Creating A Prototype Smart City for A Case of Developing World: Pathum Thani, Thailand

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ABSTRACT

The prototype of the urban development area plays an integral role in creating a smart city plan. Developing an innovation model can be performed by learning from the local community and transcribing lessons from other cities in a relevant context. Pathum Thani Province is selected as a case study located in the suburban area of Bangkok, Thailand. With the role of center of education, research and technology development, it is a must to pilot an appropriate innovation to the city by test-bedding. In creating a smart city prototype given users centric, this study reflects the needs of local people in Pathum Thani by questionnaires collection of 1,000 sets. After that, the data was input into the statistical analysis to define appropriate strategies for creating the Pathum Thani smart city prototype. The results also indicated that promoting high-quality public utilities and facilities covering the needs of people must be provided to help strengthen the occupational skills for resilience in economic stability within the smart city platform. Finally, urban planning and policy strategies can be proposed to enhance people's quality of life (QoL) in Pathum Thani through the advantages of smart city with the advancement of digital ecosystem towards a livable city and human-center oriented development.

1. INTRODUCTION

The activities of humans have pushed the global into the severity of urban problems which resulted in increasing its significant impacts on physical; infrastructure investment, environment; ecosystems and climate change [1]. To ensures sustainable development, quality of life (QoL) is recognized as a significant issue to be concerned [2]. Currently, despite only about 2% of urban space accommodating a world population of over 50%, including human activities, it produces greenhouse gas (GHG) emissions of more than 80% and the world's resources consumption more than 80% [2]. At the same time, the economic losses pressure many cities to reduce budgets and set new urban development plan priorities in each phase. Accordingly, cities face new challenges in maintaining and upgrading public facilities and utilities, particularly Information and Communications Technologies (ICTs) infrastructures, innovation, and technology plans. This paper effort to understand and introduce an approach for creating a prototype smart city based on technology, innovation towards integrated socio-economic development enabled for the sustainable urban future. Consequently, all users among diverse stakeholders are encouraged to actively participate addressing and agreed in each priority which is helping to find consensus on joint short-medium-long-term planning [3]. The prototype area is a necessity in creating an innovative city plan by focusing on the model of innovation development across learning together with the community who use it and transcribing lessons to other cities in a relevant context [4], [5] & [6].

Furthermore, coping with urban development problem arising from urbanization can be remedied by intelligent solutions. Since the traditional approach has been limited in term of capacity of solving the challenges of existing urbanization and infrastructure allocation and services, particularly, the vicinity area of mega city, Bangkok metropolitan, the capital of Thailand. Towards sustaining the inhabitants of suburban cities in enjoying the long-term benefits in the future, it is vital importance to embody key challenges from primate city development in the process of driving smart city. Thus, the comprehensive strategies to manage the urban growth with integrated policies should help to guarantee access to ICT infrastructure and social application services. With the advancement of ICTs, the smart city should carry both opportunities while minimize risks to urban development pattern which is caused by the concentration of housing, infrastructure, and social service, including employment and the potential of essential services (e.g., education and health care). The technology-oriented essence can provide a better choice for the migration from

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rural areas into urban areas to find better opportunities while improving their quality of life (QoL), health and well-being, which require an effective local plan for development intending to maximize the economic opportunities of growth and mitigate damage on environmental dimensions [7]. With advanced technological capacity, these urban problems can be systematic understood and investigated in the urban concentration of both activities and travel. The digital transformation can cope the situation of cities expanding and transforming both physical and socio-economic aspects. To reach socially and economically desirable deliverables, an improvement of socioeconomic environment at organization and government level must be considered due to the vast majority of the population still cannot bear the cost of living, especially in Bangkok metropolitan areas, where the population growth rate was 0.5%. The resulting urban areas deteriorated during the 1987s before recovering due to the BTS sky train as mass transit system development in the 1997s [8], [9] & [10]. While the urban areas have continued to expand in suburbs, the Bangkok Metropolitan Area (BMA) by the comparison between 2002 and 2015 was found that the city had expanded more than 16 times [11]. Therefore, for higher efficiency of connecting the people and urban areas with more accessibility to desired destination under existing infrastructure development, the holistic smart city can ensure the positive impact of urban facilities and mobility solutions to secure the convenient, comfortable, safe and reliable service for benefit resident's everyday life.

