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A Geographical Information System-based Mapping Model for Aligning Vocational High Schools with Industrial Needs

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Abstract

Vocational High Schools (SMKs) are essential in linking education with regional industry needs. However, mismatches between SMK programs and industry demands often hinder graduate employability. This study develops a GIS-based mapping model to analyze the spatial alignment between SMKs and industries in Greater Bandung, covering Bandung City, West Bandung, Bandung Regency, and Cimahi City. A descriptive quantitative method was used, employing ArcGIS 10.2 and satellite imagery. Data included 39 public SMKs and 2,535 industries, categorized by vocational sectors based on Ministry Regulation No. 024/H/KR/2022. Mapping and spatial overlay analysis were conducted to assess alignment. Findings show limited and uneven alignment. While some SMKs align with the manufacturing sector, key sectors such as tourism, health, and creative economy lack nearby or relevant SMK support. Many schools are not strategically located near related industries, reducing collaboration and practical training opportunities. The study recommends integrated spatial planning that aligns vocational education with local economic strengths. Improved coordination between education and industry stakeholders is essential to enhance relevance and job outcomes for graduates.

1. Introduction

Law no. 20 of 2003 provides a mandate for Vocational High Schools (SMK or known as Sekolah Menengah Kejuruan/SMK) to prepare Human Resources (HR) who are ready to enter the world of work and become a productive workforce in Indonesia. However, in reality, SMK is the highest contributor to the Open Unemployment Rate (TPT). BPS data shows that in the last three years, SMK has been in the highest position in terms of unemployment rate contributors in Indonesia as shown in Figure 1.

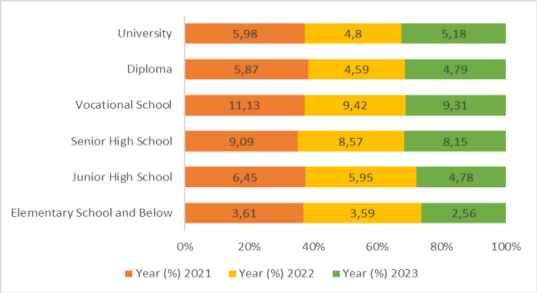

Fig. 1 *TPT based on education level (Source: processed from BPS 2023)*

The high unemployment is possible due to two factors. One of which is the competencies possessed by Vocational High School graduates are lower than the competencies required by Industry and the World of Work (IDUKA) or the competencies trained by schools are not in accordance with the demands of IDUKA. Another reason for the phenomenon is the availability of absorption capacity of Vocational High School graduates at IDUKA is very small, so it is unable to accommodate all Vocational High School graduates (Soputan, 2019). The study was conducted in The Greater Bandung area which includes Bandung City, Bandung Regency, West Bandung Regency and Cimahi City. BPS data in 2023 shows that the Bandung Regency area has 130 private Vocational High Schools and 11 public Vocational High Schools, the Bandung City area has 102 private Vocational High Schools and 16 public Vocational High Schools, the Bandung Barta Regency area has 91 private Vocational High Schools and 9 public Vocational High Schools, the Cimahi City area has 20 private Vocational High Schools. and 3 State Vocational High Schools (BPS, 2023). As intended, Vocational High Schools must prepare graduates who have competencies according to IDUKA's needs. So, in 2018 the Indonesian Government itself issued policy through Regulations on Authorization of Budget Users for Work Units of the Directorate of Vocational High School Development Number: 054/D5.6/Ku/2018 concerning Guidelines for Implementing Government Assistance for the Development of Industrial/Regional Advantage-Based Vocational High Schools in 2018 [Rahmadhani, S& Suryati, 2022)]. This shows that the Indonesian Government is serious about mapping Vocational High Schools based on industrial areas. IDUKA has an important role in absorbing Vocational High School graduates (BPS. 2020; Faturohman & Suherman, 2022). Therefore, the government needs to pay attention to the condition of industrial areas and their suitability for surrounding Vocational High Schools (Subiyanto, Tarziraf, Asmara,2023). It includes several scales of Industrial areas in Greater Bandung, which are divided into two categories, including Large Industries and Small and Medium Industries (Safitri, Nurlaela, Rijanti & Munoto, 2020). Several countries have conducted school mapping research with various objectives, in several countries as shown in Table 1.

Table 1 *List of countries have conducted school mapping*

Country	Publication
Aurangabad	Green, T. L., 2015
Canada	Osborne, S., Rigney, L. I., Benveniste, T., Guenther, J., & Disbray, S., 2019
England	Earl, L., 2018; Briguglio and Debattista, 2017; SJ Courtney, 2015; Mulaku and E. Nyadimo, 2011;
Chille	Stewart, T., Schipperijn, J., Snizek, B., & Duncan, S., 2017
Ghana	Hsu, L. J., Pacheco, M. Y., Crabtree, C., & Maddock, J. E., 2015.
India	Khobragade, S. P., & Kale, K. V., 2016
Indonesia	Ana, A., Khoerunnisa, I., Muktiarni, M., Dwiyanti, V., & Maosul, A., 2021
Kenya	Kretchmar, K., Sondel, B., & Ferrare, J. J., 2014
Malaysia	Xu, T., Jäger, H. R., Husain, M., Rees, G., & Nachev, P., 2018
Malta	Vásquez, K. Marinkovic, M. Bernales, J. Leon, J. González, and S. Castro, 2018
Minnoseta	Sein, Maung SZM, MT Khine, Phyo K., T. Aung, and PPP Tun, 2018
Myanmar	Agrawal and RD Gupta,2016
New Zealands	Moliner, O., Sales, A., & Sanahuja, A., 2017;
Spain	Demetriou, A., Merrell, C., & Tymms, P., 2017
China	J. Arnold, S. Bruce-Low, S. Henderson, and J. Davies., 2016
USA	Abd Majid, H. A. M., Danis, A., Sharoni, S. K. A., & Khalid, M., 2015; Hayati Adilin, M. A. M., Holdsworth, M., McCullough, F., Swift, J. A., & Norimah, A. K., 2015; Kwan, J. Y., Nyhof-Young, J., Catton, P., & Giuliani, M. E., 2015

