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The Impact of Capital Dredging on Port Competitive Advantage : A Qualitative Study of Muara Sampara Port

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ABSTRACT

Purpose: This study examines how capital dredging of the navigational channel influences the competitive advantage of Muara Sampara Port, Southeast Sulawesi, Indonesia. Design/Methodology: A qualitative descriptive design was employed. Seven informants were selected through purposive sampling from four stakeholder categories: port authority (KUPP Molaw), shipping agencies (PT Philhua, PT Merpati Abadi), shipping companies (PT Bahtera Adhiguna, PT CMA CGM, PT Meratus, PT Mitra Pelayaran Nusantara), and port users. Data were collected through in-depth interviews (February–May 2026), field observation, and documentary analysis (bathymetric surveys using SBES and SSS, tidal observations using the Admiralty method). Data were analyzed using Miles, Huberman, and Saldaña's interactive model (condensation, display, conclusion drawing), supported by source, technique, and time triangulation. Findings: Informants perceived that capital dredging improved vessel accessibility, expanded service capacity, reduced dependence on tidal windows, lowered waiting time, and enhanced navigational safety. Bathymetric data confirm a minimum depth of −10 mLWS at Jetty 4 and −12.69 mLWS at the channel. These operational improvements were associated with greater logistics efficiency, stronger user confidence, and a more favourable competitive position. However, informants also emphasized that the benefit is not self-sustaining: maintenance dredging, berth capacity, navigation aids, digitalization, human resources, and safety management are required. Originality/Value: The study contributes an empirically grounded pathway linking physical infrastructure capability to port competitive advantage, derived from stakeholder narratives rather than imposed from theory.

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INTRODUCTION

The central issue examined in this study is the pathway through which improved channel dimensions generate value for port users. A deeper channel may permit larger-draft vessels, but competitive advantage is not created by depth in isolation. The value arises when the additional physical capacity is translated into safer access, lower waiting time, better vessel utilization, more predictable schedules, and improved cargo movement. The thesis explicitly identifies operational indicators such as ship turnaround time, waiting time, cargo-flow volume, berth productivity, vessel-call frequency, and service efficiency as relevant to the relationship between infrastructure and port competitiveness.

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The empirical case is particularly relevant because Muara Sampara supports industrial and logistics activities in Southeast Sulawesi. The thesis identifies the port as supporting mining and nickel-processing activities and notes that smooth port operations influence the movement of raw materials and industrial products. Thus, improvements in port accessibility can have implications beyond the port boundary, potentially supporting industrial continuity, investment attractiveness, employment, and regional economic development. The thesis concludes that capital dredging should be understood as part of a broader regional development strategy rather than as a stand-alone technical project.

The research gap lies in the limited empirical explanation of how a physical infrastructure intervention becomes a source of competitive advantage from the perspective of multiple port stakeholders. Existing discussions commonly connect port infrastructure with efficiency, but the Muara Sampara case allows the relationship to be traced through stakeholder experience: channel access affects vessel capability; vessel capability affects operational flexibility; operational flexibility affects waiting time and service reliability; these factors affect logistics efficiency and user confidence; and the accumulated benefits strengthen competitive positioning. This article therefore focuses on the strategic mechanism rather than attempting to calculate a statistical causal effect.

The research questions are: (1) how does capital dredging affect vessel accessibility and service capacity at Muara Sampara Port? (2) how does the improvement affect operational constraints and waiting time? (3) how does it influence safety, logistics efficiency, and user confidence? and (4) how do these changes contribute to the port's competitive advantage and what conditions are required to sustain the benefit? The objective is to synthesize stakeholder evidence into an integrated explanation of the operational and strategic impact of capital dredging.

The contribution of the study is twofold. Theoretically, it connects port infrastructure capability with competitive advantage through an explicit operational pathway. Managerially, it provides a stakeholder-based explanation of why maintaining channel depth and complementary port facilities matters for long-term competitiveness.Despite growing recognition that port infrastructure shapes logistics performance (Bichou & Gray, 2005; Talley, 2009), there is limited empirical explanation of how a physical intervention such as capital dredging becomes a source of competitive advantage from the perspective of multiple port stakeholders. Existing studies tend to measure efficiency quantitatively or examine infrastructure in isolation. This study addresses that gap by tracing the mechanism through stakeholder experience at Muara Sampara Port. Research Questions:

1. How do stakeholders describe the effect of capital dredging on vessel accessibility and service capacity?
2. How is the improvement perceived in relation to operational constraints and waiting time?
3. How does it influence safety, logistics efficiency, and user confidence?
4. What conditions do stakeholders identify as necessary to sustain the competitive benefit?

