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Structured Abstract:

Purpose: Many cities across the world are actively investing in ways to excel in the innovation economy through the development of innovation districts as one of the most popular policy options. While innovation districts are among the leading drivers of innovation activities in cities, they are also high-cost and high-risk investments. Besides, holistic approaches for assessing these districts' multifaceted performances are scarce. Bridging this knowledge gap and evaluating innovation district performance through classification is the rationale of this study.

Design/methodology/approach: The paper introduces a multidimensional innovation district classification framework and applies it into Australian innovation districts with divergent features, functions, spatial and contextual characteristics. The study places 30 innovation districts from South East Queensland under the microscope of the framework to assess the multifaceted nature of innovation district performance. It employs qualitative analysis method to analyse both the primary and secondary data, and descriptive analysis with basic excel spreadsheet calculations to analyse the validity of the data.

Findings: The data analysis classes 30 innovation districts from South East Queensland under three performance levels—i.e., desired, acceptable, unsavoury—concerning their form, feature, and function characteristics.

Originality/value: The results disclose that the framework is a practical tool for informing planners, developers, and managers on innovation district performances; and it has the capability to provide guidance for policymakers on their policy and investment decisions regarding the most suitable innovation district types and characteristics to consider.

Keywords: innovation district; innovation economy; performance analysis; classification framework; urban policy; South East Queensland

1. Introduction

Innovation districts are undoubtedly the leading drivers of innovation activities in cities throughout the globe (Esmaeilpoorarabi et al., 2018a; Kayanan, 2021), but at the same time, they are high-cost and high-risk investments. Therefore, there is a need for a holistic assessment on their performance to inform planners, developers, and managers in identifying areas with most needed interventions as well as policy and investment decisions on developing innovation district types with characteristics that are most suitable for the specific locations (Pancholi et al., 2020). Such assessment can contribute to the success of innovation districts. Nonetheless, a priori to this assessment is to employ a holistic performance framework, which to date the literature confirms are limited (Adu-McVie et al., 2021).

Performance assessment process is commonly used by diverse disciplines including urban development, which aims to determine the efficiency and effectiveness of programs, activities, functions, and their compliance with some pre-set standards (Davis, 1990). In urban planning and development and other related fields, studies on performance assessments mostly concentrate on the regional, national and city scales and less on cluster or innovation district scales. Only few studies so far have evaluated the place quality (Esmaeilpoorarbi et al., 2018b) and sustainability (Santamaria, 2020) at the cluster or innovation district levels, but none of the studies has done a multifaceted evaluation holistically, due to the lack of a suitable assessment framework (Yigitcanlar et al., 2020b).

This study aims to contribute to the knowledge gap on the performance assessment of innovation districts by employing the multidimensional innovation district performance framework. The study adopts the framework developed by Adu-McVie et al. (2021) and employs it to holistically assess 30 existing innovation districts in South East Queensland (SEQ) region of Australia. It then employs a

combination of qualitative analysis methods to analyse primary and secondary data obtained for the 30 innovation districts, and descriptive data analysis with basic calculations, through Excel spreadsheets to analyse the validity of the data obtained.

The most notable outputs of this study are: (a) The newly introduced performance matrix assigns the 30 innovation districts into 12 performance classes of 'desired performers', 'acceptable performers' and 'unsavoury performers'. In general, innovation districts with desired overall performance are preferably located in inner cities with complex mixed land use, open layout plan, hosting diversified businesses and companies/customers, having strong human capital, skilled labour, urban green/blue infrastructure and built environment; (b) The performance ranking of innovation districts, based on the overall net scores, is developed, and; (c) Both the performance framework and performance matrix will contribute to a better understanding of how innovation district performances are assessed holistically.

The remainder of the paper is structured as follows. Section 2 presents the literature review concerning the performance assessment process, and its widespread application by diverse disciplines, including urban planning and development and the related fields. The section then introduces the multidimensional innovation district classification framework. Section 3 introduces the 30 innovation district cases from SEQ and elaborates on the data collection and methodological approach of the study. Section 4 presents the main findings, and Section 5 discusses the implications and concludes the paper.

2. Literature background

2.1. Innovation district performance assessment

Performance assessment has been widely used by diverse disciplines to determine the "efficiency and effectiveness of programs, activities, functions" and their compliance with some pre-set standards (Davis, 1990, p.35). In the context of urban development, it is used to determine if for example, a city- or cluster-level development has delivered its promise for improved economic, social, physical infrastructure and environmental benefits to the residents, workers, and other users (Wagner et al., 2019; Caird & Hallet, 2019; Adu-McVie et al., 2021).

The relevant literature on performance assessment is rich and usually adopts different methodologies depending on the study's scope and objectives. For example, in the discipline of architectural studies, Mauro et al. (2019) used 'energy simulations' to compare different scenarios representing a typical floor plan of a building to assess the effectiveness concerning energy retrofit of a case study building. A study by Hegazi et al. (2022, p.1) applied multi-methods namely "Delphi technique, ICCROM-CCI-RCE and space syntax-based to assess vulnerable spaces around heritage buildings to determine their socio-spatial properties". In the education discipline, Jeschke et al. (2019) employed 'video-based performance assessments' to assess the mathematics and economic teachers' action-related skills and used the 'established paper-pencil test' to assess their content knowledge and pedagogical content knowledge.

Besides, Iannone et al. (2020) utilised a method namely 'high stakes oral performance assessment' to assess its impact on third year mathematics students' approaches to learning. In the transportation studies discipline, Kucukvar et al. (2020) accommodated the 'data envelop analysis' method to compare efficiency and sustainability levels of airports in different contexts. In another study, Szymula & Besinovic (2021) applied a 'railway network vulnerability model' to efficiently assess network vulnerability. Like the other disciplines, urban development and related fields also employed single-to-multi-methods of performance assessments on urban developments at differing spatial scales—e.g., national, regional, city, and neighbourhood or cluster or district. Although several international measures of 'best-practice' on innovation, collaboration, competitiveness, and productivity (e.g., Global Innovation Index, World Economic Forum Global Competitiveness Report) are available, they are only suitable for the performance assessment on the regional and/or national scale (Singtel Optus, 2017). To our best knowledge, a most relevant assessment or audit framework to

this study is Brookings' 'how to guide' on assessing innovation districts (Vey et al., 2018), which focuses on the innovation districts ecosystem.

Some of the renowned examples of the prior research on the performance assessment of cities and urban regions include the following studies. Zhang et al. (2016) employed an 'optimisation model' based on multicriteria decision-making to evaluate sustainability performance of selected case study cities. Shen et al. (2018) applied two methods, i.e., the 'entropy' and 'technique for order preference by similarity to ideal solution' (TOPSIS) to holistically evaluate China's smart cities' performances. Rodrigues & Franco (2020) accommodated the 'quantitative research method' using the two multivariate statistical techniques (i.e., EFA, PCA) to assess creative cities' performance. Fan et al. (2019) used a 'multiple case analysis approach' to evaluate the status of Cluj-Napoca, Romania's regional innovation cluster. Yigitcanlar et al. (2020a) applied a quantitative performance analysis model called 'the smart city assessment model' to evaluate Australia's smart cities achievements and urban regions, where this method is also applied to evaluation of Brazilian capital cities' smartness levels (Fachinelli et al., 2022).

Regarding district scale studies focusing on innovation districts, there are currently limited studies on performance assessment due to the lack of multifaceted performance frameworks (Esmaeilpoorarabi et al., 2018b; Adu-McVie et al., 2021). These studies have only concentrated on the limited aspects of innovation districts. For example, Esmaeilpoorarabi et al. (2018b) employed descriptive and explanatory methods to identify and classify indicators of place quality at a cluster scale. Santamaria (2020) used 'qualitative method based on rapid ethnography' to analyse sustainability on Boston Innovation District and 22@ Barcelona. Mardiharini et al. (2021) accommodated the 'context, input, process, and product' model to analyse the performance progress of an Agricultural Techno Park in West Java. Nevertheless, none of these studies conducted a holistic performance assessment for their case studies of innovation districts. This calls for identifying and applying a suitable performance assessment framework for innovation districts.

3. Research design

This study applied the 'multidimensional innovation district classification framework' to 30 existing innovation districts in South East Queensland (SEQ) region of Australia for performance assessment. A three-step process is used to apply the framework and discussed in detail in the following sections. In the first step, the framework was adopted to guide both the second (i.e., data collection) and third (i.e., data analysis) stages (Pancholi et al., 2018a).

3.1. Case study

The SEQ region is selected as the case study area because it has been investing in the development of innovation districts since the early 1900s (Advance Queensland, 2021a). Initially, the study identified 31 innovation districts in the SEQ, however, one of the districts, namely Sun Central Maroochydore-CBD Precinct was excluded because it is still in its early stage of development and has no knowledge facilities yet. Overall, 30 active innovation districts located in SEQ are audited. The districts were identified from the Australian Government websites, specifically the Department of Industry, Science, Energy and Resources (DISER), Choose Brisbane, Google search and the relevant innovation district websites. The salient characteristics of the 30 innovation districts—i.e., establishment date, business partnership type, industry type, and the main anchor—are summarised in Table 1.

Table 1: Salient characteristics of case innovation districts

Innovation district	Acronym	Establishment date	Partnership type	Industry type	Main anchor/facility
Australian Trade Coast	ATC	1999	Public-private investment	• Aviation and aerospace • Shipping and marine • Logistics and manufacturing related industries	• Brisbane Airport Corporation • Port of Brisbane Corporation
Brisbane Technology Precinct	BTP	1987	Public sector investment	• Biotechnology and pharmaceuticals • Medicine and medical equipment • Engineering and defence technologies	• Johnson & Johnson Medical • Cook Medical Australia
Chermside Health & Education Precinct	CHEP	1954	Public sector investment	• Heart-lung transplant • Cardio and pulmonary research and treatment.	• The Prince Charles Hospital • QUT Institute of Health and Biomedical Research Facility
Diamantina Knowledge Precinct	DKP	2011	Public-private-university investment	• Integrated healthcare • Research and education	• Princess Alexandra Hospital (PAH) • Ecosciences Precinct-CSIRO
Health and Food Sciences Precinct	HFSP	2010	Public sector investment	• Biosecurity • Healthcare • Food technology	• CSIRO • Queensland Alliance for Agriculture & Food Innovation. • Queensland Health Scientific & Forensic Services
Herston Health Precinct	HHP	2003	Public sector investment	• Healthcare innovation, • Education, research, training • Clinical services.	• Royal Brisbane and Women's Hospital • University of Queensland
Kelvin Group Urban Village	KGUV	2003	Public-private-university investment	• Health and education research • Creativity	• Queensland University of Technology • Queensland Academy for creative industries
Pinjarra Hills Precinct	PHP	1920	University sector investment	• Biotechnology research	• University of Queensland Centre for Biotechnology pilot plant
QUT Science & Engineering Centre	QSEC	2012	Public-private-university investment	• Science and engineering	• QUT Garden Point campus • The Cube • QUT Institutes for Future Environments
Salisbury Research Facility	SRF	1918	Public sector investment	• Multidisciplinary forest products research	• Salisbury Research Facility
South Brisbane Precinct	SBP	1989	Public-private-community investment	• Health and education research • Tourism • Creativity • Business	• South Bank Parklands • Tafe QLD South Bank campus • Mater Public Hospital • QLD Children's Hospital
UQ Knowledge Precinct	UQKP	1909	Public-university investment	• Education, research, and development	• UQ St Lucia campus • CSIRO Biosciences Precinct. • Institute for Molecular Bioscience
The Precinct Fortitude Valley	TPFV	2017	Public sector investment	• SMEs start-ups, scale-ups, incubators, investors & mentors	• eHealth Queensland • Office of the Chief Entrepreneur • River City Labs
Ipswich City Health Precinct	ICHP	2019	Public sector investment	• Healthcare innovation	• Ipswich Hospital • Community Health Plaza
Ipswich Defence Industry Hub	IDIH	2016	Public sector investment	• Start-ups, accelerators, entrepreneurs, and digital- minded small businesses • Focus on defence industry sector and other defence supply chain opportunities	• Fire Station 101 • Defence Industry Hub
Knowledge Precinct Greater Springfield	KPGS	1992	Private sector investment	• Education, advance healthcare, and new technologies	• Springfield City Group • University of Southern QLD-Springfield campus

