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## A GIS application supporting urban management towards the attainment of the smart city development goals in Thai Nguyen city

Rapid urbanization and urban development must meet the requirements of smart green growth and sustainable development of Vietnam. Hence, these are the top challenges to be tackled by urban managers. Therefore, urban management databases must be accurate, relevant, and transparent. At the same time, simple access databases will enable users to quickly find the information they need. A combination of attribute data and spatial data is a smart and effective tool. Realistic data, integrated with the Internet of Things, or IoT, makes breakthroughs in the management of urban development by enabling managers and citizens to access real-time data and make effective urban management decisions. Within the framework of this study, a geodatabase was compiled to support effective urban management and information accessibility for the general public in Thai Nguyen city. The database was made in VB.net and later integrated into the Geographic Information System (GIS) to enable users to access, search, analyze, process, and manage the database information. The database will support decision making by urban managers. The co-authors' findings, on factors affecting urban management, show that local management does limit violations of urban construction regulations. This model will address the main factors affecting urban management (Community Participation, Information Technology, Law and Communication) and improve the urban management efficiency.

**Keywords:** GIS, urban database, urban development, urban management, smart city

### 1. INTRODUCTION

Publicly available data show that the rate of urbanization in Vietnam is 0.5 % higher than it was last year. Vietnam has 862 cities, including 2 special cities, 22 grade 1 cities, 31 grade 2 cities, 48 grade 3 cities, and all other cities have grades 4 and 5 [1]. Rapid urbanization and development make the government employ innovative approaches to the management of urban development. The 2018–2025 project on the sustainable development of smart Vietnamese cities encompasses the future urban development through 2030 in line with the aforementioned trend [2]. The urban system of Vietnam has been quantitatively and qualitatively developing in terms of scale. However, the process of urbanization, characterized by urban sprawl, has led to air pollution, traffic congestion, pollution of water bodies, depletion of resources, intensive use of urban land resources and the deteriorating quality of the living environment [3, 4]. The reasons underlying these phenomena, as pointed out by numerous researchers, include the poor quality of urban planning and architecture/urban construction regulations; under-revised urban planning that misses adequate technical indicators at central and regional levels; inadequate human resources and urban management capacity; insufficient construction supervision, and an incomplete urban database [5].

Thai Nguyen is located to the north of Hanoi, the capital of Vietnam, in the centre of the northern mountainous area of the country. In an effort to raise Foreign Direct Investment (FDI), Thai Nguyen has started developing the local infrastructure: new national highway No. 3, linking Hanoi and Thai Nguyen, is already in operation; it has reduced the time, needed to reach Hanoi, by more than an hour. By now, Thai Nguyen has improved its investment appeal among domestic and international investors, major economic

operators, small and medium enterprises (SMEs). Many projects have been implemented; they are a remarkable contribution to the socio-economic development of the province. Thai Nguyen has become a national leader in FDI raising.

Currently, Thai Nguyen is one of the most important economic centres and locomotives of the Northern Mountainous region; it experiences rapid urbanization and vibrant urban economic development.

Thai Nguyen has successfully become a second-grade city, that provides effective support to the city of Hanoi, and boosts the development of smaller neighboring cities. The Government of Vietnam has chosen Thai Nguyen City as the beneficiary of assistance for its economic growth potential. Traditional surveying methods and land profiles have not been effective in managing urban scenarios given the contextual changes in technologies and socio-economic requirements. What does the present-day scenario need as a tool that captures, stores, analyzes, and leads to a feasible solution? GIS is a sophisticated tool, processing spatial information and making a sequential analysis of the physical environment by using the attribute data such as Canopy, Land use, Land cover, Environmental resources, water supply, sewerage and relevant topology. Given the challenges of the modern urban society, urban planners and managers should apply GIS to develop "smart cities" which are livable, well managed, safe, and sustainable. GIS will be a helpful visual tool for effective decision-making in respect of the issuance of building permits, construction discipline management and urban planning. Rapid development of the Internet, Mobile Computing, Wi-Fi, Remote sensing, VB.net has brought multidimensional societal changes [6]. These have been

Nguyen Quoc Toan  
Nguyen Thi Thuy Hien  
Nguyen Thi Tuyet Dung



**Nguyen Quoc Toan,**  
PhD in Construction Management; Faculty of Construction Economics and Management; National University of Civil Engineering; 55 Giai Phong Street, Hai Ba Trung District, Hanoi city, 100000, Viet Nam; ORCID: 0000-0001-7086-2974; toannq@nuce.edu.vn



