How can smart city shape a happier life? The mechanism for developing a Happiness Driven Smart City

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A B S T R A C T

Smart City conception has become a global trend with the advancement of Information and Communications Technologies (ICTs). Many cities have proposed Smart City development strategies to capture the opportunities brought by ICTs. However, little attention has been given to investigate whether and how Smart City acts upon human happiness. To fill this gap, this study introduces a Happiness Driven Smart City (HDSC) mechanism to better guide the development of Smart City towards a more human-centered direction. HDSC mechanism includes a three-layer interrelated structure and is underpinned by a set of Strategic Measures. The assessment criteria have also been established for applying HDSC mechanism to investigate the performance of Smart City initiatives. The HDSC mechanism established in this study is a first attempt to assess the performance of Smart City development from the lens of human happiness. By applying HDSC mechanism in investigating Manchester's Smart City initiatives, the mechanism is proven effective to help decision makers understand the status quo of Smart City development in their urban context, based upon which the strength and weakness in the process of HDSC development can be drawn out. Consequently, Smart City blueprint can be better achieved towards a happiness-driven direction via dynamic assessment and adjustment.

1. Introduction

Smart City is expected to provide better solutions for the intensified socioeconomic and environmental challenges associated with the unprecedented urbanization by embracing advanced Information and Communication Technologies (ICTs), where challenge like climate change, energy crisis, or social inequality could all find its way out through the development and application of state-of-the-art technologies (Manville et al., 2014; Michalec et al., 2019; United Nations, D.o.E. a.S.A., 2019; Yigitcanlar et al., 2019). The idealized narrative of Smart City has been widely accepted and turned to global movement at an appreciable speed for economic expansion and societal transformation (Cheng et al., 2020; Deloitte, 2018; Vu et al., 2020). It was reported that more than 1000 cities globally have introduced the Smart City initiatives with Europe, North America, Japan and Korea at the leading position (Deloitte, 2018). By applying Smart City initiatives, some global cities keep their central position in the landscape of innovation and knowledge generation (Yigitcanlar et al., 2016), and others have revitalized their urban economy to foster, attract and retain innovation abilities

(Holland, 2015). However, it appears that Smart City's influence upon human happiness has been paid with only marginal attention amid the practices of Smart City development.

It is often assumed that Smart City may carry both opportunities and risks to human happiness due to its technology-oriented essence, but little information is available to demonstrate which specific aspects of human happiness might benefit or get hurt from the introduction of Smart City initiatives. In fact, until we understand how human happiness is affected by Smart City initiatives, the holistic benefits of Smart City development upon urban inhabitants will remain under questioning, no matter how much prosperity the advocators promise. The cost of rectifying the progress of Smart City development would be huge if any strategy or policy leads to unexpected or unwanted directions which might jeopardize human happiness. Therefore, the big question with regard to the influence upon human happiness brought by Smart City development is *whether and how* Smart City acts upon human happiness.

Both Smart City and happiness have been extensively analyzed in literature across multidisciplinary fields (Albino et al., 2015; Alexandrova, 2005; Bibri & Krogstie, 2017a; Diener et al., 2003; Echebarria

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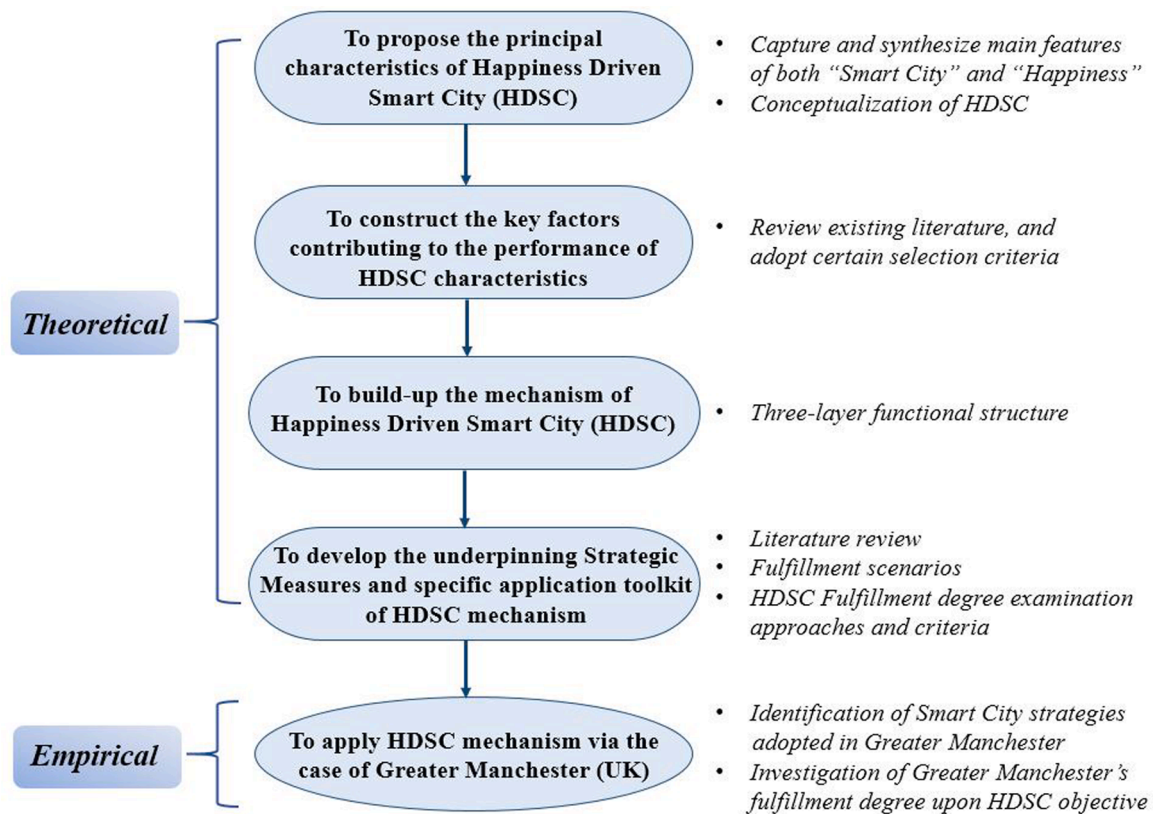
Fig. 1. Research roadmap and methodology. (Source: Authors)

et al., 2021; Glatzer, 2000; International Telecommunication Union (ITU), 2014; Kullenberg & Nelhans, 2015; Ministry of Land & transport of Korea, 2020; Seligman, 2012; Suikkanen, 2011; United Nations, 2016). Nevertheless, to the best of our knowledge, there is handful research into the nexus of Smart City and Human Happiness. Several studies have attempted to conduct empirical analysis for deciphering the impact of technologies embedded in cities upon some urban inhabitant experiences with close relationship of happiness, such as quality of life, urban well-being or life satisfaction, etc. Under this context, "happiness" is adopted as an umbrella term in this study to gain a wider understanding upon the sketch of the linkage between Smart City and Human Happiness in the existing literature.

For example, by case study approach, Macke et al. (2018) revealed four key factors for defining a successful Smart City in terms of improving citizen's quality of life. In their study, the resident's perception of quality of life in Curitiba, a highly awarded Smart City in Brazil, were investigated and analyzed by following the "Eurobarometer survey" methodology. Zakzak (2019) displayed a probing case study upon Dubai's "Happiness Agenda" in its Smart City Transformation through semi-structured interview and policy analysis, where challenges and enablers were highlighted in favor of policy-makers for developing a human-centric Smart City. Nevado-Pena et al. (2019) investigated the relationship between ICTs and quality of life at city-region level in Europe based on Eurostat data, and found that the digital citizen tend to be happier in those cities with advanced technological capacity. In addition, the Organization for Economic Co-operation and Development (OECD) has highlighted 39 types of impacts upon 12 aspects of people's lives brought by digital transformation, suggesting that opportunities and risks co-exist (OECD, 2019).

However, it appears that a systematic approach is still not available for investigating the influences that Smart City development may act upon human happiness. Existing empirical studies are predominantly based on limited samples, thus the conclusions drawn from these studies are considered neither effective nor sufficient for policy-makers to develop Smart City initiatives towards the direction of enhancing happiness.