However, in the previous research, there is still no link between school and industry mapping, although ideally Vocational High School mapping is based on the availability of industry in the area. The research was to map Vocational High Schools in Greater Bandung based on the conditions of local industrial areas using Geographic Information System (GIS) and provide an academic input on policy models for improving the quality of human resources through improving the quality and relevance of Vocational High School education. So that it can show the distribution of Vocational High Schools according to their field of expertise and in accordance with the conditions of industrial potential in the Greater Bandung area, in addition to designing industrial classes that are integrated in each Vocational High School in collaboration with industrial partners. This research also supports the achievement of the Sustainable Development Goals or SDGs 2030, which specifically supports the achievement of quality education (Goal 4). This research is in line with the direction of government policy in achieving the 2020-2024 SDGs, namely the program to strengthen the quality of vocational administration and training.

2. Methods

The research used descriptive quantitative approach which focuses on industry & school mapping. The industry and school mapping were done using Geographical Information System (GIS) with the focus area of Greater Bandung, including Bandung City, West Bandung Regency, Bandung Regency, and Cimahi City.

The instruments or data collection tools used in the research are the Greater Bandung satellite image map as the base for data visualization and ArGIS 10.2 software for school & industry mapping. Both industries and vocational high schools were then categorized based on the industry sectors/vocational school spectrums as regulated in the Head of the Educational Standards, Curriculum and Assessment Agency of the Ministry of Education, Culture, Research and Technology Number 024/H/KR/2022 concerning the concentration of expertise of Vocational High School (SMK/SMK) in Merdeka Curriculum.

The aforementioned sectors in the SMK/SMK spectrum are as follow:

- Construction and Building Technology
- Manufacturing Engineering and Technology
- Energy and Mining
- Information Technology
- Health and Social Work
- Agribusiness and Agrotechnology
- Maritime
- Business and management
- Tourism
- Arts and Creative Economy

The sectors were coded and translated into a GIS-based map, which then analyzed with the following steps:

- **Spatial Data Collection**, where the data of industries was obtained from the Department of Trade and Industry of West Java via National Industry Information System and West Java Digital Service. Based on the data collection, there are 2535 industries on various scales located within Greater Bandung. On the other hand, the list of schools used in the research are public Vocational High Schools located within Greater Bandung. There are 39 public Vocational High Schools identified in the data collection. All data were obtained through secondary sources.
- **Data Processing**, where he industry and SMK data are geocoded according to the coordinate and were transformed into spatial data according to the spectrum.
- **Data Overlay Analysis**, where the industry and SMK spatial data were then overlayed to be analyzed through spatial pattern.
- **Map Visualization**, which is the end product of the overlayed map of industry and SMK. The process is important to understand the spread of Vocational High Schools and related industries within Greater Bandung.

3. Result and Discussion

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3.1 Spatial Distribution of Vocational High Schools in Greater Bandung

The Greater Bandung region has public 39 Vocational High Schools (SMK) which spread across four cities and regencies in which Bandung City has 16 Vocational High Schools, Bandung Regency has 11, West Bandung Regency has 9 and Cimahi City 3. Among all 39 public SMKs, there are total 10 expertise spectrums with 50 expertise programs and 128 expertise concentrations. These SMK are not evenly distributed, instead they are spread across the area with Bandung City as the most concentrated region as seen in Figure 2. There are 16 SMK located in Bandung City with 87 expertise programs. The large number of SMK is due to the density as Bandung City is the capital city of West Java Province that has the highest population and the densest region among the four. The second and the third highest number of SMK are in Bandung Regency and West Bandung Regency with 11 SMK (58 expertise programs) and 8 SMK (20 expertise programs) respectively. The spread of SMK in the two regions are the most disperse as these two regions are the least densely populated area among the four. The discrepancy of SMK in Greater Bandung is in line with the school clustering policy of Bandung government that allows high concentration of quality vocational high schools in urban centers while high quality schools are rarely found in less populated areas (Akbar et al., 2018). Interestingly, Cimahi City, which is the newest developed city with smallest area has the least number of SMK but with 19 expertise programs. It means, although Cimahi only has two schools, the expertise programs are almost the same as West Bandung Regency. The phenomenon is likely due to the economic growth, which Cimahi is recorded to have the highest economic growth in 2023 compared to the other 3 regions.