**Nguyen Thi Thuy Hien,**  
PhD in Construction Management; Faculty of civil and environment engineering; Thai Nguyen University of Technology; 666 3/2 street, Thai Nguyen city, 250000, Viet Nam; nguyenthuyhien@tntu.edu.vn



**Nguyen Thi Tuyet Dung,**  
PhD in Construction Management; Faculty of Urban Management; Hanoi Architectural University; Km 10 Nguyen Trai street, Thanh Xuan District, Hanoi city, 100000, Viet Nam; ORCID: 0000-0002-4554-0786; dungntt@hau.edu.vn

► implemented in urban planning and management. The challenges that the urban management has to tackle include better controllability, easier access to updated information, appropriate, smart, and efficient decisions. It is important for the authorities to apply technological advancements in urban management and urban planning. Currently, the application of the information technology (IT) in urban management is still very limited, especially in Thai Nguyen as a province, despite the availability of numerous researches focused on the improvement of urban management in different areas and regions [5]. Therefore, the project on GIS application in support of urban management towards the development of smart cities in Thai Nguyen is a viable solution aimed at urban management improvement.

## 2. DATA AND METHODS

### *New urban management trends towards smart city development in Thai Nguyen*

Sustainable urban development has been a dominant goal, governing urban management activities. Urban planners and managers can apply the following approach in order to achieve this goal, which encompasses the following aspects [7]: (1) integrating a sustainable goal into future objectives; (2) mainstreaming economic, social, and environmental sustainability within the framework of urban planning projects.

The effect of sustainable development on urban planning management can be broken down into the following aspects:

- innovative planning methods, application of the green building approach, and linking urban planning to urban transport [8]; besides, the importance of organizing and implementing urban planning projects should be considered.
- the application of information technologies, GIS to support the management of planning and construction activities in line with the approved urban development plans. This approach not only (1) changes the perception of planning methods that are community-based and participatory for developing urban areas; but also (2) facilitates the shift from the top-down urban management to the bottom-up urban management as a more competitive and partnership-oriented management model. There is a variety of smart city frameworks that facilitate the assessment and development of cities. Smart cities have been classified using six dimensions, namely, smart economy (industry), smart governance (e-democracy), smart environment (efficiency & sustainability), smart mobility (logistics & infrastructures), smart living (security & quality) and smart people (education). Many metropolitan authorities have used these six dimensions in a smart city, that uses a set of factors to measure its success and decide on further improvements [9].

These initiatives, launched by urban leaders and professional officials responsible for construction and urban development management, have shown positive signs of urban management improvement. The framework, adopted for this study, uses safe, well managed, livable, healthy, prosperous, and sustainable tools that employ GIS, AHP (Analytic Hierarchy Process), SQL (Structured Query Language), VB.net (Visual Basic) to connect the community and the authorities, manage the urban database and the development of a friendly and livable city [10–12].

## 3. RESULTS

### *Evaluation of an IT application supporting urban management in Thai Nguyen city*

An IT application supporting urban management in Thai Nguyen city has not been implemented yet [11]. According to the results of sociological surveys, the general public believes that information technologies are insufficiently used by the urban administration in the process of urban management; urban residents hope IT will enable them to solve tasks properly. According to the general public, their involvement in and supervision over urban management have been rather limited.

Such limitations have been scientifically confirmed by the sociological surveys, examinations of reliability, Exploratory Factor Analysis (EFA), and the validation of the multi-variable regression performed to determine the extent of influence of each factor [13–16].

This study shows that an integrated GIS database can facilitate effective collection, tracking and management of property data by urban managers in Thai Nguyen city. Questionnaires were developed to collect data on the items of real estate and their owners in the study area. The database was compiled in VB.net and integrated into the GIS database. The results have proven that of three hundred questionnaires used for this study, 250 owners fulfilled their property-related obligations. The study has clearly shown that an integrated GIS database ensures a more efficient tracking and management of planning and construction works in line with urban development plans. It is recommended to use the proposed GIS database to track violations in the study area. Also, stringent measures, representing a combination of awareness generation and law enforcement, should be taken to make local residents honour their obligations.