In acknowledging the theoretical urge for a new analysis tool, the *overarching research aim of this article is to establish a conceptual mechanism of Happiness Driven Smart City (HDSC)*, which will be constructed as a three-layer interrelated functioning structure underpinned by a set of Strategic Measures. The proposed theoretical mechanism can be applied with specific assessment criteria to examine to what extent the Smart City initiative implemented in a given city has enhanced urban residents happiness and has achieved the goal of Happiness Driven Smart City. The application of HDSC mechanism can thus help urban governors to understand the status quo of the Smart City development and to better guide the design of Smart City towards a happiness-driven and human-centered direction.

The rest of the paper is organized as follows: Section 2 presents the research roadmap of this study. Section 3 presents insights into the characteristics of a Happiness Driven Smart City (HDSC). Section 4 identifies the key factors contributing to characteristics performance in a HDSC system. Section 5 establishes the rationale for developing a HDSC mechanism. Section 6 develops the specific Strategic Measures that underpins the HDSC mechanism, and also the detailed application toolkit for employing HDSC mechanism to investigate Smart City initiatives in practice. Section 7 demonstrates how the HDSC mechanism can be applied effectively via a typical Smart City case of Greater Manchester (UK). Section 8 highlights the key points of HDSC mechanism application and then moves to concluding remarks.

2. Methodology

To achieve the overarching research aim, the research roadmap of this study is designed (see Fig. 1). Five research procedures across theoretical and empirical studies will be conducted. Theoretically, this

research aims to establish an effective mechanism of Happiness Driven Smarty City that can be practically applied to investigate the performance of Smart City initiative. Four procedures will be conducted, namely, to propose the conceptualization and principal characteristics of Happiness Driven Smart City (HDSC), to construct the key factors contributing to the performance of HDSC characteristics, to build-up the HDSC mechanism, and to develop the underpinning Strategic Measures and specific application toolkit of HDSC mechanism.

Built upon the establishment of HDSC mechanism and its application toolkit, the city of Greater Manchester (UK) will be adopted as an empirical case to demonstrate the applicability and effectiveness of HDSC mechanism. In conducting the empirical case study, the Smart City strategies implemented in Greater Manchester will be identified first and then an assessment will be conducted to examine to what extent has Greater Manchester fulfilled the objectives of Happiness Driven Smart City mechanism.

Following the completion of research procedures in above research steps, a discussion upon the effectiveness and applicability of HDSC mechanism will be provided, followed by the recommendations for future research agenda to enrich the landscape of Smart City studies.

3. Characteristics of a Happiness Driven Smart City

3.1. Main features of smart city

A shared view of the concept of Smart City is not yet available although the term Smart City has gained worldwide attention and popularity among various research institutes, government bodies and business sectors in the last decade (Albino et al., 2015; Batty et al., 2012; Echebarria et al., 2021; Ibrahim et al., 2018). Depending on the lens or viewpoints taken, the concept of Smart City is described and constituted with varying focus and content (Ibrahim et al., 2018; Sheikhnejad & Yigitcanlar, 2020). Nevertheless, a comprehensive picture of what a Smart City can be drawn from exploring the Smart City definitions and indicator systems in existing literature, as summarized in Appendix 1 and Appendix 2, respectively.

Across the existing Smart City studies, the concept of Smart City always revolves around the core idea of ICT-centered city operation systems, which is clustered into two aspects: the physical-technological aspect and the human-social aspect (Batty et al., 2012; Bibri & Krogstie, 2017b). This "dichotomy landscape" is echoed with the theme appeared in existing Smart City studies, i.e., the combination of human capital, social capital and Information and Communication Technology (ICT) infrastructures to generate sustainable economic development and improve urban well-being and quality of life (Capdevila & Zarlenga Matías, 2015; Coleman, 1994). The first aspect of Smarty City studies focuses upon investigating how those advanced and innovative technologies are applied to serve city functions to reach the "smart" goals in terms of optimization, integration and efficiency-enhancement (Camero & Alba, 2019; Lu et al., 2019; Ullah et al., 2020). On the other hand, the human-social aspect emphasizes how Smart City can help people have a happier life such as better quality of living standard, better equality, more participation and more diverse culture etc. (Beretta, 2018; Bouzguenda et al., 2019).

Furthermore, smart City is a "work-in-progress" subject although many cities have been awarded or self-claimed as Smart Cities and existing studies have introduced various Smart City indicator systems from various perspectives (Huovila et al., 2019; Ibrahim et al., 2018; Sharifi, 2020; Yigitcanlar et al., 2018) (see Appendix 1). A number of cities have applied these indicators in order to become "smarter" and to benchmark the performance to establish its competitive position among fellow cities (Anthopoulos, 2019; Sharifi, 2020). Apart from its benchmarking function, the overarching goal of Smart City indicator systems is to facilitate the development of Smart City, that is, to improve or transform economic investment, energy efficiency, Quality of Life, public safety, etc., with embedded technologies in an interconnected and interacted way.

To sum up, in this study, Smart City is considered as a comprehensive transformation in almost every aspect of a city with ICTs as its fundamental enabler, which is far beyond a set of technical solutions to addressing specific challenges. From this holistic viewpoint of Smart City conception, by digesting the smart city indicators proposed in existing literature, the main features of Smart City blueprint can be portrayed across the aspects of infrastructures, economy, society, environment and governance:

- A city with accessible and secured ICT infrastructures;
- A city with reliable and efficient physical infrastructures;
- A city with productive and innovative economy;
- A city with equal and inclusive society;
- A city with sustainable and resilient environment;
- A city with participatory and transparent governance.

3.2. Main features of happiness

The term "happiness" has a great variety of meanings (Veenhoven, 2013). The research works on defining happiness can be classified into three categories, namely, subjective view-based, objective view-based and hybrid view-based research. From subjective view, happiness is interpreted as individual judgements on the overall quality of his/her life, which emphasizes personal feeling or appreciation (Veenhoven, 2013). The objective view refers happiness more about well-being, consisting of social, material and natural environments surrounding each individual, such as living environment, income level, health and education infrastructures, etc. (Kahneman, 1999). Furthermore, the hybrid view based happiness research embodies both external conditions and individual satisfaction (Chekola, 1974).

Since the subject-bound happiness is obtained from inside only and very much genetically fixed (Lykken & Tellegen, 1996), which is to large extent beyond the reach of policy manipulation (Davis, 1981; Diener et al., 2000). It is considered that the effective way to rationally affect happiness through policy manipulation such as the introduction of Smart City strategies would be from objective aspects. Therefore, this study will interpret the conception of happiness from the objective perspective.

With the objective view, the features of Happiness primarily focus on capturing the state of human well-being and quality of life with rational common pursuit of desirable life (Ballas, 2013). However, it is worth noticing that the connotation of Happiness in this study goes beyond the concept of traditional Quality of Life or well-being, as the innovative changes brought by the digital era shall be put into consideration. Keeping this in mind, some open happiness indicator systems with continuous data collection and regular report are identified and synthesized (see Appendix 3). In parallel, the major dimensions of happiness indicators included in existing literature are also scrutinized, as presented in Appendix 4. By examining Appendices 3 and 4, the main features of Happiness can be portrayed from two perspectives, namely livability of the environment and life-ability of the person, specifically including the following elements:

