How Can the Characteristics of Knowledge and Innovation Places in Developing Countries Be Identified? Insights from Lae City, Papua New Guinea

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Key words: Innovation district, research and innovation places, multidimensional innovation district classification framework, urban planning and development, performance assessment

SUMMARY

The concept of innovation district and its brands including knowledge and innovation places (KIPs) is a new urban land use type popularly embraced in many developed cities' urban policies to develop these places for the purpose of economic, social, environmental and spatial benefits. However, the concept is not popular in developing countries including Papua New Guinea(PNG) hence, there is limited empirical knowledge and data about the existence of these places. In PNG, despite the existence of KIPs (i.e., universities and research centres) and the fact there is relevant support legislations and policies, the concept and its benefits is yet to be fully embraced and realized respectively. This study focuses on addressing the understudied research area.

The paper reports the findings of a pilot study's adoption and deployment of a modified multidimensional innovation district classification framework and the use of GIS techniques on selected KIPs in PNG. The methodological approach is three-fold: First, is the adoption of the modified multidimensional innovation district classification framework to identify the KIPs salient characteristics. Second, data from two established and active KIPs in PNG namely, 'The Papua New Guinea University of Technology' and the 'National Agriculture Research Institute', both located in PNG's industrial city, Lae, Morobe Province is collected. Third, descriptive, spatial and thematic analysis are employed to produce results including graphic output.

The study's findings are in three folds: First, from the reviewed literature, the study identified 24 KIPs existing in PNG. Second, the research discovered that the modified multidimensional KIPs classification framework with the adopted methods successfully identified the salient characteristics of two selected case study KIPs. Third, the findings set the platform for similar future research to be continued on the remaining KIPs in PNG to measure their performance and classify them. Moreover, the empirical information derived from the present research will contribute to knowledge, and insights will inform managers of the case KIPs to identify areas that needs improvement.

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1. INTRODUCTION

The survey and geospatial profession have embraced creativity and innovation as the engines of growth and adaptation in a rapidly evolving world. However, innovations can only take place and be successful when suitable environments are tailored to support these activities. Such environment is referred to as 'innovation district'.

The concept of innovation district is a new preferred land use type which most cities of developed countries have embraced for the potential benefits it brings in the forms of economic, social, environmental and spatial to their host cities (Adu-McVie et al., 2021). Innovation districts are defined as the "geographic areas where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators. They are also physically compact, transit-accessible, and technically wired, and offer mixed-use housing, office, and retail" (Katz & Wagner, 2014, p.1). This new land use type is the spatial nexus of the concept knowledge-based urban development (KBUD) (Pancholi et al., 2015; Yigitcanlar et al., 2016; Yigitcanlar & Inkinen, 2019; Esmaeilpoorarabi et al., 2020a). KBUD is a "cluster of research and development (R&D) activities, high-tech manufacturing of knowledge-intensive industrial and business sectors linked by mixed-used environment, including housing, business, education, and leisure within an urban like setting" (Yigitcanlar et al., 2008, p.11).

In spite of its global popularity in the developed countries, literature reveals that not all innovation districts developed are successful. Moreover, the innovation district concept in developing countries is still unpopular. Consequently, there is limited empirical knowledge and data about their existence and salient characteristics in developing countries including Papua New Guinea (PNG).

Following this section, section two presents the literature background covering knowledge and innovation places globally, regionally and locally in PNG and then introduces the multidimensional innovation district framework. Section three outlays the research design, introduces the case study areas, and discusses the data collection methods and analysis. Section four presents the study's results and concludes with insights and recommendation.

2. LITERATURE BACKGROUND

Innovation districts are known by a variety of brand names including 'innovation clusters'

(Huggins, 2008), 'innovation precincts' (Esmaeilpoorarabi et al., 2018a) and 'knowledge and innovation spaces' (Pancholi et al. 2019). Classic examples of these places include the famous Silicon Valley in the US, One-North in Singapore and Sydney's Macquarie Park Innovation District in Australia.