The co-authors have verified the EFA to attain the following excellent results:

Dependent variable Y, that affects urban planning and construction management in line with the approved urban plans of Thai Nguyen city (MPC-Management Planning and Construction according to urban plans), is shown in the multiple linear regression equation:

$$Y (\text{MPC}) = 2.168 + 0.221 X_1 + 0.513 X_2 + 0.355 X_3 + 0.325 X_4. \quad (1)$$

Dependent variable Y(MPC) depends on 4 independent variables, including X1 — Condition, X2 — Government, X3 — Participation and Partnership, X4 — Information technologies and other independent factors shown in coefficient  $\beta_0 = 2.168$ .

X1: A group of Condition (CO) factors, including Sustainable economic development & Stable political system, Education level, Urban lifestyle.

X2: A group of Government (GO) factors, including Legal Framework; Accountability; Transparency & Supervision.

+ X3: A group of Participation and Partnership (PP) factors, including Compliance with Law, Propagation and Dissemination of the Legal system, Public, Sharing, and Advocacy.

+ X4: A group of Information Technology (IT) factors, including Decision-making Process Improvement, Time and Cost Saving, Communication [17].

All standardized regression coefficients  $\beta$  are greater than 0; in addition,  $\beta_2 = 0.513 > \beta_3 = 0.355 > \beta_4 = 0.325 > \beta_1 = 0.221$ ; thus, these coefficients marked as X1, X2, X3, X4 have a positive impact on planning and construction management within the framework of urban planning. Survey results, indicated as the Government, are the most valuable factors that influence effective planning and

construction management pursuant to the approved Thai Nguyen urban development plan. The current deterrence strategy can hardly reduce violations since it is only used as a preventive solution. When people believe they will be caught and punished, they are less likely to instigate violators. An appropriate level of sanctions coupled with a high risk of being caught is likely to prevent some potential crimes. So, it is recommended that legislators can carefully consider the likelihood and severity of punishment as an effective warning to violators.

**4. DISCUSSION**

*A GIS application in support of urban management in Thai Nguyen city*

Thai Nguyen, being a development centre located north of Hanoi, takes advantage of inter-connected regional infrastructures. Thai Nguyen City, an industrial city currently focused on iron and steel products, is to be transformed into a city of commerce, services, clean industries and high technologies. The goal of Thai Nguyen is to become a sustainable, modern city by 2035, an ideal centre of politics, economy, culture, education, healthcare, tourism and services in the Thai Nguyen province, northern midlands and mountainous regions of Vietnam<sup>1</sup>. Thai Nguyen City develops as a service provision centre of green growth, ensuring harmony between the economy, natural ecosystems, and social balance<sup>2</sup>. This focus enables the city to apply technological advancements in urban management. Recently, the development of the Internet and GIS technologies has allowed web-based data sharing by means of integrating GIS and Web (referred to as Web-GIS) [18]. The

co-authors employed the Web GIS and a Web GIS application [19] to establish a data system towards more effective management and information sharing relevant to construction management in line with the approved urban plans (i.e. building permits and construction work management). More importantly, the use of Web GIS could bring about tremendous benefits to the urban authorities of Thai Nguyen city in terms of construction permits and construction work management [5, 6, 20].

A real-data application integrates all sectors of a smart city's architectural framework [21], including its smart environment, smart transportation, and smart residential buildings. A satellite network is used with smartphones, GPS devices, while PCs and other navigation devices use the Internet to collect data with the aid of semantic Web technologies. Citizens and managers will obtain information using Web GIS technologies which have integrated cross-sectional platforms to assemble, manage, gather, analyze, and visualize spatiotemporal data for the benefit of sustainable urban planning, development, and management. The results are often displayed on the map that highlights areas featuring high to low suitability [22].

The co-authors have developed a software system by integrating SQL and VB.NET [11, 25] into GIS to allow users to access and search for information, statistical data, and reports that they need. In particular, the co-authors have developed and benchmarked spatial data and attributes of an urban planning project; land and housing information in Thai Nguyen city (the case of Residential Compound 6 of Tuc Duyen) to establish a uniform framework for the software systems to be shared by the concerned departments and agencies; it has spatial and attribute data related to individual land plots in support of the issuance of construction permits and construction work management.

All data are provided in standard forms and updated to ensure publicity and transparency. The system is operated by the database, that establishes a relationship between the government and citizens in terms of law-making and enforcement in relation to planning and planning management, state funding and protecting the benefits of the urban population.