(1) Livability of the environment:
  - Ecology (air quality, public green space, etc.);
  - Society (equity, safety, supportive relationships, etc.);
  - Economy (financial status, housing, employment, etc.);
  - Culture (culture and leisure, etc.).
(2) Life-ability of the person:
  - Health (physical health, mental health, etc.);
  - Education (schooling, skills, etc.);
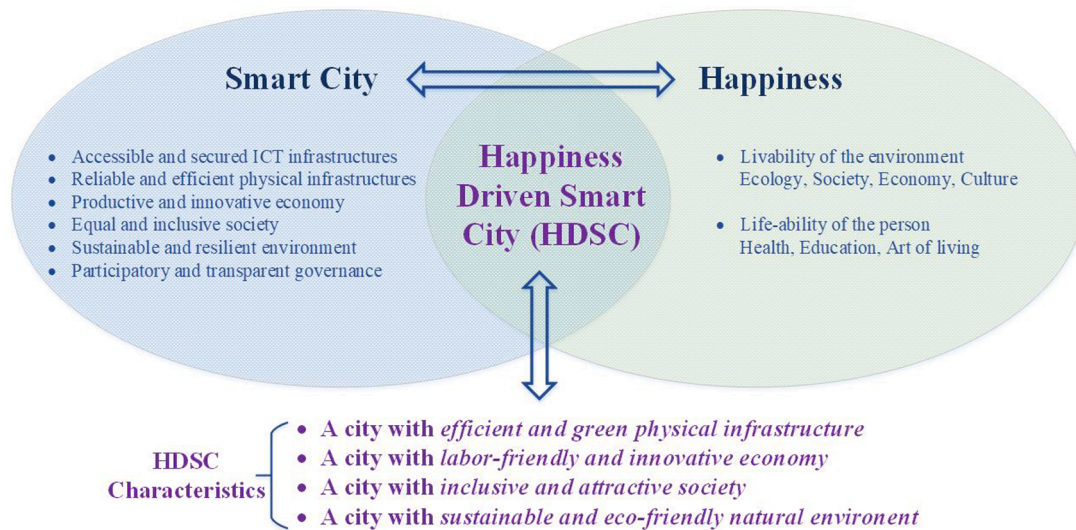 - Art of living (varied lifestyle, etc.).

Fig. 2. Happiness Driven Smarty City: Conceptualization and characteristics. (Source: Authors)

Table 1
Key factors contributing to HDSC characteristic performance.

HDSC Characteristics	Factor 1	Factor 2	Factor 3	Factor4
• Efficient and green physical infrastructure	Mobility	Energy	Public Utilities	
• Labor-friendly and innovative economy	Employment	Innovative Spirit	Entrepreneurship	
• Inclusive and attractive society	Education	Health	Safety	Culture and Leisure
• Sustainable and eco-friendly natural environment	Air quality	Pollution and Waste Treatment		

3.3. Happiness Driven Smart City: Conceptualization and characteristics

It can be seen from above Sections 3.1 and 3.2, the main features between Smart City and Happiness have not yet established a corresponding relationship. In other words, a traditionally defined Smart City will not necessarily achieve the desirable happiness goals, thereby the conventional definition of Smart City would be different from the connotation of Happiness Driven Smart City.

From the perspective of Happiness and in line with its main features, a Smart City must be able to provide "livability of environment" and "life-ability of person". "Livability of environment" refers to natural environment, built environment and social environment surrounding each individual urban inhabitant to provide a good living condition. "Life-ability of person" refers to the opportunities that a person is equipped to improve his/her capability in managing his/her life (Veenhoven, 2000). That is to say, "life-ability of person" means providing enough resources and accesses for urban inhabitant's self-development in terms of acquiring new knowledge and skills for living and enjoying life.

Hence, a Happiness Driven Smart City (HDSC) can be interpreted as a city guided by the overarching goal of improving human happiness in the prevailing digital transformation brought by technology. In a Happiness Driven Smart City, various urban subsystems can take advantages of ICTs to provide innovative and intellectual services to benefit its citizens primarily from "livability of environment" and "life-

ability of person". Grounded on the conceptualization of HDSC, taking the viewpoint that urban system is a complex of social, ecological, economic, and built infrastructure systems (McPhearson et al., 2016; Ren et al., 2018, 2021), a Happiness Driven Smart City (HDSC) is supposed to have the following characteristics as delineated in Fig. 2, namely, "A city with *efficient and green physical infrastructure*", "A city with *labor-friendly and innovative economy*", "A city with *inclusive and attractive society*", and "A city with *sustainable and eco-friendly natural environment*".

It can be seen from Fig. 2 that the characteristics of a Happiness Driven Smart City (HDSC) are different from the main features of Smart City under conventional narrative, which shows a distinctive shift towards a human happiness-oriented focus. ICT infrastructures and governance are not highlighted as HDSC characteristics, whilst these two aspects are melted into other characteristic categories. Specifically, ICT infrastructure is employed as a tool for improving other city functions and services to an aspired level, and its contribution to people's happiness is woven into the results of other "smart" aspects like physical infrastructures, economy, society and environment. Similarly, the governance regime in the context of Smart City acts indirectly upon Happiness and its influence can be reflected through sector-based initiatives. The in-depth connotation of these four HDSC Characteristics can be better understood via their underpinning Factors presented in Section 4.

The above four category characteristics of a Happiness Driven Smart City present alternative and novel interpretation of the connotation of Smart City with humanistic-oriented principle.

4. Key factors contributing to characteristic performance in a Happiness Driven Smart City system

Prior to feeding characteristics into mechanism, it is necessary to identify the key factors contributing to the characteristics performance in a Happiness Driven Smart City (HDSC) system to bridge the transforming process from characteristics to mechanism. The attempt to compile the key factors is based on the analysis regarding dimensions adopted in different sets of indicator systems and the concepts of Smart City and Happiness (listed in Appendices 1–4). Furthermore, key factors contributing to HDSC characteristic performance should be selected in the way to ensure the factors responsible for stimulating urban functions and playing an important role in facilitating urban socioeconomic activities across the aspects of physical infrastructures, economy, society and environment.

In referring to the aforementioned theoretical basis and selection principle, the key factors contributing to each characteristic of Happiness Driven Smart City (HDSC) are established as shown in Table 1.

The key factors contributing to the four HDSC Characteristic listed in Table 1 are further interpreted in details as follows:

(1) Factors contributing to efficient and green physical infrastructure

- *Mobility:* Mobility refers to any type of movement that secures the convenient, comfortable, safe and reliable service for people getting to desired destination—job, school, hospital, park, etc., and meanwhile reducing negative environmental impacts such as greenhouse gas emission (El-Sherif, 2021; Kayal et al., 2014). A number of smart mobility solutions have been introduced and widely used in cities nowadays such as navigation system, demand-responsive transport service, car sharing, bike sharing, etc. Development of efficient and sustainable mobility can have positive impact upon people's happiness, among which the reduction of congestion, traffic accidents and air pollution is apparent.

- *Energy:* Reliable, efficient and low carbon energy system with automated real-time management realized by embedded Internet of Things (IoT, composed of sensors, communication technologies and algorithms) is one of the key requirements for Smart City (Batty et al., 2012; O'Dwyer et al., 2019). Energy production and consumption are widely related to social, environmental and economic issues in both household use and commercial and industrial activities. The role of energy production and consumption system in enhancing human well-being is unquestionable (Programme, 2000).

- *Public utilities:* ICT-enabled smart utilities, such as water, sanitation, waste disposal, etc., can improve happiness by providing cleaner built environment and safer services and products to benefit resident's everyday life and health condition (Ren et al., 2021). For example, smart water management is capable to guarantee the security and safety of water quality in satisfying resident's water need even in extreme conditions (Lee et al., 2015). Furthermore, integrated smart sanitation system which combines sewage transport system, waste water treatment plant and weather forecast is helpful with a clean, green and hygienic living environment via real-time control model (Tabuchi et al., 2020).

(2) Factors contributing to labor-friendly innovative economy

- *Employment*: The work opportunities available (e.g. new job generated and old job disappeared; the transformation of job content) and labor right protection under new employment form are the main concerns regarding the employment brought by technology application in business and labor market (Chen et al., 2020; Healy et al., 2017). Employment is a distinct and powerful aspect of happiness in terms of sociological and economic aspects of human life (Liu et al., 2020).

- *Innovative spirit*: Rather than addressing solely of technology dimension, innovative spirit in Smart City takes the responsibility to reach socially and economically desirable deliverables (Chen et al., 2022). Specifically, innovative spirit is a built-in merit in Smart City where social change and economic growth happens by attracting talents and businesses to the city with the joint effort of innovations from three levels of individual, organization and government level. As such, innovative spirit is highlighted as a special favor for people's happiness through mutual satisfaction between aspiration and achievement at individual level and improved socioeconomic environment at organization and government level.

