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RESEARCH ARTICLE

Development of a smart city planning support tool using the cooperative method

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Abstract
A reduction of environmental burdens is currently required. In particular, proposing a new approach for the construction of a smart city using renewable energy is important. The technological development of a smart city is founded building equipment and infrastructure. However, planning methods and their techniques using the collaboration approach with residents are only just developing. This study aimed to develop a support tool for the construction of a smart city using renewable energy while facilitating consensus-building efforts among residents using the method for a cooperative housing development. We organized the supporting methods for the construction of residential area using the cooperative method. Then, we developed supporting tools that interface the computer with these methods. We examined the support techniques for the construction of a residential area using renewable energy technology by analyzing Japanese cases of a smart city. Moreover, we developed a support tool for the construction of a smart city on a trial basis. We integrated the smart city construction tools and the cooperative housing construction support tool. This tool has a 3D modeling system that helps residents to easily understand the space image as a result of the examination. We also developed a professional supporting tool that residents can consider for cost-effectiveness in renewable energy and its environmental load reduction rate for the planning of a smart city.

1. Introduction

Cooperative housing methods that combine consensus-building among residents and their own efforts to create a good environment and an attractive local community are currently required. In these methods, the workshop creates

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a hopeful living image. However, it required long periods of time and professional support and is not fully exploited.

A reduction of environmental burdens is required from the viewpoint of the global environment and energy saving. A smart city, which is a thorough environment-conscious city planning that contributes to enhancing energy efficiency, is considered an appropriate way to have a sustainable society. It provides not only the environment and technology but also living conveniences and comfort. Therefore, proposing a new approach to construct a smart city is important.

As for the technological development of a smart city, the field of building equipment and infrastructure is active. However, planning methods and techniques for the collaboration with residents have just emerged. Support for consensus building in the stage of the planning can help in a situation in which a planner proposes these methods and technology.

Earlier research on supporting the consensus building in planning shows the following important points: the method of space image sharing of the plan and the project evaluation methods in planning (Takiguchi et al., 2003; Koga et al., 2008; Arima et al., 2007; Nagai et al., 2011; Koga et al., 2011).

Takiguchi et al. (2003) studied consensus building in the workshop of a park. Koga et al. (2008) examined it in town landscape planning. Arima et al. (2007) investigated it in the workshop of town panning. A number of studies have been conducted on project evaluation in planning. Nagai et al. (2011) studied project evaluation in urban development for low carbon, and Koga et al. (2011) examined it in urban redevelopment. However, these studies did not conduct a project evaluation to calculate both CO_2 reduction and the business budget.

This study aimed to develop a support tool for the residential construction of a smart city with renewable energy technology while facilitating consensus building using the cooperative method.

By examining a 3D modeling of a space image of a residence, CO_2 reduction, and the business budget, a planning of residence that reflects the intention of the residents is supported. Therefore, this study is different from previous research.

2. Research method

We developed a supporting method for residential area construction using the cooperative method. On the basis of this information, we developed supporting tools interfaced with a computer using the methods. We examined the support technique for residential construction with renewable energy by analyzing the case of a construction of a smart city in Japan. We developed a support tool for the construction of a smart city on a trial basis. Moreover, we integrated smart city construction tools and the cooperative housing construction support tool. We developed a 3D modeling technique for the support tool through which users can easily understand the space image from the result of the examination. We also developed a professional supporting tool for a smart city planning that residents can use for examining the cost-effectiveness of renewable energy and the details of the environmental load reduction rate.

3. Supporting contents for planning and consensus building

In this section, we analyze the improvements in planning and consensus building using the cooperative method and the idea of a smart city. Moreover, we examine supporting contents for developing a support tool.

3.1. Planning of housing development using the cooperative method

We analyze the planning methods for cooperative housing in this section. In the construction of cooperative housing, a workshop is often held in a living environment that reflects the opinions of inhabitants. In this workshop, the development of rules for construction and habitat design is considered important. Residential area rules mainly consist of two agreements, namely, the environmental agreement on the use of the entire residential area and the building agreement on the design of a house. In this section, we also explain the case of the cooperative village of Kasugabaru Minami, which represents both the environmental and building agreements (Nakanishi et al., 2011). Table 1 shows the environmental agreement and Table 2 shows the building agreement for this village. Interestingly, an environmental rule is set in each area. Coordinators set tree rules on plant location, symbol tree species, and so on for each house.

Fig. 1 presents a discussion method for the cooperative village of Kasugabaru Minami. For topics such as the selection of symbolic tree species in a residential area, participants can discuss actively and easily their opinions and demands with each other. For the topics that require some expertize, such as exterior and design of a building,

Table 1 Environmental agreement.

Unified regulations for a whole designated area	The target area must be designated to construct a residential zone through an architectural plan for the housing construction. A tree with over 3 m in height must be planted in each housing lot. The target area where houses have a louvered balcony must be specified.
Rules for private space	All residents have the responsibility to maintain it by themselves.
Rules for public space	All union members should offer a facility for maintenance.
Rules for landscape	Installation of equipment attached to buildings that impair scenery is not allowed.