

Who Supply, Who Use? – How Sustainable Water Supply can be Achieved in Lancang-Mekong River

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Abstract

This study addresses a topic that has received limited attention in supply chain research: water supply. While industrial supply chain studies have typically focused on the supply of raw materials and downstream product pathways, the supply of water has been largely overlooked, likely due to the perception that water is an inexhaustible resource provided by nature. However, the Lancang-Mekong Basin presents an opportunity to rethink the definition of supply chains, and to consider how to ensure the stable and equitable use of natural resources, including water, in order to create greater value for all water users throughout the industrial development process. The Lancang-Mekong River Basin is the largest river basin in Southeast Asia, and it is shared by several countries, including China, Laos, Myanmar, Thailand, Cambodia, and Vietnam. This paper provides an overview of the current status of water supply and use in the Lancang-Mekong River Basin and highlights the importance of water use for the future industrial development of the coastal countries. Finally, the paper proposes a preliminary framework for managing water resources from a supply chain management perspective. The proposed framework is intended to promote sustainable development and informed water management practices in the region.

Keywords: Sustainable Development, Supply Chain Analysis, Lancang-Mekong River Basin,
Water Management

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Introduction

Functions and Main Components of Supply Chain Management

Supply chain management (SCM) addresses business challenges from manufacturing to sales by integrating all corporate activities in a seamless process, from raw material procurement to sales to the end customer. SCM encompasses the management of material, information, and capital flows and is a vital component of enterprise operations management. It includes logistics management, procurement, and supply chain planning, as well as related information analysis and financial management. With the expansion of economic globalization, the content and scope of SCM have also broadened to include international logistics, production outsourcing, strategic sourcing, and supply chain collaboration. SCM is no longer limited to internal enterprise operations but extends to the operation of the entire industry and value chain in the global market, including related risk management and sustainability.

The functions of SCM are multifold. Firstly, it aims to improve product quality and reduce product costs. Secondly, it enables sharing of information costs among members in the supply chain and facilitates the acceleration of innovative products and development of new products to enhance the competitive advantage of enterprises. Finally, SCM helps to establish a supply chain management system with the help of information technology. Standardization of report information format and efficient order inspection operations can be achieved, unnecessary warehousing operations can be eliminated, and storage space can be utilized more efficiently. SCM also enables supply and delivery operations to respond to customer needs in a timely manner.

The SCM module should include the following items: demand planning (forecasting), order promising (taking into account delivery time and constraints), strategic network optimization (for determining which market, product, and operational services to target), supplier management, inventory management, customer relationship management, production and distribution planning, production scheduling, transportation planning, and transportation execution. In the context of sustainable supply chain management, one crucial aspect that is often overlooked is the management of raw material supply. Failure to control the raw materials can result in a malfunction of the entire supply chain.

Resource sustainability management of utilities and supply chains

However, the sustainable management of supply chains often overlooks the upstream issue of raw material supply. Failure to control raw materials can cause dysfunction in the entire supply chain. A further important issue in raw material management is the acquisition of key components, such as rare earths. Similarly, utilities are often neglected in supply chain management, and companies assume that the government is responsible for their adequate supply. Utilities include electricity, water supply, waste treatment, sewage treatment, gas supply, transportation, and communications. While public utilities are typically operated by government agencies, public enterprises, or government-chartered companies, the problem of effectively managing finite resources such as water is complex, particularly when multiple units or countries are involved.

To address this, the new supply chain thinking must include front-end public resources as an indispensable part of management. For example, Taiwan's Hsinchu Science Park faced dissatisfaction from manufacturers due to an unstable power supply, demonstrating the impact of public services such as water, drainage, and transportation on the stability of the supply chain. Therefore, this article emphasizes the importance of including these basic utilities in sustainable supply chain management.