- *Entrepreneurship*: Entrepreneurship is a novel and important driver for regional innovation and economic growth by turning knowledge into new products, new jobs, and new firms (Huggins & Thompson, 2015; Kuada, 2015). In a concise narrative, entrepreneurship is the mechanism in which knowledge is commercialized and exploited to stimulate economic growth and to achieve entrepreneurs' personal value (Richter et al., 2015). Entrepreneurship is therefore considered the core asset for a Happiness Driven Smart City.

(3) Factors contributing to inclusive and attractive society

- *Education*: The popularity of technology makes education available anywhere and anytime, which transforms the inclusive and equitable education and lifelong learning into an easier achievable goal (Burbules et al., 2020). Education itself is a pathway for a happier life due to its close connection with other life indexes such as employment and financial status etc. (Powdthavee et al., 2015).

- *Health*: Health is used to describe more predictive, personalized, preventive and participatory health care to residents through the application of technologies under strict privacy protection. Convincing evidence has presented that smart healthcare system can make innovative contributions to resident's health which is the most basic life indicator of human being (Wu et al., 2020).

- *Safety*: Safety refers to the availability of a safe environment for citizens where crime and security threats can be well handled with new effective intervention and quick response under the support of technology integration corresponding to traditional public security functions (Hartama et al., 2017). Safety is not isolated to crime and security problem itself, and is the central to maintain a city an attractive place to live in (Cagliero et al., 2015).

- *Culture and leisure*: The term "culture" refers to the cultural content that can be digitalized for easy access, sharing, recreation and interaction through various applications in the digital ecosystem (Fanea-Ivanovici & Panǎ, 2020). "Leisure" refers to time spent engaged in digital practices and spaces while in a relaxed state of mind (such as social media platforms) (Silk et al., 2016). With greatly reduced time, cost and distance barriers and decentralized information channels, "culture and leisure" enables the improved and personalized experience in both virtual world and real world, and enhances the happiness through creating meanings in life, developing hobbies and favored skills, and promoting social interactions (Lee et al., 2020).

(4) Factors contributing to sustainable and eco-friendly natural environment

- *Air quality*: With embedded ICT system in Smart City, dynamically monitored air quality is proved to be a validated proxy for natural environment in a city. Real-time air quality plays an important role in people's living qualities and health as to the induced air pollution related diseases (Dutta et al., 2017; Mak & Lam, 2021).

- *Pollution* and *waste treatment*: Optimization of waste treatment has become an important element for being a Smart City. The application of ICT approaches such as the Internet of Things (IoT) at city level can facilitate waste treatment in many ways, for example, identification of the most efficient waste collection route, management and placement of garbage containers, etc. Consequently, the critical issues centered with pollution and waste treatment, such as carbon emissions, traffic, noise pollution and environment pollutions can be better addressed to improve city's sustainability and livability (Oralhan et al., 2017).

5. Mechanism for developing Happiness Driven Smart City

The synthesized characteristics of a Happiness Driven Smart City (HDSC) presented in Section 3 and the corresponding key factors identified in Section 4 are used to build up the mechanism for developing a Happiness Driven Smart City (HDSC). The mechanism is presented by the following descriptive model (1):

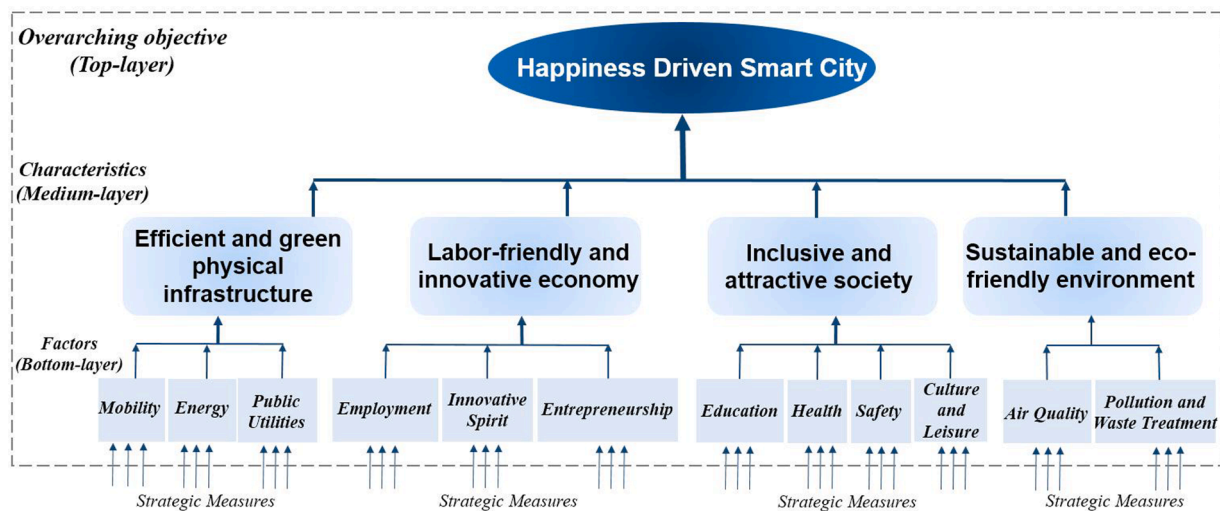$$F_{ij} \xrightarrow{sM_{ijk}} HDSC_i \qquad (1)$$

Fig. 3. Three-layer mechanism system for developing a Happiness Driven Smart City (HDSC). (Source: Authors)

Table 2
Strategic Measures for improving the performance of HDSC characteristic "Efficient and green physical infrastructure" (HDSC$_1$).

Factors influencing HDSC$_1$	Strategic Measures to act on factors for improving the performance of HDSC$_1$
F$_{11}$:Mobility	**SM$_{111}$**: To integrate the principles of green transport into the process of developing smart mobility thus the performance of green infrastructure will be improved. By developing a leveraged mobility paradigm between walking, cycling and driving, the greenhouse gas emission will be reduced (Longo et al., 2019). **SM$_{112}$**: To eliminate possible negative effects caused by the misuse and monopoly of smart mobility technologies which would hurt the users' benefits and affect negatively the development of HDSC in the long run (Moscholidou & Pangbourne, 2020). For example, regulations shall be formulated to ensure smart mobility service providers to take responsibilities on delivering a greener and more equal transport system.
F$_{12}$:Energy	**SM$_{121}$**: From industrial aspect, to take consideration of both the optimization of energy source and conservation on the consumption end (Ren et al., 2018). For example, integrating smart grid with renewable energy resources is a direct and effective solution for improving green grid management; adopting artificial intelligent and big data analysis into building, manufacture and transportation sectors to forecast and minimize energy consumption is proved-effective for minimizing energy consumption and consequently mitigating impacts upon environment and climate (Gonçalves et al., 2020; Mehmood et al., 2019). **SM$_{122}$**: From individual aspect, to create an advantageous environment with the facility of technology to encourage individual energy saving behaviors (Han & Cudjoe, 2020). The potential impact of occupants energy saving behavior on buildings are evidenced remarkable and identified as an essential approach to improve energy efficiency in green buildings and communities without jeopardizing the level of comfort (He et al., 2021).
F$_{13}$:Public Utilities	**SM$_{131}$**: To explore resource efficiency and utilization opportunities from both service providers and consumers in smart utility network development (Wang et al., 2020). For example, artificial intelligence application in leak detection of water distribution pipeline will increase water resource utilization efficiency. The water/gas consumption feedback technology can help to reduce household wasteful behavior to trigger the decrease of environmental impact in every step along the whole journey of resources processed by public utility facilities.

Where HDSC$_i$ refers to the Characteristic i of a Happiness Driven Smart City (HDSC). There are four HDSC Characteristics presented in Section 3, thus the value of i ranges from 1 to 4. F$_{ij}$ refers to the jth Factor contributing to the performance of HDSC Characteristic i. SM$_{ijk}$ denotes for the kth Strategic Measure to improve the performance of Characteristic i through addressing the jth Factor.

