Is urban development around Laem Chabang Port, Thailand, sustainable?

Nitin Agarwala [1] , *Worawut* Poma [2*], *Effi Helmy* Ariffin [3], *Abdullah* Açık [4], *Ikha* Magdalena [5,6], *Punarut* Sirichokpokin [2], *Narthsirinth* Netirith [2], *Naruphun* Chotechuang [2], *Htet Khaing* Kyi Lin [2], *R.* Nagalakshmi [7], *Lanlila* Chitsom [8], and *Chalida* Pohma [9]

[1] Naval War College, Verem, Goa, India
[2] Faculty of International Maritime Studies, Kasetsart University, Sri Racha Campus, Thailand
[3] Institute of Oceanography and Environment, Universiti Malaysia Terengganu, Malaysia
[4] Maritime Faculty, Dokuz Eylül University, Turkey
[5] Faculty of Mathematics and Natural Sciences, Bandung Institute of Technology, Indonesia
[6] Center for Coastal and Marine Development, Institut Teknologi Bandung, Indonesia
[7] Department of Civil Engineering, SRM Institute of Science and Technology, KTR, TN, India
[8] CNNC Joint Venture, 88 Bangna-Trad 30 Rd., Debaratna Bangna-Tai, Bangna, Bangkok, Thailand
[9] Faculty of Engineering and Technology, Siam Technology College, Thailand

Abstract. Mega ports are believed to urbanize their surrounding areas quickly. However, literature confirming that they actually accelerate long-term land-use development is limited. There is, hence, a need to investigate land-use changes before and after the development of a port to evaluate the interconnection and influence between such ports and their neighboring areas. This study aims to evaluate historical land-use changes between 1975 and 2021 around Laem Chabang port, the biggest container port in Thailand, using satellite images obtained from Google Earth and the U.S. Geological Survey. Standard procedures of spatiotemporal analysis were implemented for analysis. Key findings show that urbanization was rapid during the port development planning and construction phase but slowed down soon after. Accordingly, one can infer that mega ports may be considered only as a temporary catalyst for surrounding urbanization and do not bring about urbanization on a permanent basis. This study is considered important as it provides a good understanding of the relationship between urbanizing and ports and can help develop a strategy to establish a balance between coastal urban development and environmental protection.

1 Introduction

Seaports are essentially anthropogenic marine structures that extend land functions into the ocean and act as key linkages in international logistics and supply chains [1-2]. They have evolved over time not only to serve ships but also to offer value-added services such as packaging and labeling, as well as to create jobs in port zones. Port locations are selected to optimize land access in navigable waters by providing commercial trade with sheltered places where ships can be safely loaded, unloaded, refueled, or repaired. Seaports play a vital role in maritime transportation and trade facilitation, significantly influencing local, regional, and national economic, social, and environmental developments. Nowadays, ports help expand the world economy and act as engines of economic growth for a nation by providing a connection to the growing world trade. In the past, the topic of ports and their impact on the economy has been discussed in several studies. Chang et al. [3] concluded that ports stimulate economic growth at both the country and regional levels. Port development significantly raises the land value of the neighboring port area as businesses and industries take advantage of the benefits offered and mushroom in the region [4].

Ports, shipping activities, environment, and urbanization are intertwined [6-8]. The ports affect the sustainability (e.g., human well-being, green cover areas, ecosystem, biodiversity protection, and pollution management, etc.). Coastal communities and their well-being are one of the vital components of sustainable development [9]. Hence, many researchers have focused on the impacts of port development on urban expansion and land-use evolution. An extensive review regarding the sustainable development of ports and urban complexity is presented by Nebot et al. [10], who mention the vital role of ports in integrated coastal zone management. Ports and coastal areas have undergone physical transformations due to intensive port-driving competitive processes relating to land-use and port relationships. Specifically to Port Sudan,

* Corresponding author : worawut.po@ku.th

Hawash et al. [11] highlighted that the urban development rate outstripped the population growth rate, resulting in land being used for urbanization faster. Similarly, in China, Shu et al. [12] found vast urban expansion adjacent to Taicang Port in Fuqiao, China, and suggested that differentiated policies should be formulated to guide the proper expansion of urban land.