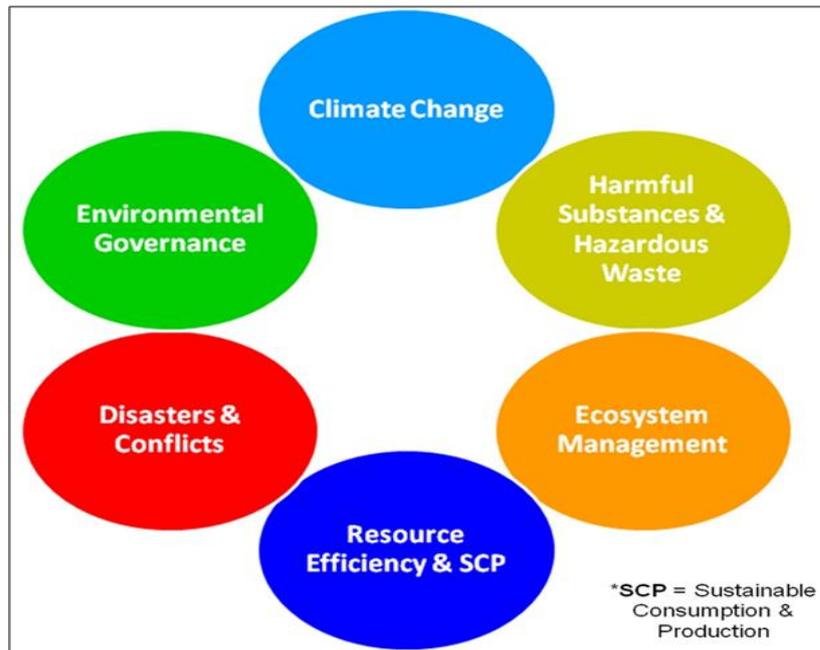


Figure 1 Sustainable supply chain management considering environmental resources

The research question and research object of this thesis are defined

Based on the preceding discussion, this paper aims to examine the sustainable operation and management of the supply chain by exploring the allocation of water rights in the Lancang Mekong River Basin. The Lancang Mekong River Basin, the most significant river basin in the Indochina Peninsula, has the potential to impact the reorganization of the world's supply chain. Therefore, this study will focus on the following three issues regarding the allocation of water resources and its potential consequences:

The significance of water in supply chain management

Potential challenges that may arise in the allocation of water rights in the Lancang-Mekong River Basin (Middleton & Devlaeminck, 2021) One of the key concerns regarding the industrial chains in the Lancang and Mekong basins is the potential impact of water supply issues in the future. This concern arises from the construction of dams in China, which can disrupt the downstream water flow. The downstream regions, encompassing significant agricultural areas and prospective sites for essential industries, are particularly vulnerable. Insufficient water supply in these areas may lead to conflicts over water resources. (Hecht, et AL., 2019)

Literature review

What are the main reasons affecting the sustainable management of the industrial chain?

Traditional supply chain management aims to optimize efficiency and customer satisfaction by coordinating purchasing, production, inventory management, and transportation among all participants in the supply chain. Through assessing and improving supply chain management, many businesses have saved significant time and costs. However, a sustainable supply chain goes beyond this and focuses on measuring and improving the environmental and human impact of products throughout the supply chain, including sourcing raw materials, production, warehousing, delivery, and every transportation step in between. The goal is to minimize environmentally harmful factors such as energy use, water consumption, and waste generation while positively impacting the people involved in the operation and surrounding communities. These additional concerns highlight the need for traditional enterprises to consider supply chain management beyond revenue and profit.

Supply chain management involves both controllable and uncontrollable factors. Managers can control factors such as supply chain operations, branding, investor relations, corporate culture, and regulatory compliance. However, key components, natural resources, and political factors are uncontrollable and are managed through supply chain risk management. Supply chain risk refers to the process of managing the risk of unexpected or changes in the supply chain that affect the system.