LITERATURE REVIEW

2.1 Port Function and Port Performance

A port is a complex system in which infrastructure, operational processes, users, authorities, and logistics networks interact. Bichou and Gray (2005) argue that port performance should be considered through the interaction of port functions and the wider transport system. This perspective is important for dredging research because channel depth is only one component of port capability. Nevertheless, it is a foundational component: if the channel cannot safely accommodate the required vessel draft, other facilities cannot be fully utilized by the affected vessel class.

Port performance can be understood through time, cost, capacity, reliability, and service-quality dimensions. Talley (2009) explains that port economics involves vessel services, cargo services, resource utilization, and transport demand. From this perspective, an improvement that reduces vessel constraints can affect resource utilization and the economic value of a port call. The thesis adopts related

operational indicators, including waiting time, turnaround time, cargo flow, berth productivity, and vessel-call frequency.

2.2 Navigational Channel, Sedimentation, and Draft

The navigational channel provides the physical route through which vessels access a port. Its effectiveness depends on depth, width, turning radius, seabed condition, and sedimentation. The thesis identifies sedimentation sources such as land erosion, river activity, currents and tides, reclamation, and industrial or shipping activity. Uncontrolled sedimentation reduces effective depth, limits vessel capacity, increases operating cost, and can reduce service quality.

Draft is particularly important because the vessel's underwater dimensions must remain compatible with available depth and the required under-keel clearance. When draft is constrained, a vessel may not be able to use its full cargo capacity. The thesis therefore links deeper navigational access with the possibility of serving larger vessels and improving cargo efficiency. The benefit is strongest where cargo demand is sufficient to justify larger vessel deployment.

2.3 Capital and Maintenance Dredging

The thesis distinguishes capital dredging from maintenance dredging. Capital dredging is associated with creating or substantially increasing the required channel dimension, while maintenance dredging addresses sedimentation that gradually reduces the achieved depth. The distinction is strategically important: capital dredging changes capacity, whereas maintenance dredging preserves that capacity. The thesis identifies maintenance dredging as a necessary condition for sustaining the competitive benefit of the initial capital investment.

2.4 Port Competitive Advantage

Competitive advantage in port management concerns the ability of a port to create greater value for users than competing alternatives. The thesis identifies physical capacity, operational efficiency, logistics cost, reliability, connectivity, innovation, and governance as dimensions of port competitiveness. Bichou and Gray (2005) provide a systems perspective, while Porter (1985) provides the broader strategic argument that superior value can emerge from activities and capabilities that distinguish an organization from alternatives.

For a port, infrastructure becomes strategically valuable when it enables a service that users value. A deeper channel can therefore be viewed as a strategic resource when it supports larger vessels, safer navigation, predictable access, and efficient cargo movement. However, a deep channel without adequate berth capacity, cargo-handling facilities, navigation aids, or service quality can create an imbalance between channel and terminal capacity. The thesis findings support this qualification because several stakeholders emphasized that dredging must be followed by supporting facility development.

2.5 Dredging and Operational Efficiency

The relationship between dredging and efficiency can be explained through the reduction of operational constraints. Before dredging, a vessel may need to wait for a suitable tide. The waiting period consumes time and may reduce vessel utilization. After dredging, greater depth provides more flexibility for vessel entry and departure. The thesis reports that stakeholders perceived reduced waiting time, smoother berthing, higher berth utilization, and lower risk of schedule disruption after capital dredging.

This mechanism is also relevant to logistics cost. Lower waiting time reduces time-related operating burdens, while greater cargo capacity can distribute voyage costs over a larger cargo volume. The thesis describes the effect as an indirect reduction in logistics cost rather than as a directly measured cost statistic. This distinction is maintained in this article because the study is qualitative and does not use a controlled before-and-after cost dataset.

2.6 Research Gap and Analytical Proposition

Capital dredging is expected to create competitive value through a sequence of linked outcomes: improved navigational accessibility → expanded vessel capability and operational flexibility → reduced waiting time and improved reliability → logistics efficiency and user confidence →

strengthened competitive positioning. Maintenance dredging and complementary facilities are enabling conditions..

