

Port Planning in the Archipelagic State of Indonesia: An Analysis Using the VOSviewer Application to Determine a Bibliometric Map

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Abstract

It is generally recognized that transportation plays a vital role in supporting a nation's economy because an increasingly integrated and efficient transportation system can enhance interactions among economic actors. Maritime transportation is an essential component of the transportation system, particularly for inter-island connectivity. Various efforts have continued to be implemented to promote infrastructure development, especially port development within the maritime transportation sector, which has received significant attention. Therefore, port construction in Indonesia has continued to be developed to support passenger transportation, container handling, general cargo services, pioneer shipping, local shipping, and community-based maritime transportation, either through the construction of new facilities or the improvement of existing infrastructure. Port development requires substantial investment; therefore, careful calculation and strategic planning are necessary to determine appropriate port development priorities. This study aimed to examine research trends in port planning by analyzing scholarly publications in leading economics and finance journals. The analysis was based on 200 indexed research articles processed using VOSviewer software to generate a bibliometric map illustrating the evolution and key themes in port planning research.

INTRODUCTION

It is generally recognized that transportation plays a vital role in supporting a nation's economy because an increasingly efficient and integrated transportation system can enhance interactions among economic actors. These interactions occur not only in the economic sector but also in social and cultural contexts. Maritime transportation is an essential component of the transportation system, particularly in supporting inter-island connectivity. Various efforts have continued to be undertaken to promote infrastructure development, especially port development within the maritime transportation sector, which has received significant attention (Li et al., 2023; Liu et al., 2020; Sadiq et al., 2021; Sibali & Jainuddin, 2024; Xiao et al., 2024).

Therefore, port construction in Indonesia has continued to be implemented to support passenger transportation, container handling, general cargo transportation, pioneer shipping services, local shipping activities, and community-based maritime transportation, either through the development of new facilities or the improvement of existing infrastructure (Hatta et al., 2019).

Port development requires substantial investment; therefore, careful calculations and strategic planning are required to determine appropriate port development decisions. Port development decisions are generally based on economic, political, and technical considerations. These three considerations are interrelated; however, economic considerations are often the most influential factors in determining port development priorities (Asgari et al.,

2015; Bhatti & Hanjra, 2019; Fedorenko et al., 2021; Tseng & Pilcher, 2019; Wahyuni et al., 2020).

Several important factors must be considered in the development of a port, including the demand for port services, economic feasibility, maritime trade volume, and connectivity with hinterland areas through both land and water transportation networks.

Before commencing port development, preliminary surveys and feasibility studies must be conducted to determine current and future trade volumes that can be anticipated from the surrounding area. Trade volume is an important factor in determining whether a port development project is feasible. In specific ports, the production capacity of a particular company or industrial area is usually known, allowing the port facilities to be planned according to operational requirements.

After several studies have been completed, the next stages involve determining the general location of the port, its primary functions, and the types and volumes of cargo to be served. The subsequent steps include conducting preliminary studies and preparing the port layout as a basis for more comprehensive field investigations required for final port planning. Several necessary investigations include hydrographic and topographic surveys of the planned location for breakwaters, docks, and other port facilities, as well as assessments of wind conditions, currents, tides, and waves.

Port planning must consider various factors that affect port structures and vessel operations. Three major factors that require consideration are wind, tides, and waves. Wind generates currents and waves and can also exert pressure on vessels and port structures. Tidal conditions are important in determining the dimensions of structures such as breakwaters, docks, mooring facilities, navigation channels, and port water areas. Wave forces acting on coastal structures must also be considered to ensure structural safety and stability. In addition, wave conditions influence the level of calmness and operational safety within port waters (Ipiimut, 2016).

A port is a facility where ships berth after completing voyages (Triatmojo, 2008). It functions as a center for various maritime activities, including passenger embarkation and disembarkation, cargo loading and unloading, refueling, freshwater replenishment, vessel maintenance, and provision supply. To support these activities, ports require essential infrastructure, including breakwaters, docks, mooring systems, cargo handling equipment, storage warehouses, open storage areas, administrative facilities, passenger waiting areas, and fueling stations.