In this study, Pathum Thani Province is targeted as the prototype area, representing the suburban area of Bangkok metropolitan (Fig. 1). The potential of allocation plays a vital role as a strategic region of education and economic development in the form of the university city and the center of the regional transportation system [12]. Furthermore, the local strategic plan is also intended to allow Bangkok mass transit system in accessibilities to local areas and suburban communities for efficient travel. In addition, it has stimulated local government investments in urban infrastructures and facilities to serve the population's needs towards improving the quality of life (QoL). By attracting local private sector-related development to the city with the joint effort among different stakeholders, the turning knowledge among them could help to promote innovation and economic growth towards local clusters' economic agglomeration in Pathum Thani province. The smart city concept is considered to create the maximum potential and improve urban life, particularly at the individual level to others. Together with the availability of technology, the transformation of knowledge based on research and innovation can be easier linked to urban development. The other socio-economic dimensions can be inclusively considered with the digital transformation process. Additionally, the participatory approach can be more actively innovated and designed for better solution due to the reason that there would be available resources to create a platform for data collection and transformation into data analytics through powerful analysis tools. Problem-solving and upgrading ICTs infrastructures and innovation within the high potential area also improve urban management by establishing an efficient infrastructure system [13]. Therefore, Pathum Thani Province, as a vicinity area connected to Bangkok, which is a significant residential area for urban workers and represented as an area to support the growth of Bangkok. To meet the need of diverse people in suburban areas as dense agglomerations where concentrated of both economic actors and workers which required a co-location of infrastructures to promote knowledge transfer and networking amongst stakeholders for prototype smart city development.

2. LITERATURE REVIEW

2.1. Smart city concept

In recent years, smart cities initiatives have been employed as leading urban solutions for efficiency of urban services while enhancing the quality of living and minimizing the negative impacts due to the rapid urbanization, socio-economic, environmental, and local management challenges, and the global innovation leadership changes [14]. The concept of smart cities has been applied for comprehensive transformation of a city with ICTs as its fundamental managing cities to be flexibility adapted to global cities for more efficient and competitive [15]. From the holistic viewpoint of smart city conception, by integrating innovation and technology in urban planning, operation, and management, the adapted innovative solutions can be employed across the governance aspects for mitigating multidimension of urban challenges [16], [17]. Therefore, the concept of smart city concept is emphasized on a digital technology application, communication and information to enhance community services both for physical-technological aspect and human-social aspect. It aims to help reduce social costs and consumption in the daily activity of people by increasing the efficiency of urban management to create a better urban well-being and quality of life (QoL) [18]. For Thailand, there is a guideline for developing smart provinces and Nakhon Nayok Province was proposed to be a model province as a pilot project and aims to provide a guideline for raising the level of urban development equivalent to international standards [19]. This challenging approach is the connecting and collaborating platforms to create new opportunities and methods with embedded technologies in more integrative approach for a prototype city. Adhere to the principles of good local governance and creating clarity in the urban development, there must be prevailing digital transformation to provide innovative and intellectual services for livability of urban environment which requires issuing manuals or white papers, research and development to point out the guidelines

or methods needed to develop [2].

2.2. Integrated Network of Smart City

Integration and collaborative action are required a high level of cooperation between all stakeholders with different expertise, roles and the complexity of implementation [20]. The degree of complexity for an integrated collaboration is ranged from a single specialized organization which must be understood. Currently, most of different organizations do not have an integrated cooperation platform. To the next level, there should be a collaboration among multi-function organizations to jointly create an inclusive, innovative and diverse economy with driven by technology as follows [21]:

1) *Intra-disciplinary*: limit to a single discipline,
2) *Cross-disciplinary*: interpretation or analysis of data from other multidisciplinary without working together,
3) *Multidisciplinary*: different disciplines using their group information or knowledge, not collaborative,
4) *Interdisciplinary*: integrate urban information, knowledge, and methods from different disciplines, and
5) *Transdisciplinary*: there is a combination and synthesis of knowledge beyond the point of view in expertise.