METHOD

3.1 Research Design

A qualitative descriptive design was employed, appropriate for understanding stakeholder experiences, perceptions, and interpretations of capital dredging rather than estimating a statistical effect size (Moleong, 2021).

3.2 Research Location and Period

The study was conducted at Muara Sampara Port, Konawe Regency, Southeast Sulawesi. Data collection took place between February and May 2026. The port was selected because (a) capital dredging had been implemented; (b) vessel and cargo activity increased after dredging; (c) the port supports regional logistics and nickel-processing industries; (d) operational data were available; and (e) channel access is directly linked to port competitiveness.

3.3 Participants and Data Sources

The informant structure included the port authority represented by KUPP Molawe, shipping agencies, shipping companies, and port users. The thesis records perspectives from KUPP Molawe, PT Pelayaran Bahtera Adhiguna, PT Philhua Shipping Agency, PT Merpati Abadi Shipping, PT Pelayaran Manalagi, PT Meratus Line, PT CMA CGM Indonesia, and PT Mitra Pelayaran Nasional. The stakeholder structure provides regulatory, agency, operator, and user perspectives and allows triangulation across groups.

Primary data were obtained through in-depth interviews and field observations. Secondary data included operational information, documentation, academic literature, regulations, and previous studies. The research focus covered capital-dredging implementation, operational effects, vessel traffic, logistics efficiency, competitive advantage, and environmental considerations.

Informants were selected using purposive sampling (Patton, 2015), with the following inclusion criteria: Direct involvement in port operations before and after capital dredging; Minimum three years of relevant professional experience; Representation of at least one stakeholder category (regulator, agency, shipowner, port user) and Willingness to participate and provide informed consent.

Table 1. Informant Profile

Code	Position	Organisation	Stakeholder Category	Experience	Interview Date	Duration
IA1	Duty Officer	KUPP Molaw / Disnav Kendari	Port Authority	3 years	1 Apr 2026	55 Min
IS1	Surabaya Branch Head	PT Bahtera Adhiguna	Shipping Company	10 years	11 Mar 2026	60 min
IS2	Operational Supervisor	PT CMA CGM Indonesia	Shipping Company	4 years	1 Mar 2026	50 min
IS3	Operational Manager	PT Merpati Abadi Shipping	Shipping Agency	5 years	29 May 2026	45 min

IS4	Operational Supervisor	PT Meratus Line	Shipping Company	4 years	23 Mar 2026	50 min
IS5	Operational Manager	PT Mitra Pelayaran Nusantara	Shipping Company	4 years	21 Feb 2026	55 min
IS6	Operational Supervisor	PT Philhua Shipping Agency	Shipping Agency	5 years	2	IS6

3.4 Data Collection

In-depth interviews were used to obtain detailed information from stakeholders who directly experienced port operations. Interview themes included the condition and purpose of the navigational channel, changes in vessel accessibility, vessel draft and capacity, waiting time, berth utilization, safety, logistics cost, service quality, user confidence, and the requirements for sustaining the benefits of dredging. The use of multiple stakeholder groups was important because the same infrastructure improvement can produce different operational consequences for a regulator, an agency, and a vessel operator.

Field observation was used to complement interview evidence by observing port access, vessel movement, and operational conditions. Documentation was used to cross-check information obtained from interviews and observations. The thesis methodology describes data presentation through descriptive narratives, tables, analytical matrices, and diagrams of relationships among research concepts.

Three techniques were used:

In-depth interviews (semi-structured, 45–60 minutes) covering channel condition, vessel accessibility, waiting time, safety, logistics cost, service quality, and sustainability requirements.

Field observation at Jetty 3, Jetty 4, and the navigational channel, including vessel movement and berthing activity.

Documentation: bathymetric survey reports (SBES South SDE-28S+ and SSS Humminbird 1199CI), tidal observations (Admiralty method, 29 piantan), and port operational records

Data saturation was assessed continuously during data collection. By the seventh interview, no new codes or themes emerged; subsequent coding confirmed thematic redundancy. The final sample of seven informants across four stakeholder categories was therefore deemed sufficient, though the study acknowledges that a larger sample could have captured additional operational nuances.

3.5 Data Analysis

Data analysis followed the Miles, Huberman, and Saldaña framework. The process consisted of data condensation, data display, and conclusion drawing and verification. Data condensation involved selecting and organizing information relevant to the research focus. Data display was used to identify patterns across stakeholders. Conclusions were developed by interpreting the evidence as a whole and checking whether the emerging findings were supported across data sources.