According to Soemartono (2010), a port is a sheltered water area that provides facilities for ships and other vessels to berth and conduct operational activities. Its main functions include passenger services, cargo and livestock handling, vessel maintenance, refueling, and other supporting activities. Ports are equipped with infrastructure such as berthing facilities, cranes for cargo handling, temporary storage areas, and warehouses for goods awaiting distribution or further transportation. Beyond their logistical functions, ports serve as gateways connecting regions, islands, continents, and countries, while also stimulating development within their surrounding hinterland areas. These hinterland regions maintain economic, social, and defense-related relationships with ports, including their potential role as supporting areas for naval operations (Rahman, 2011).

1. Dock

A dock is a port facility used for berthing and mooring vessels during loading and unloading operations for cargo and passengers. The dimensions of docks are determined based on the type, size, and operational requirements of vessels using the facility.

2. Container Stacking Yard

A container stacking yard is an area used for storing containers, both loaded and empty, before shipment or after unloading from vessels.

3. Warehouse

A warehouse is a storage facility used to temporarily or permanently store goods unloaded from vessels or goods awaiting shipment.

4. Loading and Unloading Equipment

Loading and unloading equipment consists of machinery and tools used to facilitate cargo handling activities. The use of appropriate equipment aims to increase loading and unloading efficiency and reduce vessel turnaround time at the port.

This study addressed the research gap by conducting a bibliometric mapping analysis of port planning research. The urgency of this research lies in the need for evidence-based policymaking. As Indonesia and other archipelagic nations continue to invest substantially in port infrastructure to support blue economy development, understanding global research trends can help minimize planning errors and identify effective practices. The novelty of this study lies in its specific focus on the keyword “port planning” and the application of VOSviewer to generate a comprehensive bibliometric map illustrating the structure and evolution of the research field, including major clusters, influential authors, and leading countries. This study aimed to map the development of research on port planning, particularly in relation to the Indonesian context. Through bibliometric analysis, the study identified dominant research themes, leading contributors, and knowledge gaps, thereby contributing to more effective port development strategies. The findings are expected to provide practical benefits for academics, policymakers, and practitioners involved in port planning and development.

METHOD

This study analyzed publication data from 1972 to 2021 related to port planning research obtained from various journals. The articles were retrieved through searches in the Google Scholar database using the keyword “Port Planning” and selected based on their relevance to the research topic. Only articles indexed by Google Scholar and assigned a DOI were included in the final dataset. The search resulted in 200 articles published over a 50-year period. The publication data were extracted and organized using Microsoft Excel 2010, while publication trends and bibliometric relationships were analyzed using VOSviewer software.

VOSviewer is a bibliometric analysis software used to construct and visualize bibliometric maps. The software enables researchers to analyze relationships among authors, journals, and keywords based on co-citation and co-occurrence analyses. In this study, VOSviewer was utilized to generate keyword and publication network maps to identify research trends and thematic developments in port planning studies.

The software applies the Visualization of Similarities (VOS) mapping technique to generate bibliometric networks. It supports various visualization methods, including the VOS technique and multidimensional scaling, to display relationships among research components.

The resulting maps were used to explore the structure and development of port planning research based on the selected publication dataset.

RESULTS AND DISCUSSION

The table below presents the document collection utilized in the library-based research on Port Planning. Out of the 200 documents included, they are categorized into four types: journal articles (115), anthologies or book chapters (1), conference papers (82), and review articles (2).

Table 1. Document Types

No	Document Types	Number of Articles
1	Journal article	115
2	Book chapter	1
3	Conference Paper	82
4	Review	2
	TOTAL	200

The analysis of document types reveals that journal articles are the most commonly used source for research on Port Planning, accounting for 57.5% of the references—equivalent to 115 documents. In contrast, book chapters are the least cited, making up only 0.5%, or a single document. This distribution suggests a strong reliance on credible, peer-reviewed sources, as the majority of references originate from academic journals.

Bibliometric Graphic Analysis

Bibliometrics involves the statistical analysis and quantification of scientific outputs, such as articles, publications, citations, patents, and more complex metrics. It serves as a key instrument for assessing research activities, individual scientists, laboratories, areas of scientific specialization, and national research performance. Following a discussion of its historical development, the report outlines the database used to generate the bibliometric data and describes the primary indicators applied.