					• Mater Private Hospital- Springfield
Queensland Animal Science Precinct	QASP	2008	Public-university investment	• Training, teaching, validation, and commercialisation of animal research	• UQ Gatton campus • UQ VETS Small Animal Hospital • UQ VETS Equine specialist Hospital
Agriculture Science and Engineering Precinct	ASEP	2019	Public-university investment	• Crop production, plant pathology and biotechnology research	• USQ Toowoomba • National Centre for Engineering in Agriculture
Toowoomba Health Precinct	THP	1880	Public-private investment	• Health education	• Toowoomba Public Hospital • St Vincent Private Hospital • St Andrews Private Hospital
Caboolture Health Precinct	CHP	1993	Public -private investment	• Health care services • Research & education	• Caboolture Public Hospital • Super Clinic Health Care • Caboolture Private Hospital
Redcliffe Health Precinct	RHP	1965	Public-private investment	• Clinical practice, teaching, and research in health care	• Redcliffe Public Hospital • Peninsula Private Hospital
The Mill University of Sunshine Moreton Bay Precinct	TMP	2020	Public-university investment	• Education and research and development	• USC Moreton Bay
Cleveland Health Precinct	CLHP	1987	Public-private investment	• Clinical practice, teaching, and research in health care	• Redland Hospital • Mater Private Hospital
Meadowbrook Health and Knowledge Precinct	MHKP	1990	Public-university-tafe investment	• Clinical practice, health/medical and education	• Logan Hospital • Griffith University Logan campus • Tafe QLD Loganlea campus
Coomera Creative Hub	CCH	2011	Public-tafe-university investment	• Creative education	• Tafe QLD Coomera campus • Southern Cross University Coomera campus
Gold Coast Health and Knowledge Precinct	GCHKP	2013	Public-university investment	• Health and education research	• Griffith University Gold Coast campus • Gold Coast University Hospital • Gold Coast Private Hospital
Robina/Varsity Lake Health, Education and Multidisciplinary Health Precinct	RVHEMP	1989	Public- private investment	• Multidisciplinary health services	• Robina Hospital (RH) • Bond University (BU)
Southern Gold Coast Airport Precinct	SGCAP	1998	Private-university-tafe investment	• Multidisciplinary areas of business, enterprise, technology, aviation, tourism, and health	• Gold Coast International and domestic airports • Southern Cross University-GC campus • Digital Enterprise Lab
Sippy Downs Knowledge Precinct	SDKP	1996	Public-university investment	• Education and research	• University of Sunshine Coast (USC) • Innovation Centre Sunshine Coast • Business & Technology Park
Sunshine Coast Health and Medical Precinct	SCHMP	2013	Public-private investment	• Health and allied medical research and training	• Sunshine Coast University Hospital (SCUH) • Sunshine Coast Private Hospital

3.2. Innovation district performance classification framework

Despite the urgent call for a suitable performance assessment framework to holistically assess the multifaceted performance of innovation districts, to our best knowledge, only one such framework exists in the current body of knowledge. This multidimensional innovation district classification framework was developed by Adu-McVie et al. (2021) and validated by 32 international experts through a Delphi study in 2020. The framework comprises both hard indicators such as 'locality setting', 'company size', and 'urban green and blue infrastructure' and soft indicators such as 'human capital' and 'skilled labour'.

The framework uses multidisciplinary objective methods for measuring indicators. The framework's main purpose is to classify typologies of innovation districts based on their characteristics and performances. Hence, the classification framework also serves as a performance framework. Table 2 displays the classification framework that comprises of 3 dimensions (feature, function, and form), 12 indicators (e.g., social amenity, industry type, and land-use mix) and 36 measures. For clarity and ease of reference, we include additional information in columns 'parameters' and 'justification/reference' for each of the scale of measure.

Table 2: Multidimensional innovation district classification framework (Adu-McVie et al.2021)

Dimension	Indicators	Description	Measures	Parameters	Justification/Reference
Feature	Social amenity	Presence or availability of social amenities for public use	▪ Strong presence of social amenities ▪ Moderate presence of social amenities ▪ Weak presence of social amenities	Measured by the composite score High >50 Moderate >40 Weak <40	Scale of measure is based on a study which used POSDAT, a tool to measure quality of public open space. The finding of an average attractive score was 54 (Taylor et al., 2011; Edwards et al., 2013)
	Human capital	Inventory of skilled people (i.e., information about the education and skill levels of the population and the potential stock of qualified people)	▪ Strong human capital ▪ Moderate human capital ▪ Weak human capital	Percentage of knowledge workers with BA or higher from the surrounding suburb's population High >50% Moderate <50% Weak <25%	Adopt same scale used for 'skilled labour'
	Skilled labour	Skilled employment outcome of the innovation district activities	▪ Strong skilled employment ▪ Moderate skilled employment ▪ Weak skilled employment	Ratio of knowledge worker jobs to total innovation district jobs High >50% Moderate <50% Weak <25%	Scale of measure is based on an evaluation study's result which identified that knowledge workers in the case innovation district account for 50% of the district's total employment (Jolly & Zhu, 2012)
	Locality setting	Location of the district within the metropolitan area	▪ Inner city setting ▪ Suburban setting ▪ Regional setting	Location of the innovation district based is based on ABS' SA2 definition Inner city Suburban Regional	Scale of measure based on scholarly and policy literature. Innovation districts are typically located in inner city or suburban or regional areas (ABS,2016; Winden & Cavalho, 2016; NSW Innovation and Productive Council, 2018)
Function	Company size	Relative size of the firms within the innovation district (i.e., MNE anchored, LNE dominated or SME dominated)	▪ Multinational enterprise (MNE) anchored ▪ Large National enterprises (LNE) dominated ▪ Small and medium enterprise (SME) dominated ▪	Ration of number of firm types to total firms within the innovation districts MNE anchored if >50% LNE dominated if >50% SME dominated if >50%	The method used to measure 'industry type' is adopted here to measure the relative size of firms within the innovation district.
	Industry type	Dominant business activity operating within the innovation district	▪ Technology intensive business ▪ Creativity intensive business ▪ Business support services	Dominant business activity of the district Technology intensive if >50%, Creativity intensive if >50% Business support if >50%	Scholarly literature including He & Gebhardt (2014), confirmed there are three dominant activities of existing districts: 1. Technology-intensive services 2. Creativity -intensive services 3. Business support intensive services Scale of measure (>50%) is based on findings of 22@ reported to have hosts 53% of technology intensive businesses.
	Investment type	Principal support and funding body for the development of the innovation districts	▪ Public-private-community partnership ▪ Public-private partnership ▪ Public or private sector	Principle support and funding body of the innovation district Multiple sectors Two sectors Single sector	Scale of measure is based on scholarly and policy literature including Cheng et al. (2019) which indicates that support and funding for development of districts are mostly public-driven or private sector - driven, public-private partnership, or public-private-people-partnership-driven.

	Property Management	Management model of the innovation district's properties and activities	▪ Managed by district management ▪ Managed by building management ▪ No form of management	Management model of the district District-wide Building level None	Scale of measure is based on scholarly studies including Esmaeilpoorarabi et al. (2018) which identified that operations of the innovation districts are typically managed by a district-wide body corporate, building-base body corporate or has no management.
Form	Green-blue infrastructure	Aesthetic qualities of urban green and blue infrastructure within the innovation (i.e., all natural and seminatural landscape elements that form a green-blue network)	▪ Strong presence of ecosystem services ▪ Moderate presence of ecosystem services Weak presence of ecosystem services	Measured by design principles of blue-green infrastructure -city level (blue) and cluster level (green) Strong >50% Moderate >25% Weak <25%	Scale of measure is adopted from 'The natural environment scoring tool' (Gidlow et al., 2018) which identified that water bodies, trees, and vegetation occupying >50% of the area are considered significant.
	Land use	Main land use types within the innovation district	▪ Complex mix Mixed use ▪ Single use	Mainland uses within the innovation district are measured by Work-learn-live-play Work-learn-live or play Work or learn	Scale of measure is based on scholarly studies including Pancholi et al. (2014) and Esmaeilpoorarabi (2018a;2020a) which indicates that mixed-use (work, learn, play, live) is the current best practice. However, there still exists districts developed for either 'work- learn- play or live' and 'work' or 'learn'
	Built environment	Architectural design of built forms and functions encouraging open innovation systems, connectivity, and mobility within the innovation districts	▪ Strong internal connectivity ▪ Moderate internal connectivity ▪ Weak internal connectivity	Design qualities of built form and functions within innovation districts are measured using composite score weightings to determine the adequate level of internal connectivity Strong >60 Moderate >50 Weak <50	Scale of measure is adopted from POSDAT's method (Taylor et al., 2011; Edwards et al., 2013)
	Space design	Spatial layouts design encouraging open innovation system within the innovation district	▪ Open layout plan ▪ Semi-open layout plan Close layout plan	Measured by zonings to determine if the design encourage knowledge generation within the district Open layout plan Semi-open layout Close layout plan	The measures are adopted from the '3-Factor Cluster Model' (Yun et al., 2018) which indicates design qualities of existing districts are rated low for close designs and high for open designs hence the moderate designs would be semi- open.

3.3. Data collection

The data collection process stretched over a 12-month period, from February 2021 to February 2022. The study followed Pancholi et al.'s (2018a) three-step process in employing the multidimensional innovation district classification framework on the case innovation districts. In the first step, the framework was adopted to guide both the second step of data collection, and third step of data analysis. The study applied desktop audits using the GIS tools (i.e., Nearmap, Google my map, ArcGIS) to virtually visit the sites, collect primary data, and create supporting maps and graphics. The secondary data were collected from the official websites of the case innovation districts, the Australian Bureau of Statistics (ABS) and the Dun & Bradstreet Business Directory (DBBD). The data analysis step employed both analytical reasoning method and the deductive approach, where the latter approach adopts the validated framework and tests each of the indicators accordingly against the case studies (Yin, 2011).

Primary data collected from audits of the 30 case innovation districts are in the form of spatial and descriptive information on 'social amenities', 'built environment', 'land use' and 'space design'. With the aid of the mapping software, each of the innovation districts was virtually visited and assessed in the following manner. Firstly, using the mapping software, base maps for each innovation district were created to identify their legal boundaries. Marking out the boundaries was the first crucial step to ensure all audits performed are within the legal boundaries of the case innovation districts. The base map is also used to create supporting graphics and maps. The audit tools and process employed, and the type of data collected are discussed in following sections.

The aim of auditing 'social amenities' is to identify any 'presence and availability of amenities for public use' within the innovation districts. The audit sheet for the amenities is derived from Taylor et al.'s (2011) 'new POST' used for measuring the quality of public open space. The current study expanded the POST's audit checklist to include measures of other amenities including restaurants and cafes, cultural and entertainment facilities, public parks, and playgrounds. The audit checklist (see Appendix A) focused on five themes namely 'activities;' 'centrality/locality', 'environment quality', 'amenity' and 'safety.'

Each of the theme has a key question which guides the auditor to answer either by checking options 'No or Yes or N/A', and Likert scale scores ranging from 0-5. The auditor's assessment is based on virtual observation using both Google my map and Nearmap. For instance, question 1 for 'activities' is "What type of activities is the social amenity designed for? (Check an answer for each activity)" If it is a restaurant then the auditor checks 'Yes' for the relevant activity from the option listed and 'No' for the others. On the other hand, question 6(b) for 'environment quality' asks "Is there shade along paths (check one only)". This question is only relevant for parks, open spaces, and outdoor-ground level social amenities hence, indoor social amenities above ground level are scored N/A. The auditor checks the selected Likert scale score ranging from 0-5 based on aerial observation of the tree canopies, guided by the given parameters of 6(b) as per: the scores given for 'Yes or No or N/A' ranges from 0-2, where No=0, Yes=1 and N/A=2 whilst the Likert scores ranges from 0-5 where 0=Very poor (little or no shades), 1=Poor (canopies of trees don't touch and trees spread apart), 2=Medium (canopies of trees do not touch but trees close together), 3=Good (canopies of some trees touch), 4=Very good (canopies of many trees touched), 5= Not applicable as there are no paths).

After converting the descriptive scores to values, the raw scores derived from all social amenities of each innovation districts are transferred to excel spreadsheet to formulate a 'master scoresheet' (see Appendix B). The computed overall sum is then normalised by averaging to get composite mean score which defines the innovation district's performance—i.e., strong, moderate, weak. Overall, 44 social amenity attributes are audited for each innovation district.

In terms of 'urban green and blue infrastructure,' the aim is to investigate any presence of urban green and blue ecosystem services for aesthetic qualities within the innovation districts, where the ecosystem services refer to all natural and seminatural landscape elements that form a green-blue network. The audit sheet (see Appendix C) employed is derived from the design principles for green-blue infrastructure (Bosh et al., 2016), which has two parts; The first part focuses on identifying the

presence of green ecosystem services on street level at innovation districts and has seven themes, including mitigating heat stress and noise reduction. The second part focuses on the blue ecosystem services at city level and has eight themes including green-blue corridors. In total, the green and blue infrastructure audit sheet has 23 attributes for assessment. Scores are given as Absent=0, Limited presence=0.5 and Unlimited presence=1. Furthermore, the audit sheet has a guideline to assist the auditor(s) in their ratings between various innovation district sizes. For instance, a small innovation district that has less than two trees with large crowns for 'mitigating heat stress' is rated 'limited presence' (0.5 score) and those districts with more than two trees with large crowns is considered unlimited (1 score). In terms of the blue ecosystem services, if the district's host city has less than 10 'places to meet' e.g., restaurants/eateries along seashores and riverbanks, it is rated limited and more than 10 is unlimited.

Overall, the composite scores of green ecosystem and blue ecosystem are combined and computed to percentage score to define the innovation district's performance—i.e., strong, moderate, or weak. It is noteworthy since blue ecosystem services are measured at the city level; all case innovation districts in their respective Local Government Areas (LGAs) share the same score for blue ecosystem services. Figures 1-4 are exemplar images of selected innovation districts showing overall 'strong' and 'moderate' performance for green and blue ecosystem services respectively.

