Modernization of Chiang Mai's Infrastructural Space: A Case Study of its Electricity and Telecommunications Systems

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Abstract

Since the 1950s, Chiang Mai's infrastructure has gradually developed and modernized, culminating in its recent endorsement of smart city policies in 2018. We will explore how Chiang Mai's development has changed and affected its residents by examining data related to both its historical development and the early stages of its new transformation policies. The aims of this paper are the following: 1) to gather data, including an architectural survey, that maps the changes in Chiang Mai's electrical and telecommunications systems from the 1950s to today, 2) to examine the city's historical transformation since the 1950s through the notion of infrastructural space, and 3) to further illustrate the development of Chiang Mai's infrastructural space in relation to smart city policies. This research utilizes qualitative methods and combines data from various sources, such as historical photos of Chiang Mai city and interviews with key informants, including the head of Chiang Mai Electrical Substation 1-2-3, a high-level electrical engineer, and the curator of the Telephone Museum Northern District. The following highlights can be illustrated: 1) the infrastructural space in the city lacks coordination and has become chaotic, 2) smart city policies seem to be dissociated from any historical development of infrastructural space of Chiang Mai city, and 3) The public and private sectors in Chiang Mai approach the development of infrastructural space differently.

Keywords: infrastructure, city development, urbanization, smart cities, Chiang Mai

Introduction

The notion of modernization of a city is the way in which the city has been conceptualized through the transformation process–the growth of the city's fabric, the mobilization of the population, economic and political changes, and the introduction of new technologies to run the city. To explore this transformation, many media have been employed–such as road or highway networks, various forms of architectural styles, or a city's zoning analysis–showing the changing boundary between new housing projects and agricultural areas, allowing researchers to understand and visualize these transformations. But that is not the case for a city's infrastructure, which is integrated closely with the way people live, the buildings they use, and the city in which they dwell. This is also the case for Chiang Mai, the second largest city in Thailand, with a history stretching back more than 700 years.

While considerable research has focused on Chiang Mai prior to the 1950s–particularly its Lanna history (Kanchanaphan, 1984; Chananon, 1986; Ongsakul, 2004; Ongsakul, 2006; and Phetrung, 2010), research on its "modern transformation" since then remains limited. This includes Philip Jablon, who explored the modern historical transformation of Chiang Mai city through the development of stand-alone movie theaters as they related to changing lifestyles, the growth of the city fabric, and the development of the shopping complex (Jablon, 2010: 4-6). Sant Suwatcharapinun also examined this transformational period through an historical investigation of Chiang Mai's remaining early modern buildings by first measuring, photographing, and modelling them; and then conceptualizing them through four lenses in the city's transformation–educational, economic, political, and infrastructural (Suwatcharapinun, 2013: 41-121). In addition, Peerapong Promchart and Sant Suwatcharapinun elaborated the modern political transformation found in Chiang Mai's modern architecture (Promchart and Suwatcharapinun, 2016: 579-587). In short, the modernization of Chiang Mai since the 1950s can be summarized in terms of three key factors: 1) transportation and trade expansion-the arrival of the railway in 1921

facilitated the transportation of goods and raw materials, leading to an expansion of the trade economy in Chiang Mai. This economic growth played a significant role in the city's expansion. 2) The influence of American Presbyterian missionaries–who arrived in Chiang Mai in 1867 played a role in shaping education and public health in the region. Their presence contributed to changes in these areas, impacting the city's development. 3) The changing governance system–Chiang Mai's governance system evolved from a provincial municipal system to become part of the provinces of Siam. This transition led to shifts in political beliefs and government practices, as well as influencing the lives and livelihoods of the city's residents. It represented a negotiation between Lanna's traditional beliefs and Siam's modernity. The present research project is an effort to search for another factor, which emerges from the development of the city's infrastructure.

This research, first, re-establishes the link between Chiang Mai's past and the present through the development of its infrastructure. Second, it re-examines the connection not only from the utility customer or end-user locations, such as businesses and residences, to the larger infrastructural network of roads, utility poles, and wiring, but also from the more traditional wiring to the new wireless connections increasingly common in the city. This research argues for reconsidering the historical development of the city's visible connections, in this case its electrical and telecommunications systems, helping to conceptualize how the city has grown and evolved, as well as connections with current smart city policies.