Basic industrial facilities and sustainable industrial chain

The provision of basic industrial facilities such as electricity, water, and transportation and telecommunications services are crucial for industrial development. However, in the context of sustainable development, there is a growing need to innovate and adopt circular economy principles in the supply chain. Innovation is key to achieving sustainability, and circular economy and data-driven supply chains are two important paths to achieve this. In this regard, this paper focuses on the sustainable management of electricity, water, and transportation and telecommunications. Electricity is an essential element for the operation of high-tech industries and its stable supply is crucial for industrial development. Similarly, a stable and clean source of water is necessary for smooth plant operation. Therefore, the development of the industry should be premised on the provision of these two basic needs. Additionally, transportation services play a critical role in ensuring that finished products reach their destination on time, which requires careful attention in supply chain management.

Research methods

Investigation on the use of water sources in the Lancang Mekong River Basin

This study aims to investigate the current state of water usage in the Lancang Mekong River Basin and its impact on the industrial chain's future development in this important region. The methodology employed is document analysis, a systematic procedure for reviewing and analyzing documents that involves evaluating a wide range of materials such as books, periodicals, newspapers, diaries, and printed or electronic materials

(Bowen, 2009). The evaluation process involves a systematic review of these documents without the intervention of researchers. This study utilizes literature analysis to assess hydrological evidence, including direct and indirect human impacts on water resources, as well as the impact of international agreements on water resources management.

This article employs a comprehensive analysis approach to explore various texts and examine their implications, culminating in the formulation of research conclusions. To ensure the reliability of these conclusions, a meticulous examination of different arguments is conducted, emphasizing objectivity. Distinct from quantitative analysis methods, this study adopts a comprehensive analysis perspective, allowing for an in-depth analysis of the significant economic and management characteristics of the Lancang-Mekong River Basin. The selection of measurement indicators differs from previous studies, as water resources are chosen as the focal point. Given that water resources serve as a common factor in supply chain management, they are deemed a suitable and credible indicator. Furthermore, evaluating the stability of the supply chain using water resources as a management indicator represents an innovative approach in this study.

Analysis of water rights disputes in the Lancang and Mekong River Basins

For a prolonged period, water resource utilization in the Lancang Mekong River Basin has not posed any issue. However, in recent years, due to the economic growth of coastal regions, the demand for water resources has surged substantially, leading to an imbalance in the distribution of water resources. This phenomenon is a crucial analysis parameter for us to scrutinize the industrial supply chain. (Hung, 2020)

Results and discussion

Overview of the use of water sources in the Lancang Mekong River Basin

The Mekong River, stretching 4,350 kilometers, is one of the longest rivers in the world and the longest in Southeast Asia. Originating from the Qinghai-Tibet Plateau, the river's upper reaches are called the Lancang River, flowing through three provinces of China, namely Qinghai, Tibet, and Yunnan. As it flows down, it passes through Thailand, Laos, Myanmar, Cambodia, and Vietnam before emptying into the South China Sea (Ouyang, 2016)



Figure 2 Location map of the Lancang Mekong River Basin

The Mekong River Basin is one of the most important river systems in Southeast Asia, spanning a total length of 4,350 kilometers and flowing through six countries. The lower basin is home to approximately 60 million people who rely on its abundant water resources for their livelihoods. However, in recent years, the water levels in the lower Mekong have been decreasing, causing significant disruptions to fishing and agricultural activities. According to a study conducted in the United States, above-average humidity was observed at the source of the watershed from May to October 2019, but below-average humidity in the Laos and Thailand regions, with Thailand experiencing severe drought. Some experts attribute the declining water levels to China's construction of 11 dams in the upper Mekong basin, which could reduce water levels by up to two-thirds in the lower basin. However, the Chinese government has claimed that reduced rainfall is the cause of the drought. The Thai government has criticized the limited data that China has shared with the six countries and has requested more information. In August 2020, the Lancang-Mekong Cooperation (LMC) held a virtual summit to address the issue of the Mekong River's record-low water levels for the second consecutive year. The Mekong River Commission (MRC) has also highlighted the need for China to provide more data. As noted by Ouyang (2016), the capitals of Laos and Cambodia are situated along the Mekong River, and Thailand and Vietnam rely heavily on the river for rice production. Hydropower, which involves the transfer of water from the rainy to the dry season through reservoir storage, has been a significant factor in water management in the region. However, it can lead to droughts, river destruction, ecological changes in water bodies, and dam collapse, as highlighted by Campbell (2009). The Mekong's water resources mainly come from rain and snow-capped mountain meltwater, as noted by Ouyang (2016). Beech (2020) reported that water levels in China