To expand on the meta-analysis findings, this section includes a visual mapping of 200 journals related to Port Planning. The keyword mapping analysis identifies significant or distinctive terms within these publications and forms the foundation for organizing them visually. This mapping process helps reveal core knowledge components, their structural relationships, evolution over time, and how they interact with one another.

In the context of bibliometrics, science mapping refers to techniques that visually represent scientific domains. Such visualization typically takes the form of a landscape-like map that illustrates the structure and distribution of research topics (Royani et al., 2013). Below is the network visualization showing the word map of 200 journals focused on Port Planning:

Bibliometric Author Mapping

With the help of VOSViewer software, we generated a bibliometric map of authors, displayed in the image below. Authors who have published more frequently on Port Planning are represented by larger shapes and more vivid colors.

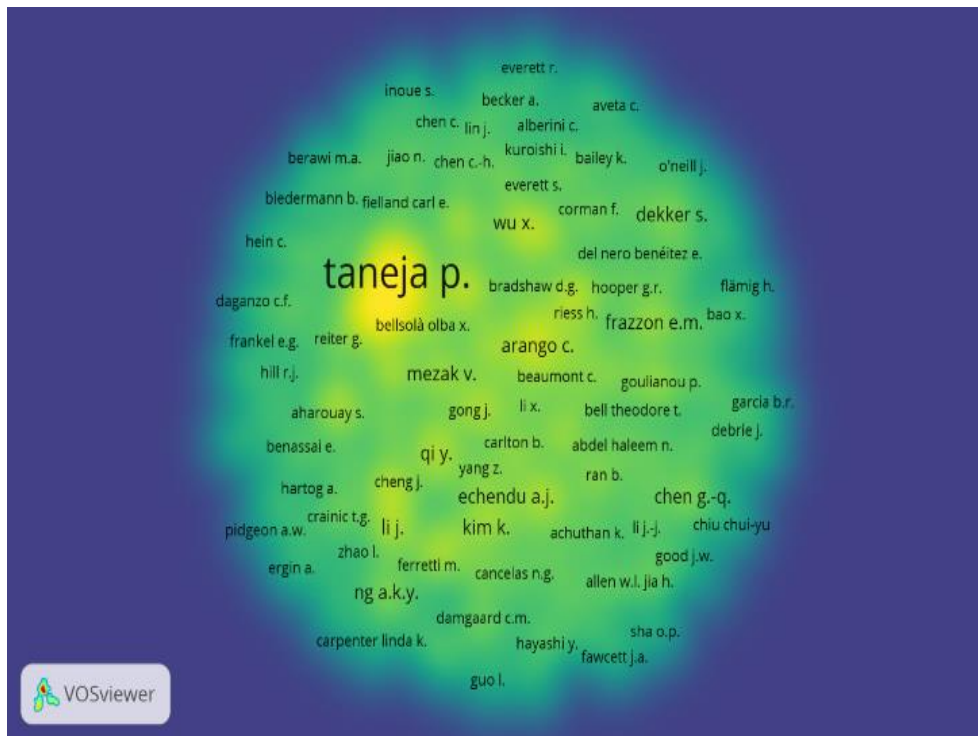


Figure 2. Bibliometric Author Mapping

The density of clusters is reflected by the intensity of the yellow hue, indicating that brighter areas on the map correspond to regions with a higher concentration of interconnected items. This visualization helps identify key areas within the bibliometric map, offering insight into the overall structure and highlighting topics of significance. By examining the map, one can also assess which authors have contributed the most publications.

Researchers vary in their publishing habits—some frequently work alone, while others collaborate extensively, leading to clusters of differing densities. Authors appearing in denser clusters tend to have produced more work in port planning compared to those in sparser areas, making these patterns valuable for guiding future research.

Generally, the size and prominence of an author's name on the map reflect their publication output. According to the bibliometric analysis, Taneja P. is the most prolific author in the field of Port Planning.

Bibliometric Institutions Mapping

In bibliometric analysis, the institutions from which authors originate can be identified. These results allow us to interpret which institutions author the most publications.

As shown in the image above, the size of each circle representing a country corresponds to its volume of published papers—larger circles indicate higher publication output. China and the United States stand out with the largest and most prominent circles, reflecting their leading roles in research on port planning. This suggests that these two countries produce more scholarly work in this field than any others.