An integrated information and communication among public and private sectors as new collaboration models is conducive for knowledge transferring and potentially radical innovation. The private sector can lead an open innovation and technology brings to the urban development which could help for economies of scale for both productions and distribution (goods and services) [20]. Therefore, all stakeholders (private, public, and education) in solving the urban problems can focus on the critical issues by exchange and collaborate while facing similar demographic, socio-economic and environmental challenges. To identify and implement solutions, such networks can contribute for initiatives involving local economics, people and communities [14]. With innovative capacity, urban planning could be consequently improved due to rapid technology and innovations developments. Currently, the sharing role of the local private sector is increasingly influencing on urban development by acting as service providers, users and investors dimension [22], [23]. With the urban complexity management and budgetary constraints, it is needed for the local government and public sector to be involved by attracting the investor's collaboration with the local government which can contribute to the formulation of strategic measures for smart city planning. Three group of management strategies can be explained as follows [4], [20] & [24];

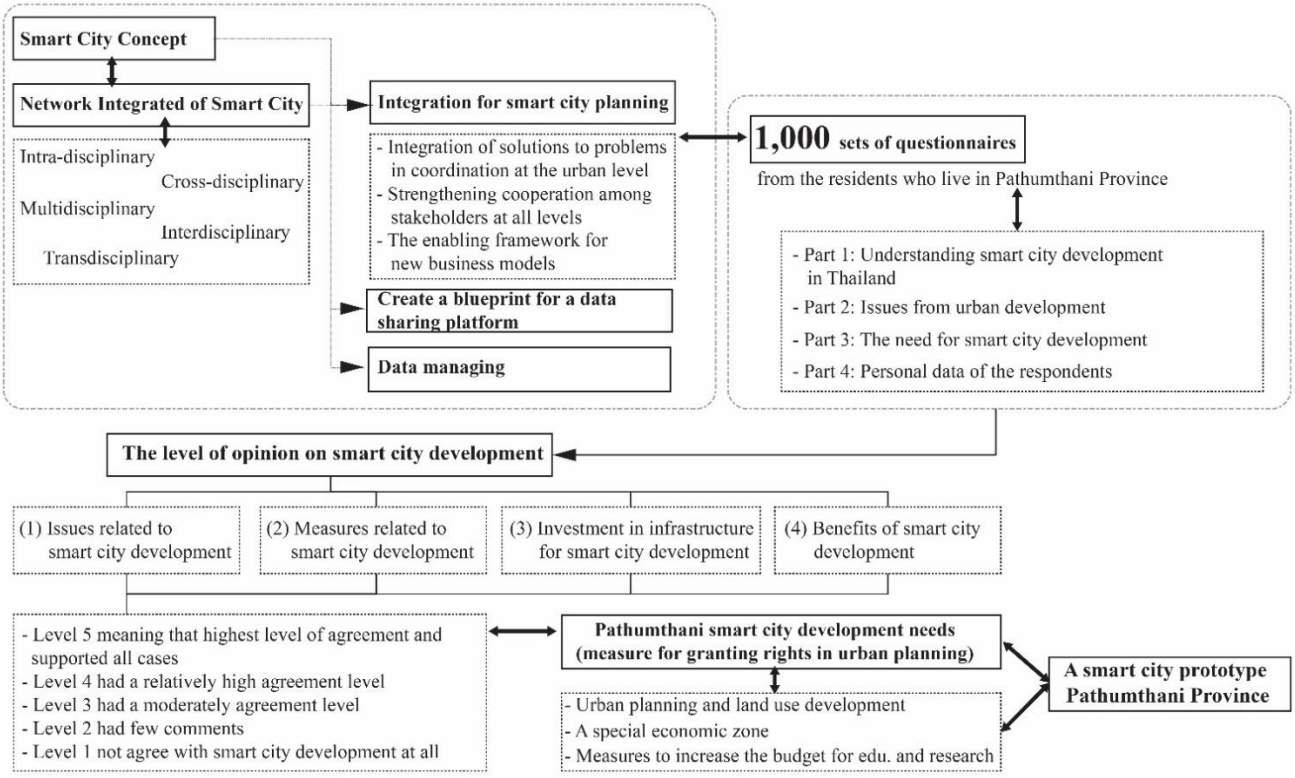

Fig. 1. Pathum Thani smart city development (SCD) framework.

1) Network interoperability management in city planning in all dimensions: the government sector should provide collaborative platform for city engagement through an integrative management system based on innovation and particularly digitalization [25]. This collaboration requires different levels of support as follows:

– *To integrate solutions in solving urban problems and collaborate with society*: from the analysis of the case studies, there are still limitations in the comprehensive solution for many reasons. Private sector cooperation plays a key role as a local co-creation for integrated and supporting urban planning and design with applicable technologies/ innovations/ tools/ perspectives.