Data were analysed using the Miles, Huberman, and Saldaña (2014) interactive model:

1. Data condensation – selecting, coding, and organising interview transcripts and field notes.
2. Data display – presenting codes in matrices and thematic tables to identify patterns across stakeholder groups.
3. Conclusion drawing and verification – interpreting patterns and checking them against all data sources.

Table 2. Illustration of Coding Process

Raw Data (Quotation)	Initial Code	Category	Theme
"Setelah alur diperdalam, kapal tidak lagi terlalu bergantung pada kondisi pasang surut." (IS6)	Reduced tidal dependence	Operational flexibility	Improved vessel accessibility
"Waiting time umumnya menurun karena akses pelabuhan lebih mudah." (IS1)	Reduced waiting time	Operational efficiency	Reduction of operational constraints
"Risiko kandas berkurang." (IS4)	Reduced grounding risk	Navigational safety	Safety improvement
"Kami dapat memberikan informasi ETA dan ETD yang lebih akurat kepada principal." (IS6)	Improved schedule reliability	Service reliability	User confidence

3.6 Data Validity

The study applied triangulation to strengthen credibility. Source triangulation compared information from different informants. Technique triangulation compared interview results with observation and documentation. Time triangulation considered information collected at different times to test consistency. The thesis explicitly identifies triangulation as the method used to ensure the validity of qualitative findings.

Criterion	Strategy Applied
Credibility	Source triangulation across 7 informants from 4 stakeholder categories; technique triangulation (interviews vs. observation vs. bathymetric documents); member checking with two informants.
Transferability	Thick description of port context, informant profiles, and operational conditions provided in Sections 3.2–3.5 and 4.1.
Dependability	Audit trail: interview guides, transcripts, coding matrices, and bathymetric reports retained and available upon request
Confirmability	Reflexivity statement (Section 3.8); findings linked directly to verbatim quotations; contradictory evidence reported (Section 4.6).

3.7 Scope and Limitations of Method

The study concentrates on the operational and strategic consequences of capital dredging and does not attempt to reproduce the engineering design or calculate dredging productivity. The qualitative design also means that findings should be interpreted as stakeholder-based evidence of mechanisms and perceived outcomes. Where the thesis reports lower logistics cost or increased vessel activity, the article presents these as findings reported or perceived by stakeholders rather than as statistically isolated effects of dredging.

This study does not measure the statistical effect of dredging. It does not include a controlled before-and-after cost dataset. It relies on stakeholder perceptions triangulated with documentary evidence. Environmental impacts are discussed qualitatively and are not quantified.

3.8 Analytical Indicators

The analytical indicators derived from the thesis are: channel depth and vessel draft for physical accessibility; waiting time, turnaround time, vessel flow, and berth productivity for operational efficiency; vessel-call frequency and service capacity for port attractiveness; logistics cost and cargo capacity for economic efficiency; and user confidence and service quality for competitive advantage. Environmental considerations include turbidity, marine habitat disturbance, water quality, and dredged-material disposal.

The first author has professional experience in shipping operations, which facilitated access to informants but may also have shaped interpretation of operational efficiency. To mitigate potential bias,

the researcher (a) maintained a reflexive journal throughout data collection; (b) deliberately sought disconfirming evidence; (c) compared interview claims against bathymetric and tidal documents; and (d) conducted member checking with two informants. No financial or institutional relationship exists between the researcher and Muara Sampara Port.

RESULT

4.1 Initial Operational Constraints

The thesis describes limited channel depth as a significant operational constraint before capital dredging. Larger-draft vessels could not access the port freely and had to consider suitable tidal conditions. This constraint affected scheduling and created waiting time. In addition, vessels could not necessarily maximize cargo intake, which could increase the operating cost associated with transporting each unit of cargo. The condition had strategic implications because ports with better navigational depth could potentially offer greater flexibility to shipping operators.

Before capital dredging, effective channel depth was constrained by sedimentation. Bathymetric data from June 2023 recorded depths as shallow as 3.0–3.5 mLWS at several points (see Appendix). Informants from the port authority and shipping companies consistently reported :

"Sebelum pengerukan, alur pelayaran relatif dangkal sehingga draft kapal terbatas hanya max draft 12 mtr sehingga harus menunggu pasang atau melakukan lightening di Anchorage." (IS1, PT Bahtera Adhiguna)

"Sebelum dilaksanakan capital dredging, kondisi alur pelayaran mengalami keterbatasan kedalaman akibat sedimentasi yang terjadi secara alami." (IA1, KUPP Molawe)

These constraints produced three operational consequences reported by informants: (a) dependence on tidal windows; (b) waiting time; and (c) inability to maximise cargo intake.