Although the concept is not popular in developing countries, reviewed literature confirms that the developing countries have also adopted the innovation district concept. Some examples include the Nairobi Innovation Hub (Kenya), Biotechnology Innovation Cluster (India), Cape Innovation District (South Africa), Kigali Innovation Hub (Rwanda) and Bengaluru-India's Silicone Valley (India) (iHUB, 2025; Economic Times, 2025; Panethos, 2023; Innovation City, n.d; CMU, 2025). Moreover, the innovation district concept exists in the Pacific Island Countries (PICS), but is mostly developed in the conventional forms of universities and small-medium scale stand-alone research or innovation hubs. Some examples include the University of South Pacific (Fiji); V-Lab Entrepreneurship Innovation Hub (Vanuatu); Innovation Hub & Co-Working Space (USP-Fiji); Nusatupe Innovation Hub (Solomon Islands), and Pacific Climate Change Centre (Samoa) (USP & UNDP, 2022; CGIAR, 2023; PIURN, 2025). Most of the innovations hubs in the PICs are outcomes of the ongoing collaborations between the respective island governments, non-government organisations (e.g. UNDP), and the universities.

Despite the existence of the research and innovation hubs in the PICs, empirical knowledge on their salient characteristics are limited hence, is a potential area of research which is this paper's focus.

2.1 Knowledge Innovation Places in PNG

The authors opined that the term 'knowledge and innovation places'(KIPs) is appropriate to use for PNG context, because PNG is a member of the Pacific island developing countries, where the innovation district concept is still unpopular.

In PNG, the existing KIPs are mostly in the form of a network of stand-alone universities and research centres. These places were established and supported by relevant national legislation and policies including the *PNG Science and Technology Council Act 1992* and a recently established *Policy on Academic Research Cooperation between PNG Universities and Research Institutes* (DHERST, 2024) which encourages knowledge generation and innovation.

Despite their existence, the KIPs significance and potential to contribute economic, social, environmental and spatial benefits to the country are not yet fully embraced. This is due to lack of empirical knowledge and data about these places. Using the generic classification criteria based on the KBUD's definition— "cluster of research and development (R&D) activities, high-tech manufacturing of knowledge-intensive industrial and business sectors linked by mixed-used environment, including housing, business, education, and leisure within an urban

like setting" (Yigitcanlar et al., 2008, p.11), 24 existing KIPs are identified and listed in Table 1.

Table 1. Existing knowledge and innovation places in PNG

1	**Knowledge and Innovation Places**	**Location**
2	Bougainville Innovation Hub	Buka
3	Enga University of Innovation	Enga
4	University of Goroka	Goroka
5	PNG Institute of Medical Research	Goroka
6	Melanesian Institute	Goroka
7	Tree Kangaroo Conservation	Huon Gulf, Morobe
8	University of Western Pacific	Ialibu
9	Mahonia Na Dari	Kimbe
10	PNG University of Technology	Lae
11	National Agriculture Research Institute	Lae
12	PNG Forest Research Institute	Lae
13	Divine Word University	Madang
14	New Guinea Binatang Research	Madang
15	University of Papua New Guinea	Port Moresby
16	Pacific Adventist University	Port Moresby
17	Institute of Business University	Port Moresby
18	National Research Institute	Port Moresby
19	Institute of National Affairs	Port Moresby
20	Tourism Business Incubation Hub	Port Moresby
21	PNG Digital ICT Cluster	Port Moresby
22	PNG University of Natural Resources & Environment	Rabaul
23	PNG Coco & Coconut Research Institute	Rabaul
24	Wau Ecology Institute	Wau, Morobe

2.2 Innovation District Classification Framework

Based on reviewed literature, the multidimensional innovation district classification framework was selected as suitable to adopt for identification of the salient characteristics of KIPS in PNG mainly due to its dual functions: First, it can be utilized to holistically assess the performance of KIPs based on their context, feature, form, and function dimensions, and second, based on the results of the performance assessments, the KIPs can be classified into typologies. The present study's objective is aligned with the former function of the classification framework, which the output will include identification of the KIPs salient characteristics.

The multidimensional framework comprises of four dimensions: context, feature, function and form. Each of the dimensions has four indicators. The dimension feature comprises of social amenity, human capital, skilled labour and local setting; function comprises of company size, industry type, investment type, and property management; and form comprises green-blue infrastructure, land-use mix, built environment and space design. The context dimension is the external environment which comprises of the spatial system, societal system, governance system and economic system. Together these dimensions and their 16 indicators were

successfully employed in a similar study to assess the performance and classification of selected innovation districts in Australia (Adu McVie et al., 2021; 2022).