were above average in 2019, but downstream countries suffered from severe drought, with some areas experiencing complete drying up of the riverbed. Dams in China have blocked over 125 meters of water resources, as per one study. (The News Lens. 2020) (Tiezzi, 2020)

Table 1 Basic information of Lancang-Mekong River Basin

No.	Item	Detail
1	Length	4,350 km
2	Discharge	16,000 m ³ /s
3	Source	Lasagongma Spring
4	Mouth	Mekong River Delta
5	Countries	Vietnam, Thailand, Laos, Cambodia, China, Myanmar (Burma)
6	Cities	Ho Chi Minh City, Vientiane, Phnom Penh, Nong Khai, Krong Kampong Cham
7	Bridges	Thai–Lao Friendship Bridge No.1, MORE

The role of water in supply chain management

The secure and consistent supply of water is a crucial aspect of supply chain management. However, recent data has left many industry managers uncertain. According to a report by the Stimson Center, a US-based think tank, rainfall during the first six months of 2019 was above average, leading to increased water storage in Chinese dams. Nonetheless, countries in the Lower Basin have faced unprecedented droughts (Eyler & Weatherby, 2020). It has also been suggested that if China's dams did not impede water flow, sections of the Mekong along the Thai-Laos border would have had above-average flows from April 2019 to the present, instead of experiencing severe drought conditions (Eyler & Weatherby, 2020).

What problems may arise in the allocation of water rights in the Lancang Mekong River Basin?

The lack of a fair and reliable mechanism for water rights allocation has led to a series of environmental problems that have directly impacted the stability of water supply in the region. Some of the most significant water-related disasters include droughts, floods, and dam collapses. Despite the Third Lancang-Mekong Cooperation Leaders' Meeting held on August 24, 2020 Grünwald, R. (2021). which aimed to reach a consensus among the countries, these disasters continue to cause damage (Basist & Williams, 2020).

Changes in water ecology

Alterations in the water ecology have compelled numerous farmers in Chiang Rai, Thailand to relocate their farms to higher ground to evade artificial flooding. Consequently, the agricultural yield, including sprouts, has been significantly impacted, with a noticeable reduction in the number of bean sprout fields (BBC, 2018). The resultant ecological changes, including the impact on plants, birds, and aquatic animals, are a major cause for concern among biologists. (Godoy, 2019)

Dam collapse

The collapse of Saddle Dam D in Laos in 2018 had significant impacts on the region. On July 23, approximately 500 million cubic meters of water were released, leading to flooding, and causing extensive damage in at least seven villages. (Doquese, 2020; Kailu. 2010) The incident resulted in the loss of over 20 lives, with hundreds more reported missing. Furthermore, approximately 7,000 individuals were forced to evacuate, and 14 bridges were destroyed. The Lao government declared the affected area a National Emergency Disaster Zone (NCDR, 2021)

Table 2 The Collapse of Saddle Dam D in Laos (NCDR 2021) (STIMSON, 2021)

month	date	time	Description
July	22 nd	21:00	Engineers found more than 10 cracks in Saddle Dam D, and the Laos authorities notified populations downstream to evacuate. However, heavy rain damaged the road and the repair team cannot fix the cracks.
July	23 rd	03:00	Released water from the main dam to lower the water level.
July	23 rd	12:00	Dam problems were not controlled, and the Laos government evacuated downstream residents.
July	23 rd	20:00	Dam collapsed and flooded villages downstream with about 500 million cubic meters of water.
July	24 th	09:30	At least seven villages were flooded, more than 20 people killed, hundreds missing, about 7,000 evacuated, and 14 bridges destroyed.
July	26 th		The South Korean government sent rescue team to help.