As with most cities in Thailand, the utility wiring in Chiang Mai appears chaotic. What started with electrical wiring grew with telephone cables, and then exploded with fiber optic cables. Information on this infrastructure in Chiang Mai is scattered, neglected, and overlooked; both residents and relevant authorities tend to focus on progress and new outcomes, with little concern for the past. Creating a set of this data on how the city's electrical and telecommunications infrastructure has developed and helped transform Chiang Mai is important to implementing smart city policies, as well as for designing and supporting

the city's future expansion. To do this, we employed the notion of "infrastructural space" coined by Keller Easterling as a conceptual framework–a notion of how to represent infrastructural systems in relation to the space of the city (Easterling, 2016: 10-11). As Easterling described, the infrastructural systems that surround us–from the electrical power grids located underground inside various and complex pipeline systems, to microwaves for satellite transmission, even to the digital appliances that we hold in our hands–unknowingly shape our social relations, while, at the same time, controlling our daily lives. That is to say, the way in which infrastructural systems aim to manage, regulate, and control people and their everyday lives in cities is similar to the notion of how powerfully planners, architects, and engineers of various interconnected systems influence our urban spaces. When the term "infrastructure" is combined with the concept of "space," it implies both an abstract connotation and concrete implications–meaning it can be discerned from the exact locations of electrical power plants, utility poles, and telecommunication cables hanging chaotically throughout a city, as well as new activities or architectural programs emerging there.

"Infrastructural space" aims to respond to the demands of the people who live in cities to improve their everyday lives. It shapes how we live, our social relations, and our perception of cities as a whole, including their development and our connection both to the city and the communities within. We will use this concept to explore the space in Chiang Mai municipality, but given our limited scope and time frame, we will focus on only two of the many complex infrastructural systems that make up a city–the electrical and telecommunications grids. It is hoped that this will help expand the data available to city planners, who have generally relied on road networks in their planning (Sammanithi and Sammanithi, 2007: 105-126; Shummadtayar and Ongsavangchai, 2018: 70-73).

Objectives and Methodology

This research focused on three different time frames: 1) 1957-1977, Chiang Mai's modern transition period that included the National Eco-

nomic and Social Development Plan No.1 (1961-66), which transformed the city with development of the Chiang Mai-Lampang Superhighway, the City's Ring Road, and an increasing number of electrical systems; 2) 1978-1997, a period that included the major development of the west side of Chiang Mai, or Hang Dong, and a number of new settlements in the high-density zone; and 3) 1998 to the present, when Thailand's 4.0 Strategic Development Plan emphasizing the digital economy and smart city policies were introduced.

This paper aims to: 1) generate a dataset that maps the changes in Chiang Mai's electrical and telecommunications systems from the 1950s until today, 2) examine the city's historical transformation since the 1950s through the notion of infrastructural space, and 3) further illustrate the development of Chiang Mai's infrastructural space in relation to smart city policies. This research is based on a qualitative method. Data were collected from a variety of sources, including black-and-white photos depicting Chiang Mai city's historical development from the collection of Boonserm Satrabhaya; information about the establishment and development of Chiang Mai's electrical stations through an interview with the head of Chiang Mai Electrical Substations 1-2-3 and electrical engineers (level 9); and information based on an intelligent traffic control system from the Traffic Engineering Department of Chiang Mai municipality. The research also conducted in-depth interviews, including one with the deputy director of operations and maintenance, Provincial Electricity Authority District 1 (Northern Region), Chiang Mai Province, and another with the curator of the Telephone Museum Northern District.

Historical Transformation of Chiang Mai's Electrical System

Based on an interview with the deputy director of operations and maintenance, Provincial Electricity Authority District 1 (Northern Region), the city of Chiang Mai had electricity before 1957, preceding the establishment of both the Electricity Generating Authority and the Provincial Electricity Authority in Chiang Mai. It was produced at a

diesel plant, the Baan Den Diesel Power Plant, located in Wat Ket district, now converted to Baan Den Public Park (Limpanawat, 2020) (see Figure 1). The plant was located away from the city center, where people were concentrated, but not so far as to create excessive power loss during transmission–i.e., at the "edge of the city," an area where foreigners or outsiders were granted land by the Lanna monarch to build their settlements. This area was clearly outside of the Old City wall on the opposite side of the Ping River where American Presbyterian missionaries built the First Church of Chiang Mai (1868), public schools, including Dara Academy (1887) and Prince Royal's College (1905), as well as McCormick Hospital (1888) and McKean Hospital (1908).