With significant developments occurring in these port areas, numerous undesirable consequences have been studied in greater detail by various researchers, including water quality degradation, coastal resource degradation, and air quality issues [13]. Port-driven urbanization can negatively affect the allocation of coastal resources. Economically, Deng et al. [14] found that these ports do not significantly contribute to economic growth. In return, since industries are concentrated in the vicinity of major ports, they significantly affect the lives of employees and their family members, sometimes even leading to conflicting land-use at unprecedented rates with the main competition being between residential and recreational services for access to limited coastal space. Our traditional belief that port-induced urbanization is always good for coastal inhabitants may not be the case if we consider aspects from these publications.

Since urban expansion always requires adequate infrastructure preparations (including coastal structures, transportation networks, water, and electricity), and those infrastructures come with costs and environmental impacts [15], it is essential that the urban growth pattern around mega ports be correctly comprehended. An incorrect idea of whether a mega port temporarily or permanently stimulates city expansion patterns can result in wasteful investments. Thus, this raises our research question of whether a port can continuously accelerate surrounding urbanization or it just creates only a short-term impact on coastal urban development. This study thus aims to answer this question by investigating land-use changes around Laem Chabang Port, the biggest container port in

Thailand. The study is considered important as it can help the government, city planners, and coastal managers to create a strategic urban development plan for areas surrounding the ports.

2 Study site and methodology

Thailand has a coastline of 3,148 km with over 4,000 km of waterways for both domestic and coastal transportation. For this study, we aim to focus on Laem Chabang (LCB) port.

2.1 Laem Chabang Port description

Laem Chabang (LCB) port is one of the major deep-sea ports of South Asia, located in Chonburi province. It is characterized as the most efficient container port by leading international deep seaports, with 80% of the international trade of Thailand being handled by this port alone. The development of the LCB port was undertaken in three phases. In the first phase, construction continued from 1987 to 1991. The second phase of construction began in 1997 and was completed in 2000. In 2025, the third phase is being constructed (Figure 1). The LCB port has been one of the main economic drivers for Thailand, hosting numerous small and large industries and, systematically decentralizing economic prosperity, and speeding up rural development. On the other hand, rapid urban area expansion, accelerated by the presence of the LCB port, has created conflicts among other coastal users. In addition, coastal problems such as maritime traffic and accidents, decreased marine life presence, marine debris, and wastewater discharge into the ocean emerged due to this urban development.

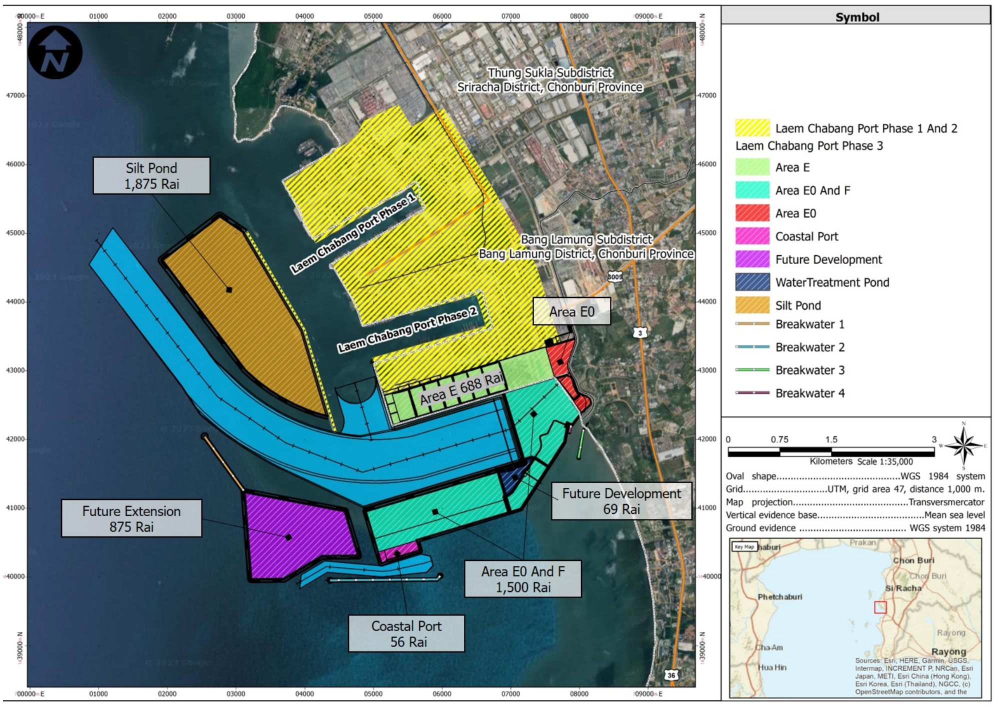

Fig. 1. Laem Chabang Port (sources: [30, 31])