River Destruction

The Thai government announced in December 2017 that the Chinese government had agreed to stop blasting. However, the blasting had already altered the ecological environment, and the construction of dams had a negative impact on water resources and fishing activities. As a result, it can be observed that the river's ecology has been disrupted, with over 125 meters of water resources blocked. (Grunwald, 2020). (Middleton & Devlaeminck, 2021)

The Change of Lancang-Mekong River Basin

Satellite data has revealed that surface humidity in China's Yunnan province was above average from May to October 2019, while water levels in Thailand and Laos were three meters below average, suggesting that no water was released downstream even during the monsoon season (Reuters, April 2020). Data also showed that while the Tibetan Qingqing Plateau, the source of the Mekong River, did not experience drought, downstream countries such as Cambodia and Thailand faced severe water shortages

What industrial chains may be affected by water supply in the Lancang and Mekong basins?

The ecological changes in the river basin have had a significant impact on the future economic development of the region. In recent years, Thailand, Vietnam, Laos, and other countries have seen a continuous influx of foreign investment, leading to the rapid formation of new industrial clusters. The instability of the water supply due to the aforementioned changes may seriously hinder the future industrial development of the region. To understand the possible impact, this study compiles and analyzes potential new industrial clusters in the Lancang and Mekong basins and predicts their possible impact.

Greater Mekong Subregion Economic Cooperation (GMS).



Source: MRC Strategic Environmental Assessment: ICEM, 2010
 *Initially proposed as a 3,300 MW project, 465 MW and 2,600 MW options have also been studied.

Figure 3 Regional map of economic cooperation in the Greater Mekong Subregion

In 1992, the Greater Mekong Subregion Economic Cooperation (GMS) mechanism was launched, including China's Yunnan Province and Guangxi Zhuang Autonomous Region, Cambodia, Laos, Myanmar, Thailand, and Vietnam, with a total area of 2,568,600 square kilometers and a population of approximately 326 million. The region has rich resources, including water, biological, and mineral resources, with tremendous economic potential and development prospects. However, this also means that in future economic development, all countries will have a high demand for water resources. (Grunwald, 2020; Rafaeli & Raban, 2005)

The GMS project covers seven areas of cooperation: transport, energy, telecommunications, environment, tourism, human resources development, and trade and investment. It is expected that there will be a high demand for utilities in the region in the future. Based on the "three vertical and two horizontal" transportation corridors, the GMS Economic Corridor will be built into an economic belt integrating industry, trade, and infrastructure, leading to rapid economic development. The "three verticals" are north-south, and the "two horizontals" are east-west (see Table 2)

The construction of the sub-regional economic corridor will strengthen economic and technological cooperation in the region and gradually improve the overall economic level. However, it also means that the industrial chain will accelerate its formation, leading to greater pressure on water demand.

Table 3 Areas through which the GMS Economic Corridor passes

direction	numbering	route
Longitudinal	Longitudinal 1	Kunming, Yunnan - Dali, Yunnan - Dehong in Yunnan - Mandalay, Myanmar - Yangon, Myanmar
	Longitudinal 2	Kunming, Yunnan - Xishuangbanna, Yunnan - Laos - Bangkok, Thailand
	Longitudinal 3	Kunming, Yunnan - Honghe in Yunnan - Hanoi, Vietnam - Haiphong in Vietnam
across	Horizontal 1	Mawlamyine, Myanmar – Phitsanulok, Thailand – Savannakhet, Laos – Da Nang, Vietnam
	Horizontal 2	Yangon, Myanmar – Bangkok, Thailand – Phnom Penh, Cambodia – Ho Chi Minh City, Vietnam.