Bibliometric Keyword Mapping

VOSViewer can generate bibliometric maps showing the most commonly used keywords in Port Planning, particularly those related to economics and finance. The visualization below displays these keyword mappings, where larger font sizes correspond to higher usage frequency in Port Planning journals.

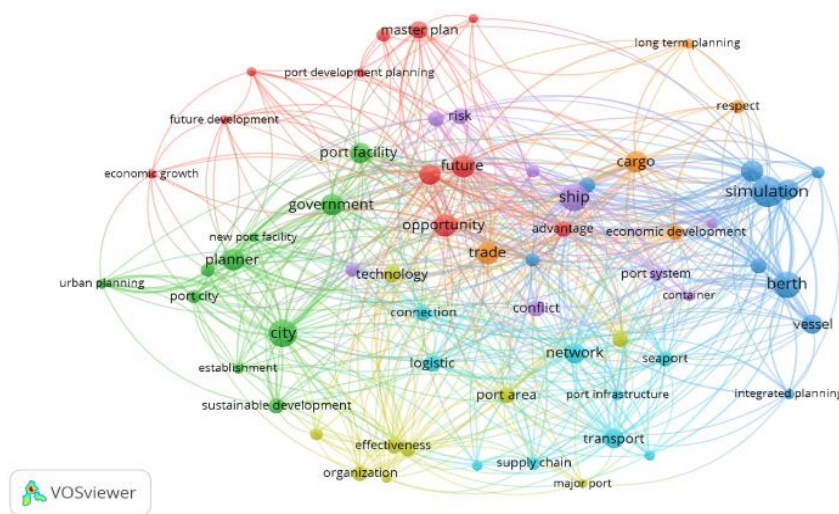


Figure 5. Bibliometric Keyword Mapping

Several frequently occurring keywords in studies addressing Port Planning can be categorized into seven distinct clusters, namely:

1. Cluster 1 in red consists of 11 keywords: Advantage, Economic Growth, Expansion, Future, Future Development, Master Plan, New Port, Opportunity, Port Development, Planning, Port Master Plan, Port Project.
2. Cluster 2 in green consists of 10 keywords: City, Establishment, Government, New Port Facility, Planner, Port City, Port Facility, Sustainability, Sustainable Development, Urban Planning.
3. Cluster 3 in dark blue consists of 10 keywords: Berth, Integrated Planning, Port Capacity, Port Expansion, Port Planner, Scenario, Simulation, Simulation Model, Throughput, Vessel.
4. Cluster 4 in yellow consists of 9 keywords: Effectiveness, Knowledge, Major Port, Maritime Transport, Organization, Port Area, Port Management, Strategic Planning, Technology.
5. Cluster 5 in purple consists of 9 keywords: Adaptive Port Planning, Conflict, Container, Nature, Port Operation, Port System, Risk, Safety, Ship.
6. Cluster 6 in light blue consists of 9 keywords: Connection, Dry Port, Inland Port, Logistic, Network, Port Infrastructure, Seaport, Supply Chain, Transport.

7. Cluster 7 in orange consists of 5 keywords: Cargo, Economic Development, Long Term Planning, Respect, Trade.

The keywords grouped into seven clusters are displayed within colored circles that represent each cluster. This visualization helps identify keyword trends over the past year.

A bibliometric analysis highlights keywords commonly found in research publications. The size of each circle corresponds to how frequently a keyword appears—larger circles indicate higher occurrence. Lines connecting the keywords illustrate the strength of their relationships with one another.

Bibliometric Index Mapping

Furthermore, the study produced results in the form of indexes commonly used by the author, which are linked to the topic of Port Planning within the context of Islamic economics, as illustrated in the image below. Indexes sharing the same color reflect a particularly strong connection.