– *Strengthening collaboration with all stakeholders at different levels*: smart cities planning is complex, requiring the local government and communities to cooperate among different sectors and understanding smart city ecosystem development. It emphasizes the participation among various sectors involved seriously.

– *The strategic measure for urban data framework promotes new business/startup*: should be flexible in deciding the roles and responsibilities of all stakeholders. The local government must consider management, design and initiative step forward, and it should be defined law or regulation that guarantees attractiveness of collaborative platform, specifically the private sector.

2) Create big data and a data-sharing platform: create open data for prediction and diagnosis on the basis of empowering social inclusiveness. This innovative role can provide co-creation, comprehensive urban data in each sector for the multi-level competition in different dimension of services, platforms and applications.

3) Data managing: is a vital key in creating digital society. Since the integrated urban plan can apply the collected urban data for further analysis and design in each process, share real-time data and analyze urban data. It must be able to ensure that application of digital technology can contribute for digital equity and social inclusion.

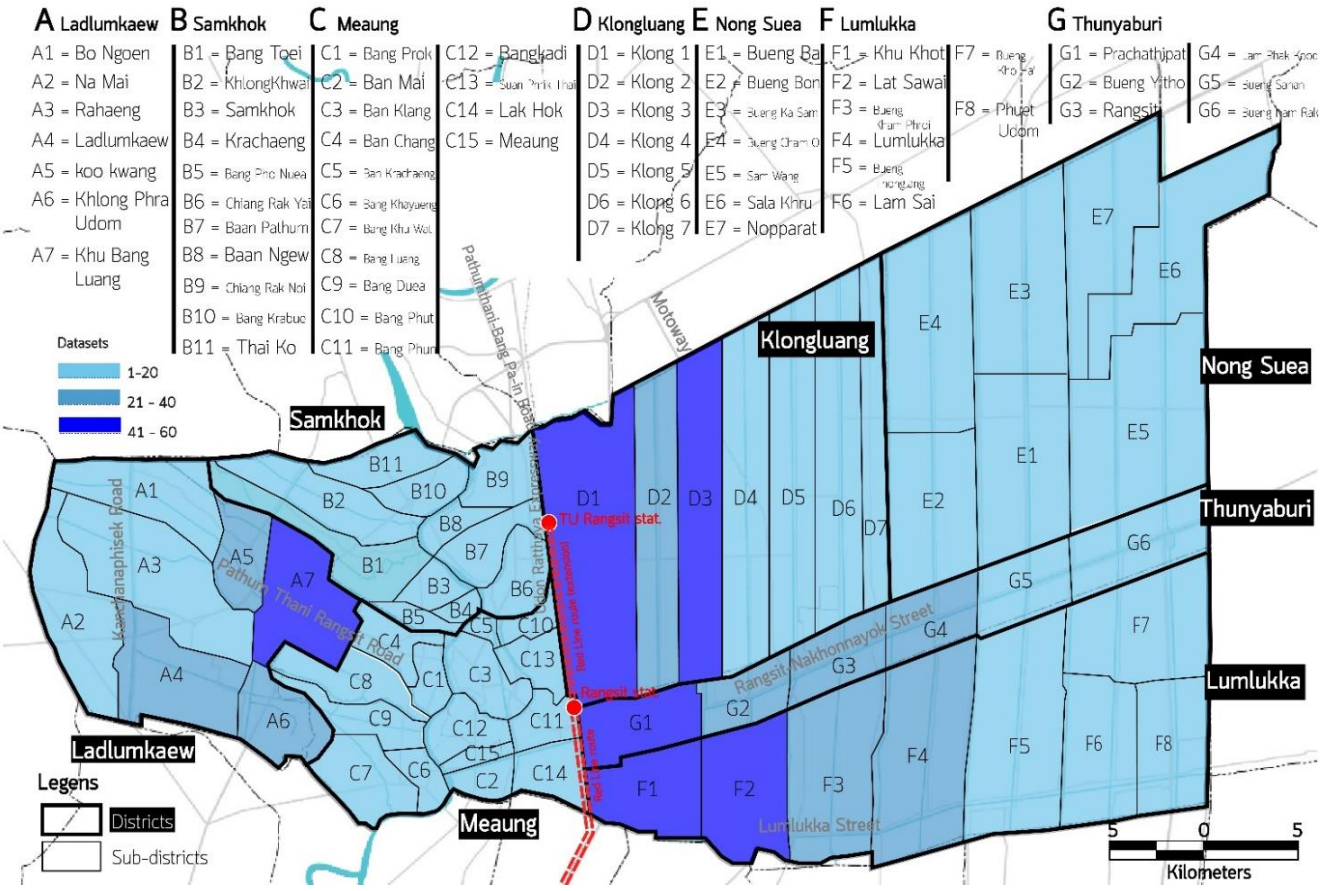

Fig. 2. Data collection in the study area.