2.2 Methodology

The applications of remote sensing (RS) and geographical information systems (GIS) have been widely applied in data acquisition to obtain timely and accurate spatial data on land cover, assessing the spatiotemporal changes of marine and coastal resources [16]. The remotely sensed images can effectively monitor land-use conditions, serving as an excellent data source for coastal landforms and land-use change analysis [17]. GIS provides a flexible platform to collect, store, display, and analyze digital data necessary for change detection. It has been widely applied in the context of port-related matters, as seen in the study of Gao et al. [18], where they applied GIS to measure China's port accessibility from the perspective of land-sea coordination. Ayotamuno et al. [19] examined changes in land use and economic activities between 1986 and 2005 in a residential complex in Port Harcourt, Nigeria that was originally developed for senior civil servants and military personnel, showing the rapid expansion of commercial activities within what was exclusively a residential area. Sonde et al. [20] applied RS satellite data to investigate fast unrestricted growth due to domestic use and industrialization around Jawaharlal Nehru Port Trust in India. Hence, applying RS and GIS to analyze historical urbanizing characteristics at the LCB port in Thailand was considered feasible and appropriate.

High-resolution satellite images for the LCB port were freely available from two sources: the U.S. Geological Survey (USGS) and Google Earth. These satellite images were available for the period commencing 1975. Images chosen for this study were those that did not have any cloud covering the study area or that allowed the authors to see land use characteristics clearly. Information on the year of construction of the port was gathered. Although LANDSAT imagery, provided by USGS, had a rather coarse resolution, it had been popularly applied in many coastal urban land cover transformations. More recent satellite images were extracted from Google Earth because of their higher image resolution. In order to find noticeable changes, the USGS or Google Earth satellite images were collected in a 5-year interval (4-6 years) from 1975 to 2021, as detailed in Table 1., depending on image availability and cloud cover. They were later processed to obtain land-use cover percentages of pre- and post-port development. The methodology framework adopted in the study is illustrated in Figure 2. The authors carefully rectified and geo-referenced the images. Then, we conducted field surveys and ground truthing. At a later step, the authors applied visual interpretation to discriminate residential areas, sea areas, and agricultural/forest areas. Afterward, land-use maps from 1975 to 2021 were created. Finally, the authors were able to analyze the change in the land use around the LCB port.

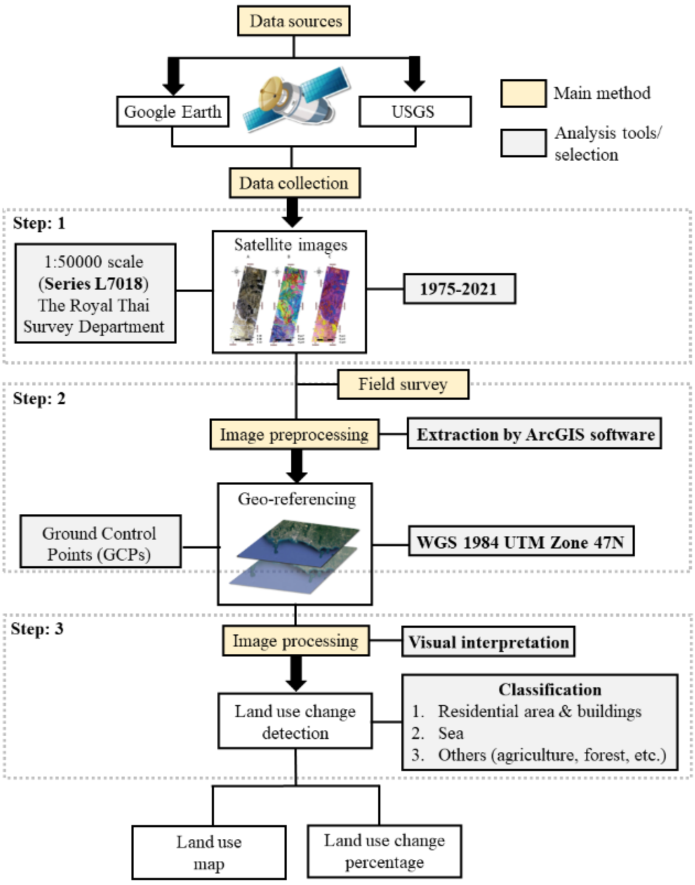

Fig. 2. Flowchart illustrating steps to monitor land-use changes at the LCB port

Table 1. Data used in this study

Focus Area	Image sources	Satellite	Image Date
Laem Chabang Port	Google Earth		10/8/2021
			6/11/2016
			9/1/2011
			29/12/2006
			31/12/2001
	USGS	Landsat 5	15/11/1996
		Landsat 5	2/11/1996
		Landsat 5	31/12/1986
		Landsat 2	8/10/1976
		Landsat 2	31/12/1975