3. MATERIALS AND METHODS

Following the previous studies' (Rasid et al., 2019; Adu McVie et al., 2021; 2022) method, the present study employed the case study method to test the adopted multidimensional classification framework's suitability for application to PNG's context. The case study method is commonly used by diverse disciplines and is identified as a qualitative form of research design. (Zainal, 2007; Rashid et al., 2019). Moreover, the study adopted Pancholi et al.'s (2019) three-step process (Figure 1) to apply the framework. Discussion on the process is presented in section 3.2.

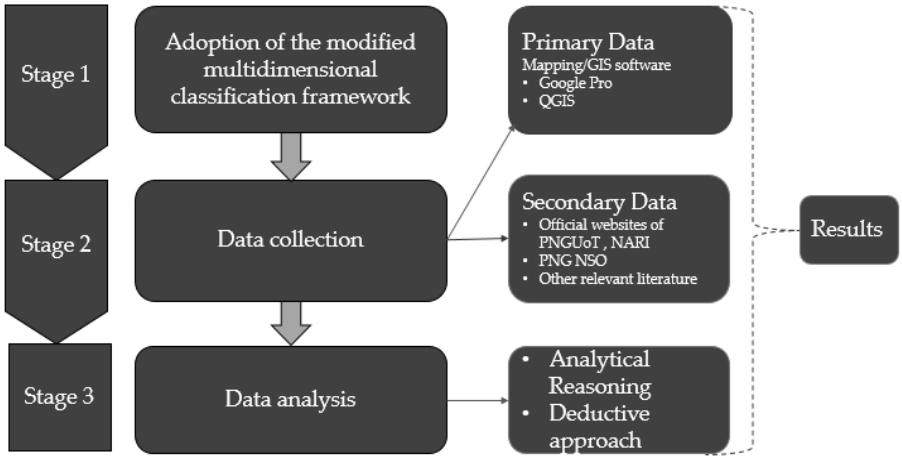


Figure 1. Three step research method (adopted from Pancholi et al. 2019)

3.1 Case Study

Lae is the host city to three established KIPs namely the Papua New Guinea University of Technology (PNGUoT), PNG Forest Research Institute (PNGFRI) and the National Agriculture Research Institute (NARI). From the three KIPS, two are selected for the pilot study: the PNGUoT represents universities and the NARI represents stand-along research centres. The PNGUoT is one of the oldest and second largest university in PNG, and the only technological university in the South Pacific Region outside of Australia and New Zealand (Unitech, 2025). On the other hand, NARI is an established statutory research organisation mandated "to conduct and foster applied and adaptive research in any branch of biological, physical and natural sciences related to agriculture; cultural and socio-economic aspects of the agricultural sector,

especially of the smallholder agriculture; and matters relating to rural development and of relevance to PNG" (NARI, 2025, p.1).

Figure 2 shows the locations of the case study KIPs—QGIS, an open source software was used to create the figure.