The aim of auditing 'built environment' features is to investigate if the architectural design of the built forms and functions within the innovation districts encourage open innovation systems, connectivity, and mobility. The audit sheet employed (see Appendix D) is derived from the 'healthy built environment designs' (NSW Health, 2021; Victoria Walks, 2021). It has eight themes including street connectivity and smaller block sizes and number of local living destination less than one kilometre off the innovation districts. The scores are given as No=0, Limited=5, Unlimited=10. The sum score is accepted as the composite score which defines the innovation district's performance i.e., strong, moderate, or weak. Figures 5-8 are exemplar images of selected innovation districts with 'unlimited' and 'limited' evidence of 'transport and movement network' and 'public open and green space' <2.5km radius respectively.

The purpose of auditing 'land use' is to identify the existing main land use types within the innovation districts. The three main types of land-use are 'complex mix' (i.e., work-learn-play-live), 'mixed use' (i.e., work-learn-play or live) and 'single use' (i.e., work or learn). The mapping software is used to virtually identify each innovation district's design.

Regarding 'space design', the auditing process aims to investigate if the innovation districts' spatial layout design is encouraging open innovation system within the district in terms of land-use zonings. In this case, a 'three-element cluster model' is employed to determine if the innovation districts are 'closed', 'semi-close' or 'open' innovation systems. Three zonings are considered in this cluster model: R&D (university), house (market consumer) and park or entertainment facility (museum). The measure is about the permeability from the house zone to the R&D/university zone based on three assumptions: (a) Open innovation system in a three-factor cluster takes place when people in the house zone have to pass through a R&D/university zone to get to the park/entertainment zones; (b) Semi-open innovation system takes places when people in the house zone can go directly to the park/entertainment without passing the R&D but the R&D is nearby to motivate them to make connections and communications with the R&D; (c) Close innovation system is when people in the house zone go directly to the park/entertainment and have limited encounter with the R&D (Yun et al., 2018). Figures 9-11 are exemplar images of showing evidence of selected innovation district's 'land use' types and space design.

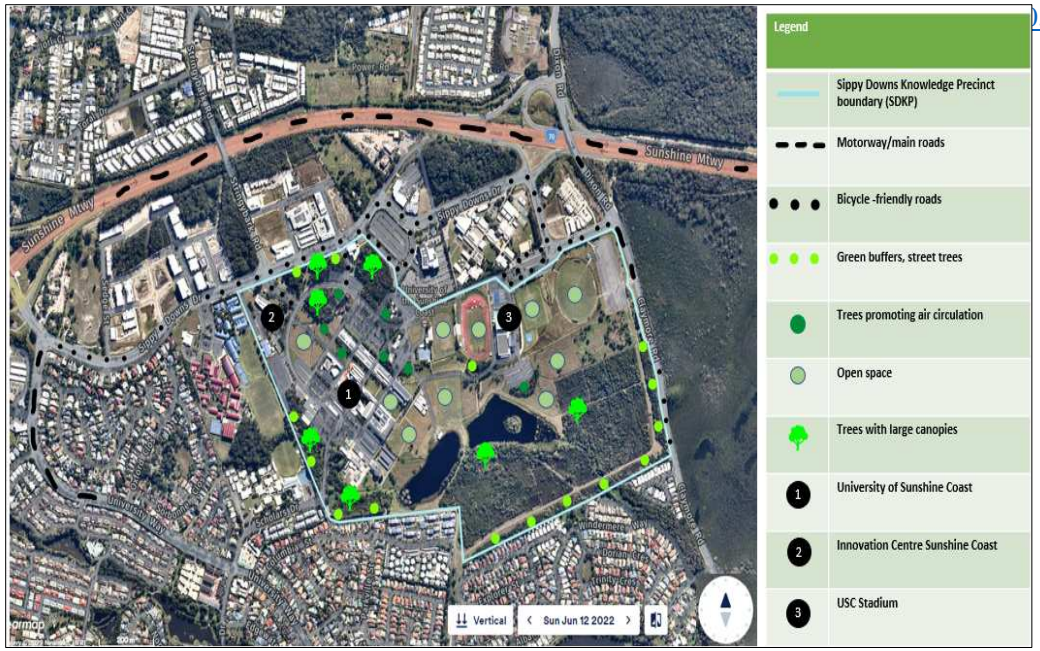

Figure 1: Aerial image of SDKP showing unlimited presence of green ecosystem services

Figure 2: Aerial image of MHKP showing limited presence of green ecosystem services

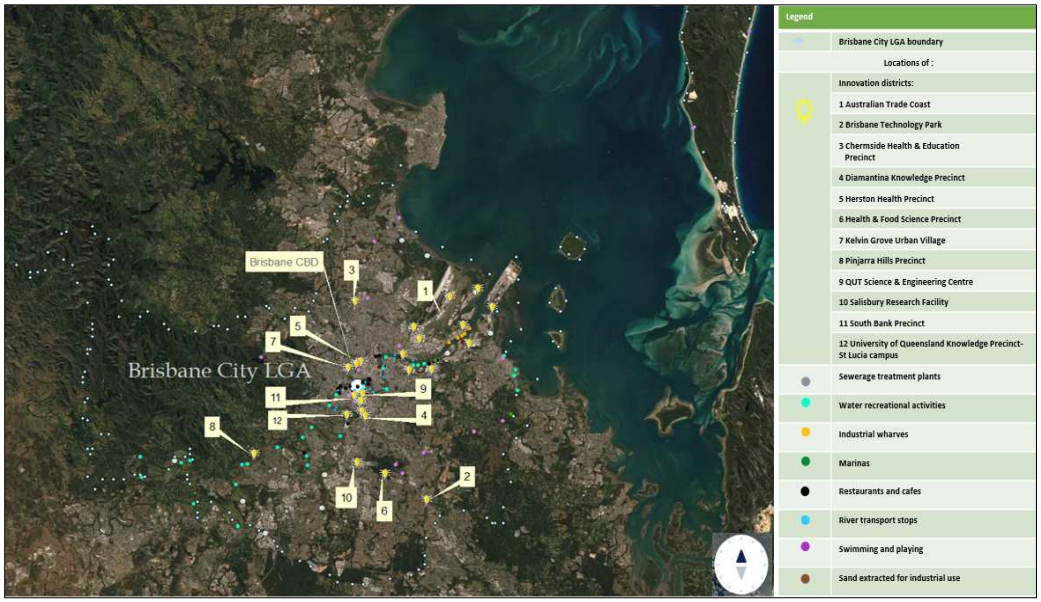

Figure 3: Map of Brisbane City LGA showing evidence of unlimited presence of blue ecosystem services

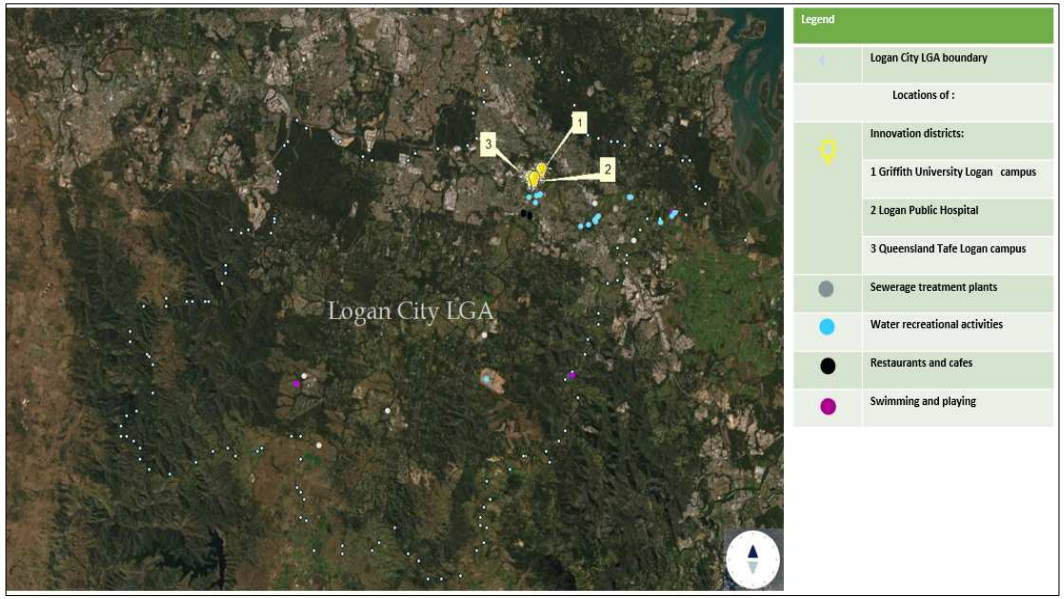

Figure 4: Map of Logan City LGA showing evidence of limited presence of blue ecosystem services

Figure 5: Aerial image of HHP showing unlimited evidence of transport and movement network

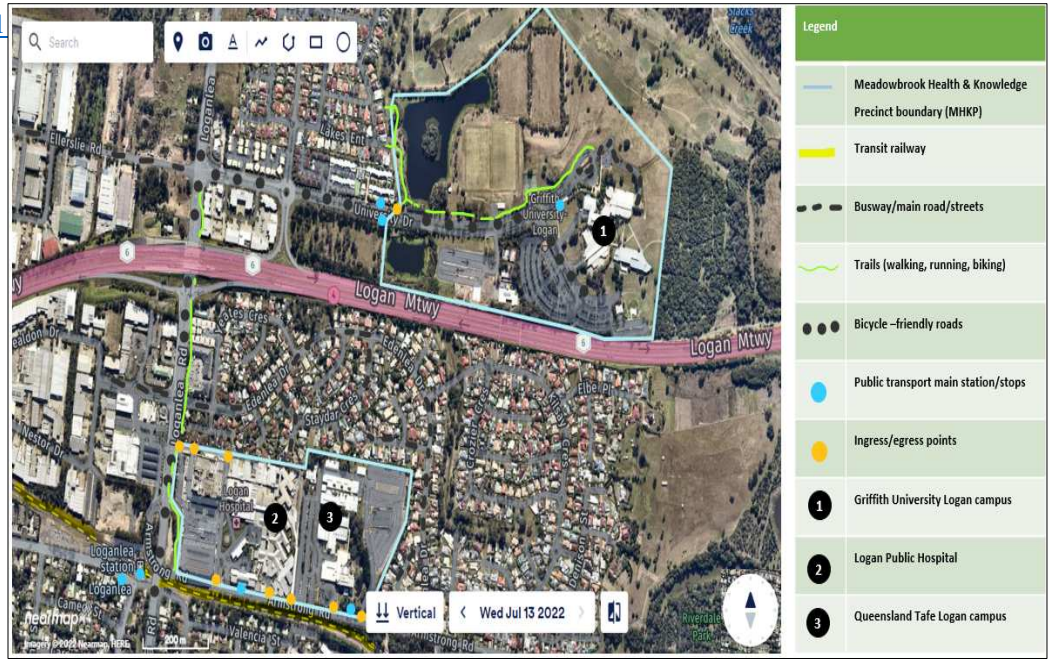

Figure 6: Aerial image of MHKP showing limited evidence of transport and movement network

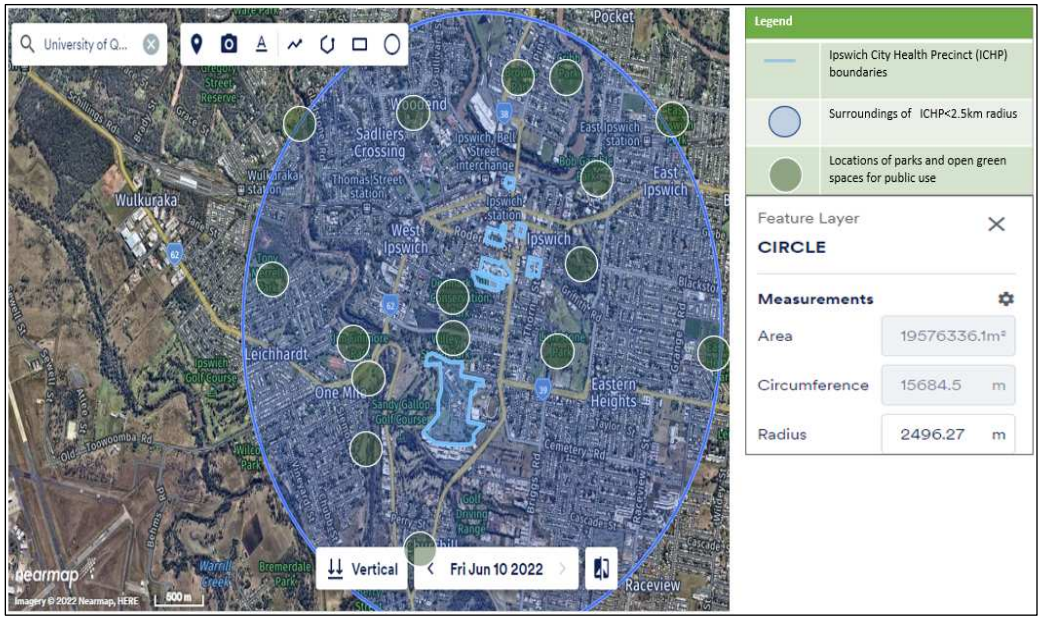

Figure 7: Aerial image of ICHP showing unlimited evidence of public open and green space <2.5km radius