Eastern Economic Corridor of Thailand

The Eastern Economic Corridor (EEC) represents the most significant investment plan by the Thai government over the last 30 years. The plan involves setting up economic zones in Chachoeng, Chonburi, and Rayong provinces on the eastern coast, coupled with developing infrastructure and a range of investment preferential policies. The objective is to transform eastern Thailand into a world-class economic, trade, transportation, and logistics center that integrates sea, land, and air transportation systems. The EEC area covers a total land area of 30,000 rai (1 rai = 1,600 square meters) in Chon Buri, Rayong, and Chachoengsao. Four large-scale infrastructure projects are currently underway in the EEC: (1) high-speed rail connecting

Suvarnabhumi, Don Mueang, and U-Tapao airports; (2) U-Tapao Airport Renovation Project; (3) Map Ta Put Industrial Port Phase 3 Expansion; and (4) Laem Chabang Port Phase 3 expansion project. The total investment for these projects is 620 billion baht (about NT\$529.3 billion), with an actual investment of 10 billion baht (about NT\$8.5 billion) expected this year. The EEC aims to attract investment in 12 S-curve industries, including automotive, smart electronics, medical and health tourism, agriculture and biotechnology, food, industrial robotics, logistics and aviation, biofuels and biochemistry, digital technology, medical services, defense, and education development. However, given the EEC's proximity to the Lancang-Mekong River basin, competition for water and electricity resources may put significant pressure on the distribution of water resources in this region.