In line with the above descriptive model (1), the mechanism for developing a Happiness Driven Smart City (HDSC) can be portrayed graphically in Fig. 3. In the mechanism, HDSC mechanism is composed of three components, namely, Overarching objective (top-layer), Characteristics (medium-layer) and Factors (bottom-layer). The working mechanism of HDSC shows the structural relationships between these three components. The bottom-layer Factors are the sources of changing the performance of HDSC Characteristics, which in turn contribute to the Overarching objective of developing Happiness Driven Smart City. The functions of HDSC system are underpinned by a set of Strategic Measures which act directly upon the Factors in the HDSC system. By applying various Strategic Measures to change Factors, momentum can be gained to improve the performance of medium-layer Characteristics. Consequently, the Overarching objective of developing Happiness Driven Smart City (HDSC) can be achieved.

6. Strategic measures and assessment process for the application of HDSC mechanism

6.1. Strategic measures

As shown in Fig. 3, the key to make a Happiness Driven Smart City happen is the application of a set of Strategic Measures. These Strategic Measures are developed through examining the interrelationship between the three components in the HDSC system, and the examination and establishment of the Strategic Measures is conducted through comprehensive literature review. Consequently, a set of Strategic Measures have been developed, which are presented in referring to each of the four HDSC Characteristics, as shown in Tables 2, 3, 4 and 5, respectively. In these tables, a shortlist of Strategic Measures is developed in addressing different factors which exert driving influence upon the concerned HDSC Characteristic.

6.2. HDSC mechanism based assessment upon Smart City initiative

A "*process-outcome*" dual-perspective assessment process is constructed and applied to provide a consistent approach for applying HDSC mechanism to examine where the Smart City initiative in a specific city

Table 3

Strategic Measures for improving the performance of HDSC characteristic "Labor-friendly and innovative economy" ($HDSC_2$).

Factors influencing $HDSC_2$	Strategic Measures to act on factors for improving the performance of $HDSC_2$
F_{21}:Employment	SM_{211}: To prepare solutions and resources to minimize the potential disruptive impact on employment during the dramatic changing process and to create a labor-friendly employment market environment to help citizens quickly fit into the new economy. Policies to stimulate education evolution for promptly fulfilling high profile new business requirements and training programs to look after disadvantaged labors shall be taken into full implementation (Chinorácký & Čorejová, 2019; O'Connor, 2021). SM_{212}: To enact labor protection and social protection rules and regulations that are suitable and in favor of employees to keep the new digital economy development under a labor-friendly premise. It would be ideal if the policymakers are able to take a longer view and make foreseeable actions on the employment influence arising from the digital economy instead of keeping the legal and social regulation system in a passive adaption situation.
F_{22}:Innovative Spirit	SM_{221}: To make Smart City as a nexus for open innovation, which should not just refer to industry but also the ways government and other institutions work and collaborate with society, to jointly create an inclusive, labor-friendly and innovative economy (Paskaleva, 2011). All sources of innovation from different levels and different sectors shall be encouraged to actualize an innovative and diverse economy where technology play the catalyst role. SM_{222}: To inspire the potential of new bottom-up approaches based on user-generated content through the experiences of the citizens themselves, which enable citizens to build the social capital and capacity required to become co-creators and co-producers of new and innovative services with the means to ensure that they are delivered in more effective and inclusive ways, taking full advantage of new Internet-based technologies and applications (Cahn, 2000).
F_{23}:Entrepreneurship	SM_{231}: To encourage the utilization of new technologies and promote a strong pro-entrepreneurial state ethos where innovative economy is nurtured and accelerated (Hollands, 2008). SM_{232}: To encourage and facilitate entrepreneurial citizens to trigger, apply and transform emerging technologies and knowledge into new products, new jobs, and new firms, which in turn enables the creation of labor-friendly innovative economy (Edoho & Kuada, 2015; Huggins & Thompson, 2015). SM_{233}: To promote neo-liberal attempts to inclusively and effectively incorporate the local community into the entrepreneurial city, via the approaches of various participatory ICT projects (Hollands, 2008).

Table 4

Strategic Measures for improving the performance of HDSC characteristic "Inclusive and attractive society" ($HDSC_3$).

Factors influencing $HDSC_3$	Strategic Measures to act on factors for improving the performance of $HDSC_3$
F_{31}:Education	SM_{311}: To create easy environment for innovation during the digital transformation process of education paradigm through a participatory approach to enhance social inclusiveness and talent attractiveness in education sector. All stakeholders in this venturous journey, such as teachers, students, administrators, online platform company, software and hardware providers etc., shall be encouraged to be more active to innovate and design better solutions to meet the brand new need (Iivari et al., 2020). SM_{312}: To address the equity of education resources and opportunities to avoid extreme deprivations caused by the digital transformation to ensure a more inclusive development in cities (Molnar, 2021). For example, online education shall take in consideration of the balance between commercial online education programs and public-free courses so as to benefit the widest audience from the well-educated to the low-skilled learners (Lambert, 2020).
F_{32}:Health	SM_{321}: To improve accessibility to health facilities and services to the widest public for disease prevention and health promotion where technological innovation can be applied as a tool for empowering social inclusiveness. For example, more attention and fund shall be paid on mental health care services where big data and artificial intelligence technology can play an innovative role in prediction and diagnosis (Liang et al., 2019). SM_{322}: To encourage the application of new technologies aiming to produce new opportunities to improve the health treatment to a more accurate and effective level where patient can receive higher quality and safer medical service with reduced cost and wastage (Varshney, 2013). The improvement of affordability and effectiveness in medical service and health care driven by smart technology will positively affect the inclusiveness of the society.
F_{33}:Safety	SM_{331}: To create a safer social environment by taking actions to prevent the occurrence of crime before it happens via the application of new technology based crime risk prediction analysis approach (Wang et al., 2020). Safety clearly exerts higher impacts on urban attractiveness.
F_{34}:Culture and Leisure	SM_{341}: To create an environment that encourages wide public participation, culture diversity, digital equity in the context of digital technology to contribute to city's attractiveness and social inclusion. The development of cultural policy that aims for culture participation may also involves other policy areas such as economic and education sectors (Casemajor et al., 2020). SM_{342}: To provide pleasant environment and necessary support for both offline and online leisure activities to provide greater opportunities for urban residents enjoying a higher level of life satisfaction and social inclusion (Vacchiano & Valente, 2021).

sits in the radar of the HDSC mechanism.

"*Process*" perspective emphasizes that the initiatives or actions taken by a Smart City regarding a certain Strategic Measure should be supported or relied upon ICT-centered solutions that the conception of Smart City sits on. There will be two assessment situations from the *Process* perspective, namely, "Yes" situation and "No" situation: In "Yes" situation, the Smart City initiatives or actions under assessment are fully supported or relied upon ICT-centered solutions; and in "No" situation, the Smart City initiatives or actions under assessment are not supported by ICT-centered solutions.

"*Outcome*" perspective examines the extent that the concerned Smart City initiatives meet up with the expected achievements (capabilities) of corresponding Strategic Measures defined in HDSC mechanism. As the Strategic Measures under each HDSC Factor are the targeted status for HDSC development, thus the HDSC fulfillment of a specific city can be examined via these Strategic Measures (SM). For this, four situations are set from *Outcome* perspective to delineate the matching-degree between the local reality and designed criteria for each Strategic Measure:

(1) O=1: The expected achievements or capabilities of SM_{ijk} (as depicted in Section 5, SM_{ijk} denotes for the kth Strategic Measure to improve the performance of Characteristic i through addressing the jth Factor) is well-achieved in a comprehensive and manageable way through the Smart City initiatives;

(2) O=2: The expected achievements or capabilities of SM_{ijk} can mostly be achieved through the Smart City initiatives, or only a fraction of SM_{ijk} is left untouched;

(3) O=3: The expected achievements or capabilities of SM_{ijk} can partly be achieved through the Smart City initiatives, or a larger part of SM_{ijk} is not taken into consideration;

(4) O=4: The expected achievements or capabilities of SM_{ijk} is poorly demonstrated through the Smart City initiatives, or only a minor part of SM_{ijk} is covered.