Figure 8: Aerial image of QASEP showing limited evidence of public and open green space <2.5km

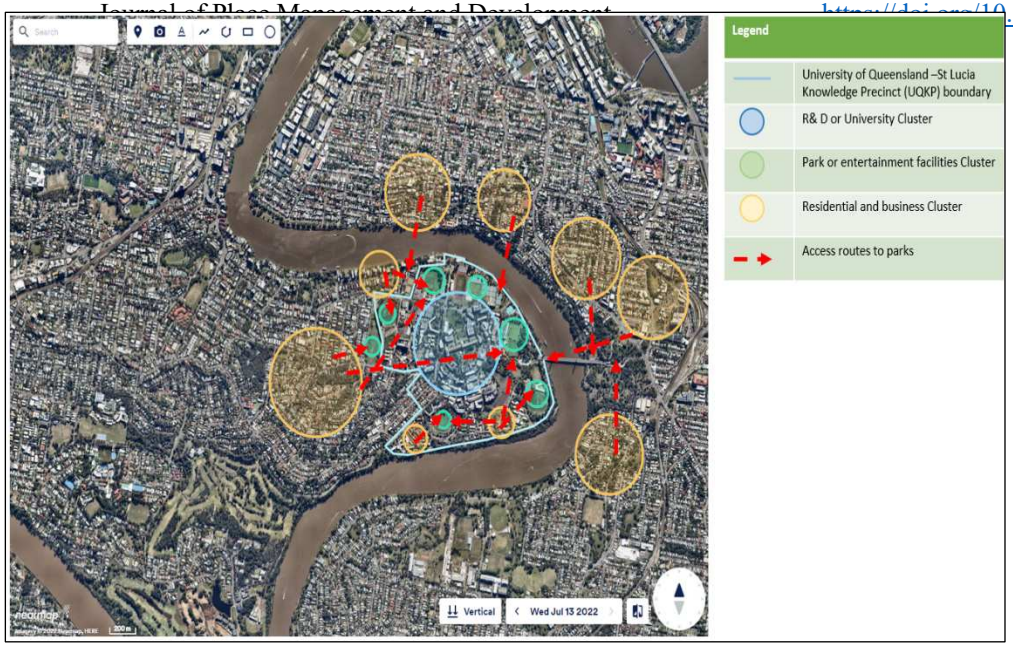

Figure 9: Aerial image of UQKP St Lucia -exemplar of an open layout design

Figure 10: Aerial image of ASEP -exemplar of a semi-open layout design

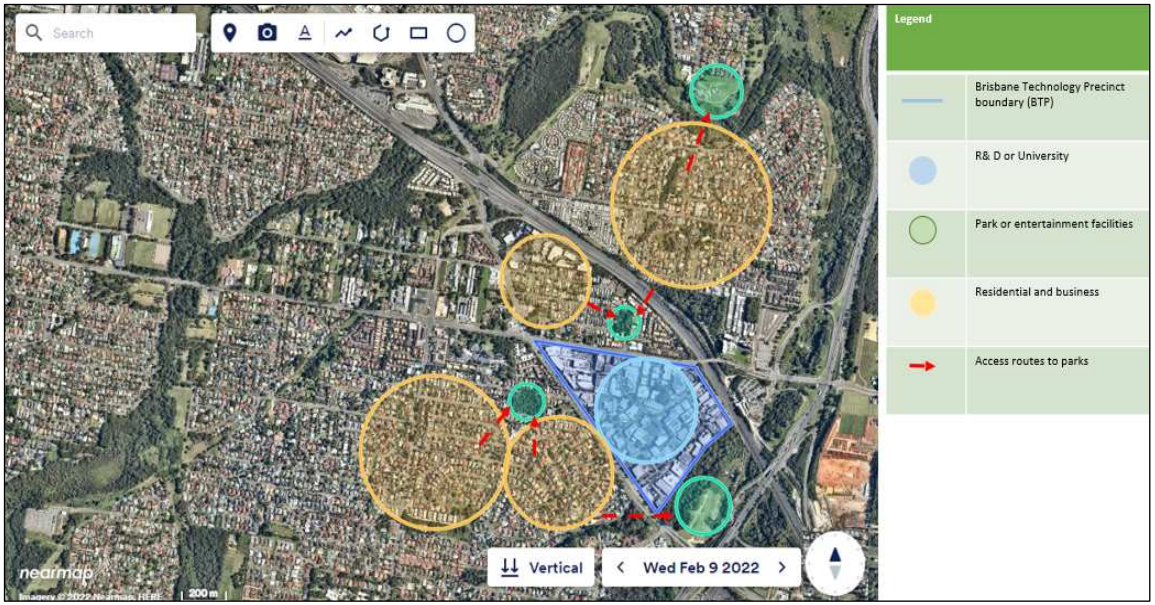

Figure 11: Aerial image of BTP - exemplar of a close layout design

The secondary data collected in this study involve statistical, financial, and descriptive information on 'industry type and employment skills', 'population and demographics', 'principal support and funding body of the district', 'property management' and 'locality' of the innovation districts from the CBD. This information is accessed from various sources including the innovation districts' websites, ABS and DBBD in the following manner.

The names of companies or businesses are identified both from the base maps created from Google My Map during primary data collection stage, and the innovation district websites. These names are then searched on DBBD to generate information on the actual or estimated 'annual income', 'number of employees', 'nationality status of the companies' (i.e., foreign, or national), and 'industry types'. The company's annual income and the number of employees provide information on the relative size of the company—i.e., if it is a 'multi-national enterprise' matching the criteria (=>$1 million, =>50 employees, Australian based company with branches overseas or vice versa) or large national enterprise (=>$1 million, =>50 employees, Australian based) or small and medium enterprise (<$1 million, <50 employees, Australian based). Additionally, the data on number of employees provides an important input for assessing the 'skilled employment' level (i.e., those with Bachelor+ qualifications) within the innovation districts, while 'human capital' level (i.e., potential workforce with Bachelor+ qualifications) is identified by including the surrounding suburbs. We identified surrounding suburbs using ABS statistical area 2 (SA2) definition, meaning human capital statistics included are only from those suburbs that are listed together with the hosting suburb of the innovation district.

Data on the number of industries (i.e., technology intensive business, creativity intensive business and business support service) operating within the innovation district helps to identify the dominant industry type. The 'technology intensive businesses' are defined as those firms involved in industries that provide ICT services, biotechnology or use high-technology and knowledge for production of goods and services and carry out research to generate knowledge and innovation (Baum et al., 2007; Forsyth, 2014) whilst 'creativity-intensive businesses' are those involved in music, films, and gaming industries to generate cultural knowledge (Zheng, 2011; Yigitcanlar et al., 2020b). The third type, 'business support services', are composed of firms providing services such as marketing, auditing, and insurance (Yang & Wang, 2008; Pancholi et al., 2018b) to tenants within the innovation districts.

This study adopts Yigitcanlar et al.'s (2020b) definition of 'technology intensive business' and 'business support services' categories which is beyond the composition suggested in the current literature, to estimate the total business population of the case innovation districts. The expanded composition of the 'technology intensive businesses' includes other health care facilities besides hospitals (e.g., private surgeries and dentistry services), all manufacturing activities and mechanical or engineering workshops. Likewise, other services excluding retail that do not fall into either of the former or 'creativity-intensive services' categories were added to 'business support services' category. These include real estate, wholesalers, consultancy services (including those in the built environment), engineering, financial services, and community services.

Furthermore, data on principal support and funding body of the innovation district development identifies if the initial investment type and partnership is of 'multiple sectors' (i.e., public-university-private-community) or 'two sectors' (i.e., public, and private sector) or 'single sector' (i.e., public, or private sector). Finally, the study relied on SA2 to identify the locality of the innovation districts, whether they are inner city, suburban or regional districts.

All raw data are electronically recorded on either word document (for audit sheets), excel spreadsheet (tenant listing and type), power point slides (graphic evidence of social amenities) or map formats (base maps).

The next step was the process of filtering and normalising of raw data which is a common practice and crucial step in research field prior to the analysis stage. The filtering process aims to avoid bias in the analysis (Morais & Camanho, 2011; Audretsch & Belitski, 2022). For this study, the filtering process was done twice. Firstly, we scanned the identified innovation districts (n=31) to determine their suitability for the audit assessment and removed one (i.e., Sun Central Maroochydore CBD) due

to its still-in-development stage and lack of significant research/knowledge activities, hence, reducing the number of case study sites to 30.

Secondly, all existing tenant businesses with missing values for the estimated annual income and number of employees are excluded from the analysis. However, for those that have at least one missing value e.g., number of employees, instead of following Morais & Kamanho's (2011, p.402) approach of using "minimum value observed in the database for that variable", we adopt average values calculated from the same company size within the same innovation district. Furthermore, the filtering process ensures data brought forward for analysis are reliable and valid, meeting the minimum requirement of the study. In this regard, the raw scores obtained are averaged to obtain a mean composite score (M-scores) which defines the innovation district performance (i.e., strong-moderate-weak) in terms of social amenities, built environment, urban green, and blue infrastructure; computed percentage scores (i.e., strong-moderate-weak) in terms of human capital and skilled labour, industry type (i.e., technology intensive-creativity intensive-business support) and company size (i.e., multinational-large national-small and medium enterprises).

The preliminary findings for the 30 innovation districts within the three jurisdiction areas are summarised in Tables 3-5.

Table 3: Summary results for innovation districts in Brisbane

Dimension	Indicator	Description	Parameter	Measure	Innovation district												
					ATC	BTP	CHEP	DKP	HFSP	HHP	KGUV	PHP	QSEC	SRF	SBP	TPFV	UQKP
Feature	Social amenity	Presence or availability of social amenity for public use	Strong presence of social amenities Moderate presence of social amenities Weak presence of social amenities	Measured by mean composite score. Strong>60, Moderate>50, Weak<50	Weak	Weak	Moderate	Weak	Weak	Moderate	Moderate	Weak	Moderate	Weak	Moderate	Moderate	Moderate
	Human capital	Inventory of skilled people (i.e., information about education and skilled level of the population and potential stock of qualified people)	Strong human capital Moderate human capital Weak human capital	Percentage of knowledge workers with BA or higher. Strong>50%, Moderate>25%, Weak<25%	Moderate	Strong	Moderate	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Moderate
	Skilled labour	Skilled employment outcome of the - innovation district activities	Strong skilled employment Moderate skilled employment Weak skilled employment	Ratio of knowledge workers jobs to total innovation districts jobs. Strong>50%, Moderate>25%, Weak<25%	Weak	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Strong
	Locality setting	Location of the district within the metro-politan area	Inner city Suburban Region	Location of the innovation district. Inner city, Suburban, Region	Suburban	Suburban	Suburban	Suburban	Suburban	Inner city	Inner city	Suburban	Inner city	Suburban	Inner city	Inner city	Suburban
Function	Company size	Relative size of the firms within the innovation district (i.e., SME dominated,- LNE dominated or MNE anchored)	Multinational (MNE) anchored Large national (LNE) dominated Small and medium (SME) dominated	Ratio of number of firm types to total - firms within the innovation districts. MNE anchored if >50%, LNE dominated if >50%, SME dominated if >50%	LNE	LNE	LNE	LNE	LNE	LNE	SME	LNE	LNE	LNE	LNE	LNE	LNE
	Industry type	Dominant business activity operating within the innovation district	Technology intensive business Creativity intensive business Business support services	Dominant business activity of the district. Technology intensive if >50% Creativity intensive if >50% Bussiness support if >50%	Business support	Technology intensive	Technology intensive	Technology intensive	Technology intensive	Business support	Business support	Technology intensive	Business support	Technology intensive	Business support	Business support	Business support
	Investment type	Principle support and funding body for the- development of the innovation district	Public-private-community partnership Public-private partnership Public or private sector	Mutiple sectors Two sectors Single sector	Multiple sectors	Single sector	Two sectors	Multiple sectors	Multiple sectors	Two sectors	Multiple sectors	Two sectors	Multiple sectors	Single sector	Multiple sectors	Multiple sectors	Two sectors
	Property management	Management model of the innovation district's properties and activities	Managed by a district management Managed by a building management No form of management	District wide Building level None	District wide	District wide	District wide	Building level	District wide	District wide	District wide	Building level	District wide	Building level	District wide	District wide	District wide
Form	Urban green and blue infrastructure	Aesthetic qualities of urban green and blue- infrastructure within the innovation district (i.e., all natural and semi-natural landscape- elements that form a green-blue network)	Strong presence of ecosystems services Moderate presence of ecosystems services Weak presence of ecosystems services	Measured by design principles of blue-green infrastructure- City level (blue infrastructure) and Cluster level (green infrastructure) Strong>50%, Moderate>25%, Weak<25%	Strong	Strong	Strong	Strong	Strong	Moderate	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
	Land use-mix	Main land use types within the - innovation districts	Complex mix Mixed use Single us	Work-learn-live-play Work-learn-live or play Work or learn	Mixed use	Mixed use	Mixed use	Mixed use	Mixed use	Mixed use	Complex mix	Mixed use	Mixed use	Mixed use	Complex mix	Complex mix	Complex mix
	Built environment	Architectural designs of built forms and- designs encouraging connectivity; and mobility within the innovation districts	Strong internal connectivity Moderate internal connectivity Weak internal connectivity	Measured using composite scores to determine- internal connectivity. Strong>60, Moderate>50, Weak<50	Moderate	Strong	Moderate	Strong	Moderate	Strong	Strong	Weak	Strong	Weak	Strong	Strong	Strong
	Space design	Spatial layouts design encouraging- open innovation system within the - innovation districts	Open layout plan Semi-open layout plan Close layout plan	Measured by zonings to determine if the design- encourage knowledge generation within- the innovation district. Open layout plan, Semi-open layout and Close- layout plan	Close layout	Close layout	Close layout	Close layout	Close layout	Close layout	Open layout	Close layout	Open layout	Close kayout	Open layout	Open layout	Open layout