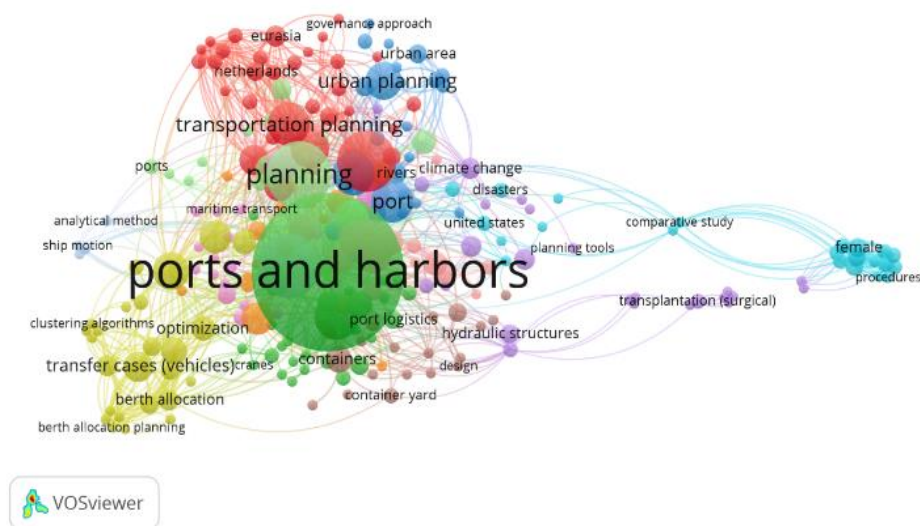


Figure 6. Bibliometric Index Mapping

Based on the results, the less darker the color, the more recent is the use of the term. In the word index for the paper on the topic of Port Planning, which relates to Islamic economics, the most common words are “Ports” and “Harbors,” followed by “Planning”.

Table 2: Keywords, Authors and Institutions with the Highest Publication

Rank	Keyword by Occurrence	Authors with The Highest Publication	Institution with The Highest Publication
1.	Ports and Harbors	Taneja P.	Cognitive Computing and Medical Imaging, Fraunhofer IGD, Darmstadt, Germany
2.	Port Planning	Dastgheib A.	Antai College of Economics and Management, Shanghai Jiaotong University, China
3.	Planning	Eskafi M.	Department of Civil and Environmental Engineering, University of California at Berkeley, United States
4.	Port Development	Stefansson G.	Department of Civil and Environmental Engineering, University of Washington, United States
5.	Port	Thorarinsdottir RI.	Ingeniería de Organización, Engineering School of Seville, University of Seville, Spain
6.	Port Terminals	Ulfarsson GF.	Center Interuniv. de Recherche sur les Reseaux d'Entreprise La Logistique et le Transport(CIRRELT), School of Management, Université du Québec à Montréal, Canada
7.	Cargo Handling	Arango C.	Dipartimento di Scienze Statistiche, Sapienza Università di Roma, Italy
8.	Transportation Planning	Cortes P.	Istituto per le Applicazioni del Calcolo Mauro Picone, Consiglio Nazionale delle Ricerche (CNR), Italy
9.	Sustainable Development	Munuzuri J.	Department of Geosciences, Oregon State University, United States
10.	Strategic Planning	Onieva I.	Marine Resource Management Program, College of Oceanic/Atmospheric Sci., Oregon State University, United States

Table 3. Most cited articles in 1972 to 2021

Rank	Title	Author	Year	Journal	Total
1.	Climate change impacts on international seaports: Knowledge, perceptions, and planning efforts among port administrators	Becker, A. , Inoue, S. , Fischer, M. , Schweigler, B.	2012	Climatic Change	131
2.	Planning local container drayage operations given a port access appointment system	Namboothiri, R. , Erera, AL	2008	Transportation Research Part E: Logistics and Transportation Review	108
3.	Intraoperative laparoscope augmentation for port placement and resection planning in minimally invasive liver resection	Feuerstein, M. , Mussack, T. , Heining, S. M. , Navab, N.	2008	IEEE Transactions on Medical Imaging	101
4.	Port planning and development.	Frankel, EG	1987		97
5.	Double cycling cranes in container ports: Planning methods and evaluation	Goodchild, AV , Daganzo, CF	2007	Transportation Research Part B: Methodological	93
6.	Daily berth planning in a tidal port with channel flow control	Zhen, L. , Liang, Z. , Zhuge, D. , Lee, L.H. , Chew, E.P.	2017	Transportation Research Part B: Methodological	66