In line with above discussion about the HDSC mechanism-based assessment process, six fulfillment scenarios describing to what extent the Smart City initiatives in a certain city have achieved the goal of

Table 5

Strategic Measures for improving the performance of HDSC characteristic "Sustainable and eco-friendly natural environment" (HDSC$_4$).

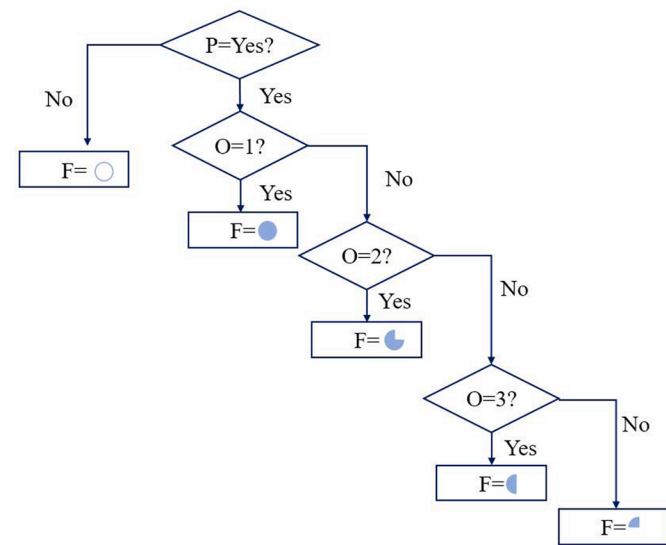| Factors influencing HDSC$_4$	Strategic Measures to act on factors for improving the performance of HDSC$_4$
F$_{41}$:Air Quality	**SM$_{411}$**: To monitor and forecast air quality more precisely in both vicinity (building and neighborhood) and city level through collecting and analyzing data with the ubiquitous upgraded devices and advanced algorithm, and to satisfy the evolved need for environment protection and human life by taking more targeted and effective solutions (Dutta et al., 2017; Mehta et al., 2016). **SM$_{412}$**: To enable citizens have tailored air quality notification to help prevent any exposure risks against vulnerable groups to reduce ecological threat on public health (*ibid*).
F$_{42}$:Pollution and Waste Treatment	**SM$_{421}$**: To control emissions and effluents through IoT-enabled smart system in various sectors including building, manufacturing industry and logistics etc. (Neirotti et al., 2014; Yan et al., 2020). **SM$_{422}$**: To modernize traditional waste management system to prevent the negative effects of incorrect operation on both people and the environment during the whole process including waste collection, disposal, recycling, and recovery (*ibid*). **SM$_{423}$**: To enable citizens to track daily personal pollution footprint via smart approaches to better understand and behave upon reducing waste emission and production towards a sustainable and eco-friendly environment.

Table 6

Six scenarios upon the fulfillment degree of HDSC strategic measures.

% of Fulfillment	Fulfillment Scenarios	Process (ICT-supported or not)	Outcome (Expected achievement or improvement satisfied)
○	Scenario 1	No	No
	Scenario 2	No	Yes
●	Scenario 3	Yes	The expected achievements or capabilities of SM$_{ijk}$ is **well-achieved** in a comprehensive and manageable way through the Smart City initiatives.
◔	Scenario 4	Yes	The expected achievements or capabilities of SM$_{ijk}$ can **mostly be achieved** through the Smart City initiatives, or only a fraction of SM$_{ijk}$ is left untouched.
◐	Scenario 5	Yes	The expected achievements or capabilities of SM$_{ijk}$ can **partly be achieved** through the Smart City initiatives, or a reasonable part of SM$_{ijk}$ is not taken into consideration.
◕	Scenario 6	Yes	The expected achievements or capabilities of SM$_{ijk}$ is **poorly demonstrated** through the Smart City initiatives, or only a minor part of SM$_{ijk}$ is covered.

Fig. 4. "Process-outcome" based assessment for examining HDSC fulfillment degree. (Source: Authors) Notes: "P" refers to "process-perspective based situation"; "O" refers to "outcome-perspective based situation"; "F" refers to "HDSC fulfillment degree".

Happiness Driven Smart City can be gained by following the flowchart in Fig. 4. The fulfillment degree of each scenario is denoted as"*% of fulfillment*" and is presented in the form of Harvey ball, which is widely adopted for setting the criteria of qualitative evaluation (Han & Kim, 2021). See the detailed explanation of these six HDSC fulfillment scenarios in Table 6.

Following the principle of six fulfillment scenarios, the examination upon to what extent the Smart City initiatives in a given city have fulfilled the objective of Happiness Driven Smart City (HDSC) will be conducted following the procedures of: (1) To understand the local development context of the concerned city and whether the city is under active efforts devoting towards the achievement of smart city blueprint. (2) To identify and synthesize the key policy strategies being implemented in the city to harness the development of smarty city initiatives. (3) To scrutinize these key policy strategies via content analysis, and above assessment principle of six scenarios will be strictly followed to examine the degree to which the concerned city has fulfilled the Strategic Measures of HDSC objective, for this, scholars and experts with good knowledge upon local Smart City actions would be invited to join the focus group to finalize the examination results.

Above examination principles and procedures will be demonstrated in a more detailed manner via a case study of Greater Manchester in Section 7.

7. A Greater Manchester case study

7.1. Understanding the local development context

Greater Manchester in the United Kingdom (see its spatial location in Fig. 5) is selected as the case to illustrate how the HDSC mechanism developed in this study can be applied. The illustration is conducted by assessing how the practice of Manchester's Smart City development fits into the HDSC mechanism.

Manchester is used as a representative case for two reasons. Firstly, Manchester is a typical case in terms of urban socioeconomic revitalization. As the world's first industrial city, with handful of core industries (cotton, textiles and coal mining) and the effective use of new technologies (steam power and the railways), its heyday was in the late 19th century (Williams, 1996). Later on, with the city's industrial decline across the 20th century, Manchester has entered the process of de-industrialization accompanied by a radical restructure of urban fabric. The urban regeneration and branding of the city embarked from the late 1980s-, and the city has successfully shaken off the image of decline (see Fig. 6). Nowadays, Manchester is committed to capture the opportunities of ICTs development, and aims to shed the last vestiges of post-industrial decline experienced, and become once again a globally recognized city for its digital innovation (Harding et al., 2010). Manchester's effort and approach upon Smart City development would highlight the experiences for learning and solutions for transferring to

Fig. 5. Greater Manchester's spatial location. (Source: Corresponding Author)

Fig. 6. (Left) Regeneration of industrial warehouse in the Castlefield of Manchester city area (Right) Regeneration of Salford Quay and now being as the UK Mediacity (Source: Photo by Corresponding Author).

Table 7
Smart city strategical documents being implemented in Greater Manchester.

Smart City Initiatives	Authority	Issued Year	Link
The Greater Manchester Digital Strategy 2018–2020	Greater Manchester Combined Authority (GMCA)	2017	https://www.greatermanchester-ca.gov.uk/media/1090/digital-strategy-2018–2020.pdf
The Greater Manchester Digital Blueprint	GMCA	2020	https://www.greatermanchester-ca.gov.uk/media/2960/gmca_blueprint_downloadable-website-pdf-apr-20.pdf
The Greater Manchester Strategy	GMCA	2017	https://www.greatermanchester-ca.gov.uk/media/1084/greater_manchester_summary__full_version.pdf

the other cities worldwide who are under similar revitalization and transformation trajectory.