Table 4: Summary results for innovation districts in Ipswich, Lockyer, Toowoomba, Moreton Bay, Redland, and Logan

Dimension	Indicator	Description	Parameter	Measure	Innovation district										
					ASEP	CHP	CLHP	ICHP	IDIH	KPGS	MHKP	QASP	RHP	THP	TMP
Feature	Social amenity	Presence or availability of social amenity for public use	Strong presence of social amenities Moderate presence of social amenities Weak presence of social amenities	Measured by mean composite score. Strong>60, Moderate>50, Weak<50	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak
	Human capital	Inventory of skilled people (i.e., information about education and skilled level of the population and potential stock of qualified people)	Strong human capital Moderate human capital Weak human capital	Percentage of knowledge workers with BA or higher. Strong>50%, Moderate>25%, Weak<25%	Moderate	Weak	Moderate	Moderate	Moderate	Moderate	Moderate	Weak	Moderate	Moderate	Moderate
	Skilled labour	Skilled employment outcome of the - innovation district activities	Strong skilled employment Moderate skilled employment Weak skilled employment	Ratio of knowledge workers jobs to total innovation districts jobs. Strong>50%, Moderate>25%, Weak<25%	Moderate	Strong	Strong	Strong	Moderate	Moderate	Strong	Moderate	Strong	Strong	Strong
	Locality setting	Location of the district within the metro-politan area	Inner city Suburban Region	Location of the innovation district. Inner city, Suburban, Region	Inner city	Regional	Inner city	Inner city	Inner city	Inner city	Inner city	Regional	Regional	Inner city	Regional
Function	Company size	Relative size of the firms within the innovation district (i.e., SME dominated,- LNE dominated or MNE anchored)	Multinational (MNE) anchored Large national (LNE) dominated Small and medium (SME) dominated	Ratio of number of firm types to total - firms within the innovation districts. MNE anchored if >50%, LNE dominated if >50%, SME dominated if >50%	LNE	LNE	LNE	LNE	SME	LNE	LNE	LNE	LNE	SME	LNE
	Industry type	Dominant business activity operating within the innovation district	Technology intensive business Creativity intensive business Business support services	Dominant business activity of the district. Technology intensive if >50% Creativity intensive if >50% Bussiness support if >50%	Technology-intensive	Technology-intensive	Technology-intensive	Technology-intensive	Technology-intensive	Business-support	Technology-intensive	Technology-intensive	Business-support	Technology-intensive	Technology-intensive
	Investment type	Principle support and funding body for the- development of the innovation district	Public-private-community partnership Public-private partnership Public or private sector	Mutiple sectors Two sectors Single sector	Single sector	Single sector	Two sectors	Two sectors	Two sectors	Two sectors	Single sector	Single sector	Single sector	Two sectors	Single sector
	Property management	Management model of the innovation district's properties and activities	Managed by a district management Managed by a building management No form of management	District wide Building level None	District wide	District wide	Building level	Building level	Building level	District wide	Building level	District wide	Building level	District wide	District wide
Form	Urban green and blue infrastructure	Aesthetic qualities of urban green and blue-infrastructure within the innovation district (i.e., all natural and semi-natural landscape-elements that form a green-blue network)	Strong presence of ecosystems services Moderate presence of ecosystems services Weak presence of ecosystems services	Measured by design principles of blue-green infrastructure- City level (blue infrastructure) and Cluster level (green infrastructure) Strong>50%, Moderate>25%, Weak<25%	Strong	Moderate	Strong	Strong	Weak	Strong	Strong	Strong	Strong	Moderate	Strong
	Land use-mix	Main land use types within the - innovation districts	Complex mix Mixed use Single us	Work-learn-live-play Work-learn-live or play Work or learn	Complex mixe	Mixed use	Single use	Mixed use	Single use	Complex mixe	Mixed use	Complex mixe	Single use	Mixed use	Mixed use
	Built environment	Architectural designs of built forms and- designs encouraging connectivity; and mobility within the innovation districts	Strong internal connectivity Moderate internal connectivity Weak internal connectivity	Measured using composite scores to dtermine- internal connectivity. Strong>60, Moderate>50, Weak<50	Strong	Moderate	Strong	Strong	Moderate	Strong	Moderate	Weak	Moderate	Moderate	Moderate
	Space design	Spatial layouts design encouraging- open innovation system within the - innovation districts	Open layout plan Semi-open layout plan Close layout plan	Measured by zonings to determine if the design- encourage knowledge generation within- the innovation district. Open layout plan, Semi-open layout and Close- layout plan	Semi-open	Close	Close	Semi-open	Close	Semi-open	Semi-open	Open	Close	Close	Semi-open

Table 5: Summary results for innovation districts in Gold Coast and Sunshine Coast

Dimension	Indicator	Description	Parameter	Measure	Innovation district					
					CCH	GCHKP	RVHEMP	SGCAP	SDKP	SCHMP
Feature	Social amenity	Presence or availability of social amenity for public use	Strong presence of social amenities Moderate presence of social amenities Weak presence of social amenities	Measured by mean composite score. Strong>60, Moderate>50, Weak<50	Weak	Weak	Weak	Weak	Weak	Weak
	Human capital	Inventory of skilled people (i.e., information about education and skilled level of the population and potential stock of qualified people)	Strong human capital Moderate human capital Weak human capital	Percentage of knowledge workers with BA or higher. Strong>50%, Moderate>25%, Weak<25%	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
	Skilled labour	Skilled employment outcome of the - innovation district activities	Strong skilled employment Moderate skilled employment Weak skilled employment	Ratio of knowledge workers jobs to total innovation districts jobs. Strong>50%, Moderate>25%, Weak<25%	Strong	Strong	Strong	Strong	Strong	Strong
	Locality setting	Location of the district within the metro-politan area	Inner city Suburban Region	Location of the innovation district. Inner city, Suburban, Region	Suburban	Inner city	Suburban	Suburban	Suburban	Suburban
Function	Company size	Relative size of the firms within the innovation district (i.e., SME dominated,- LNE dominated or MNE anchored)	Multinational (MNE) anchored Large national (LNE) dominated Small and medium (SME) dominated	Ratio of number of firm types to total - firms within the innovation districts. MNE anchored if >50%, LNE dominated if >50%, SME dominated if >50%	LNE	LNE	LNE	SME	SME	SME
	Industry type	Dominant business activity operating within the innovation district	Technology intensive business Creativity intensive business Business support services	Dominant business activity of the district. Technology intensive if >50% Creativity intensive if >50% Bussiness support if >50%	Creativity-intensive	Business - support	Business - support	Business - support	Business - support	Business - support
	Investment type	Principle support and funding body for the-development of the innovation district	Public-private-community partnership Public-private partnership Public or private sector	Mutiple sectors Two sectors Single sector	Single sector	Single sector	Two sectors	Two sectors	Single sector	Single sector
	Property managemen	Management model of the innovation district's properties and activities	Managed by a district management Managed by a building management No form of management	District wide Building level None	District wide	District wide	District wide	District wide	District wide	District wide
Form	Urban green and blue infrastructure	Aesthetic qualities of urban green and blue-infrastructure within the innovation district (i.e., all natural and semi-natural landscape-elements that form a green-blue network)	Strong presence of ecosystems services Moderate presence of ecosystems services Weak presence of ecosystems services	Measured by design principles of blue-green infrastructure- City level (blue infrastructure) and Cluster level (green infrastructure) Strong>50%, Moderate>25%, Weak<25%	Strong	Strong	Strong	Strong	Strong	Strong
	Land use-mix	Main land use types within the - innovation districts	Complex mix Mixed use Single use	Work-learn-live-play Work-learn-live or play Work or learn	Single use	Complex mixe	Mixed use	Complex mixe	Mixed use	Complex mixed
	Built environment	Architectural designs of built forms and-designs encouraging connectivity; and mobility within the innovation districts	Strong internal connectivity Moderate internal connectivity Weak internal connectivity	Measured using composite scores to dtermine-internal connectivity. Strong>60, Moderate>50, Weak<50	Moderate	Strong	Moderate	Strong	Moderate	Strong
	Space design	Spatial layouts design encouraging-open innovation system within the - innovation districts	Open layout plan Semi-open layout plan Close layout plan	Measured by zonings to determine if the design-encourage knowledge generation within-the innovation district. Open layout plan, Semi-open layout and Close-layout plan	Close layout	Semi-open	Semi-open	Close layout	Open layout	Open layout

3.4. Methodology and results

The study employed qualitative analysis methods to analyse primary and secondary data obtained for the 30 innovation districts. In addition, descriptive data analysis and basic calculations, through Excel spreadsheets, are performed to analyse the validity of the data obtained. These approaches have been commonly used for data analysis in the research field including urban studies in assessing place quality in innovation districts (Esmaeilpoorarabi et al., 2018a) and urban quality of life (Jensen et al., 2004; Li & Weng, 2007; Shen et al., 2013), thus found appropriate for the current study.

Descriptive data of all 30 innovation districts in Tables 3-5 are then converted into a 'case study matrix' for ease of reference. The matrix has three vertical levels of A, B, and C representing the three tier measures (e.g., strong, moderate, weak, or inner city, suburban, regional) in the framework and 12 horizontal levels (i.e., o1-o4; e1-e4; u1-u4) representing 12 indicators under three dimensions of form, feature, and function. At this stage of data analysis, the matrix provides a brief descriptive analysis of each of the case innovation districts.

For example, Table 6 describes Diamantina Knowledge Precinct as per type [o1B, o2C, o3A, o4A] + [e1A, e2A, e3C, e4B] + [u1A, u2A, u3B, u4B] (shaded in grey), which can be described as: '*A mixed-use close design innovation district with strong features in the forms of built environment and urban green and blue infrastructure, located in a suburban area with weak social amenity and with strong human capital, skilled labour. It is funded by a multiple-sectors investment partnership and is dominated by large national technology intensive businesses under building level management.'*

Table 6: An example case study matrix: Diamantina Knowledge Precinct

Form				
		A	B	C
Land-use mix	o1	Complex mixed	Mixed use	Single use
Space design	o2	Open	Semi-open	Closed
Built environment	o3	Strong	Moderate	Weak
Urban green and blue infrastructure	o4	Strong	Moderate	Weak
Feature				
		A	B	C
Human capital	e1	Strong	Moderate	Weak
Skilled labour	e2	Strong	Moderate	Weak
Social amenity	e3	Strong	Moderate	Weak
Locality setting	e4	Inner city	Suburban	Regional
Function				
		A	B	C
Investment type	u1	Multiple sectors	Two sectors	Single sector
Industry type	u2	Technology intensive	Creativity intensive	Business support
Company size	u3	Multinational	Large national	Small and medium
Property management	u4	District wide	Building level	None

Similar descriptions are also formulated for the remaining innovation districts under study. As a next step, the descriptive measures of A, B, and C per example in Table 6 are converted to categorical values to compute the overall performance scores. The categorical values of the measurements are translated as: A=complex mix, open, strong, inner city, multiple sectors, technology intensive, multinational and district wide, B=mixed use, moderate, suburban, two sectors, creativity intensive, large national and building levels, and C= single use, closed, weak, regional, single sector, business support, small and medium and none. For example, as highlighted in Table 6, DKP's audit scores are the following: Land-use mix=B, Space design=C, Built environment=A, Urban green-blue infrastructure=A, Human capital=A, Skilled labour=A, Social amenity=C, Locality setting=B, Investment type=A, Industry type=A, Company size=B and Property management=B. Similar conversion of descriptive measures to categorical values are repeated for the other 29 case districts then excel spreadsheet is used to compute the 'net scores' of all the categorical values to develop a performance score table and analyse the innovation districts' performances (see Table 7).