The software interfaces are presented on Fig. 1-3.

1 Thủ tướng Chính Phủ. Quyết định số 1536/QĐ-TTg về việc phê duyệt Nhiệm vụ điều chỉnh quy hoạch chung thành phố Thái Nguyên, tỉnh Thái Nguyên đến năm 2035. 2014. (Government, Decision No.1536/QĐ-TTg approving the task of adjustment general planning of Thai Nguyen city to 2035. 2014: Government Prime.)  
 2 Ủy ban nhân dân thành phố Thái Nguyên, Thuyết minh tổng hợp điều chỉnh Quy hoạch chung thành phố Thái Nguyên đến năm 2035. 2014, thành phố Thái Nguyên (Thai Nguyen city People's Committee, General explanation of adjustment general planning for Master plan of Thai Nguyen City to 2035. 2014, Thai Nguyen city People's Committee.)

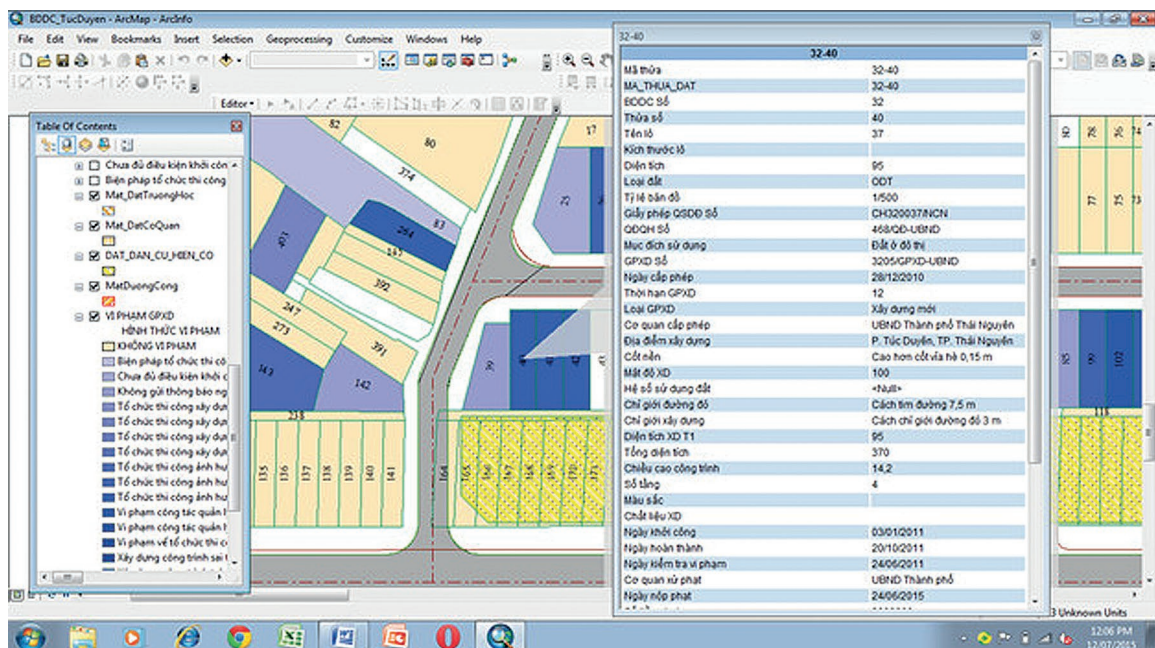


Fig. 1. The interface of integrated GIS and VB.net (General land information)