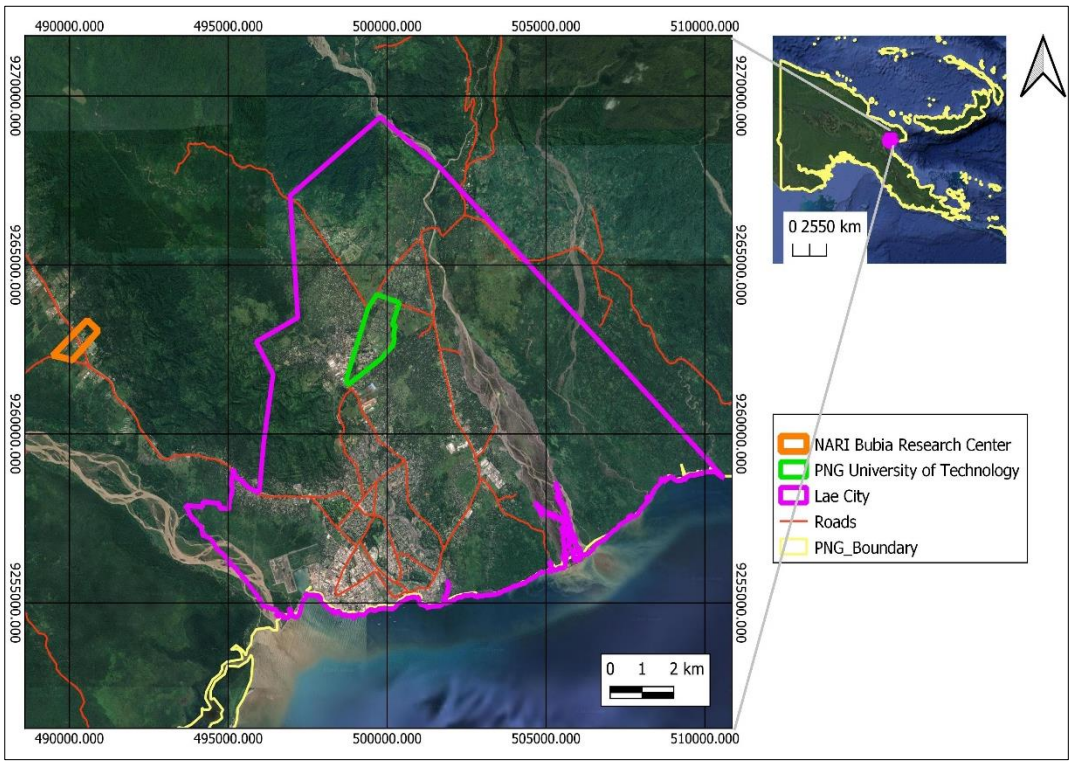


Figure 2. Locations of the KIPs (source: derived from QGIS)

3.2 Data Collection

The study employed a three-step process (Figure 1) to test the application of the multidimensional framework on two selected KIPS. In the first step the study the adopted the framework to guide the remaining two stages of data collection and analysis respectively. In the second step, the study applied desktop audits using mapping and GIS software specifically Google Earth Pro and QGIS to collect primary data including land-use mix, green-blue infrastructure and space design. The secondary data about the KIPs are collected from the KIPs official websites; demographic data from the PNG's National Statistics Office (NSO), and the economic data from the Bank of PNG Quarterly Economic Bulletins. In the third step, the study employed analytical reasoning method and the deductive approach for the data analysis. The multidimensional framework was employed in the deductive approach to test each of the indicators for the two KIPs. The audits on PNGUoT and NARI are all conducted remotely on desktop utilizing the Google Pro and QGIS mapping tools. Ground truthing followed to verify the desktop data.

3.3 Modified multidimensional knowledge & innovation places classification Framework

The study modified the adopted multidimensional innovation district framework to PNG's context (table 2) before applying it on the case study KIPs. The modification included renaming the framework to 'multidimensional knowledge & innovation place classification framework' and replacing the use of the term 'innovation district (ID)' with 'knowledge and innovation place (KIPs)' throughout the framework. The most affected dimension was the 'function' dimension (changes are highlighted in blue font) due to PNG KIPs functions are limited to the conventional teaching and research hence, the function's indicator 'company size' was replaced with 'research/business Centre activity' in the modified multidimensional KIPs classification framework.

Figures 3-6 are selected exemplars of the spatial data collected for feature and form dimensions and their respective indicators.