7.	Berth allocation planning in Seville inland port by simulation and optimization	Arango, C. , Cortés, P. , Muñuzuri, J. , Onieva, L.	2011	Advanced Engineering Informatics	66
8.	Port Placement Planning in Robot-Assisted Coronary Artery Bypass	Cannon, JW , Stoll, JA , Selha, SD , (...), Howe, RD , Torchiana, DF	2003	IEEE Transactions on Robotics and Automation	59
9.	Modeling dry-port-based freight distribution planning	Crainic, T.G. , Dell'Olmo, P. , Ricciardi, N. , Sgalambro, A.	2015	Transportation Research Part C: Emerging Technologies	57
10.	Multi-objective optimization for planning liner shipping service with uncertain port times	Song, D.-P. , Li, D. , Drake, P.	2015	Transportation Research Part E: Logistics and Transportation Review	54

Table 3 presents the 10 most quoted articles related with Port Planning, by the number of times cited in other academic works. The first most cited article is Climate change impacts on international seaports: Knowledge, perceptions, and planning efforts among port administrators (Becker, A., Inoue, S., Fischer, M., Schwegler, B., 2012), being cited 131 times. This article addresses the vulnerability of Seaports due to climate change on vulnerable coasts to sea level rise, coastal submergence, and coastal storms, as well as at the estuaries of large rivers liable to flooding. Since they are located at the front line of the economy, both local, regional, and global, their strategic position within an environmentally sensitive estuary must be taken into account to minimize damage to natural habitats. The impact of climate change such as, for example, the sea level rise (SLR) projections from 0.6 to 2 m and the doubling of category 4 and 5 storms by 2100, will affect the frequency of extreme weather events in many of the ports mentioned. For evaluate knowledge latest about problem here , we surveyed authority harbor from all over the world about How the administrator's feeling that change climate can influence operation they , change surface sea What will create problem operational , and how they planning For adapt with condition environment new . Plan expansion fast ports reported by respondents survey show that steps adaptation must considered Because harbor build infrastructure new that may be Still used at the end century this. Respondent agree that community harbor need overcome problem this and some big feel relatively No get information about potential impact climate. Although part big harbor feel that SLR does not will become problems at the port they century this, increase surface sea still become a very concerning problem. Our results suggest opportunity for community scientific For involved with practitioners harbor For prepare in a way proactive impact change climate in the sector This.

The second-ranked article, Planning local container drayage operations given a port access appointment system (Namboothiri, R., Erera, A.L., 2008), cited 108 times, focuses on managing truck fleets that handle container pickup and delivery (drayage) at ports using an appointment-based access system. In response to growing congestion and its consequences, many U.S. port terminals have adopted appointment systems, yet the effects of these systems on drayage fleet efficiency remain poorly understood. To fill this gap, the authors propose a

planning method based on integer programming heuristics that incorporates the port's access control mechanism. This method optimizes the sequence of daily pickups and deliveries to minimize transportation costs. Using this framework, the study evaluates how access control systems may influence drayage productivity. A key finding is that terminal operators must ensure adequate access capacity, as increasing it by 30% can boost vehicle productivity by 10–24%. Furthermore, even reasonable but suboptimal choices in appointment time slots by drayage firms can significantly affect service levels, potentially reducing the number of customers served by up to 4% under fixed access capacity.

CONCLUSION

This study aimed to assess the development of research on port planning from 1972 to 2021. The findings indicated an increasing trend in scholarly publications, with more than 200 articles published during the period, particularly showing significant growth in recent years.

The bibliometric analysis and visualization mapping revealed that Taneja P. was the most prolific author in this research field. The institution with the highest number of related publications was Cognitive Computing and Medical Imaging at Fraunhofer IGD in Darmstadt, Germany. China and the United States were identified as the leading countries in terms of research output related to port planning.

The research landscape was categorized into seven distinct clusters. Cluster 1 consisted of 11 thematic topics, Clusters 2 and 3 each contained 10 topics, Clusters 4, 5, and 6 each included 9 topics, and Cluster 7 comprised 5 topics. The keyword analysis of port planning research showed that “ports” and “harbors” were among the most frequently occurring terms, indicating their central relevance within the research domain.

For academics, this study suggested opportunities for further exploration of transportation economics and related fields by utilizing bibliometric insights. Future research could employ frequently used keywords, select relevant sources based on influential authors, institutions, countries, and citation impact, and strengthen literature reviews by focusing on high-quality sources, such as Scopus-indexed publications. Researchers may also consider alternative bibliometric tools, such as R Biblioshiny, to generate more comprehensive and diverse research visualizations.

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