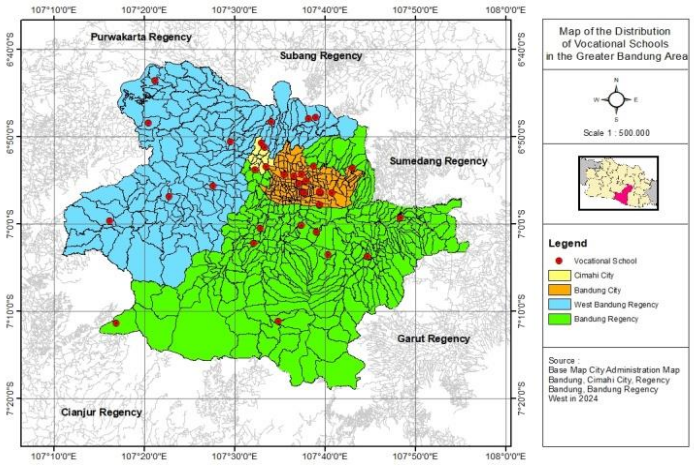


Fig. 2 *Map of vocational high school distribution in the Greater Bandung area (Source: Base map administrative map of Bandung City, Cimahi City, Bandung Regency, West Bandung Regency 2024)*

The 39 Public Vocational High Schools/SMKs varies in sectors. Among ten sectors, manufacturing and engineering technology scored the highest followed by Art and Creative Economy. In maritime sector, there is no SMK available as Greater Bandung is surrounded by mountains and has no direct access to sea. Interestingly, health and social work also has the second least SMKs with only 3 public SMK available in Bandung City and Bandung Regency. The distribution in percent can be seen in Figure 3.

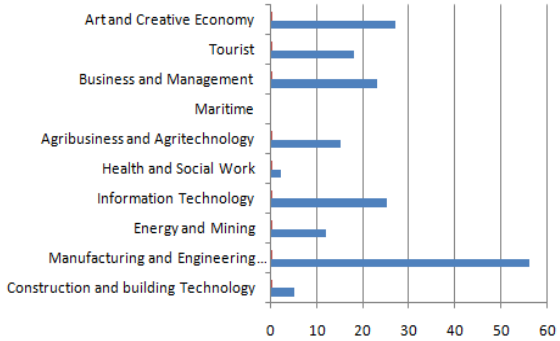


Fig. 3 *Comparison of sectors of SMK in the Greater Bandung Area (Source: Results of research analysis in 2024)*

In terms of sectors, some SMKs have very diverse programs (e.g SMKN 2 Cimahi, SMKN 11 Bandung), some are very specialized (e.g. SMKN 10 Bandung in Art, SMKN 12 Bandung in Aviation engineering, SMKN 1 Cipongkor in Business and management). In details, the distribution of sectors in SMKs is as seen in Table 2.

Table 2 *The number of SMK according to the sectors/spectrums and regions in Greater Bandung*

Sectors/Spectrum	Bandung City	Bandung Regency	West Bandung Regency	Cimahi City	Total
Construction and Building Technology	4	1	0	0	**5**
Manufacturing and Engineering Technology	29	14	4	5	**52**
Energy and Mining	6	8	0	2	**16**
Information Technology	10	8	4	3	**25**
Health and Social Work	2	1	0	0	**3**
Agribusiness and Agrotechnology	0	9	5	0	**14**
Maritime	0	0	0	0	**0**
Business and management	9	8	6	1	**24**
Tourism	8	7	0	4	**19**
Arts and Creative Economy	19	2	1	4	**26**
Total	**87**	**58**	**20**	**19**	**184**

In most regions, the manufacturing and engineering technology sectors dominate vocational education (SMK). However, West Bandung Regency is an exception, with a greater emphasis on business and management programs. The distribution of SMK programs does not always align with the industrial characteristics or economic potential of the region. For example, in Bandung City, manufacturing and engineering technology programs significantly outnumber those in the arts and creative economy; even though the city is widely recognized for its creative and technology industries (Nahwan, 2023). Similarly, key economic sectors such as construction, retail, and transportation, which have been identified as having high growth potential (Ramdani, 2022), are underrepresented in the SMK spectrums. In West Bandung Regency, tourism is reportedly experiencing promising

growth, supported by government initiatives like the "Breathtaking West Bandung" campaign (Salam, 2022). Yet, this potential is not reflected in the vocational education spectrum, as no public SMK in the region offers expertise programs in tourism.

3.2 Spatial Distribution of Industries in the Greater Bandung Area

Based on data obtained from *National Industrial Information System* and from the results of the analysis, the most numerous industries are in the Bandung Regency area, namely 964 industries, Bandung City 953 industries, West Bandung Regency 355 industries and Cimahi City 263 industries. This is presented in figure 4.