3 Results

Land-use transformation around the LCB port from 1975 to 2021 is presented in Table 2 and Figure 3. One observes that agricultural, forest, and undeveloped lands decreased from 50 sq. km in 1975 to 12.3 sq. km in 2021. It can be observed that the urbanization rate around the LCB port surged sharply during the port planning stage. The urbanization rate was approximately 0.72% per year (from 1975 to 1986) but jumped to 1.4% per year (from 1986 to 1991). If the LCB port had not been constructed in 1991, the urbanization rate would have increased steadily instead of aggressively, as observed. Another sharp rise in urbanization rate around the LCB port was observed during 2011 – 2016 when the port publicized its third phase expansion by reclaiming 1,600,000 sq.m. The 3rd phase feasibility study happened during 2011-2016, followed by the conduct of environmental and health impact assessment (EHIA), which was approved by the cabinet in October 2018. That is why one can notice the surge in urbanization rate during 2011-2016. The non-linear urbanizing transformation rate, as analyzed, is seen in Figure 3 and Figure 4. One notices that the LCB port saw growth in residential areas and buildings within a 5-km radius. This growth was from 0.7 sq. km in 1975 to 36.6 sq. km in 2021.

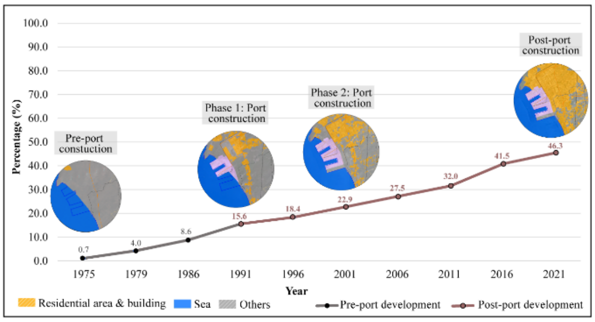

Fig. 3. Percentage of urbanization from 1975 to 2021 in the radius of 5 km around the LCB port

Table 2. Urbanization rate from 1975 to 2021 in a radius of 5 km around the LCB port

Type of land use									
Year	Port		Residential area and buildings		Sea		Others		Total area (km²)
	Area (km²)	Percentage	Area (km²)	Percentage	Area (km²)	Percentage	Area (km²)	Percentage	
2021	7.7	9.7	36.6	46.3	22.5	28.5	12.3	15.5	79.1
2016	7.7	9.7	32.8	41.5	22.5	28.5	16.0	20.3	
2011	7.7	9.7	25.3	32.0	22.5	28.5	23.6	29.8	
2006	7.7	9.7	21.8	27.5	22.5	28.5	27.2	34.3	
2001	7.7	9.7	18.1	22.9	22.5	28.5	30.8	38.9	
1996	7.7	9.7	14.5	18.4	25.9	32.8	33.2	41.9	
1991	5.5	6.9	11.9	15.1	25.9	32.8	35.8	45.2	
1986	5.5	6.9	6.8	8.6	28.7	36.2	43.7	55.2	
1979	-	-	3.2	4.0	28.7	36.2	47.3	59.8	
1975	-	-	0.5	0.7	28.7	36.2	50.0	63.1	