To calculate the 'net scores' also known as 'net performance scores' following simple formula is employed:

Net score = Percentage of A dimensions – Percentage of C dimensions

For example, DKP has 6 As, 2 Cs and 4 Bs; therefore, the net score is 33. The maximum net score is achieved if a district receives all As, the net score would be 100; whereas a district with all Cs will have -100 net score. In other words, innovation districts with more A's have positive net scores than those with more Cs that will have negative scores. According to the rule of calculating 'net scores', the B scores are excluded because they are regarded as 'Passive' scores (Baehre et al., 2022) and do not contribute value. Furthermore, both the percentage of As and Cs are expressed in percentile score whilst the net scores are expressed in metric. The analysed performance scores for all case districts are presented in Table 7. For ease of reference, each indicator is colour coded according to their performance.

After calculating the performance net scores, the 30 innovation districts are ranked according to the ranking criterion inspired by a combination of Australia's Green Star Rating and the 'net promotor score' (NPS). The former's rating system is an internationally recognised Australian sustainability rating and certification system by the Green Building Council of Australia (GBCA). It has four rating tools including 'Green Star-Communities' and 'Green Star-Performance' which are related to the current study. While the former tool assesses the development stages of large-scale development projects of a precinct or community scale and covers five categories including 'governance', 'liveability', 'economic prosperity', 'environment' and 'innovation' (GBCA, 2021), the latter tool assesses the operational performance of existing buildings which covers broad environmental issues related with the building development process including 'indoor environmental quality', 'energy efficiency' and 'water efficiency' (Xia et al., 2013; Zuo et al., 2016).

Green Star's ranking criterion ranges from 1 Star to 6 Star, where 1 Star rating = 10 points score indicating minimum practice, 2-4 Star Rating = 20-40 scores representing average to best practice, respectively. A 5 Star rating = 60 points score represents the Australia's best practice, and 6 Star rating =75+ point score stands for World leadership. Meanwhile, the latter's rating system "is a summary statistic commonly used in commercial survey research to estimate the propensity of business' customers to exhibit desirable behaviors" (Reichheld, 2003; Rocks, 2016, p.365). The NPS typically uses a marketing accountability metric known as a 'Likelihood-to- Recommend' (LTR) question to obtain responses from customers. A Likert scale of 0-10 scores is presented in a single questionnaire for customer's rating (Baehre et al., 2022). The NPS ranking criterion ranges from -100-0 (Needs improvement), 0-30 (Good), 30-70 (Great), 70-100 (Excellent) (Retently, 2022). Note that the criterion range can also be in decimal form (i.e., -1.0-0.00, 0-0.3, 0.3-0.7, 0.7-1.0).

The current study adopts the combination of Green Star's ranking system and the NPS' operational method of analyzing the audit scores. The reason being that the Green Star Rating system is most relevant to the study as it concerns performance assessment of built environment and land development projects unlike NPS' which concerns customer recommendations for businesses. However, whilst we chose not to adopt NPS' ranking system, we have adopted its operational method of calculating the 'net scores' because it is statistically sound for analysis of the categorical variables (see Table 7). Hence, the study generally adopts Green Star Rating system however, we modified the ranking criteria to: net scores from -100 to 10 are defined as Unsavoury category (red colour); 10 to 60 net scores as Acceptable category (yellow in colour) and 60-100 net scores as Desired category (green in color). The rationale for modifying the ranking criteria is firstly, to cater for our derived net scores range of -100 to 100 secondly, to set a very high-performance rating ??as we are assessing the holistic dimensions of innovation districts in terms of their form, feature, and function. Furthermore, there is very high expectation for innovation districts to deliver socioeconomic benefits to the cities that host them. Table 7 presents summary of the innovation districts' net scores with a colour coding for visual interpretation. Note that 'B' values are blank out due to their exclusion in the net score calculation.

Table 7: Innovation district performance net scores

Dimension	Category	Indicator	ASEP	ATC	BTP	CHP	CHEP	CLHP	CCH	DKP	GCHKP	KPGS	HFSP	HHP	ICHP	IDIH	KGUV	MHKP	PHP	QASEP	QSEC	RHP	RVHEMP	SRF	SDKP	SBP	SGCAP	SCHMP	TMP	THP	TPFV	UQKP
Form	Complexity & Layout	Land-use mix	A	B	B	B	B	B	C	B	A	A	B	B	B	C	A	B	B	A	B	C	A	B	B	A	A	B	B	B	B	A
		Space design	A	C	C	C	C	C	C	C	B	B	C	C	C	C	A	B	C	A	A	C	A	C	A	A	C	A	B	C	C	A
	Connectivity & Design	Built environment	A	B	A	B	C	A	B	A	B	B	B	A	B	B	A	B	C	C	A	B	B	C	B	A	A	A	B	B	A	A
		Urban green or blue infrastructure	A	A	A	B	A	A	A	A	A	B	A	B	A	C	A	A	A	A	A	A	A	B	A	A	A	A	A	B	B	A
		Sub-net score	*100*	*0*	*25*	*-25*	*-25*	*25*	*-25*	*25*	*50*	*25*	*0*	*0*	*0*	*-75*	*100*	*25*	*-25*	*50*	*75*	*-25*	*75*	*-50*	*50*	*100*	*50*	*75*	*25*	*-25*	*0*	*100*
Feature	Centrality & Amenity	Social amenity	C	C	C	C	B	C	C	C	C	C	C	B	B	C	B	B	C	C	B	C	B	C	B	B	B	B	C	C	B	B
		Locality setting	A	B	B	C	B	A	B	B	A	A	B	A	A	A	A	A	B	C	A	C	B	B	B	A	B	B	C	A	A	B
	Intelligence & Concentration	Human capital	B	B	A	C	B	B	A	A	B	B	A	A	B	B	A	B	A	C	A	B	B	A	B	A	B	B	B	B	A	B
		Skilled labour	B	C	A	A	A	A	B	A	A	B	A	A	A	B	A	A	A	B	A	A	A	A	A	A	B	A	A	A	A	A
		Sub-net score	*0*	*-50*	*25*	*-50*	*25*	*25*	*0*	*25*	*25*	*0*	*25*	*75*	*50*	*0*	*75*	*50*	*25*	*-75*	*75*	*-25*	*25*	*25*	*25*	*75*	*0*	*25*	*-25*	*25*	*75*	*25*
Function	Specialisation & Diversity	Investment type	B	A	C	B	B	B	B	A	A	A	C	B	B	B	A	A	B	B	A	C	A	C	B	A	A	A	B	B	C	B
		Industry type	A	C	A	A	A	A	B	A	C	C	B	C	A	A	C	C	A	A	C	A	C	A	C	C	C	C	A	A	A	C
	Scale & Support	Company size	B	B	B	B	B	B	B	B	B	B	A	B	B	C	B	B	B	B	C	B	B	B	C	B	C	C	B	C	B	B
		Property management	A	A	B	B	A	B	A	B	A	A	A	A	A	B	A	B	B	A	A	B	B	B	A	A	B	A	A	B	B	A
		Sub-net score	*50*	*25*	*0*	*25*	*50*	*25*	*25*	*50*	*25*	*25*	*50*	*0*	*50*	*0*	*25*	*0*	*25*	*50*	*0*	*0*	*0*	*0*	*-25*	*25*	*25*	*0*	*50*	*0*	*0*	*0*
		Total No. Categorical values	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
		Percentage 'A' dimensions	*58*	*25*	*42*	*17*	*33*	*42*	*25*	*50*	*50*	*33*	*42*	*42*	*42*	*17*	*75*	*33*	*33*	*42*	*67*	*25*	*42*	*25*	*33*	*75*	*33*	*50*	*33*	*25*	*42*	*50*
		Percentage 'C' dimensions	*8*	*33*	*25*	*33*	*17*	*17*	*25*	*17*	*17*	*17*	*25*	*17*	*8*	*42*	*8*	*8*	*25*	*33*	*17*	*42*	*8*	*33*	*17*	*8*	*25*	*17*	*17*	*25*	*17*	*8*
		Net score	50	-8	17	-17	17	25	0	33	33	17	17	25	33	-25	67	25	8	8	50	-17	33	-8	17	67	8	33	17	0	25	42

Note: 1. Category sub-net scores are highlighted in bold-italic, and overall net-scores are highlighted in bold for easy identification. 2. Green represents desirable performance, Yellow represents acceptable performance, Red represents unsavoury performance, Category sub net-scores and overall net- scores cells are highlighted by boxing for easy identification.

4. Findings

The data collected are analysed using qualitative and descriptive analysis and excel spreadsheet computation. One of the main outcomes of this study is the performance matrix, presented in Figure 12, displaying nine classes of the innovation districts according to their performance regarding the form, feature, and function. In addition, three main classes represent overall performance levels of innovative districts as desirable, acceptable, and unsavoury. Particularly, innovation districts are ranked first in terms of the sub-net scores for each of the three dimensions, i.e., form, feature, function. Those with sub-net scores between 60-100 are rated as 'desirable' performers, while those with 10-60 sub-net scores are rated as 'acceptable' performers and the least ones with sub-net scores—100-10 are rated as 'unsavoury' performers. Secondly, they are rated according to their overall performance based on the net scores calculated from all the three dimensions. Another important outcome of the study is the performance ranking of innovation districts based on the overall net scores (see Table 8).

The results for the 'form' dimension reveal that seven innovation districts perform at the desirable level whilst ten at acceptable level and the remaining thirteen are below acceptable level or unsavoury performers. Score wise, ASEP, KGUV, SBP, and UQKP have the top sub-net score of 100 due to scoring A scores across all 4 indicators whilst QSEC, RVEMP and SCHMP scored lower with a net score of 75. The difference in net scores by 25 points between the top seven performers was due to the lower group having one B score amongst the A scores which is excluded in the net score calculation. The exclusion rule of the B scores is applicable throughout the analysis. The acceptable performers include GCHKP, QASP and SDKP with the net score of 50 and the lower performers include BTP, KPGS and MHKP with the net score of 25. The 25-points difference between the top and low performers in this class is due to the top performers having a mixture of A and B scores and lower performers B and C scores. Regarding the unsavoury performers, ATC, HHP and TPFV are among the top range of low performers with net score of 0 and IDIH is the only low range performer with the net score of -75 (Figure 12). The difference of -75 net score is due to the top performer having one A and one C scores which cancels each other whilst the low performer has three C, one B and no A scores hence, the negative net score.

Results for 'feature' dimension show that five innovation districts are in the desirable performance class whilst fifteen are in acceptable performance and ten in unsavoury performance classes. KGUV, SBP and QSEC continue to maintain their position as top performers as in the 'form' dimension while the other four, namely ASEP, RVHEMP, SCHMP, and UQKP dropped in their performance and are replaced by HHP and TPFV. Score-wise, all five innovation districts have a sub-net score of 75 across, they fell short of 25 scores to the full net score of 100 due to having one B score amongst the A scores. Likewise, six of the acceptable performers including BTP, CHEP, CLHP, and DKP maintain their leading position as in 'form' whilst the other four drop in performance and are replaced by five new inclusions including ICHP, RVHEMP and UQKP. Score wise, the top performers have a sub-net score of 50 and the low performer's sub-net score is 25. The difference of 25 net score between the top and low performers in this class is due to the former having only A and B scores compared to the latter having A and C scores. CHP and RHP continue to be in the unsavoury cluster as they are in 'form' while the other five including CCH, IDIH and PHP improve their performance from unsavoury class in 'form' to acceptable class in 'feature'. The new inclusions for unsavoury class are ATC, QASP and TMP, their top sub-net score is 0 and low of -75 (Figure 1).

Results for 'function' dimension indicate that no innovation district qualify for desirable performance, seventeen are in the acceptable performance and thirteen in the unsavoury classes. KGUV and SBP are the leading performers for the former two dimensions (i.e., form and feature) however, their performance dropped for function dimension due to having a mixture of A, B and C scores whilst the other innovation district's low scores are due to having more B scores which are excluded in the net score calculations. Score-wise, the top net score for acceptable performance class was 50 and the lowest score was 25. The top performers in the unsavoury performance class include BTP, QSEC and UQKP with the same net score of 0. These districts either have one A and one C

scores which cancels themselves or all B scores which are excluded. On the other hand, SRF is the only low performer with a negative net score of -75.

In sum innovation districts with all or more A scores perform better than those with a mixture of A and C or C only. The overall performance of the 30 case districts is illustrated in a performance matrix.

The performance matrix, presented in Figure 1, is created based on the net score calculation for each of the 30 innovation districts. According to the matrix, two innovation districts; namely, KGUV (Kelvin Grove Urban Village) and SBP (South Brisbane Precinct) qualify as overall desirable performers and are the top performers in SEQ region (see Table 8). Whilst majority (n=18) of the innovation districts including DKP, GCHKP and SDKP qualify as acceptable performers, and ten unsavoury performers including ATC, CHP, IDIH, RHP, and SRF due to performance below the acceptable level.