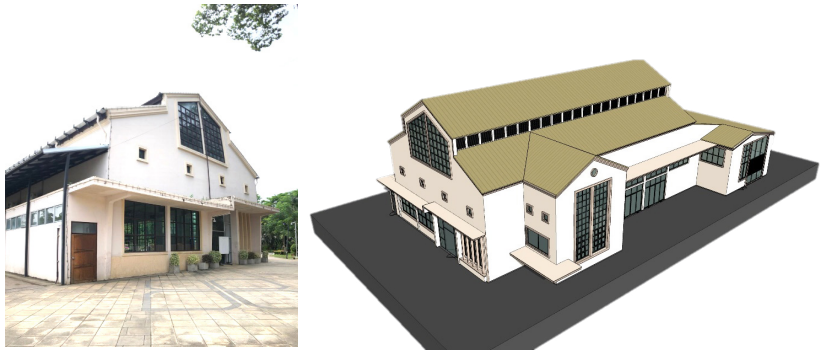


Figure 1 Photo and computer model of Chiang Mai's Baan Den Public Park, which used to be the Baan Den Diesel Power Plant (Photo and computer model by research team, 2021)

The local diesel power station was gradually replaced by more efficient and reliable sources of electrical power by the Electricity Generating Authority (EGAT) and the Provincial Electricity Authority (PEA). This transition can be seen in the establishment of Chiang Mai Power Stations Nos. 1-2-3. No official records show when Chiang Mai Power Station No.1 was established or began distributing electricity. However, the land–in the Nong Hoa area, close to the Baan Den Diesel Power Plant–was purchased in January 1970. Chiang Mai Power

Station No. 2 began distributing electricity in 1968. In 1979, the power supplies from Chiang Mai Power Stations Nos. 1 and 2 were connected to better support the increasing electrical demands of the inner city. As Chiang Mai city expanded southward along the second ring road, construction began on Chiang Mai Power Station No. 3 (Hang Dong) in 1985, as a part of Chiang Mai City Planning by Ministerial Regulation No. 38. Along with the development of the southwestern area of the city, many important government projects also occurred during this period, including construction of the 700-Year Chiang Mai Sports Complex (1995), the Chiang Mai Night Safari Project, and Rajapruek Park (2006). These not only helped justify building Chiang Mai Power Station No. 3 in Hang Dong, but along with the expansion of Chiang Mai University and Maharaj Hospital on the same side of the city, the construction of Power Station No. 4 (previously, Chiang Mai University had its own power plant). The site selection and construction of Chiang Mai's power stations not only supported the city's expansion policies – through its expanding road network, including three ring roads, but also attracted settlement that fulfilled those expansion plans (see Figure 2).

Chiang Mai's development has been guided by central government plans, which currently aim to accelerate digital era changes, as seen in the smart city policies of 2018-2022 as endorsed by the Chiang Mai Provincial Administrative Organization. Chiang Mai municipality is responding to various aspects of the smart cities policy, taking into consideration both their working potential and available budgets. They have chosen to take on a central role in connecting various relevant agencies, in terms of both space and budget, to work together with a primary focus on economic development and tourism promotion. For example, both the Provincial Electricity Authority and Chiang Mai municipality have worked closely to support these smart city policies in their development and expansion plans, although their focus is somewhat different. The Provincial Electricity Authority is working on developing a smart electrical grid system, promoting the use of electric vehicles, and making its infrastructure less visible (such as by burying cables and relocating transformers), particularly in the Old City.

Chiang Mai municipality is focused solely on the traffic system – in line with smart mobility. According to the Traffic Engineering Department of the Chiang Mai municipality, nine sets of intelligent webcams were installed at key intersections and a surveillance system based on geo magnetics was installed in the Nimman area to prevent cars from parking in restricted areas. The two agencies have implemented the notion of 'smart' differently–one focused on improving the existing electrical grid to improve people's way of life, the other on managing and controlling through machines and monitoring technology.

Historical Transformation of Chiang Mai's Telecommunications System

Along with the Baan Den Diesel Power Plant, another historical landmark, Hong Sai (1893), also reflects Chiang Mai's modern infrastructural transformation, but in this case for its telecommunications system. Hong Sai became the Post and Telegraph Office in 1909. Change can be seen through the increased demand for telephone service in the 1950s, when the first telephone junction (the Mae Ping Junction) was installed on the opposite side of the Ping River; in 1990 it became the Northern Telephone Museum (see Figure 3). Its location in the new "central business district" reflected the modern transitional period in the city's development during the 1960s. It was part of a trading network area on the west side of the Ping River that linked Tha Phae, Wichayanon, Chang Moi, and Ratchawong Roads. According to Wittaya Yaowapaksophon, a former Telephone Organization of Thailand (TOT) staff member now in charge of the Northern Telephone Museum, this area was Chiang Mai's "most prosperous urban area" (Yaowapaksophon, 2020) in the 1950s.