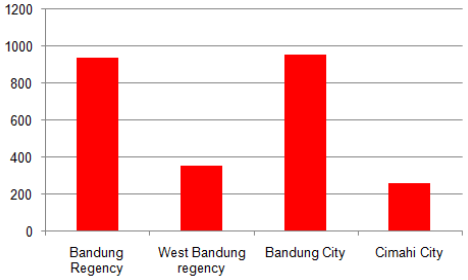


Fig. 4 *Number of industries in the Greater Bandung area (Source: National Industrial Information System and analysis results in 2024)*

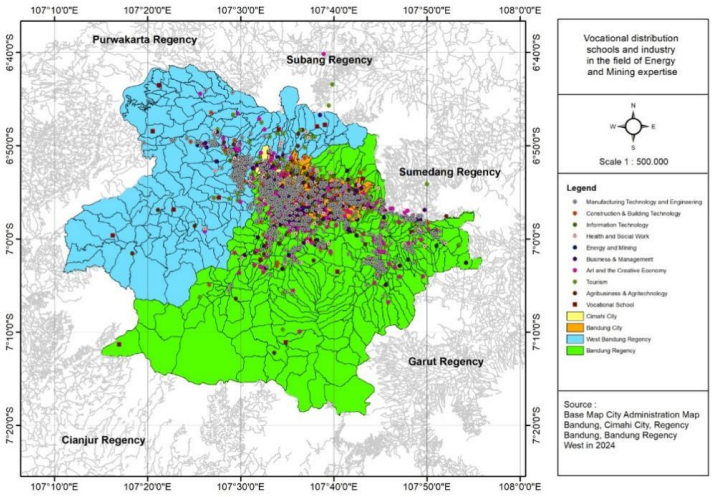


Fig. 5 *Industrial distribution map of the Greater Bandung Area (Source: Base map administrative map of Bandung City, Cimahi City, Bandung Regency, West Bandung Regency 2024)*

Based on the results of the analysis, it was found that the majority of industries are concentrated in the city center. In the Greater Bandung area, a comparison of the number of industries by sectors shows that the largest proportion—989 industries or 39%—are engaged in manufacturing and engineering technology. This is followed by industries related to arts and the creative economy, comprising 590 industries or 23%, and business and management, with 310 industries or 12%. The tourism sector accounts for 276 industries or 11%, while health and social work includes 131 industries or 5%. Industries associated with agribusiness and agrotechnology make up 73 industries or 3%, and those in information technology represent 71 industries or 3%. Construction and building technology sectors account for 58 industries or 2%, and the remaining 37 industries, or 1%, are related to energy and mining. A detailed comparison of the number of industries by sectors is presented in Table 3.

Table 3 *The number of industries according to the sectors/spectrums and regions in Greater Bandung*

Sectors/Spectrum	Bandung City	Bandung Regency	West Bandung Regency	Cimahi City	Total
Construction and Building Technology	23	18	14	3	**58**
Manufacturing and Engineering Technology	336	396	141	116	**989**
Energy and Mining	17	12	6	2	**37**
Information Technology	51	11	7	2	**71**
Health and Social Work	43	48	27	13	**131**
Agribusiness and Agrotechnology	23	32	14	4	**73**
Maritime	0	0	0	0	**0**
Business and management	148	97	34	31	**310**
Tourism	112	84	59	21	**276**
Arts and Creative Economy	200	266	53	71	**590**
Total	**953**	**964**	**355**	**263**	**2535**

The distribution of industries across the Greater Bandung area; comprising Bandung City, Bandung Regency, West Bandung Regency, and Cimahi City; shows notable variations in sectoral dominance. Bandung Regency hosts the highest total number of industries (964), slightly surpassing Bandung City (953), while West Bandung Regency and Cimahi City have considerably fewer industries, at 355 and 263 respectively. However, among the ten sectors, manufacturing and engineering technology remains the largest in all regions. In Bandung Regency, manufacturing and engineering technology is followed by arts and creative economy (266), and tourism (84). There are several contributing factors that makes manufacturing industry in Bandung Regency is dominant, namely competitive wages that attracts industries (Arifin, 2003) while still in close proximity to Bandung City as the economic center of West Java as well as supported by transportation and logistics connectivity (Kuncoro, 2003). Similarly, Bandung City also shows strong dominance in manufacturing and engineering technology (336 industries) followed by arts and creative economy (200), yet differs in its higher concentration in business and management (148) and tourism (112), reflecting the city's urban and service-oriented profile. Although Information Technology does not make into the top three, it is predicted that the ICT sectors will grow more rapidly in Bandung City (Dhewanto et al., 2015). In contrast, West Bandung Regency has a relatively smaller industrial base, with its leading sectors being manufacturing (141) and tourism (59); however, despite government efforts to promote tourism, this sector remains underrepresented compared to its potential. Cimahi City, though the smallest in area, has a notable concentration in arts and creative economy (71) and manufacturing (116), which aligns with its growing reputation as a creative and technology hub. Across all regions, the maritime sector is absent as there is no diret link between the area with sea. Moreover, sectors such as energy and mining, agribusiness, and construction remain marginal. In energy and mining, although Greater Bandung has mineral resources, Haerani et al. (2019) argued that local populations have shifted their focus towards sustainable practices such as geotourism. In Agribusiness, there are several factors which makes the industry does not thrive. Abdoellah et al (2023) stated that it is due to commercialization pressures and food insecurity. Ruswandi et al. (2007) also argues that throughout the year, many agricultural lands were converted into housing or commercial areas. These differences suggest that while manufacturing remains a unifying industrial backbone, each region demonstrates unique sectoral strengths influenced by their spatial, economic, and policy contexts.