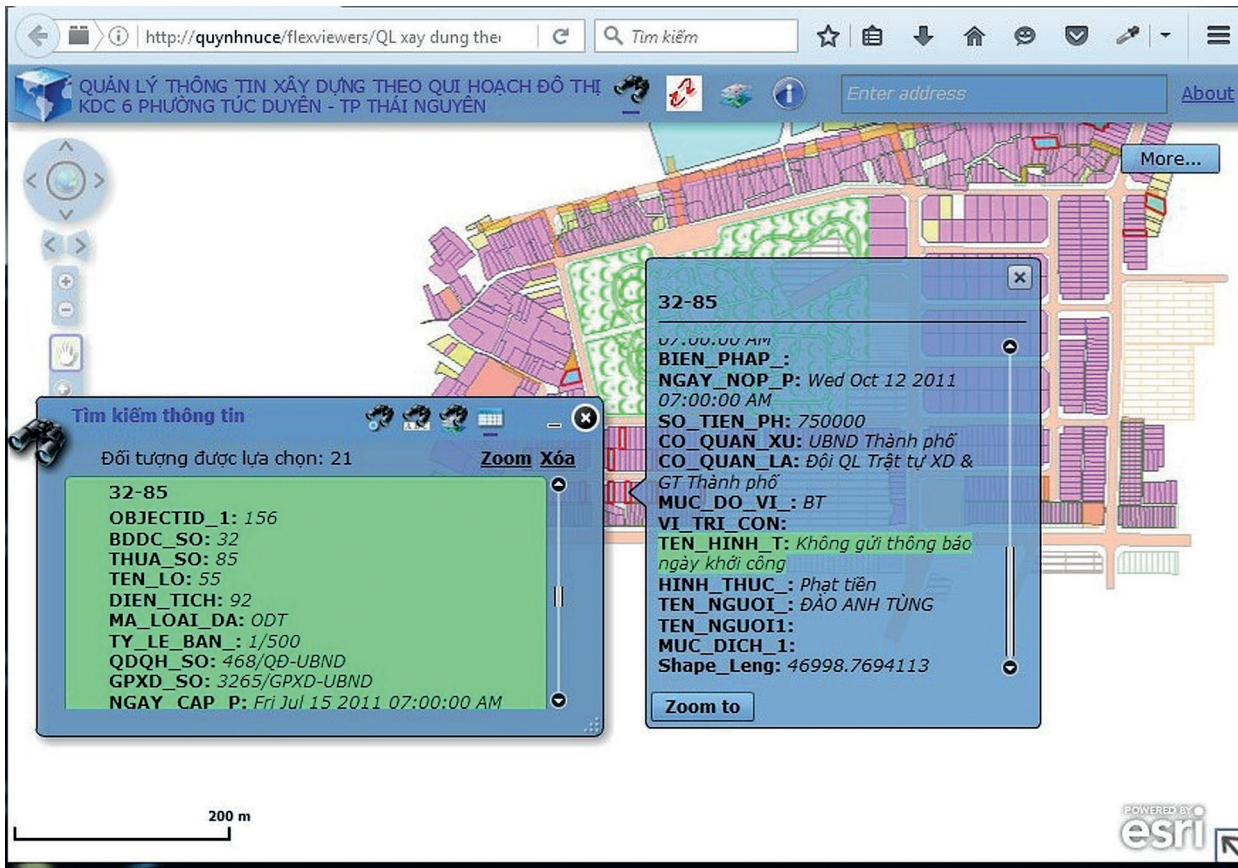


Fig. 2. The interface of integrated GIS and VB.net (construction permit and construction work management information)