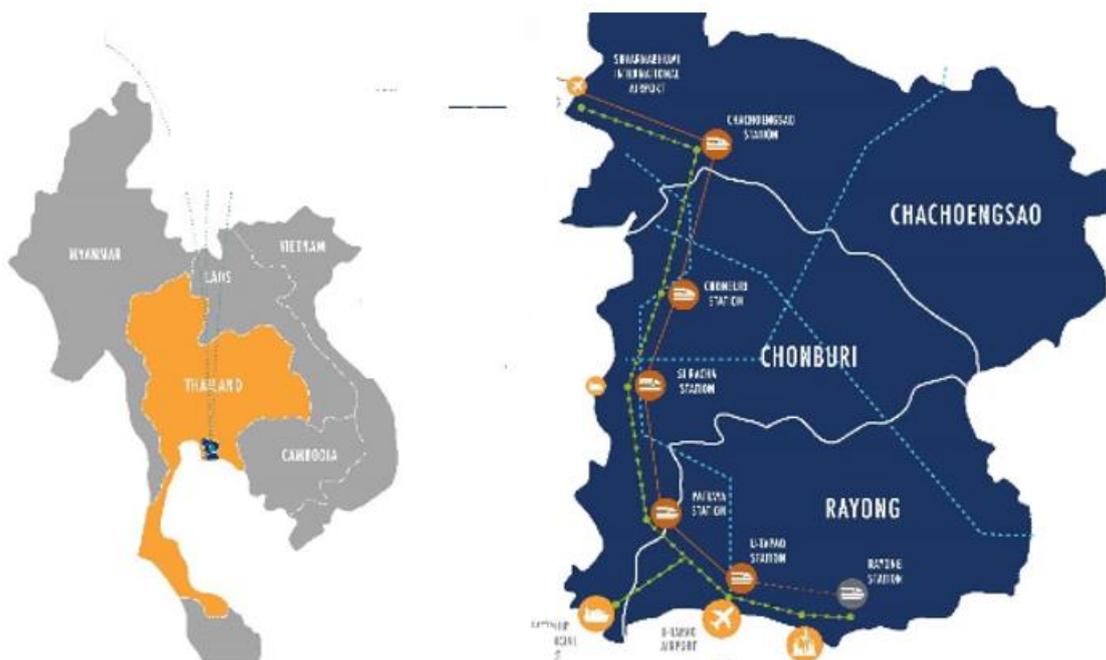


Figure 4 Regional Map of Thailand's Eastern Economic Corridor

Industrial and agricultural areas in southern Vietnam

The lower reaches of the Lancang Mekong River Basin flow into the southern coast of Vietnam, which is the country's most significant agricultural area and the fastest-growing economic region. The Southern Key Special Economic Zone (SKEZ) comprises eight provinces and cities, including Ho Chi Minh City, Binh Duong, Dong Nai, Long An, Ba Ria Vung Tau, Binh Phuc, Xining, and Qian Giang. Due to its proximity to shipping and low transportation costs, the SKEZ focuses primarily on light industry, furniture manufacturing, and other low-value, high-volume products. Ho Chi Minh City is one of the country's economic centers, comparable to Shanghai, China, and has the most developed industries, such as textiles, machinery, sugar refining, and rice milling, accounting for about a quarter of Vietnam's total industrial output value. To promote foreign investment and expedite infrastructure development, the Linh Trung Export Processing Zone and Tan Thuan Export

Processing Zone have been established. Ho Chi Minh City is a crucial transportation hub in the south, and its port network, with the port of Saigon at the center, accounts for 67% of Vietnam's total port throughput. However, Vietnam's competitive advantages, such as low labor and land costs, are diminishing due to the global trend of manufacturing and processing transfers. For instance, the rental price of industrial land in the Giang Dien Industrial Park in Dong Nai province has risen from US\$60 to US\$70 in 2017/square meter to \$90/square meter in early 2019, and in some regions, it has reached \$130 per square meter, similar to industrial parks in major Chinese cities. This development underscores the controversy surrounding the region's industries and their water resource competition in the Mekong River Basin.

Table 4 Major industries in industrial zones in southern Viet Nam

No.	category	description
1	Textile and Garment:	The textile and garment industry is one of the largest industries in southern Vietnam, with many industrial zones dedicated to the production of fabrics, clothing, and accessories.
2	Electronics	With the rise of electronic devices, the electronics industry has become an important sector in southern Vietnam. Many industrial zones in the region specialize in the manufacturing of electronic components and devices.
3	Food and Beverage:	The food and beverage industry is another major industry in southern Vietnam, with many industrial zones dedicated to the production of food and drink products such as seafood, rice, coffee, and beer.
4	Plastics:	The plastics industry has experienced significant growth in southern Vietnam, with many industrial zones producing a range of plastic products, including packaging materials, containers, and consumer goods.
5	Chemicals:	The chemical industry in southern Vietnam includes the production of a wide range of chemicals, such as fertilizers, pesticides, and cleaning agents.
6	Mechanical engineering:	The mechanical engineering industry in southern Vietnam includes the production of a range of machinery and equipment, including automobiles, motorcycles, and industrial machinery.
7	Construction materials:	The construction materials industry in southern Vietnam includes the production of a range of building materials, such as cement, bricks, and roofing materials.
8	Leather and Footwear:	The leather and footwear industry is another major industry in southern Vietnam, with many industrial zones specializing in the production of shoes, bags, and other leather goods.

Conclusions and Recommendations

In conclusion, this study sheds light on the critical issue of water supply in the Lancang-Mekong River Basin and its importance for sustainable industrial development in the region. The paper highlights the need to consider water supply as an integral part of supply chain management, and to ensure equitable and stable access to water resources for all users. The proposed framework provides a preliminary guide for water management practices in the region, promoting sustainable development and informed decision-making. As the Lancang-Mekong River Basin continues to face challenges related to population growth, economic development, and climate change, effective water management practices are essential to ensure the long-term availability and sustainability of this critical resource. By adopting a holistic approach that considers water supply as an integral part of the supply chain, we can create greater value for all water users and contribute to a more sustainable future for the region.

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