3.3 Distribution & Spatial Gap Between SMK and Industry Sectors

The spatial alignment between vocational high schools (Sekolah Menengah Kejuruan/SMK) and relevant industry sectors plays a critical role in determining the effectiveness of vocational education systems. Ideally, SMKs should be strategically located near industry clusters that match their training programs to ensure students have access to internships, hands-on learning opportunities, and eventual employment (Ahmad et al., 2024; Khoerunnisa et al., 2020; Yoto et al., 2024). SMK should also be built to support local industry needs and align with regional economic strategy (Deng & Chen, 2023). The availability of SMK also contributes greatly to cultivate a workforce that drive economic growth (Cheng & Zhou, 2022). However, in many regions of Indonesia, a signi ficant spatial mismatch persists, where SMKs are not geographically aligned with relevant industries, limiting the opportunities for school-industry collaboration and reducing the employability of graduates including in Greater Bandung.

As seen in Table 4, the dominant industry in the region is not always well represented in the number of SMK, except for Manufacturing and Engineering Technology across all regions. For example, industries in Arts & Creative Economy in Bandung Regency is the second largest industry but there are only 2 public SMK offers aligned programs. Health and Social work in West Bandung Regency is another example, as the industry is quite large but there are no programs available in public SMK. On contrary, in Information Technology sector, many SMK offers the program but the industry available in the area far smaller in number compared to other sectors.

Table 4 *The comparison between number of industries & SMK according to the sectors/spectrums and regions in Greater Bandung*

Sectors/Spectrum	Bandung City		Bandung Regency		West Bandung Regency		Cimahi City		Total	
	Industry	SMK	Industry	SMK	Industry	SMK	Industry	SMK	Industry	SMK
Construction and Building Technology	23	4	18	1	14	0	3	0	58	5
Manufacturing and Engineering Technology	336	29	396	14	141	4	116	5	989	52
Energy and Mining	17	6	12	8	6	0	2	2	37	16
Information Technology	51	10	11	8	7	4	2	3	71	25
Health and Social Work	43	2	48	1	27	0	13	0	131	3
Agribusiness and Agrotechnology	23	0	32	9	14	5	4	0	73	14
Maritime	0	0	0	0	0	0	0	0	0	0
Business and management	148	9	97	8	34	6	31	1	310	24
Tourism	112	8	84	7	59	0	21	4	276	19
Arts and Creative Economy	200	19	266	2	53	1	71	4	590	26
Total	953	87	964	58	355	20	263	19	2535	184

In Bandung City, both SMK and industry are spread quite evenly (see Figure 5) with some areas to be more concentrated than the others. There is a dense concentration of vocational schools (marked in red squares) particularly in the central and southern areas of the region. These schools are interspersed with a wide range of industries, with notable clusters of manufacturing and engineering technology, construction and building technology, and information technology (shown in brown, purple, and blue dots respectively). This is particularly prevalent in manufacturing industry in the southwestern part of Bandung City, as there are large textile industries like Kahatex and Cigondewah Textile Industrial Complex. While some vocational schools are co-located with relevant industries, suggesting potential alignment and opportunities for collaboration, there are also visible areas; especially toward the northeastern and western edges; where vocational schools appear isolated from major industry clusters. This spatial gap may indicate reduced access to work-based learning opportunities and weaker school-industry linkages in those regionsas well as reduced job opportunities and tougher competition among graduates (Lavrijsen & Nicaise, 2017; Fukunishi & Machikita, 2017).

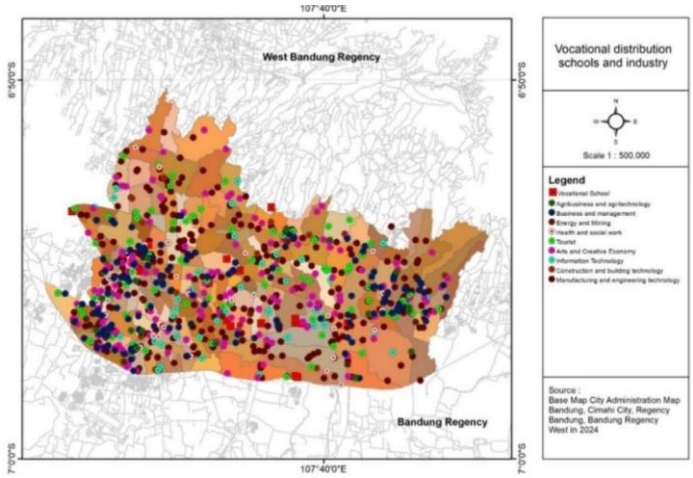


Fig. 5 *Industrial and SMK distribution map of Bandung City*

Figure 6 illustrates the spatial distribution of vocational schools (SMKs) and related industries in West Bandung Regency. The data indicate a pronounced concentration of vocational and industrial activities in the sectors of Manufacturing, Tourism, and the Arts and Creative Economy. Among these, Manufacturing emerges as the dominant sector (represented in orange), with nearly all associated industries concentrated along the Padaleunyi Toll Road corridor and the Padalarang area, including the planned urban development of Kota Baru Parahyangan. This clustering pattern highlights the strategic importance of infrastructure and accessibility in shaping vocational and industrial landscapes. The spatial configuration suggests considerable potential for aligning vocational education—particularly in manufacturing, construction, and creative industries—with local economic development priorities.