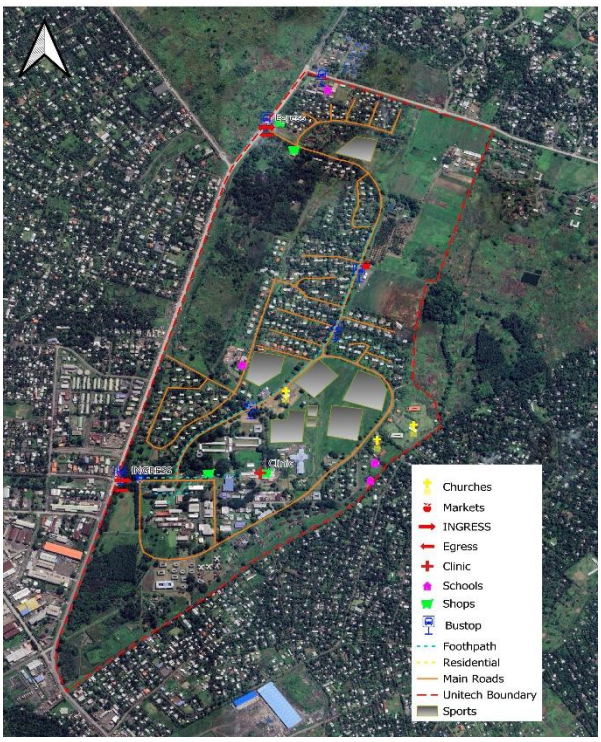


Figure 3. PNGUoT social amenities and mobility access

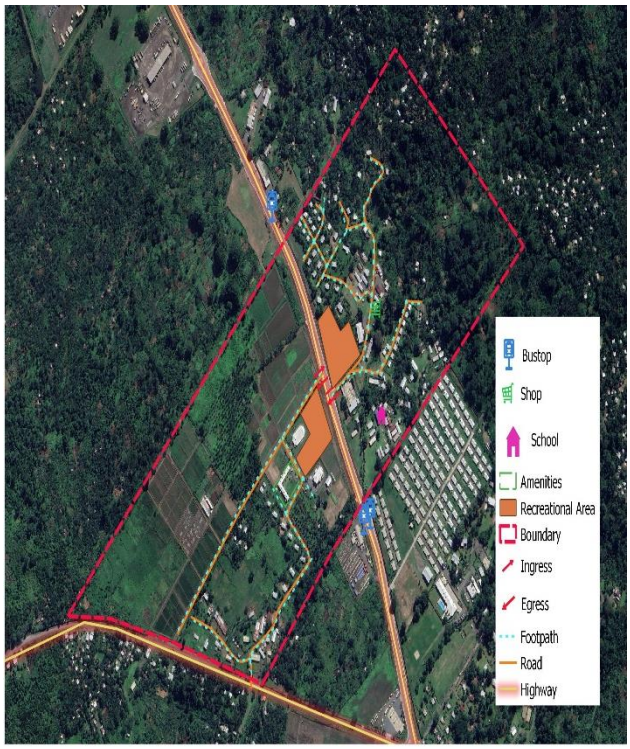
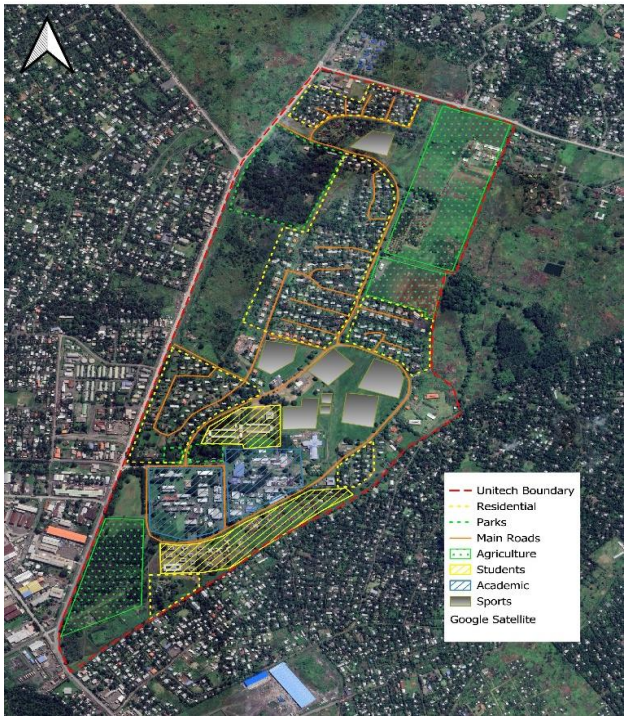


Figure 4. NARI social amenities and mobility access (derived from QGIS)