Secondly, Manchester is a strong presence of Smart City in terms of the scale. Global Megacities, like New York, London and Singapore, tend to easily attract a disproportionate share of superior resources to reinforce their pre-eminent economic status, especially in the digital era, yet only very few cities are titled and privileged to enjoy that advantages (Ren, 2021). Mid-sized cities like Manchester need to take efforts on
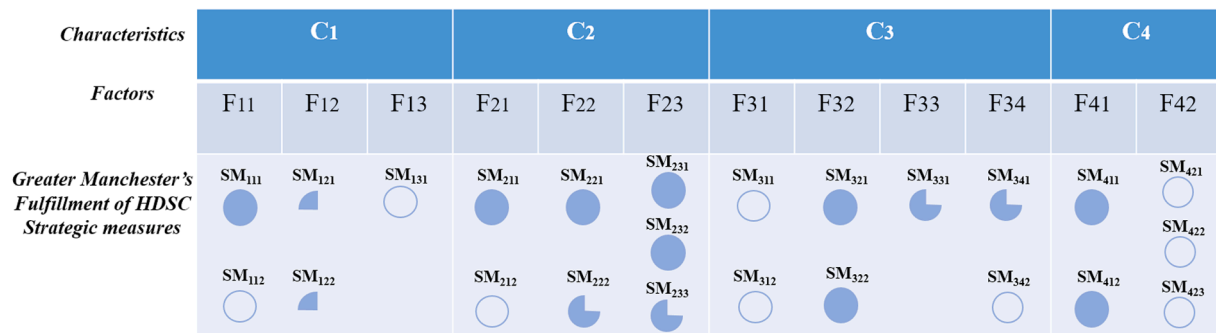
Fig. 7. Examination result of the extent to which Greater Manchester's Smart City initiatives fit into HDSD mechanism. (Source: Authors)

leveraging resources and developing new capabilities to set development priorities and deliver their ambitions. Therefore the solutions adopted for addressing challenges in Manchester provide a more generic reference to a broader body of cities globally.

7.2. Identification of the strategies taken by Greater Manchester in developing Smart City

An introduction to Greater Manchester's Smart City strategies is presented before diving into the illumination on how its Smart City strategies fit into the HDSC mechanism developed in this study.

Greater Manchester's Smart City initiatives are key components of the Greater Manchester Strategy, contributing to delivering the city's ambition of "to make Greater Manchester one of the best places in the world to grow up, get on, and grow old" (The Great Manchester Combined Authority, 2018). Following a wide range of documentary searching, three strategic documents are employed as core evidence for scrutinizing the performance of Manchester's Smart City initiatives according to the Strategic Measures underpinning HDSC proposed in Section 6. As listed in Table 6, these three key Smart City initiatives include: *The Greater Manchester Digital Strategy 2018–2020* (released in December 2017); *The Greater Manchester Digital Blueprint* (released in February 2020); and *The Greater Manchester Strategy* (launched in October 2017). The first two strategic initiatives are targeted specifically towards Smart City development whilst the third strategy is a comprehensive development strategy covering various aspects of Greater Manchester's development vision. In *Greater Manchester Digital Strategy 2018–2020*, five priorities are set with detailed action plans, namely, Inclusion, Infrastructure, Skills & Talent, Marketing & Communications, Growth & Productivity. In the *Greater Manchester Digital Blueprint*, more focus is given upon the benefits delivery to people's lives. With "digital talent pipeline" and "digital infrastructure" as enablers, the five pillars highlighted in Manchester Digital Blueprint are: empowering people; enabling innovative public services; digitally enabling all businesses; creating and scaling digital business; and being a global digital influencer. In the document of *Greater Manchester Strategy*, ten priorities are set with the aim to cover the whole life journey of people, where the effective delivery and the outcomes are particularly emphasized. In addition, the specialized instruments designed for sub-sectors in the document Greater Manchester Strategy are also adopted and considered equally in this case study, including transport, work & skills, climate change, environment, public services, culture and creativity, health and social care, police and crime, etc. The three documents are used collectively for conducting the examination of to what extent Greater Manchester's Smart City development have fulfilled the objective of Happiness Driven Smart City (HDSC) (Table 7).

7.3. Assessment on the fulfillment degree of Manchester Smart City strategies to HDSC mechanism

In line with the Strategic Measures underpinning the proposed HDSC mechanism, the assessment on the fulfillment degree of Manchester's Smart City strategies can be conducted via content analysis of the above three Manchester Smart City documents. Content analysis can ensure the assessment is evidence-based, where the evidence is in the form of both implied and explicit information extracted from the three documents. On top of the content analysis, the fulfillment degree is measured in accordance with the assessment procedure and criteria established in Section 6.2. For the focus group, 5 scholars at different career stages from the University of Manchester, University of Melbourne and Manchester Metropolitan University with good knowledge upon both smart city theory and the action taken in Greater Manchester in developing Smart City blueprint were invited to discuss and finalize jointly the fulfillment degree of Greater Manchester in terms of the HDSC goal.

Consequently, the assessment results upon the fulfillment degree of Greater Manchester's Smart City initiatives to HDSC mechanism are obtained, as shown in Fig. 7.

Based on the examination results shown in Fig. 7, the strength and weakness of Manchester's Smart City strategies in terms of accomplishing the objective of Happiness Driven Smart City can be captured. The assessment results on the fulfillment degree of the 24 HDSC Strategic Measures can be further categorized into three groups for delineating Manchester's profile regarding HDSC mechanism and for taking corresponding actions and implementing tailored policy measures:

- *Well-performed*: Health (F_{32}) and Air quality (F_{41}) are best addressed factors in Manchester's Smart City initiatives which demonstrate full implementation of corresponding HDSC Strategic Measures, followed by Innovative Spirit (F_{22}), Entrepreneurship (F_{23}) and Safety (F_{33}) where only a fraction of relative Strategic Measures is left untouched. Taking F_{22} as an example, according to GMCA (2017), the city-region has been spearheading innovation at a rate doubling the national average of UK (GMCA, 2020).
- *Room for improvement*: From Fig. 7 it can be observed that Energy (F_{12}) has received limited attention from Manchester's Smart City initiatives to serve its efficient and green development. Also, Employment (F_{21}) and Culture and Leisure (F_{34}) are expecting more efforts to improve the performance of corresponding HDSC Characteristics.

- *Gap to fill*: It can be seen from Fig. 7, Public Utilities (F_{13}), Education (F_{31}) and Pollution and Waste Treatment (F_{42}) in the case city Manchester perform the worst fulfillment of HDSC mechanism, evidenced by the fact that all the proposed Strategic Measures under these three HDSC factors have not been implemented in Manchester's Smart City initiatives. This research finding echoes with the fact revealed in the study by Uyarra and Gee (2013) that Greater Manchester has been encountering considerable technological, political and financial challenges about waste management. In other words, Manchester is tagged as environmental laggard when it comes to sustainable waste practices.

8. Discussion and conclusion

This paper argues that human happiness should be embodied as a key element in the process of Smart City development. The study embarks with the research question that *whether* and *how* Smart City acts upon human happiness in the trendy development of Smart City globally. By conceptualizing the Happiness Driven Smarty City (HDSC) and capturing the Characteristics and Factors of HDSC, a Happiness Driven Smart City Mechanism has been established, which is underpinned by various applicable and measurable Strategic Measures. To our knowledge, the HDSC Mechanism is a first attempt to assess the performance of Smart City development from the lens of human happiness, which integrates human happiness into the planning, constructing and delivering process of Smart City strategies. The established HDSC Mechanism in this study provide an applicable toolkit to urban governors for better harnessing Smart City blueprint towards a happiness-driven and human-centered direction. The applicability and effectiveness of HDSC mechanism has been validated via the empirical investigation to Greater Manchester's Smart City initiatives.

Theoretically, this study enriches the literature development in the research discipline of Smart City and offers a novel view into the spectrum of Smart City studies by adding the important perspective of human happiness to the spectrum. Practically, in applying the established HDSC Mechanism, decision makers and urban governors can capture and understand the status quo of Smart City development in terms of not only smart technologies but also human happiness in their urban context, based upon which the strength and weakness in the Smart City development practice can be investigated. Consequently, Smart City blueprint can be better achieved towards a happiness driven direction via dynamic assessment and adjustment (Wang et al., 2019).

The limitation of this study can be appreciated. The Strategic Measures built in HDSC Mechanism are mainly based upon literature investigations, for which additional fieldwork investigations can contribute to the formulation of better Strategies Measures. In addition, as only one case has been investigated empirically in this study in applying HDSC mechanism, future research can conduct comparative studies by referring more empirical cases upon the implementation of Happiness Driven Smart City between different cities globally.