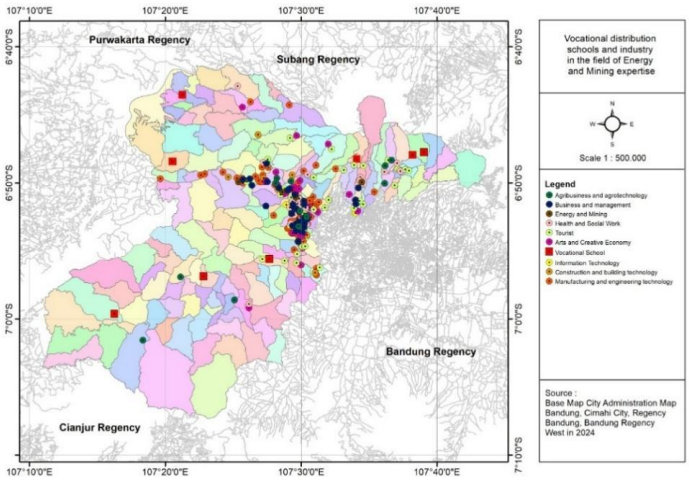


Fig. 6 *Industrial and SMK distribution map of West Bandung Regency*

However, a notable mismatch exists between the vocational education offerings and industrial sector demands. Despite Manufacturing accounting for approximately 40% of the regional industrial landscape, only 20% of SMKs in the regency offer programs in this field. Conversely, Business and Management programs constitute the largest proportion of SMK offerings (30%), even though the sector represents merely 9% of the local industry. Similarly, the Arts and Creative Economy, which ranks second in industrial prominence, is significantly underrepresented

in the vocational education system, with only one SMK offering a related program. Furthermore, emerging sectors such as Tourism and Health & Social Work, despite showing industrial growth, currently lack corresponding SMK programs. This misalignment suggests the need for policy interventions to better synchronize vocational education with local economic structures and labor market demands.

In Bandung Regency (see Figure 7), there are 58 vocational schools and 964 industries across ten vocational sectors. The northern and northeastern zones of the regency, especially near the Padaleunyi Toll Road and industrial areas such as Padalarang and Kota Baru Parahyangan, are the most densely populated with both schools and industries, highlighting their strategic positioning along major infrastructure corridors.

Percentage-wise, the Manufacturing and Engineering Technology sector is the most dominant, comprising 41.1% of all industries (396 out of 964) but served by only 24.1% of vocational schools (14 out of 58). In contrast, Energy and Mining and Information Technology each account for only 1.2% of industries, yet each is supported by 13.8% of schools. The Arts and Creative Economy sector hosts 27.6% of all industries, the second-highest share, but is served by just 3.4% of schools. This discrepancy indicates a misalignment between education supply and labor market demand, particularly in creative, manufacturing, and service sectors. These findings suggest an urgent need for better alignment between vocational school specializations and Bandung Regency's industrial composition, to optimize workforce readiness and regional economic synergy.

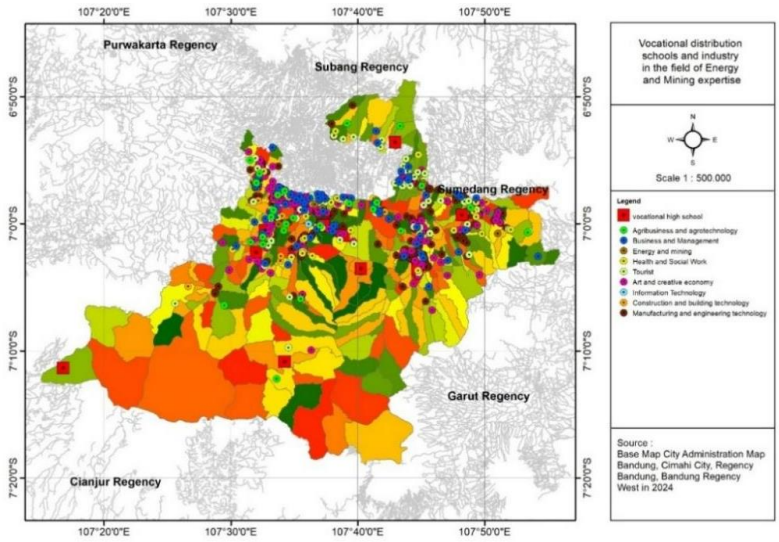


Fig. 7 *Industrial and SMK distribution map of Bandung Regency*

Cimahi City, depicted in Figure 8, reveals a significant imbalance between the presence of industries and the number of vocational schools (SMK) across sectors. The map visualizes the sectoral distribution within Cimahi, showing distinct geographic clustering particularly in the Manufacturing and Engineering Technology and Information Technology sectors. These sectors dominate both the industry landscape and the educational offerings, with 116 out of 263 industries (44.1%) and 5 out of 19 SMKs (26.3%) focusing on manufacturing, and 3 SMKs (15.8%) aligned with information technology. Spatially, these institutions and companies are concentrated in the central to southern districts of Cimahi, indicating a natural or planned agglomeration that potentially enhances school-to-industry linkages.