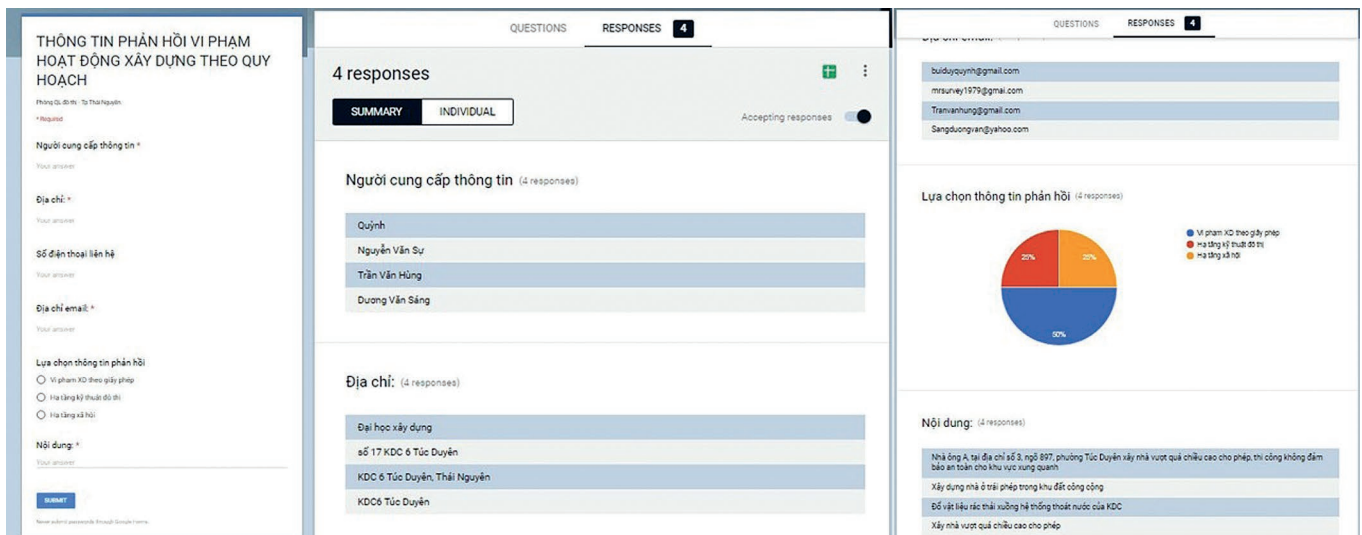


Fig. 3. The interface of the Web-GIS technology application

### 5. CONCLUSIONS AND RECOMMENDATIONS

GIS applications are widely used in Thai Nguyen in support of urban management aimed at the smart city development. Management software can be used by local authorities when the database system is fully operable. Not only the government and citizens of Thai Nguyen city will benefit from the use of the software, it may also be applied by similar localities.

The research on “A GIS application in support of urban management towards the attainment of smart city development goals in Thai Nguyen” is meaningful and essential to Thai Nguyen in promoting their specific regional strengths. The paper addresses new contributions to the theory and practice of urban management.

IT applications are used to implement urban management solutions; they enable users to access information, statistics, and

reports. The co-authors have developed a software system that integrated SQL and VB.NET into GIS to enable users to access and search for information, statistics, and reports.

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## ГИС-приложение для поддержки городского управления в достижении целей развития умного города в Тай Нгуен

Быстрая урбанизация и развитие городов должны соответствовать требованиям разумного, «зеленого» роста и принципам устойчивого развития Вьетнама, которые были и остаются важными задачами для менеджеров. Это требует, чтобы городская база данных была точной, актуальной и прозрачной для управления. В то же время люди должны легко находить нужную информацию. Один из умных и довольно эффективных инструментов — комбинация атрибутов данных и пространственных данных. Комбинация между реальными данными и Интернетом вещей (IoT — Internet of Things) создает прорыв в управлении городским развитием, облегчая менеджерам и гражданам доступ к данным в реальном времени, а городскому управлению — принятие эффективных решений. В этом исследовании была собрана и создана база геоданных для поддержки эффективного управления городским хозяйством и обеспечения ее доступности для жителей города Тай Нгуен. На основе собранной информации руководители будут принимать решения. База данных была создана в VB.net, а затем интегрирована в географическую информа-

ционную систему (ГИС), чтобы предоставить пользователям возможность доступа и поиска, анализа, обработки и управления информацией. Выводы исследования о факторах, влияющих на городское управление, показывают, что местное управление действительно, играет роль в ограничении нарушений городского строительства. В этой модели рассмотрены основные факторы, влияющие на управление городским хозяйством, которые выявили исследования (участие сообщества, информационные технологии, право и связь), улучшены управленческие возможности правительства города.

**Ключевые слова:** ГИС, городская база данных, градостроительство, управление городским хозяйством, умный город

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Об авторах: **Нгуен Куок Тоан** — кандидат технических наук по управлению строительством; факультет экономики и менеджмента в строительстве; **Национальный строительный университет**; 100000, Вьетнам, г. Ханой, район Хай Ба Трунг, ул. Гиай Фонг, д. 55; ORCID: 0000-0001-7086-2974; toannq@nuce.edu.vn;

**Нгуен Тхи Тху Хьен** — кандидат технических наук по управлению строительством; факультет гражданской и экологической инженерии; **Технологический университет Тай Нгуен**; 250000, Вьетнам, г. Тай Нгуен, улица 3/2, д. 666; nguyenthuyhien@tnut.edu.vn;

**Нгуен Тхи Туэт Зунг** — кандидат технических наук по управлению строительством; факультет городского управления; **Ханойский архитектурный университет**; 100000, Вьетнам, г. Ханой, район Тхань Суан, улица Нгуен Чай, 10км; ORCID: 0000-0002-4554-0786; dungntt@hau.edu.vn.

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