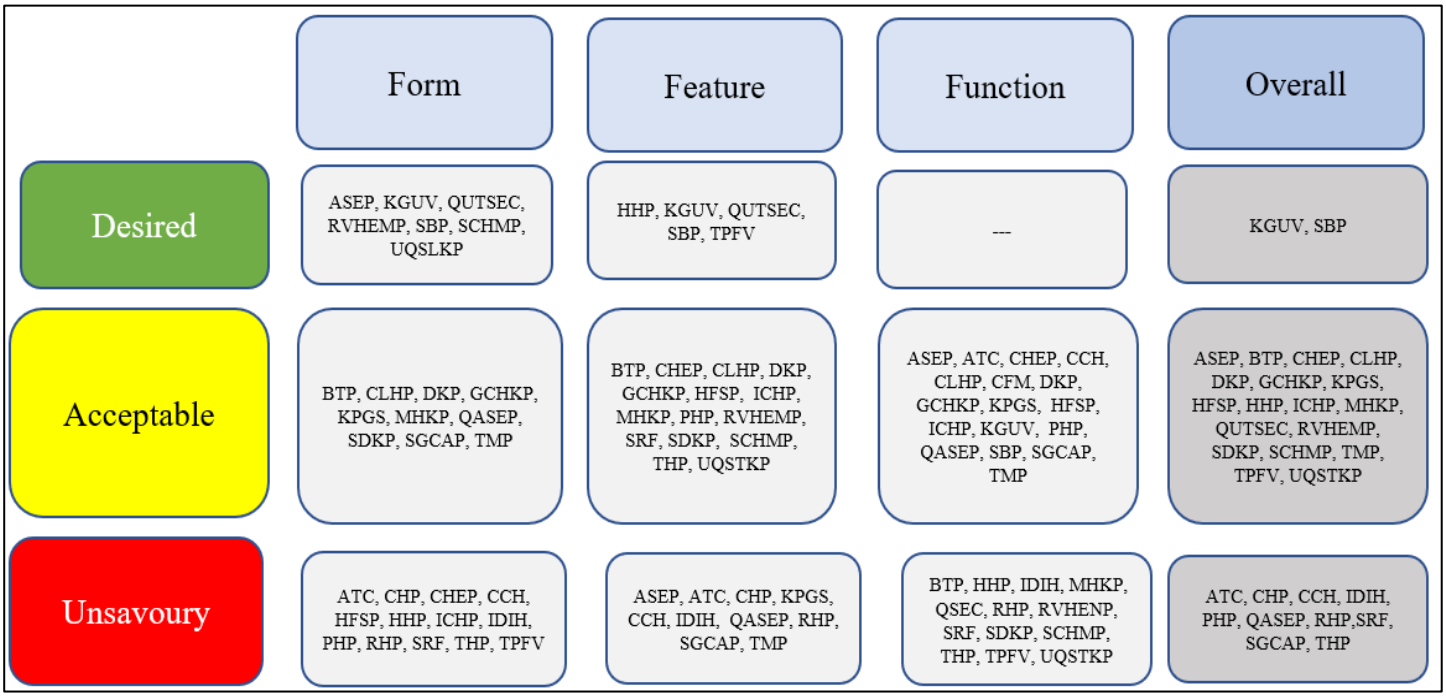

Figure 12: Performance matrix of the case innovation districts

Note: Innovation district abbreviations are listed in Table 8

Table 8: Ranking of top and bottom innovation districts based overall mean score

Local government area	Innovation district	Abbreviation	Score*	Ranking
Brisbane	Kelvin Grove Urban Village	KGUV	67	1
Brisbane	South Brisbane Precinct	SBP	67	1
Toowoomba	Agriculture Science & Engineering Precinct	ASEP	50	2
Brisbane	QUT Technology Precinct	QSEC	50	2
Brisbane	UQ St Lucia Knowledge Precinct	UQKP	42	3
Brisbane	Diamantina Knowledge Precinct	DKP	33	4
Gold Coast	Robina/Varsity Lake Health, Education & Multidisciplinary Precinct	RVHEMP	33	4
Gold Coast	Gold Coast Health and Knowledge Precinct	GCHKP	33	4
Sunshine Coast	Sunshine Coast Health & Medical Precinct	SCHMP	33	4
Ipswich	Ipswich City Health Precinct	ICHP	33	4
Brisbane	Herston Health Precinct	HHP	25	5
Brisbane	The Precinct Fortitude Valley	TPFV	25	5
Redland	Cleveland Health Precinct	CLHP	25	5
Moreton Bay	Meadowbrook Health and Knowledge Precinct	MHKP	25	5
Brisbane	Brisbane Technology Precinct	BTP	17	6
Brisbane	Chermside Health and Education Precinct	CHEP	17	6
Brisbane	Health and Food Science Precinct	HFSP	17	6
Ipswich	Knowledge Precinct Greater Springfield	KPGS	17	6
Sunshine Coast	Sippy Downs Knowledge Precinct	SDKP	17	6
Moreton Bay	The Mill (USC) Precinct	TMP	17	6
Brisbane	Pinjarra Hills Precinct	PHP	8	7
Lockyer Valley	Queensland Animal Science Precinct	QASP	8	7
Gold Coast	Southern Gold Coast Airport Precinct	SGCAP	8	7
Gold Coast	Coomera Creative Hub	CCH	0	8
Toowoomba	Toowoomba Health Precinct	THP	0	8
Brisbane	Australian Trade Coast	ATC	-8	9
Brisbane	Salisbury Research Facility	SRF	-8	9
Moreton Bay	Redcliffe Health Precinct	RHP	-17	10
Morton Bay	Caboolture Health Precinct	CHP	-17	10
Ipswich	Ipswich Defence Industry Hub	IDIH	-25	11

*Note: * Scores are out of 100; Green colour represents desirable performance, Yellow represents acceptable performance, Red represents unsavoury performance*

5. Discussion and conclusion

Majority of the innovation districts (18 out of 30) qualify as acceptable performers. Unlike the desirable performers, which are only located in the inner cities, acceptable performers comprise of innovation districts located in inner-city area (e.g., QSEC), suburban areas (e.g., BTP), and regional areas (e.g., QASP). The top performers in this class are those that have a net score above 20 and are ranked in placings from 2 to 5 (table 8). They include QSEC and UQKP (Brisbane), ASEP (Toowoomba), RVHEMP (Gold Coast) and SCHMP (Sunshine Coast), ICHP (Ipswich), CLHP (Redland) and MHKP (Moreton Bay) whereas the bottom performers include BTP (Brisbane), KPGS(Ipswich) and TMP (Moreton Bay).

This class comprises of five innovation districts which are in Brisbane's eight global precincts namely 'Boggo Rd, PA Hospital-UQ' (UQKP, DKP); 'Kelvin Grove-Herston' (HHP); 'Valley Gateway' (TPFV) and 'Mt Gravatt-Eight Mile Plains' (BTP) (BCC,2019). Furthermore, some of these innovation districts performance is supported by previous research which justify their inclusion in this class. They include DKP and BTP which were ranked second and third placings respectively in terms of 'place quality' (Esmaeilpoorarabi et al., 2018b). Gold Coast Health and Knowledge Precincts (GCHKP) is referred as a world -class hub of knowledge, innovation, employment, and investment', and RVHEMP is recognised as Gold Coast's second largest knowledge and health precincts respectively (O'Hare et al., 2012).

In fact, the wide-spread distribution of these innovation districts in the region shows Queensland's effort to turn its region into hubs for innovation and enterprise (Advance Queensland, 2021a, b). The common strength of acceptable performance class is 'urban green and blue infrastructure,' 'skilled

labour' and 'property management'. The performance indicators that need future intervention include 'space design', 'social amenity' and 'investment type.'

The unsavoury performers are also situated in all the localities, including suburban areas (e.g., ATC, CHP, SRF), inner-city (IDIH), and regional areas (RHP). The top performers in this class include PHP (Brisbane), QASP (Lockyer Valley) and SGCAP (Gold Coast) and the low performers include ATC (Brisbane), RHP (Moreton Bay), and IDIH (Ipswich). It is interesting to note that this class is composed of the largest precinct (ATC) to the smallest hubs (IDIH & SRF) in the region, which suggests that the size of innovation district does not automatically equate its performance in terms of the form, feature, and function. For instance, ATC's inclusion in this class may seem contradictory to the common knowledge of it being one of the solid contributors to the SEQ region and to the State's gross domestic product (DILGP, 2017; Colliers International, 2019). However, despite its economic significance in the region and state, it has limited presence of R&D facilities and activities and is dominated by business support services (i.e., industrial, and commercial activities). Furthermore, ATC is a close-design development because Queensland's two largest ports it hosts—i.e., the Brisbane Airport and Port of Brisbane, are special land-use developments. Such characteristics result in lower scores for ATC. This cluster's common strength is in 'skilled labour' indicator, while all other indicators need intervention.

The result of the unsavoury performance of these precincts clearly points to the directions for interventions to improve their social and economic significance. For example, innovation districts with weak level in social amenities needs to improve to moderate or strong level or land-use mix from single to mixed use or complex-mixed use. However, it is noteworthy that the proposed interventions may not be practicable for some existing innovation districts. For instance, those districts that scored low for space-design cannot be immediately redesigned into open innovation districts (which is the preferred one) due to the initial purpose for development (e.g., HFSP). Although the same rule applies for locality setting, a change in property management style from building level to district wide level or a change in investment type is practicable. Hence, the findings of this study are most relevant and appropriate for consideration in the planning and development phases of innovation districts rather than the existing ones.

To conclude, our analysis of ranking innovation districts shows that the top-two performers, KGUV and SBP (Brisbane) equally share the first placing and are in inner Brisbane City. Furthermore there is a consistency in the placement of innovation districts from the second to the seventh placings (acceptable performance), representing all of the eight LGAs in SEQ. Specifically, ASEP (Toowoomba) and QSEC (Brisbane) equally share the second placing; UQKP (Brisbane) sits on the third placing; DKP (Brisbane), RVHEMP and GCHKP (Gold Coast), SCHMP (Sunshine Coast) and ICHP (Ipswich) equally share the fourth placing and similar pattern of performance is seen down the rank. It is noteworthy that, having more than one innovation district sharing a placing suggest that there is a strong competition amongst innovation districts in terms of their form, feature, and function characteristics. Lastly, the unsavoury innovation districts occupy the seventh to eleventh placings, representing six LGAs: Brisbane, Moreton Bay, Gold Coast, Toowoomba, Lockyer Valley, and Ipswich.

In sum, considering there is large gap in the score difference between each rank from the top performers to bottom performers which range from 8-17 scores, the authorities responsible should consider interventions (where practicable) to improve performance of their innovation districts─ especially for the 'function' dimensions' which no district qualified for desirable performance.

The findings of this study provide number of theoretical contributions and practical implications. The findings contribute to the body of knowledge by bridging the research gap through a holistic approach (i.e., employment of the multidimensional performance framework) for assessing innovation districts' multifaceted forms, features, and functions. The findings also consolidate our understanding on the key characteristics of innovation districts and identify that the 'function' dimension is the most concerning across all innovation districts for interventions to improve performance.

Practically, carrying out a holistic assessment of innovation districts' performance is important not only for urban planners, but also for developers, managers, and local policymakers. Such assessment

can contribute to the success of innovation districts but making decisions on where and what type to develop, which industry type to invest in and other areas that most need intervention is difficult. Thus, this study's outcome helps the stakeholders to compare the innovation districts' performances, identify areas that need intervention, and provides a guidance for policymakers' policy and investment decisions on the most suitable innovation district types and characteristics to consider.

All in all, the main aim of this study is achieved by operationalising the multidimensional innovation district performance framework on 30 innovation districts in SEQ—the testbed case study context—and confirming its suitability. The study sheds lights on how to assess innovation district performance and generates new research directions. For instance, the outcome of this study will inform our future prospective research that is to implement the framework in across different regions and countries and classify the innovation districts into distinctive typologies for more precise assessment of their performances in their own typology groups.

The study relied mainly on desktop audit using GIS tools, specifically Nearmap and Google my map to collect primary data. Whilst this method of data collection is acceptable and have been successfully employed previously by other related studies, the potential of committing error during the process is possible hence, it is important to counter audit by direct approach (i.e., physically visiting the case study sites) to confirm data collected by aerial observation. Only limited number of investigated case studies were ground-truthed. This was due to COVID-19 restrictions that were in effect at the time of data collection.