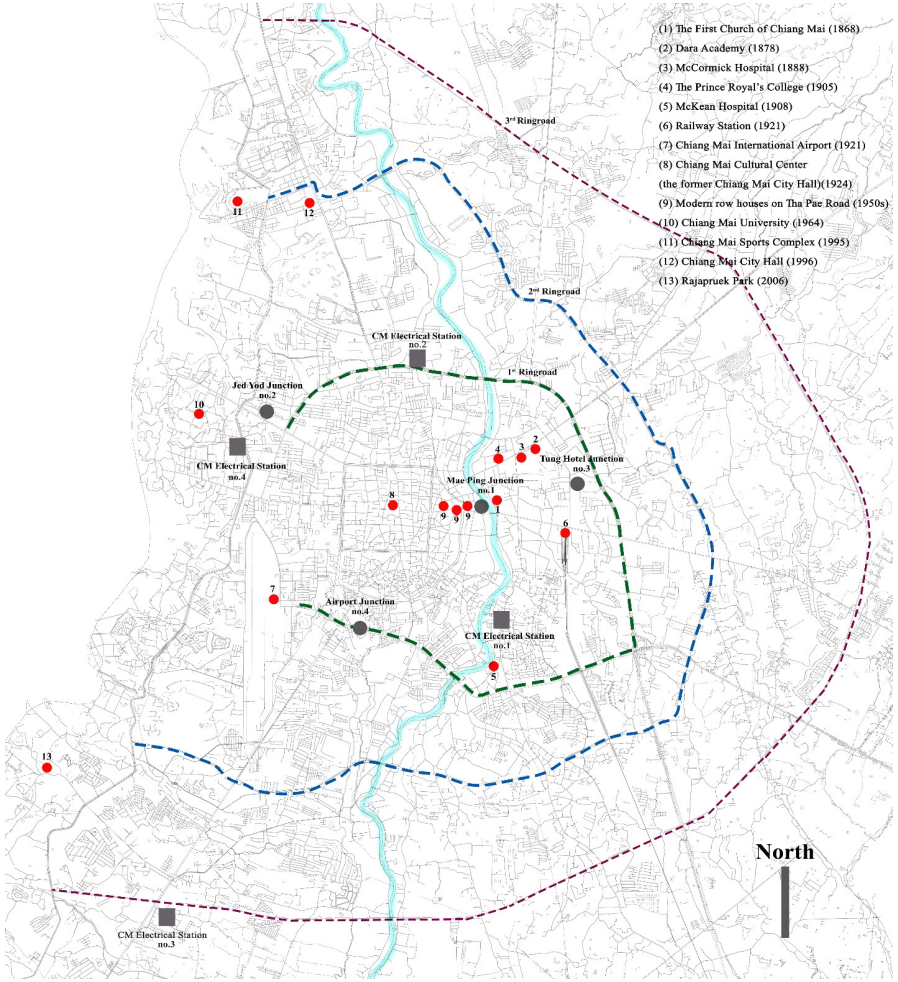


Figure 2 Map of Chiang Mai city in relation to the service area of electrical stations and telephone junctions (graphic by research team, 2021)



Figure 3 The Northern Telephone Museum (left), the former Mae Ping Junction (built 1950). The Chiang Mai Philatelic Museum (right), the former Hong Sai (built 1893) (Photos by research team, 2020)



Figure 4 Modern row houses dating from the 1950s on Tha Pae Road (Photos by research team, 2020)



Figure 5 Photos showing the transformation in the Chang Moi area in 1967. This was the year carts were banned from the city center and replaced by motorcycles (Photos, left to right, by: Boonserm Satrabhaya, Lanna in the Past, and Information Technological Service Center, CMU, 2021)

While the location of the Mae Ping Junction (1950) reflected its significant telecommunications role, it also shows how it precipitated a parallel social transformation. Modernization of Chiang Mai's telecommunications system can be divided into six periods. The first period was before 1957, when the city center began to shift from the old town towards the Ping River. The siting of Hong Sai and Mae Ping Junction supported this shifting of the city center. During that time, only a few could afford the cost of connecting a home or business to the central telecommunications junctions. Except for a few merchants trading with Bangkok or other cities, most people did not need long-distance communication. The siting of the Mae Ping Junction supported the shifting of the central business district's location and coincided with the rise of wealthy merchants and foreign consulates that began requesting more telecommunications services (see Figures 4-5).

The second period, 1957-1987, saw demand for telecommunications services dramatically increase. During this period, the more people used telecommunications services, the less they paid for the service. Telephone networking infrastructure was expanded in response to residential growth moving out from the city center, including the Vieng Bua, Nimmanhaemin, Hang Dong, and San Khampaeng areas. Chiang Mai city's telephone network junctions or service areas are relatively simple, with four stations (each services a five-kilometer radius) covering the municipality: Station No. 1, the Mae Ping Junction, services the Ping River area on its western side towards the northern part of the city; Station No. 2, the Jed Yot Junction, services the western side of the city; Station No. 3, the Tung Hotel Junction, services the eastern part of the city; and Station No. 4, the Airport Junction, services the southern part of the city. These junctions were sited in response to the city's population growth and expansion (Yaowapaksophon, 2020).