Table 1. Local resident's opinion on smart city development (SCD)

	Variables	X_n	Level				
			1.00	2.00	3.00	4.00	5.00
Issues related to smart city development (X_1)	Digital Economy Promotion Agency should be the main unit of driving smart cities	X_{11}			3.34		
	Urban development should have the cooperation among the public and private sectors and education sector	X_{12}			3.41		
	Government sectors are essential to driving smart cities	X_{13}			3.62		
	Private sectors are essential to driving smart cities	X_{14}			3.65		
	Smart city areas will create start-ups and technology subsidiary	X_{15}			3.71		
	The local sector must be the core of the implementation of urban development projects	X_{16}			3.75		
	Urban innovation development must be achieved through the cooperation of the public and private sectors	X_{17}			3.71		
Measures related to smart city development (X_2)	People should benefit from providing smart utilities in the city	X_{21}			3.73		
	Personal income tax deduction for executives, experts, researchers, and entrepreneurs for smart city development startups	X_{22}			3.63		
	Investors can provide intelligent services for all 7 pillars will be exempted from corporate income tax for a period of 8 years (with a limit)	X_{23}			3.28		
	Benefits for attracting target of industry groups to develop in Pathumthani Province	X_{24}			3.14		
Investment in infrastructure for smart city development (X_3)	The smart city area should have a space for testing / extending technology	X_{31}			3.55		
	Smart city development must be driven by cutting edge of urban innovation.	X_{32}			3.58		
	Investment in high-speed internet (5G) network system	X_{33}			3.65		
	The development of a smart city should give people access to all areas	X_{34}			3.56		
	Data collection from devices or sensors installed on roads or in office buildings and housing	X_{35}			3.55		
	The use of technology should be friendly to the environment and people	X_{36}			3.52		
	Big data analysis center to forecast urban future events such as weather, dust or disasters	X_{37}			3.53		
Benefits of smart city development (X_4)	Smart city development should help boost the city's economic development	X_{41}			3.65		
	Smart city development should help reduce social inequality	X_{42}			3.66		
	The urban environment should be improved by smart cities development	X_{43}			3.66		
	People will have a better quality of life through the development of smart cities	X_{44}			3.54		
	The city's innovation will make provide more comfortable for everyday life	X_{45}			3.53		
	Smart city development is essential for future urban development	X_{46}			3.55		

Overall Average Score= 3.56

3. RESEARCH METHODOLOGY AND ANALYSIS

This study conducted a pilot survey and collected data from local community to derive their needs by face-to-face questionnaires for 1,000 sets from the residents in each sub-district of Pathum Thani Province (Fig. 2). The main objective of this study is to make local people in the study area understand the essential Smart City Development (SCD) and consider the readiness of each locality for utilize in planning policies that are suitable for the local area in the future. To quantify the opinions from the residents in quantitative term, the assessment of residents' perception was performed by divided into six levels, ranging from 1-6, by the lowest to highest (1-6). The details of analysis can be explained in later part of this section. The collection of data was input into the statistical step forward to analyze by an applicable model for reflecting the needs of the local people and recommending a smart city prototype of Pathum Thani Province. The assessment of public opinion was gathered through the questionnaires by face-to-face interview, the detail of questions can be divided into four parts as follows:

Part 1: Understand local SCD in Thailand contexts together with the fundamental development, opinions, and perceptions about smart city.

Part 2: Identify critical issues in urban development, define the factors in driving SCD and prioritize the urban solutions.

Part 3: Demonstrate opinion on the mechanism of local SCD, reflect the needs by considering local government measures and approaches.

Part 4: Evaluate the level of sharing activities in each community about the satisfaction level with the community's environment (e.g., mobility choices, infrastructures, and access to services).