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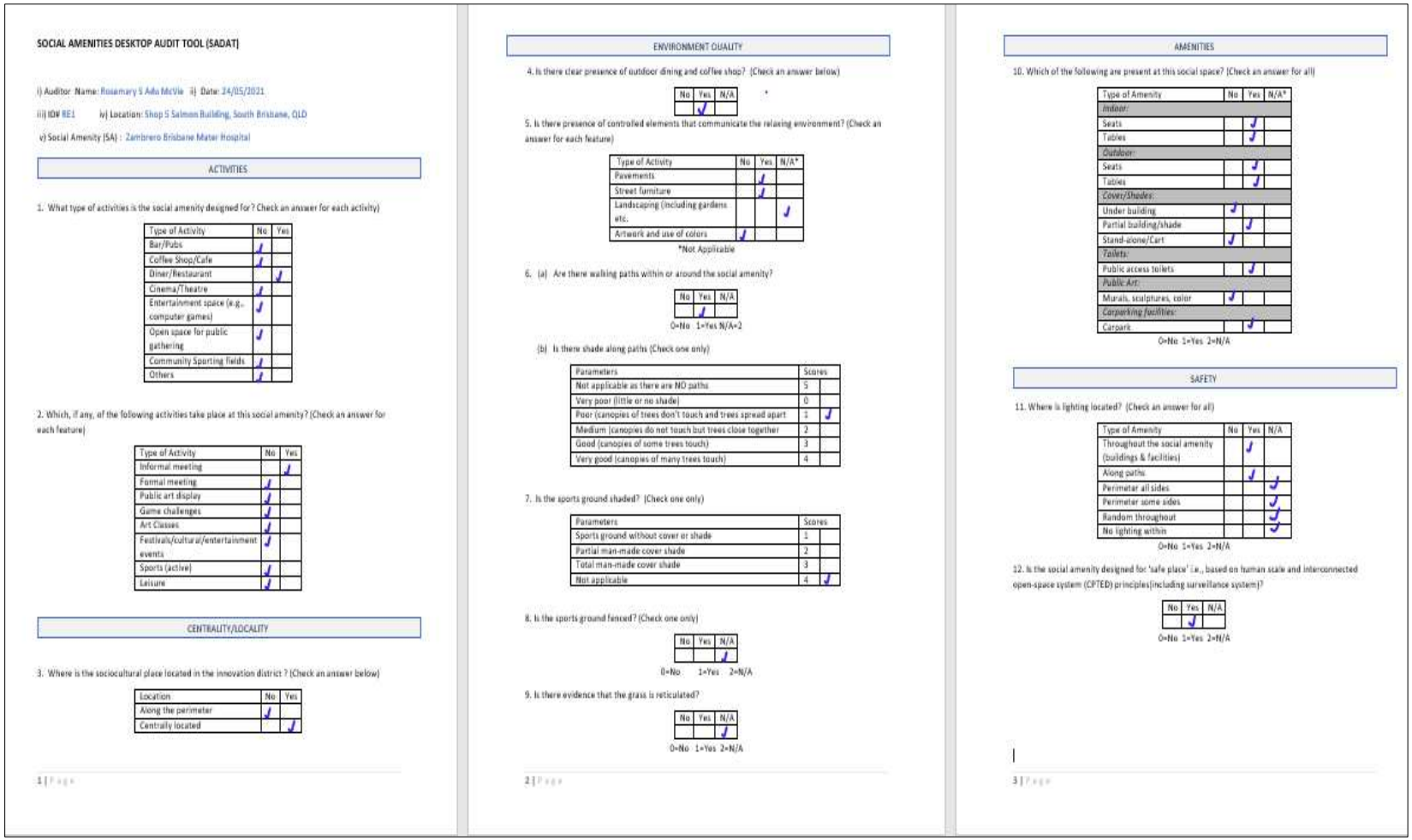
Appendices

Appendix A: Sample of audit checklist used for social amenities



SOCIAL AMENITIES DESKTOP AUDIT TOOL (SADAT)

i) Auditor Name: Rosemary S Adu McVie ii) Date: 24/05/2021

iii) ID# RE1 iv) Location: Shop 5 Salmon Building, South Brisbane, QLD

v) Social Amenity (SA) : Zambrero Brisbane Mater Hospital

ACTIVITIES

1. What type of activities is the social amenity designed for? Check an answer for each activity)

Type of Activity	No	Yes
Bar/Pubs	✓	
Coffee Shop/Cafe	✓	
Diner/Restaurant		✓
Cinema/Theatre	✓	
Entertainment space (e.g., computer games)	✓	
Open space for public gathering	✓	
Community Sporting fields	✓	
Others	✓	

2. Which, if any, of the following activities take place at this social amenity? (Check an answer for each feature)

Type of Activity	No	Yes
Informal meeting		✓
Formal meeting	✓	
Public art display	✓	
Game challenges	✓	
Art Classes	✓	
Festivals/cultural/entertainment events	✓	
Sports (active)	✓	
Leisure	✓	

CENTRALITY/LOCALITY

3. Where is the sociocultural place located in the innovation district ? (Check an answer below)

Location	No	Yes
Along the perimeter	✓	
Centrally located		✓

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ENVIRONMENT QUALITY

4. Is there clear presence of outdoor dining and coffee shop? (Check an answer below)

No	Yes	N/A
	✓	

5. Is there presence of controlled elements that communicate the relaxing environment? (Check an answer for each feature)

Type of Activity	No	Yes	N/A*
Pavements		✓	
Street furniture		✓	
Landscaping (including gardens etc.			✓
Artwork and use of colors	✓		

*Not Applicable

6. (a) Are there walking paths within or around the social amenity?

No	Yes	N/A
	✓	

0=No 1=Yes N/A=2

(b) Is there shade along paths (Check one only)

Parameters	Scores	
Not applicable as there are NO paths	5	
Very poor (little or no shade)	0	
Poor (canopies of trees don't touch and trees spread apart	1	✓
Medium (canopies do not touch but trees close together	2	
Good (canopies of some trees touch)	3	
Very good (canopies of many trees touch)	4	

7. Is the sports ground shaded? (Check one only)

Parameters	Scores	
Sports ground without cover or shade	1	
Partial man-made cover shade	2	
Total man-made cover shade	3	
Not applicable	4	✓

8. Is the sports ground fenced? (Check one only)

No	Yes	N/A
		✓

0=No 1=Yes 2=N/A

9. Is there evidence that the grass is reticulated?

No	Yes	N/A
		✓

0=No 1=Yes 2=N/A

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AMENITIES

10. Which of the following are present at this social space? (Check an answer for all)

Type of Amenity	No	Yes	N/A*
Indoor:			
Seats		✓	
Tables		✓	
Outdoor:			
Seats		✓	
Tables		✓	
Cover/Shades:			
Under building	✓		
Partial building/shade		✓	
Stand-alone/Cart	✓		
Toilets:			
Public access toilets		✓	
Public Art:			
Murals, sculptures, color	✓		
Carparking facilities:			
Carpark		✓	

0=No 1=Yes 2=N/A

SAFETY

11. Where is lighting located? (Check an answer for all)

Type of Amenity	No	Yes	N/A
Throughout the social amenity (buildings & facilities)		✓	
Along paths		✓	
Perimeter all sides			✓
Perimeter some sides			✓
Random throughout			✓
No lighting within			✓

0=No 1=Yes 2=N/A

12. Is the social amenity designed for 'safe place' i.e., based on human scale and interconnected open-space system (CPTED) principles(including surveillance system)?

No	Yes	N/A
	✓	

0=No 1=Yes 2=N/A

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Appendix B: Sample master score sheet derived from audit of social amenities

	Table 1: Description of Social Amenitie's Attributes -South Brisbane Precinct		
	Attributes	**(n=132)**	**Audit Scores**
1	**Place Design**		
	Bar		15
	Coffee Shops/café		26
	Diner/Restaurant		47
	Cinema/Theatre/Entertainment		11
	Cultural/Museum Estabishments		9
	Computer Games		2
	Public Gathering		3
	Clubs/User Pay Sporting Fields		0
	Other (Parks excluding user-pay sports field)		19
2	**Activities**		
	informal meetings		124
	Formal meetings		26
	Public Art display		9
	Game Challenges		2
	Art Classes		6
	Festivals/Cultural/Entertainment events		16
	Sports (active)		0
	Leisure		22
3	**Centrality/Locality**		
	Along the perimeter		74
	Central location		58
	Environment Quality		
4	*Outdoor dining and coffee shop presence*	Yes	58
		No	0
		N/A	98
	Controlled elements present (that		0
	communicate a relax environment)		0
5	*pavements	Yes	132
		No	0
		N/A	98
6	*street furniture	Yes	132
		No	0
		N/A	0
7	*landscaping including gardens	Yes	130
		No	0
		N/A	4
8	*artwork and use of colors	Yes	40
		No	0
		N/A	126
9	Walking paths present	Yes	22
		No	0
		N/A	220
10	*Shade along paths present*		0
	*no paths	N/A	550
	*very poor		0
	*poor		0
	*medium		6
	*good		0
	*very good		76
11	*Sports ground shaded*	Without cover/shade	0
		Partial man-made cover shade	0
		Total man-made cover shade	0
		N/A	528
12	*sports ground fenced*	Yes	0
		No	0
		N/A	264
13	*reticulated grass*	Yes	22
		No	0
		N/A	220
	Amenities		0
	Amenities present		0
14	*seatings	Indoor - Yes	89
		Indoor - No	0
		Outdoor- Yes	53
		Outdoor- No	0
		N/A	80
15	*tables	Indoor - Yes	84
		Indoor - No	0
		Outdoor- Yes	52
		Outdoor- No	0
		N/A	80
16	*cover/shades	Full bldg cover -Yes	57
		-No	0
		N/A	46
		Partial shade cover -Yes	54
		-No	0
		N/A	48
17	*Public/Patrons toilet access*	Yes	131
		No	0
18	*public art*	Yes	14
		No	0
		N/A	236
19	*carpark*	Yes	132
		No	0
	Safety		0
	Lighting present		0
20	*building & facilities	Yes	116
		No	0
		N/A	32
21	* along paths	Yes	49
		No	0
		N/A	0
22	*perimeter all sides	Yes	0
		No	0
		N/A	264
23	*perimeter some sides	Yes	0
		No	0
		N/A	264
24	*random throughout	Yes	0
		No	0
		N/A	264
25	*No lighting within SCP	Yes	0
		No	0
		N/A	264
26	*Design for safe place (CPTED Principles)*	Yes	132
		No	0
		N/A	0
		Sum	**5,736.00**
		Average	**43**

Appendix C: Sample of audit sheet used for green and blue ecosystem services

Code/ecosystem services	Description	Type of green infrastructure	Score 0=Absent 0.5=Limited 1=Unlimited
ESG1. Mitigating heat stress	Trees with large crown improve thermal comfort	Trees with large crowns Green walls Green roofs Green façade	1 0 0 0
ESG2.Noise reduction	Dense vegetation close to the source maximises noise reduction	Street trees Street gardens Green buffers	1 1 1
ESG3.Physical activity	Green spaces designed on the citizen's needs for physical activity	Playing fields Walking/Biking tracks	0 1
ESG4. Water quantity regulation	More open soil surface increases infiltration capacity	Open spaces	1
ESG5.Stress reduction	Viewing or experiencing green spaces of good quality reduces stress	Parks/gardens Wood	1 1
ESG6 Social interaction	Attractive accessible green spaces increase social interaction	Public Parks with amenities	0
ESG7. Air quality regulation	Well-placed green infrastructure promotes air circulation	Well placed trees on allotments	1
		Total score (n) = 14	9

Code/ecosystem services	Description	Type of Blue Infrastructure	Score 0=Absent 0.5=Limited 1=Present
ESB1. Green/blue corridors	For cycling, running, skating, walking and connections for animals	Biking/running/walking/skating tracks.	1
ESB2. Places to meet	Restaurants/eateries along the banks	Sea shores/river- banks	1
ESB3. Swimming/playing	For playing and swimming	Sea/rivers/lakes/Pools	1
ESB4. Fish consumption	For fish farming	Ponds/lakes	0
ESBB5. Agriculture use	For irrigation in food production	River/lake/storm water/ground water	0
ES6. Recreation	For sailing, rowing, and other water sports	Sea/rivers/lakes/Pools Water parks	1
	For house boats	Yacht clubs/jetty/boat shed	1
ESB7. Industrial	For industrial extraction	River/lakes/storm water	0.5
ESB8. Natural purification	For sewer	Sewerage ponds	1
		Total score (n=9)	6.5
Total scores for green=9 + blue ecosystem services=6.5=15.5. Total average score in %= 15.5/23=67%			

Score guideline: green ecosystem services	
Type	Measure criteria
Small-to-Medium Hubs	Limited<2, Unlimited>2
Large Districts	Limited<10, Unlimited>10
Score guideline: blue ecosystem services	
Service Type (Millennium Ecosystem Assessment, 2005)	Measure criteria
Supporting services (e.g., Habitat provision)	Limited<10, Unlimited>10
Regulating services (e.g., sewerage ponds)	Limited=1, Unlimited>1
Cultural services (e.g., recreational)	Limited<10, Unlimited>10
Provisioning services (e.g., Food production)	Limited<10, Unlimited>10

Appendix D: Audit tool: features of built environment encouraging connectivity and mobility within Brisbane Technology Park and surroundings

Features	**Description**	**Score** **0= No evidence** **5= Limited evidence** **10=Unlimited evidence**
Street connectivity and smaller block sizes	Influence walkability, permeability, and route options	10
Pedestrian pathways	Minimise conflict between vehicles, cyclist, and pedestrians	10
Location, size, amount, and connections (within 2.5km) (Green within 2.5km range of demand" (TO2-ACC-WP3, 2016, p.17)	Public open and green space	10
Transport and movement networks	Public transport, pedestrian pathways, and cycleways	10
No. of local living destinations within walking or cycling distance (<1km) (Urban design for walking, victoriawalks.org.au)	Transit stations, shops, community facilities and open space	5
Greater diversity in land use	Mixed use development (i.e., work-learn-play-live)	5
Boundaryless allotments	No physical boundaries (i.e., fence) between neighbour allotments	10
Total (n) = 7		60