The third period, 1988-1997, saw the introduction of mobile networks in Chiang Mai. The advent of pagers in 1989 and portable mobile phones in 1992 started a gradual reversal in the popularity of landline telephone service. By the fourth period, 1998-2007, internet usage and mobile networks were becoming a part of everyday life. This

period saw dramatic expansion in mobile networks to meet high demand, along with some expansion in the landline telephone system to support the housing projects sprouting up on the outskirts of the city with completion of the Second Ring Road.

The fifth period of telecommunications transformation, 2008-2017, which also saw a dramatic expansion in mobile phone and internet services growth, coincided with a significant change in national policies that required state approval for private concessions with TOT newly rebranded in 2005, and the Communications Authority of Thailand (CAT), established in 2003. In a very competitive environment, and with the government agencies slow to develop new services, both had difficulty competing with the private sector in telecommunications. The agencies began to shift their operational strategy to expanding the internet network in remote areas where people lacked access to government services and the private sector had less market incentive to invest. They aimed to provide free internet service to reduce inequality, while creating opportunities for people in remote areas to better access government services. This project was called the "Net Pracharat Project." With the merger of TOT and CAT to form the National Telecom Public Company Limited in January 2020, the sixth period of transformation in telecommunications services in Chiang Mai began. This newly merged state enterprise has focused on driving the Thai economy and society in the digital age. It emphasizes telecommunications infrastructure services and digital quality to promote the security of the state and bring innovation and digital technology to enhance the quality of life of Thai people (National Telecom Public Company Limited, n.d.).

Chiang Mai's telecommunications systems have been transformed over these six periods from operator-reliant, fixed-location services that were limited to a small number of wealthy people to advanced wireless telecommunications systems that were much more widely accessible–a transformation that corresponds to the growth of the city in the digital era. The transformation as it occurred highlights the difficulties the government has in competing with the private sector, and reminds us how the private sector may be most effective developing and managing their infrastructure with minimal government collaboration.

In 1987, during the third transformation period for telecommunications, the internet became available in Chiang Mai using the same network wiring system as the telephone. When first introduced, the internet relied on a government system that was only available within Chiang Mai University, a network called Thainet (Information Technology Services Center, 2012). The internet gradually expanded from the university through the existing telephone network system to the public, first through Huay Kaew Road and then beyond to Chang Phueak, Tha Phae, Charoen Mueang, and Charoen Prathet. From there, internet access expanded to new housing estates and condominiums in Chang Pueak, Nimmanhaemin, Chet Yot, and Santhitham. This provided new opportunities for small businesses, such as internet cafés, around the university and student dormitories.

When the internet system changed to high-speed ADSL (ISDN – Integrated Service Digital Network) in 1997, the function of internet cafés changed from working spaces for students to conduct research, send emails, and write reports, to venues for online entertainment activities and streaming games, such as Raknarok (2002), Pangya (2005), and Audition (2006). In 2007, the wireless internet using Wi-Fi signals was introduced to Chiang Mai. People could now easily connect to the internet from their own personal computing devices, and no longer had to rely on shop-provided desktop computers. Online game stores evolved from their traditional fixed format to become more flexible. Internet cafés became co-working spaces, used for both work and entertainment simultaneously. These changes in access and use of the internet fit within the paradigm of infrastructural space, contributing to both social change and creating new possibilities for alternative lifestyles. Co-working spaces have attracted a new group of people called "digital nomads," who have come to Chiang Mai for both recreation and work. According to Nomadlist and Digital Nomad Demographics, which survey the most popular digital nomad destinations, Chiang Mai city has become a very popular destination to work and live (Nomad Destination, n.d.).

It is important to note that since the internet was introduced to Chiang Mai in the 1980s, it has gradually shaped the city. The telecommunications infrastructure has moved beyond the emerging university system to one supplied by the private sector, reflecting the increased demand for services that has attracted investment. As mobile internet service gets faster, the existing wired telephone system may no longer support such service. The telecommunications system in Chiang Mai has been built upon multiple layers. Location relative to access and speed of telecommunications services becomes a key factor for where people, including digital nomads, choose to work or live.

The internet has affected the city's transformation in three ways. First, it offers a new possibility to transform Chiang Mai into a destination for digital nomads. Their schedules often need to be flexible, as they may work across time zones and, importantly, may not be attached to any specific geographical location. Their criteria for where to live and work includes a fast internet connection. Since 2010, many co-working spaces have popped up in the city around Nimmanhaemin, Sirimangkalajarn, Huay Kaew, Santitham, and some parts of the old town area, responding to and attracting digital nomads. A more detailed assessment of these places should factor in the variety of internet services, reliability of internet connections, and affordability of co-working space rental rates, which could be hourly, daily, or monthly. Co-working spaces have become increasingly attractive to students and freelance workers as well (Kitika, 2021: 421-483) (see Figure 6).