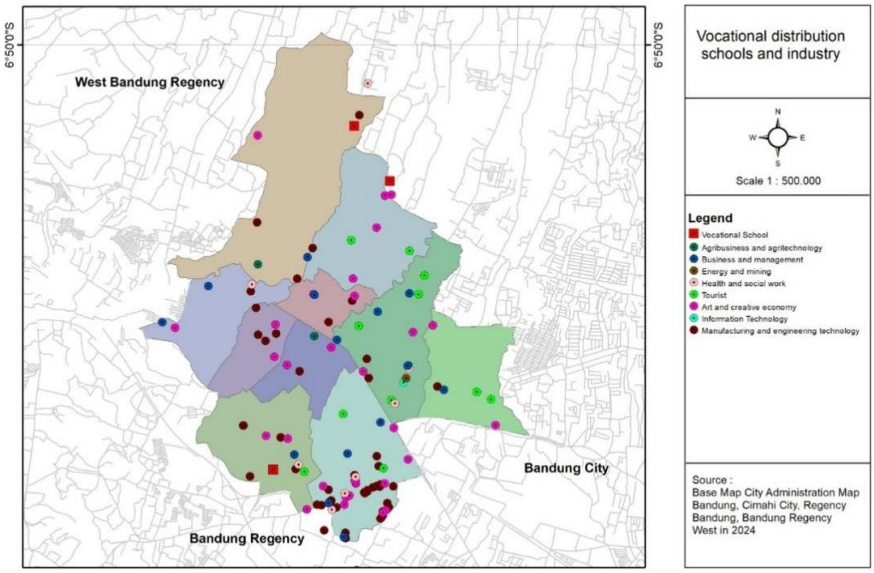
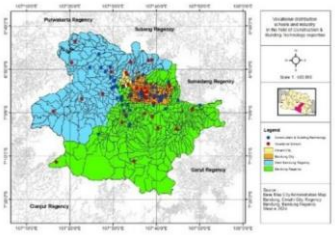


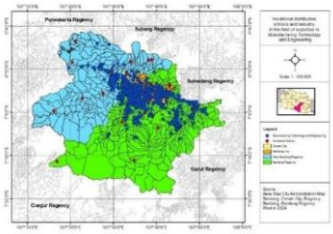
Fig. 8 *Industrial and SMK distribution map of Cimahi City*

However, there is a notable mismatch between industrial demand and SMK supply in several areas. For example, Business and Management accounts for 11.8% of industries (31 industries) but is supported by only 1 SMK (5.3%), while Arts and Creative Economy, with 27% of industries (71 industries), is matched by only 4 SMKs (21.1%). Similarly, Health and Social Work and Agribusiness and Agrotechnology are represented by 13 and 4 industries respectively, but have no corresponding SMKs. On the other hand, sectors such as Energy and Mining (2 SMKs, 2 industries) and Tourism (4 SMKs, 21 industries) show a relatively better alignment. The Construction and Building Technology sector is notably underrepresented, with 3 industries but no dedicated SMK programs, despite its relevance to urban infrastructure. This disparity underscores the need for more targeted vocational program planning to better match local economic structures and improve graduate employability.

The government of Cimahi City appears to have taken some necessary steps to address the emerging sectors. For example, seeing how Art and Creative Economy thrive in Cimahi, the government establish Cimahi Techno Park (CTP), fostering more small and medium enterprises (SMEs) and startups to grow (Triastuti et al. 2023). Proximity to CTP is crucial for SMK which create more collaborative environment and prepare SMK graduates to enter workforce seamlessly by being exposed to industry early on. In terms of sectoral distribution (see Figure 9), it is clear that some sectors have to prioritized to be supported by SMKs, such as health and social work; agribusiness and agro-technology, tourism, and art & creative economy.



