability, providing accurate and secure carbon emission and absorption information.

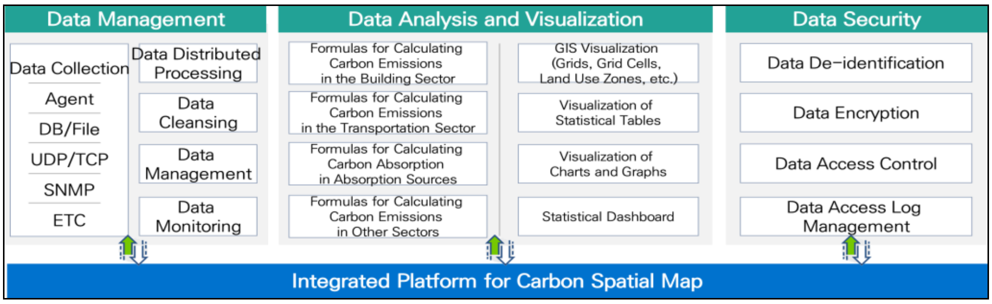

Figure 5 Design of Carbon Spatial Map System Framework

2.7. Purpose and Application of Research Deliverables

Through carbon neutral monitoring of the national Spatial unit, a carbon Spatial map system can be established to monitor carbon emissions and absorption performance of the entire country. This is used by related ministries, including the Ministry of Land, Infrastructure and Transport, to understand the current status of carbon neutrality in land Spatial.

It is also used to support the establishment of carbon neutral policies by local governments. Through spatial unitization of greenhouse gas inventories, local governments can establish carbon neutral policies based on spatial information. This helps local governments establish sustainable carbon neutral policies and contributes to reducing carbon emissions.

It is also used to support the establishment of carbon-neutral city planning. By reflecting the carbon-neutral city planning elements specified in the city county's basic planning guidelines in the city planning process, a plan aimed at carbon neutralization of the city can be established.

Finally, it is used to provide carbon neutral information to large citizens. Ordinary citizens can check the carbon neutrality of the region in their daily lives through the citizen service. This helps raise public awareness of carbon neutrality and reduce individual carbon emissions.

3. Conclusion - Expected effect

As a policy expectation effect, carbon Spatial maps can be used to evaluate the current status of greenhouse gas reduction and to set requirements for designating carbon-neutral cities. In addition, policy measures such as designating carbon emission concentrated areas, supporting spatial planning, and establishing carbon-neutral urban spatial structures can be provided to cope with local governments' obligation to establish and implement carbon-neutral basic plans.

The expected effects of science and technology can contribute to narrowing the technology gap in urban areas by introducing analysis, prediction, and optimization technologies for carbon neutrality in urban planning. It also provides a scientific technology foundation for the transition from emission-oriented management to spatial emission and absorption-based planning and management.

Economic and social expected effects can contribute to greenhouse gas reduction by building infrastructure in the city and establishing a plan to reduce greenhouse gas emissions by sector using carbon Spatial maps. In addition, greenhouse gas reduction can be accelerated by establishing a carbon-neutral spatial structure transformation strategy that reflects regional characteristics.

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