Second, the value of rental properties depends on the speed of the internet – the faster the internet, the more expensive the rent, all else being equal. The more advanced the telecommunications system, the less people rely on the city's existing infrastructure. This can be seen with the expansion of WIFI networks. We found many transmission towers on the top floor of buildings, hidden from sight. This has created an alternative cityscape within the physical city.

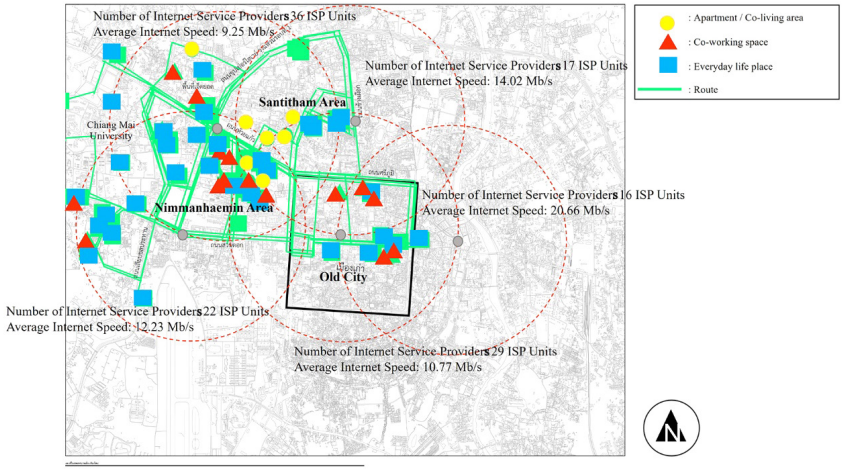


Figure 6: Map of Chiang Mai municipality indicating various businesses and co-working spaces where we frequently found digital nomads (Kitika, 2021: 421-483)

Third, we can clearly see how Chiang Mai municipality willingly embraced such a policy by introducing new operational systems, such as the adaptive transportation control system–a real-time detection system using Artificial Intelligence (AI) and CCTV at major intersections in the city that sends real-time transportation information to a remote control station (Chiang Mai Traffic Engineering Center and CCTV, 2021). This is part of the smart mobility projects that focus on transportation and logistics. The Smart Nimman Project, which is operated by the Smart Energy and Environmental Lab at the Faculty of Engineering, Chiang Mai University, is another example. The Smart Nimman Project aims to make it easier to find parking spaces around the Nimmanhaemin area, thereby reducing energy consumption and pollution, while increasing traffic flow. It uses sensors to detect changes in the geomagnetic field based on whether a car is parked in the designated spot or not. Information from the sensors transmits signals in real time to a Cloud server via the Internet. Users can then use a mobile application to check the number and location of available parking spots on Nimmanhaemin Road. The project started using the system in

May 2020, with 62 sets installed in the Nimman area and another 109 to be installed elsewhere in Chiang Mai municipality.

Rethinking Chiang Mai's Smart City through Infrastructural Space

From collecting and interpreting historical data on how the infrastructural spaces in Chiang Mai have been modernized and transformed, we have conceptualized and illustrated how the city has grown and changed. Our research has shown that the relationship between the development of infrastructural spaces and the direction of urban expansion is similar for both the electrical and telecommunications systems. The modern transformation period that began in the 1950s gave us a glimpse of two starting points for exploring the emergence of modern infrastructural spaces, namely the Baan Den Diesel Power Plant and Mae Ping Junction, on opposite sides of the Ping River. These locations responded to the economic expansion of the city's trade from the 1950s onwards. Further expansion to the north and east of the city in 1968-1977 was marked by the establishment of Chiang Mai Power Station No. 1, located close to the Baan Den Diesel Power Plant and the emergence of Chiang Mai Power Station No. 2 along the Super Highway, as well as the new Telephone Junction Station No. 2 at Communication Road in Jed Yod district. Many new activities in the city also appeared in this urban zone that included Chang Moi, Ratchawong, Tha Phae, and Santitham. Subsequently, Telephone Junction Station No. 3 at Tung Hotel Road supported the further expansion of the city to the north and, mostly, east in 1978-1987. Finally, during 1988-1997, the city expanded southward and westward, supported by construction of Chiang Mai Power Station No. 3 in Hang Dong District, as well as the new Telephone Junction Service No. 4 at Airport Junction. During the same period, Chiang Mai gradually entered a new infrastructural space–that of the internet. Completion of the Ring Road in 2007 led to a major new expansion of the city. People moved to suburban areas like San Kamphaeng and San Sai in the northeast, and further away to Hang Dong district in the south,

with construction of many new housing estates (Jengcharoen, 1999: 95-111) (see Figure 7).