Construction and building technology



Manufacturing and engineering technology

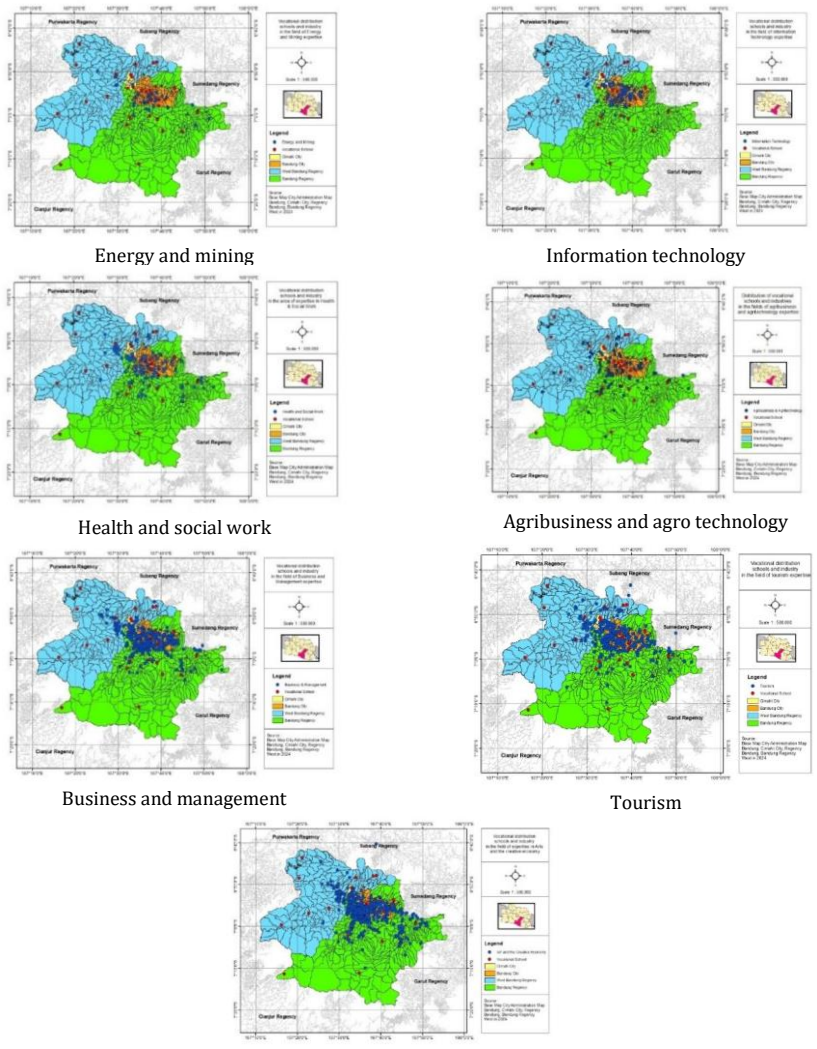


Fig. 9 *Maps of agglomeration of SMK and industry by sectors*

In Indonesia, the establishment of vocational high schools (Sekolah Menengah Kejuruan/SMK) and the development of their expertise programs are governed by national and regional policies. At the national level, Permendikbud No. 9 of 2016 on Guidelines for the Establishment of Vocational Secondary Education Units and Permendikbud No. 7 of 2021 on the Establishment, Amendments, and Closure of Formal Education Units by Local Governments emphasize alignment with industry needs and collaboration with employers. These principles are echoed in regional guidelines, such as technical instructions (juknis) issued by the West Java Provincial Government. However, in practice, partnerships between vocational schools and industry actors are often limited to symbolic agreements, with Memoranda of Understanding (MoUs) serving as administrative formalities rather than drivers of curriculum co-design, internship integration, or joint certification (Setiawan et al., 2021; Dirjen Vokasi, 2022).

In contrast, countries with strong vocational education systems often institutionalize the alignment between school planning and sectoral mapping. For instance, in Germany, the dual education system is embedded in national legislation and supported by chambers of commerce, requiring that training programs reflect regional economic profiles and sectoral labor forecasts (Euler, 2013). New training occupations are only introduced after sector-wide consultations and demand projections. Similarly, Singapore's SkillsFuture initiative mandates regular national skills demand analyses, linking the establishment of new Institute of Technical Education (ITE) programs with emerging economic sectors like fintech, advanced manufacturing, and digital services (SkillsFuture Singapore, 2020). In Australia, state-level Technical and Further Education (TAFE) institutions are required to align program offerings with regional skills priority lists derived from labor market modeling and industrial development plans (NCVER, 2021). In Victoria and South Australia, for example, new training centers are located within or near industrial precincts to maximize synergy between skills development and local employment.

Indonesia has begun experimenting with similar models. One example is the MM2100 Industrial Town in Bekasi, where SMK Mitra Industri is directly embedded within the industrial estate, facilitating seamless collaboration in training and internships (Suharto & Prakoso, 2019). Other cases include the Batamindo Industrial Park and the Jababeka Industrial Estate, which work closely with vocational and higher education institutions to develop talent pipelines for local industries (Iskandar & Widiastuti, 2022; Nurhadi, 2020). These emerging models underscore the need for an overarching spatial and regulatory framework that enables co-location of vocational schools and industrial clusters, supported by policy incentives such as special grants, tax relief for company partners, and recognition schemes. Strengthening pathways to employment through curriculum co-design, workplace-based learning, and teacher immersion in industry can significantly reduce skills mismatches and build a more resilient workforce (OECD, 2019; World Bank, 2020).

4. Conclusion

The alignment between Vocational High Schools (SMKs) and industry sectors in Greater Bandung is still limited and uneven. While some alignment exists, especially in the manufacturing sector, many key industries, such as tourism, creative economy, and health services, are not adequately supported by corresponding SMK programs. In several cases, vocational schools are not strategically located near relevant industry clusters, reducing opportunities for collaboration, practical training, and employment pathways. The close proximity between SMKs and industries is important to foster effective partnerships, ensure relevant skill development, and enhance graduate absorption. However, current planning practices often overlook spatial and sectoral needs, leading to mismatches in supply and demand for skilled labor. To address these gaps, vocational school development should be guided by integrated spatial planning that considers both the distribution and specialization of local industries. Stronger coordination between education planners and industry stakeholders is essential to ensure that vocational programs reflect regional economic strengths. Moreover, policy efforts should encourage more practical and sustained collaboration between schools and industries, enabling better alignment of training with labor market needs.

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Author Contribution Statement

A. Ana conceptualized the study and led the project administration and writing of the manuscript. Vina Dwiyanti and Ana Ramdani Sari contributed to data collection, GIS analysis, and interpretation of spatial data. S. Saripudin assisted in the methodology design and drafting of the results section. M. Muktiarni contributed to the literature review and manuscript editing. All authors reviewed and approved the final version of the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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