CRediT authorship contribution statement

Huiying Zhu: Conceptualization, Methodology, Data curation, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Liyin Shen:** Conceptualization, Methodology, Writing – review & editing. **Yitian Ren:** Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

None.

Appendix

Appendix 1
A summary of typical smart city definition with characteristics delineated.

No.	Reference	Definition	Dimensions
1	Kourtit and Nijkamp (2012)	Smart cities are the result of knowledge-intensive and creative strategies aiming at enhancing the socio-economic, ecological, logistic and competitive performance of cities. Such smart cities are based on a promising mix of human capital (e.g. skilled labor force), infrastructural capital (e.g. high-tech communication facilities), social capital (e.g. intense and open network linkages) and entrepreneurial capital (e.g. creative and risk-taking business activities).	(1) Human capital (2) Infrastructural capital (3) Social capital (4) Entrepreneurial capital
2	Yeh (2017)	A general definition involves the implementation and deployment of information and communication technology (ICT) infrastructures to support social and urban growth through improving the economy, citizens' involvement and government efficiency.	(1) Economy (2) Citizen (3) Government
3	Caragliu et al. (2011)	A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.	(1) Economy (2) Quality of life (3) Natural resource (4) Governance
4	Lee et al. (2014)	A smart city aims to resolve various urban problems (public service unavailability or shortages, traffic, over-development, pressure on land, environmental or sanitation shortcomings and other forms of inequality) through ICT-based technology connected up as an urban infrastructure. Smart cities are envisioned as creating a better, more sustainable city, in which people's quality of life is higher, their environment more livable and their economic prospects stronger.	(1) Quality of life (2) Environment (3) Economy (4) Sustainability
5	Alizadeh (2017)	Smart cities are all urban settlements that capitalize on telecommunication technologies to enhance livability, workability and sustainability.	(1) Livability (2) Workability (3) Sustainability

Appendix 2

A summary of typical smart city indicator systems.

No.	Reference	Name	Acronym	Developer	Dimensions
1	ETSI (2020)	Access, Terminals, Transmission and Multiplexing (ATTM); Sustainable Digital Multiservice Communities; Key Performance Indicators for Sustainable Digital Multiservice Areas; Part 1: Description of Key Performance Indicators	ETSI TS 103 463-1 v1.2.1	European Telecommunications Standards Institute	● People (Health; Safety; Access to (other) services; Education; Diversity and social cohesion; Quality of housing and the built environment; ● Planet (Energy and mitigation; Materials, water, land; Climate resilience; Pollution and waste; Ecosystem; ● Prosperity (Employment; Equity; Green economy; Economic performance; Innovation; Attractiveness and competitiveness; ● Governance (Organization; Community involvement; Multilevel governance.
2	Organization, I.S. (2019)	ISO 37,122:2019 Sustainable cities and communities — Indicators for smart cities	ISO 37,122:2019	International Organization for Standardization	Economy; Education; Energy; Environment and Climate Change; Finance; Governance; Health; Housing; Population and Social Conditions; Recreation; Safety; Solid Waste; Sport and Culture; Telecommunication; Transportation; Urban/Local Agriculture and Food Security; Urban Planning; Wastewater; Water.
3	International Telecommunication Union (ITU), 2014	Key performance indicators related to the use of information and communication technology in smart sustainable cities	ITU-T Y.4901/ L.1601 (06/ 2016)	Telecommunication Standardization Sector of International Telecommunication Union (ITU-T)	● Information and Communication Technology (Network and access; Services and Information platforms; Information security and privacy; Electromagnetic field) ● Environmental sustainability (Air quality; Water, soil and noise) ● Productivity (Capital investment; Trade; Innovation; Knowledge economy) ● Quality of Life (Education; Health; Safety/security public place) ● Equity and social inclusion (Openness and public participation; Governance) ● Physical infrastructure (Infrastructure/ connection to service – piped water; Infrastructure/ connection to services – sewage; Infrastructure/ connection to services – electricity; Infrastructure/ connection to services – road infrastructure; Building)
4	Giffinger et al. (2007)	European Smart City Model	eusc	Center of regional science (srf), vienna university of technology; the department of geography at university of ljubljana; the otb research institute for housing, urban and mobility studies at the delft university of technology	● Smart Economy (Innovative spirit; Entrepreneurship; City image; Productivity; Labour Market; International integration) ● Smart Mobility (Local Transport System; (Inter-)national accessibility; ICT-Infrastructure; Sustainability of the transport system; ● Smart Governance (Political awareness; Public and social services; Efficient and transparent administration) ● Smart Environment (Air quality (no pollution); Ecological awareness; Sustainable resource management) ● Smart Living (Cultural and leisure facilities; Health conditions; Individual security; Housing quality; Education facilities; Touristic attractiveness; Social cohesion) ● Smart People (Education; Lifelong learning; Ethnic Plurality; Open-mindedness)

Appendix 3

A summary of typical happiness indicator systems from authorities and research institutes globally.

No.	Reference	Name	Developer	Main Dimensions
1	www.oecdbetterlifeindex.org	Better Life Index	OECD (Organization for Economic Cooperation and Development)	Housing, Income, Jobs, Community, Education, Environment, Civic engagement, Health, Life Satisfaction, Safety, Work-life balance
2	www.isqols.org	International-level Quality-of-Life Indicator	ISQOL (International Society for Quality-of-Life Studies)	Economic Wellbeing: Banking, Business and Entrepreneurship, Consumer Finances, Government Finances, Income and Employment; Education Wellbeing; Environmental Wellbeing; Equity: Children and Young Adults, Gender; Health Wellbeing; Infrastructure: Communication, Energy, Resources, Transportation; Political Wellbeing; Safety Wellbeing; Subjective Wellbeing; Technology Wellbeing; Work Wellbeing.
3	www.acqol.com.au	Personal Well-being Index	ACQol (Australian center on Quality of Life)	Standard of living; Health; Achieving in life; Relationships; Safety; Community connectedness; Future security; Spiritualty/Religion.
4	hdr.undp.org	Human Development Index	UNDP (United Nations Development Programme)	Life expectancy index; Education index; GNI index
5	neweconomics.org	National Accounts of Well-being	NEF (New Economic Foundation)	● Personal well-being: Emotional well-being, Satisfying life, Vitality, Resilience and self-esteem, Positive functioning; ● Social well-being: Supportive relationships, Trust and belonging, Well-being at work
6	uwaterloo.ca	Canadian Index of Well-being	University of Waterloo	Community Vitality; Democratic Engagement; Education; Environment; Healthy Populations; Leisure and Culture; Living Standards; Time use;

Appendix 4

Major dimensions of happiness indicator systems of existing literature.

No.	Reference	Main Dimensions
1	Liao (2009)	Medical service; Domestic finances; Work; Education; Leisure; Public safety; Environmental quality;
2	Veenhoven (2000)	(1) Livability of environment (Ecological, Social, Economical, Cultural, etc.); (2) Life-ability of the person (Physical health, Mental health, Knowledge, Skills, Art of living, etc.); (3) Objective utility of life (External utility, Moral perfection, etc.); (4) Subjective appreciation of life (Appraisal of life-aspects, Prevailing moods, Overall appraisals, etc.).
3	Felce and Perry (1995)	(1) Physical Well-being (Health, Personal safety, Fitness, Mobility); (2) Material Well-being (Finance/Income, Housing quality, Neighborhood, Privacy, Transport, Possessions, Meals/Food); (3) Social Well-being (Interpersonal relationships, Community Involvement); (4) Development and Activity (Competence/Independence, Job, Home life/Housework, Leisure/Hobbies, Education)
4	Rapley (2003)	(1) Individual factors (e.g. disability, educational attainment, income, life transitions); (2) Social and other factors (e.g. social capital, transactions, social change, economic conditions).
5	Statistics (2001)	(1) Natural environment (light, heat, air, land, water, minerals, flora, fauna); (2) Human made environment (material objects, buildings, road, machinery, appliances, technology; (3) Social arrangements (families, social networks, associations, institutions, economies); (4) Human consciousness (knowledge, beliefs, understanding, skills, traditions).

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