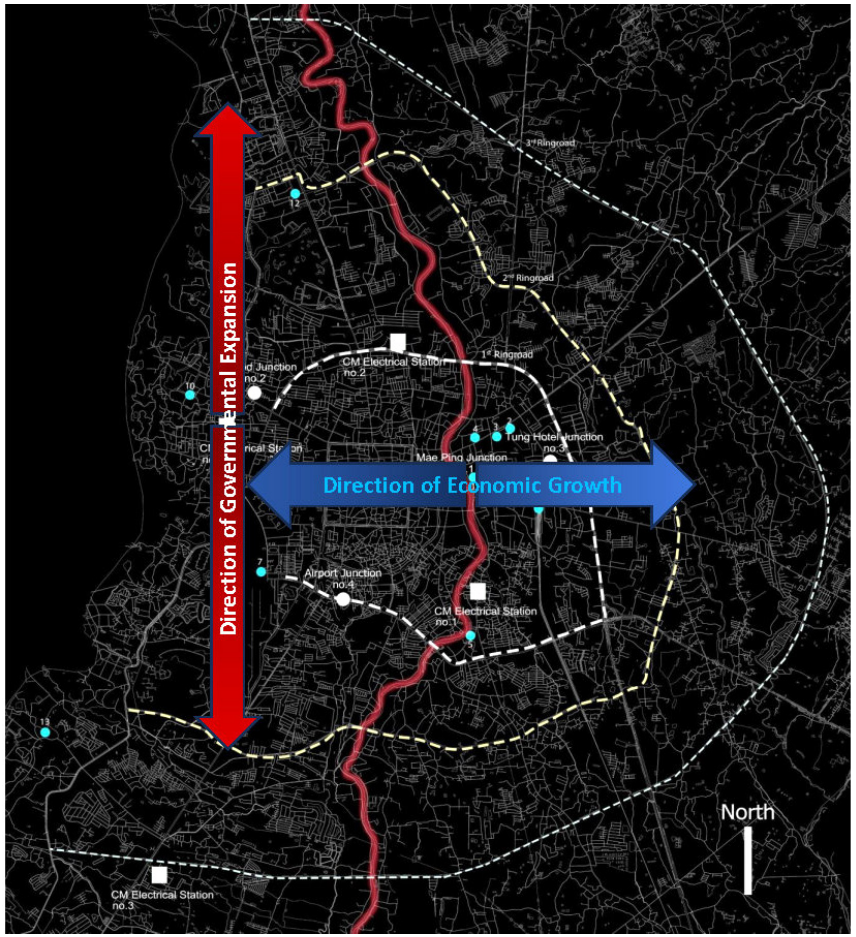


Figure 7 Conceptualization of how Chiang Mai city grew in relation to the development of infrastructure from the 1950s onwards. It follows two directions: the direction of economic growth along the east-west axis and the direction of governmental expansion along the north-south axis (graphic by research team, 2021)

The early development of both the electrical and telecommunications systems along the east-west connection axis served the increasing growth and demand of settlements well. Later expansion followed a north-south axis with relocation of the government center or city hall, as well as the 700 Year Sports Stadium (1995), Chiang Mai Royal Flora (2006), and Chiang Mai Night Safari (2006). The development and expansion of Chiang Mai city began initially along the Ping River and gradually extended towards the east first and then to the north. Subsequently, the construction of the first and second ring roads around the city in 2007 led to an expansion of urban areas towards the south. Moreover, the development of the city also shifted towards the west due to the establishment of several large-scale government projects, including the new provincial administrative center. Notably, the growth of the internet network played a crucial role in supporting the connectivity between the old and new city centers. Chiang Mai city expansion can be attributed to various factors. Population growth and increasing settlements have contributed to this expansion, but it has also been influenced by factors such as the completion of the ring road system, the relocation of government centers, and the implementation of significant government projects that were approved through political decisions and economic resolutions at the time. The research shows the consistent correlation between the development of infrastructural space and the direction of urban expansion, particularly in terms of the electrical and telecommunications systems.