4 Discussion

Land-use change is a process associated with both natural and anthropogenic activities that have profound impacts on human settlements and the coastal environment. Ports are an essential link within a complex system of societal and environmental interactions, especially in coastal zones. In this study, urbanization change analysis was based on establishing the LCB port as a time node. It was observed that prior to port planning and construction, the urban expansion rate was limited. When the project of developing a port was announced, the growth rate of residential areas sharply increased and continued for a few years. This trend is similar for nearly all infrastructure projects across the world and is based on an expected demand wherein speculators tend to invest in undeveloped areas at low rates to make quick profits when the project eventually develops. However, such urbanization cannot continue for long and hence sees a drop, as observed in this study. The study area shows similar trends and results to show that while there is a concerted view that mega ports lead to extensive urbanization in surrounding areas, this is not entirely true, and such projects can best provide such growth and development for a short period, which depends entirely on demand. Once the demand is met, further urbanization slows before the fresh expansion of the port is declared. This trend is considered similar to any other infrastructure project. Similarly, it is undeniable that mega ports, regardless of their magnitude of influence, transform undeveloped land into residential and industrial buildings, which, too, is akin to other infrastructure projects. Since vast land tracks in the countryside and forest areas have been converted to urban territory to deal with rapid population growth and to sustain economic growth in the port area, there is a need for proper management schemes to manage coastal areas and control unplanned urbanization in the port region. Only such a managed effort will ensure that the ill effects of urbanization, such as pollution through plastics, chemicals, sewage, oil, nutrients, litter, shipping-related pollution such as wastewater discharge and ballast water [7, 21] and many more, can be avoided.