After that, the data was analyzed based on a statistical model by using descriptive data analysis for explaining the driving factors of SCD in Pathum Thani Province. This study demonstrated local opinions by considering the acceptance level of the SCD under the vision of the local government sector. It is a vital part of driving relevant policies, measures, laws and regulations for the implementation of SCD in the study area. The analysis detail can be explained in Table 1 and Table 2.

3.1. The public opinion on SCD

From inquiries about the opinions level on SCD, the respondents were asked to review the transition in policy and development of smart city in Thailand by focusing on the questions in 4 dimensions. The detail of question comprised of: role of different sectors, measurement related to smart city development, infrastructure investment for development, and benefits of smart city development. The reflection of public opinion was done and adopted five levels of rating which are:

- *Level 5:* highest level of agreement and support all cases of development
- *Level 4*: a relatively high agreement level
- *Level 3*: a moderately agreement level
- *Level 2*: few comments
- *Level 1:* not agreed at all

Based on statistical analysis, it was found that the general opinions of people in Pathum Thani Province had a tendency of supportive idea on SCD by presenting the high rating scope of 3.56 which was in the range of moderate to relatively high opinion. It is a great sign of the beginning step of readiness on SCD. However, it is necessary to set up a basic system for the understanding context of urban development which the details are as follows:

(1) *Issues related to SCD* (X_1): The overall public's opinion presents its rating score about 3.60. In this regard, the local sector must be the core of implementing urban development projects with the highest level of opinion (X_{16}=3.75). Then, it is followed by the opinion about smart city areas to create start-ups, urban innovation and development which must be initiated from the cooperation among the public and private sectors (X_{15}, X_{17}=3.71).

(2) *Measures related to SCD* (X_2): The public has a strong opinion (3.44) which citizens should benefit from smart utility and services in city. The tax exemption from service revenue can be an alternative option which was proposed from residents' opinions. The application based on the development of smart platforms presents the highest opinion (X_{21}=3.73), followed by a reduction of personal income tax for executives, experts, researchers and entrepreneurs in starting the smart city development (X_{22}=3.63). Investors can carry out their businesses under umbrella of public-private collaboration covering a management model aimed at minimizing the debate about the conflict of interests which related to all 7 pillars of smart systems by receiving corporate income tax exemption for a period of 8 years (with a limit) (X_{23}=3.28).

(3) *Investment in infrastructure for SCD* (X_3): The overall picture from public opinion is at the moderate level of 3.57. Most people agreed with the investment in high-speed internet (5G) network (X_{33}=3.65), followed by smart city development that must be driven by innovation (X_{32}=3.58). A smart city area should be ready for upgrading a level of technology expansion in the study area (X_{34}=3.56).

Table 2 Results of Pathum Thani smart city development (SCD) needs

No.	Measure for granting rights in urban planning	Pathumthani smart city development needs level					Planning phase (%)		
		Level 1 (1.00)	Level 2 (2.00)	Level 3 (3.00)	Level 4 (4.00)	Level 5 (5.00)	Short-term (1-3 y.)	Medium-term (3-5 y.)	Long-term (5-10 y.)
1	Measures for changing the land use plan, $\overline{X}_1$			2.52			53.02	46.84	0.14
2	Measures for requesting a special economic zone, $\overline{X}_2$			2.34			55.60	44.25	0.14
3	Measures for requesting a promotion zone for special activities, $\overline{X}_3$			2.27			60.39	32.78	6.83
4	Permission for new urban areas as a dedicated test-bedding ground for new technologies and protect those involved, $\overline{X}_4$			2.14			48.63	34.46	16.91
5	Requesting to be a water sales service provider fire sale, waste management in the new city, $\overline{X}_5$			1.94			37.26	47.31	15.42
6	Encouraging the public sector, together with the private sector, to establish a city development agency that is responsible for controlling the city, $\overline{X}_6$			2.03			51.85	37.50	10.65
7	Benefit by exempting smart utilities in cities, $\overline{X}_7$			2.11			46.26	41.16	12.59
8	Personal income tax reduction for people who promote the use of smart city developed platforms, $\overline{X}_8$			2.12			40.17	47.12	12.71
9	Provides tax reduction benefits for attracting target industries in the city of Pathum Thani, $\overline{X}_9$			1.89			34.21	45.86	19.92
10	Reduced some requirements of the regulartery by allowing the use of internationally safe construction standards, $\overline{X}_{10}$			1.90			30.93	46.69	22.37
11	A city that is defined as a smart city must have a data center analytic, $\overline{X}_{11}$			1.87			30.28	41.12	28.60
12	Providing connectivity of the secondary system to connect people to the main city areas (light rail or special express buses), $\overline{X}_{12}$			2.01			19.00	32.71	48.29
13	Increase the budget for education and research as a base development and extension of urban development innovation, $\overline{X}_{13}$			2.23			11.89	43.27	44.84
14	Increasing the incentive land use measurement (FAR Bonus), $\overline{X}_{14}$			1.79			61.85	37.57	0.58
15	Provide a transfer of development right (TDR) measure, $\overline{X}_{15}$			1.43			48.95	50.75	0.30