Taking all these developments into account, the inner city of Chiang Mai's municipality is ready to embrace the new central governmental policies, namely smart city. These policies aim to improve the efficiency of city management. Smart city policies call for collaboration between local government and the private sector to improve the quality of life for everyone. The City Data Platform, covering as many locations as possible, is the key not only to efficient environmental management, but also to better quality of life, happiness, and sustainability (Tobey, Binder, Chang, Yoshida, Yamagata, and Yang, 2019: 522-537). However, smart city is not solely about satisfying

technological needs, but also about creating the ability to affect socio-technical transformation–it aims to make the city "intelligent." Developing an intelligent city can be simplified and separated into two approaches, either coordinated control/systematic management of people and their way of life, or use of such technology to establish better communication/connection with people in the city (Sumali and Team, 2017: 12-17). However, by implementing the tools and advanced technologies in a specific and selected location of the city, it can paradoxically create a sense of inequality development. The city itself becomes spatially segregated.

Chiang Mai has responded to smart city policies in several ways. The Provincial Electricity Authority has worked closely with the Chiang Mai municipality to install many control and monitoring devices, such as vehicle speed detection devices and surveillance cameras at many intersections, as well as removing overhead electrical cables and burying them underground along many major roads within the old town. More projects are in development, including online devices to check and digitally report on street lighting. All of these have been designed to connect with each other and to link to the central controller via an online system. Future plans include promoting electric vehicles, installing electric car charging stations, and implementing a smart grid – an online electrical system able to monitor and manage individual households separately. Aside from the electrical system, the merger of government's CAT Telecom Public Company Limited and the Telephone Organization of Thailand (TOT), forming the National Telecom Public Company Limited (NT Plc.) in 2020, was aimed to upgrade the country's telecommunications system infrastructure–for example, by taking over operation of the "Net Pracharat," a government project that began in 2016 to expand internet infrastructure and access to remote areas or villages countrywide.

Chiang Mai municipality has gradually and continuously adopted new technologies in order to shape and digitize the city. Yet, based on our findings, the municipality's attitude emphasizes the technological aspects of management and control, rather than focusing

on how to improve the quality of life and well-being of people in the city. As mentioned previously, smart city policies should not focus solely on information technology, or they risk lacking the human touch of connectivity and an empathy for living. The reality of the city, various ways of life, public participation and decision-making–all of these should be taken into account, as changes within the city affect everyone (Kong and Woods, 2021: 117). Government organizations overseeing different aspects of the city and its infrastructure tend to operate independently with little collaboration. Even worse, they manage their sectors without concern for local people or knowledge of what actually happens in the communities (Advanced Info Service Public Company Limited (AIS), 2019; Manowanna, 2021, Pongsriwat and Suriyamanee, 2021; and Nuamkhrut, 2021).

Knowledge of local contexts and social conditions leads to better and more complete city analysis. For example, familiarity with communities and infrastructural space–not only physical, but also social and technological conditions–helps to support internet-related activities and emerging communities like digital nomads. It is important to remember that, to become a smart city, Chiang Mai needs to consider not only the physical aspect of the city, but also its people, their communities and ways of living, because soon all of these will be integrated and embedded as part of their daily lives.

Conclusion

We examined the transformation and development of Chiang Mai's infrastructural systems–focusing on its electrical and telecommunications systems, as they are regarded as infrastructural spaces that connect, operate, and integrate within the city in relation to its people, communities, and their spaces. This research aimed to show not only how these infrastructural spaces developed from the modern transitional period of the 1950s to the present, but also to analyze the connection between where this infrastructure was sited in relation to the ways of the people living in the city–including where they chose to live, how they moved

around the city, and where they did business–as we regarded this connection as infrastructural space.

Since the 1950s, Chiang Mai's urban expansion has followed various directions. It expanded eastwards, connecting with economic growth and the introduction of railways, while also extending northwards for government-related expansion, and southwards for significant government projects. The city's growth can be attributed to both the expansion of ring roads and the development of infrastructure systems that facilitated this expansion. Research consistently shows the correlation between urban expansion and infrastructure development, particularly in terms of electrical and telecommunications systems.

This correlation is evident from the placement of numerous power stations and telecommunications switching stations, which were constructed following the existing road network until 1988. However, after 1988, the coverage of these systems had already reached a substantial extent, leading to a slowdown in further development. This was especially noticeable in the transition from the old telecommunications system to a new infrastructural system, the internet. The internet's growth relied on technologies like fiber optic cables and wireless transmission, departing from the use of the existing telecommunications wiring and infrastructure.

Starting in 2018, Chiang Mai Municipality embraced the smart city policy, aligning it with national strategies and the development plan for Chiang Mai province. The Smart Nimman Project, as mentioned earlier, serves as a prime example of smart city initiatives that prioritize the enhancement of traffic, transportation, and tourism.

The infrastructure of the old and new telecommunications systems remains distinct and layered on top of each other, without full integration or replacement. The old system played a vital role in supporting the city's growth and economic prosperity, while the new system has been employed to "tighten" the city's operations, including monitoring people's lives more closely.

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