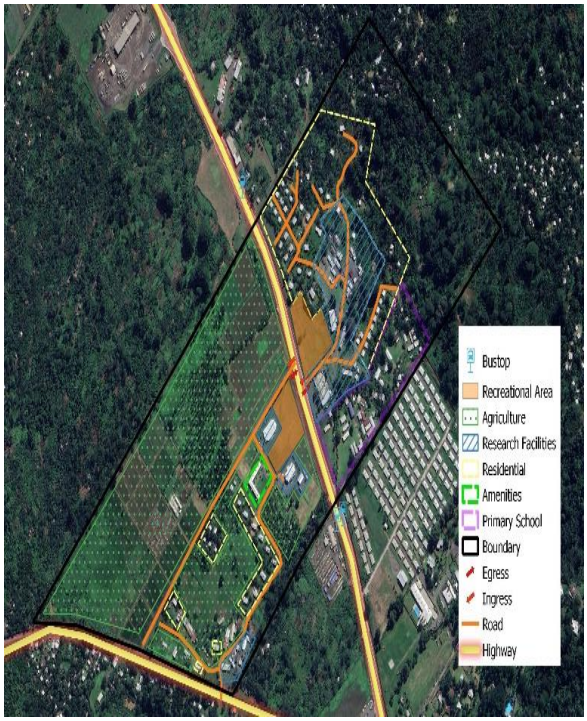


Figure 5. PNGUoT land use (derived from QGIS) **Figure 6**. NARI land use (derived from QGIS)

4. ANALYSIS AND RESULTS

Following previous similar studies ((Morais & Camanho, 2011; Audretsch & Belitski, 2022), all the raw data obtained are filtered and normalized to prevent any potential bias in the analysis stage. The raw scores obtained are standardized to obtain a mean composite score (m-scores) for social amenities, built environment, urban green-blue infrastructure; percentage scores for human capital and skilled labour, industry type (i.e., technology intensive-creativity intensive-business support) and research/business centre activity (i.e., research focus-commercial focus or community service focus). The mean scores and percentage scores are given weighting values e.g., strong>1.5, moderate<1.5, weak<1.0 or descriptive values e.g., technology intensive, creativity intensive, business support which defines the KIP's characteristics and performance. Both primary and secondary data obtained were analysed using qualitative and quantitative analysis methods to compute percentage scores. Moreover, aerial data on land-use, green-blue infrastructure, built environment and space design were digitized accordingly based on reference maps, local knowledge and ground truthing. Spatial analysis (buffering) was also applied to identify amenities within a given distance and the final graphic output were in maps and images.

The results for each KIPs understudy are presented in Table 2 in a descriptive form. The salient characteristics identified for each of the KIPs are; PNGUoT representing universities, is a 'mixed-use open design KIP with strong urban green-blue infrastructure, located in a suburban area with weak social amenity, moderate human capital and skilled labour. It is a single sector investment dominated by teaching and research focus centres. The KIP is a technology intensive business under a place-wide management model, surrounded by strong societal system, satisfactory spatial system and weak economic, and governance systems. Conversely, NARI representing stand-alone research centre is a semi-open design KIP with strong green-blue infrastructure, located in a suburban area with weak social amenity, strong human capital and skilled labour. It is a two sector investment and is dominated by research focus centres. The KIP is a technology intensive business under a place-wide management model surrounded by strong societal system, satisfactory spatial system and weak economic, and governance systems.

The study's findings are in three folds: First, from the reviewed literature, the study identified 24 KIPs in PNG. Second, the study found that the modified multidimensional KIPs classification framework with the adopted methods successfully identified the salient characteristics of the selected case study KIPs. Third, the present study's findings set the platform for future research to continue identifying salient characteristics of remaining KIPs in PNG, measure their performance and classify them onto their typologies. Moreover, the empirical information derived from the proposed research will contribute to knowledge, and insights which will inform decisions of policymakers in investing the type of KIPs suitable for PNG context.

Table 2. Case study results based on modified multidimensional KIPs classification framework

Dimension	Indicators	Description	Parameters	Measures	PNGUoT	NARI
Feature	Social amenity	Presence or availability of social amenities for public use within the KIPs	Strong presence of social amenities Moderate presence of social amenities Weak presence of social amenities	Presence of social amenities measured by composite score weighting. Strong>60, Moderate>50, Weak<50	Weak	Weak
	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) within the KIPs and its immediate surroundings.	Strong human capital Moderate human capital Weak human capital	Percentage of knowledge workers with BA or higher within the KIPs & its surroundings. Strong>50%, Moderate>25%, Weak<25%	Moderate	Strong
	Skilled Labour	Skilled employment outcome of the KIPs activities	Strong skilled employment Moderate skilled employment Weak skilled employment	Ratio of knowledge worker jobs to all KIP's job Strong>50%, Moderate>25%, Weak<25%	Moderate	Strong
	Locality setting	Location of the KIPs within the metropolitan area	Inner city Suburban Regional	Location of the KIPs. Inner city, Suburban, Regional	Suburban	Suburban
Context	Spatial system	City-wide spatial layout and architecture qualities (e.g., physical environment, spatial conditions, physical urban development)	Excellent spatial design Satisfactory spatial design Unsatisfactory spatial design	Composite index of quality of physical environment, unique natural environment and physical patterns using 'value efficiency analysis (VEA)' average quality scores. Excellent=1, Satisfactory>0.5, Unsatisfactory<0.5	Satisfactory	Satisfactory