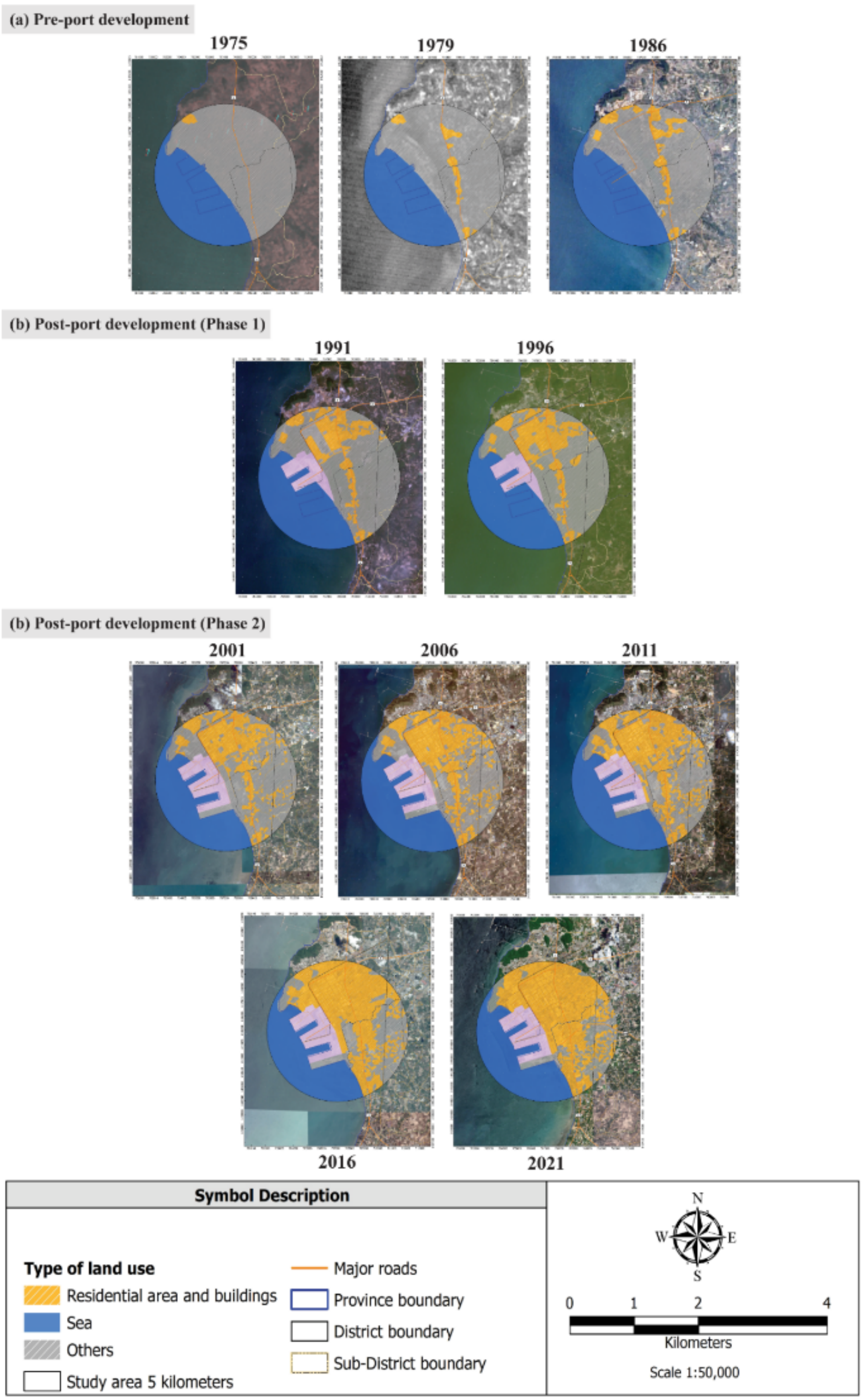

Fig. 4. Land cover map around the LCB port in a 5-km radius

It is important to mention that different ports have different development bases and hence may result in a disparity in their surrounding land-use patterns. The Semarang port of Indonesia is a live example of this disparity. When it was developed, the area surrounding the port had been profoundly impacted. Although the port successfully promoted economic growth in coastal areas that benefited neighboring communities, it induced environmental pollution and urban traffic congestion because of the high population density around the port region. Yet another example is the Port Harcourt in Nigeria, which is the largest harbor and center of petroleum activities in Nigeria. The port city saw an urbanization increase of over 300% during 1986-2003, expanding from 135 sq. km to 550 sq. km, displaying remarkable changes in land use [22]. This was possible due to limited opportunities available for the local population, which encouraged the movement of the population to the port city and, hence, enhanced urbanization. One notices that the geographical location of the port and the goods it handles (such as processing of goods, logistics operations, shipbuilding, or ship repairing) can also alter the direction of development followed by the port city. Accordingly, these cities may become 'maritime hubs', 'secondary service centers', 'specialized waterfront cities', or just distressed urban areas, thereby dictating the resulting urbanization and pollution patterns in these areas. In recent times, with a focus on sustainability, improved transportation and digitalization in ports have altered the relationship between a port and its hinterland, thereby ensuring that the ills of pollution emanating from ports can be reduced. This has also encouraged urbanization to move to the hinterland, encouraging the decongestion of the port and its surrounding areas.

As countries look for economic growth and find the maritime sector as a growth engine to propel such economic growth, the development of ports and maritime sectors is natural to happen. However, one needs to be careful of the downsides of the resulting unabated and unplanned urbanization, which demands continuous involvement of policymakers in fine-tuning the governing policies to provide the requisite economic growth while ensuring that the ills of such growth are kept to a minimum. It should also be remembered that by merely developing a port infrastructure cannot guarantee its success with an existing demand. While demand for own shipping can be a starting point, it cannot sustain mega ports, which require these ports to attract large-scale transshipment traffic.

The study shows that nearly every mega port in the world would have experienced the same pattern of urbanization around them, first with a sharp increase before the port construction, followed by a decline in growth rate soon after the construction was finished. A similar analysis, when undertaken for other port projects, such as Sihanoukville port in Cambodia and Penang port in Malaysia by the authors (not presented in this article) has brought similar results as obtained for the LCB port. Hence, the study can safely conclude that while the traditional belief that a port encourages urbanization of the surrounding area is true, it is limited to spikes that are driven by policy decisions related to further development and use of these ports. However, there is a need that such development and growth of ports be done in a planned manner with proper advanced technology [23] to ensure that sustainable growth and urbanization are achieved and the ills of environmental degradation, enlarged poverty gap, decay of a sense of community, and cultural conflicts can be avoided and kept to a minimum.

5 Conclusions

The evolution of land use at the LCB port in Thailand was investigated to develop a correlation between port development and urbanization in the surrounding areas of the port. It was observed that the urbanization rate due to development of port was accelerated only for a short duration before the port construction, which faded soon after the port began to operate before spiking again for a short duration. This trend is considered to be in line with other infrastructure projects, which display that such a surge in urbanization is linked to opportunists creating facilities when the project is announced for encashment, and then such urbanization is visible when the project facility is created to meet the demand of the working community and their families. Once the demand it met, the next surge is possible only if there is growth in the project. While this is true for most cases, there are variables such as commodities handled by the port, policy support, and social conditions that may govern the urbanization of surrounding areas of ports. Whatever the reason, it is essential that careful planning and effort are put in to ensure that the proposed development is sustainable, eco-friendly, and does not cause a negative impact on the coastal ecosystem, air quality, and biota of the region, which is otherwise a common downside of ports. If such urbanization effects are misunderstood or incorrectly estimated, they can lead to bad investments, as seen in Hambantota and Eemshaven, and undesirable social and environmental consequences.

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