Overall Average Score= 3.56

(4) *Benefits of SCD* (X_4): overall public opinion is about moderate to high level of 3.60. The smart city development should help in reduction of social inequality. Additionally, the urban environment should be improved through advanced technological capacity with smart city development approach due to the most opinionated issue (X_{42}, X_{43}=3.66). Followed by economic growth driven through smart city development, it should help stimulate urban economic development by attracting innovative employment and businesses brought by technology applications (X_{41}=3.65). Finally, intelligent technology is necessary for contributing to future urban development more attractive and social inclusion (X_{46}=3.55).

3.2. The public opinion on Pathum Thani smart city development needs

Regarding the urban planning rights measure, the overall preference level of Pathum Thani local people represents the low level of 2.01. The measures for requesting to modify the land use plan represents the highest level ($\bar{X}_1$ =2.52), however, both values present the lower score compared to the previous mentioned aspects. This might be due to the land use classification which has demonstrated rapidly changes in residential areas, especially, housing estates. Developing areas for the economic agglomeration should be improved to promote the liveliness of the area and the local economy for sustainable growth, followed by a measure to request a special economic zone ($\bar{X}_2$=2.34).

It is directly related to SCD. When Pathum Thani Province is ready to comprehensive data collection and transform through powerful analysis tools for urban planning and management as a smart city prototype, the next step is to be certified by the Digital Economic Promotion Agency. Requesting a special economic zone should be proposed for the next step in smart urban development. Providing opportunities for Thai and foreign investors would definitely help promoting the co-creation of the economic growth in corresponding to the vision of city development. Also, other measures including the measure for requesting a special promotion zone ($\bar{X}_3$=2.27) as well as measures to increase the budget for research & development represents a basis for urban planning and extension of urban development innovation ($\bar{X}_{13}$=2.23). The lower priority of needs is the permission of new urban areas for targeting a specific testing area as an establishment of new technology and to protect relevant persons ($\bar{X}_4$=2.14). The detail of the analysis is provided in Table 2.

4. CONCLUSIONS

A key issue for SCD, the local sector needs to be ready to drive for digital city transformation. Especially at the community level, people must understand the direction of urban development and be ready to accept the accessibility of technology. Based on the reflections among residents in Pathum Thani Province based on face-to-face questionnaire survey, the study found a moderate level of opinion on the SCD ($\bar{X}$ =3.56) from a collection data of 1,000 sets. However, to drive for SCD, the local authorities must be the main role for implementation which demonstrates the highest average of 3.75. Due to the potential of communication strategy to promote local people in innovative approach which must be performed based on bottom-up attempt. People pay close attention to urban planning and land use development together with a special economic zone and measures by increasing the budget for research & development. Social engagement represents a basis for urban planning and integration of urban development innovation that emphasizes on the cooperation among local stakeholders. Other areas of focus include creating start-ups and urban innovation development which must be achieved through cooperation between the local government and private sectors.

Measures related to smart city development should be addressed, especially targeted residents/local users who benefit from providing smart utilities in the city with an average score of 3.73. The results revealed that people who consider the benefits of SCD expected an emphasizing on technological aspect in response to the needs and interests of cities and citizens [26]. Consequently, based on people-centric of economic development, the social and spatial exclusion can be monitored and considered in term of the social dimension and leads to sustainable city from the social oriented point of view. Finally, the results of needs assessment of Pathum Thani SCD presents the overall level of opinion at the average value ($\bar{X}$=2.12) which requires innovative measurements to transform the land use plan with appropriate requesting a special economic zone. The result also represents the same line with the current plan to stay in the short-term planning of more than 53.02 percent among all respondents' opinion which means the urgency of SCD execution in the study area.

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