	Societal system	Societal progress of the city (e.g., diversity, tolerance, equality, age structure, participation in cultural/community activities	Strong social assets Moderate social assets Weak social assets	A city's diversity and inclusiveness are measured using composite scores based on Brookings Institute's 'audit guide' Strong>60, Moderate>50, Weak<50	Strong	Strong
	Governance system	Political progress of the city (e.g., political institution effectiveness, accountability, transparency, participation)	Strong governance effectiveness Moderate governance effectiveness Weak governance effectiveness	Composite index of quality of public services, civil service, and degree of its independence from political pressures, quality of policy formulation & implementation, and credibility of the - government's commitment to such policies of the city Strong >2.0, Moderate <2.0, Weak <1.0	Weak	Weak
	Economic system	Macroeconomic progress of the city (e.g., monetary, and fiscal performance to maintain stability of economic growth)	Strong economic performance Moderate economic performance Weak economic performance	Composite index of government gross debt, real GDP growth, inflation rate, and unemployment rate of the city measured by efficiency scores. Strong =1, Moderate >0.5, Weak <0.5	Weak	Weak
Function	Research/Business Centre activity	Relative operations focus of the research/business centres	Commercial focus Research focus Community service focus	Relative focus of research/business centres within the KIP Research/Conservation focused if >50%, Commercial focused if >50%, Community service focused if >50%	Research	Research
	Industry type	Dominant business activity operating within the KIPs	Creativity intensive Technology intensive Business support	Dominant business activity of the KIPs Creativity intensive if >50%, Technology intensive if>50% Business support service if >50%	Technology	Technology
	Investment type	Principal support and funding body for the development of the KIPs	Public-private-community partnership Public-private partnership Public or private sector	Multiple sectors Two sectors Single sector	Single sector	Two sectors

	Property Management	Management model of the KIPs properties and activities	Managed by a place management Managed by a building management No form of management	Model used for management of the KIPs operation and facilities. Place-wide Building level None	Place-wide	Place-wide
Form	Urban green and blue – infrastructure	Aesthetic qualities of urban green and blue infrastructure within the KIPs (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 presence of ecosystem services guided by the 'design principles' of blue-green infrastructure─ city level (blue infrastructure), and cluster level (green infrastructure) Strong >50%, Moderate >25%, Weak <25%	Strong	Strong
	Land use-mix	Main land use types within the KIPs	Complex mixed Mixed use Single use	Measured by main- land uses within the KIPs. Complex mixed, mixed use or single use	Mixed use	Mixed use
	Built environment	Architectural design of built forms and functions encouraging connectivity, and mobility within the KIPs	Strong internal connectivity Moderate internal connectivity Weak internal connectivity	Design qualities of built form and functions are measured using composite scores to determine the level of internal connectivity Strong >60, Moderate >50, Weak <50	Moderate	Moderate
	Space design	Spatial layouts design encouraging open innovation system within the KIPs	Open layout plan Semi-open layout plan Close layout plan	Layout's design of the KIPs is measured by their zonings to determine if the design encourage/discourage knowledge generation within the district. Open layout Semi-open layout Close layout	Open layout	Semi-layout

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BIOGRAPHICAL NOTES

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Dr. Cathy Koloa is currently a senior lecturer in the GIS section at the School of Surveying and Lands, Papua New Guinea University of Technology. She has over 5 years of experience as an academic and her research interests include Spatial Modeling and GIS analysis covering the topics of hazard and risk mapping, soil loss, runoff, and coastal studies. She has co-published in esteemed international journals in the field of hydrology and geospatial science.

Mrs. Camilla Yanabis Kwaudi is currently a Lecturer of GIS at the School of Surveying & Lands, Papua New Guinea University of Technology, Lae, Papua New Guinea. She completed her Masters of Philosophy in 2020 and her research interests includes spatial databases & web mapping. She was previously a technical officer turned academic and was involved in numerous consultancy projects within the school.

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