4.2 Implementation Objective of Capital Dredging

The capital-dredging project was undertaken as part of the port's infrastructure development. The thesis identifies five central objectives: increasing channel depth, improving navigation safety, reducing navigation constraints, increasing vessel-service capacity, and strengthening port competitiveness. These objectives show that the project was conceived as an integrated operational improvement rather than simply as seabed excavation.

4.3 Vessel Accessibility and Capacity

The first major empirical finding is improved vessel accessibility. Interviews with the port authority, shipping companies, and shipping agencies indicate that capital dredging increased the capacity of vessels that could be served. Before dredging, larger-draft vessels experienced access limitations. After dredging, larger vessels could enter and leave more safely and with less dependence on tidal conditions. One agency informant summarized the operational change by stating that after the channel was deepened, vessels were no longer as dependent on tidal conditions, which made voyage planning easier and improved operational efficiency.

All informants reported that capital dredging expanded the range of vessels that could be served :

"Setelah alur diperdalam, kapal tidak lagi terlalu bergantung pada kondisi pasang surut. Hal ini memudahkan perencanaan pelayaran dan meningkatkan efisiensi operasional kapal." (IS6, PT Philhua Shipping Agency)

"Setelah pengerukan, pelabuhan dapat menerima kapal dengan kapasitas muatan yang lebih besar dibandingkan sebelumnya." (IS2, PT CMA CGM)

"Kami sangat mengalami peningkatan ukuran kapal bahkan muatan kami tambah." (IS4, PT Meratus)

Triangulation : Bathymetric survey (September 2025) recorded an average depth of −14.94 mLWS at Jetty 4 and −27.62 mLWS at the channel, with minimum depths of −10.0 mLWS and −12.69 mLWS respectively. This documentary evidence supports informant claims of improved accessibility.

Interpretation : The finding indicates that capital dredging changed the physical constraint under which vessels operate, expanding feasible draft range and reducing tidal dependence

The increased vessel capacity is strategically relevant because it allows the port to support greater cargo quantities per voyage. The thesis notes that larger vessel capacity can improve the efficiency of the logistics chain because more cargo can be moved in a single voyage. The benefit is therefore both physical and economic: the port becomes accessible to a broader range of vessel options while cargo movement can be organized more efficiently.

4.4 Reduction of Operational Constraints

The second major finding is a reduction in operational constraints. Before dredging, vessels often had to wait for suitable tides. After dredging, the dependency on tidal conditions was reduced, resulting in shorter waiting time, smoother berthing, better berth utilization, and lower risk of schedule delays. The thesis reports that the benefit was experienced across stakeholders: shipping companies gained more efficient vessel operating time, agencies experienced smoother service coordination, and the port benefited.

Informants across all stakeholder categories reported reduced waiting time :
"Waiting time umumnya menurun karena akses pelabuhan lebih mudah dan tidak terlalu dibatasi oleh draft." (IS1, PT Bahtera Adhiguna)
"Pengerukan mengurangi waktu tunggu karena kapal dapat sandar dengan lebih lancar tanpa terkendala kedalaman alur pelayaran." (IS3, PT Merpati Abadi)

"Sebelum pengerukan, beberapa kapal harus menunggu kondisi pasang yang sesuai untuk dapat melintas dengan aman. Setelah pengerukan, lalu lintas kapal menjadi lebih lancar." (IA1, KUPP Molaw)

Triangulation : Field observation during three days in April 2026 recorded no vessels waiting at the anchorage area, contrasting with pre-dredging conditions described by informants.

Interpretation : The reduction of tidal dependence translates directly into operational flexibility, which informants associate with more predictable scheduling.

4.5 Vessel Traffic and Port Attractiveness

The thesis reports a tendency toward increased interest among shipping companies in using Muara Sampara after capital dredging. Improved depth provides greater confidence that the port can accommodate larger vessels and provide safer access. Some operators also began considering larger vessels to improve transportation efficiency. The finding is interpreted as an indicator of increased port attractiveness rather than as a statistically established causal increase in vessel calls.

4.6 Navigation Safety and Security

Safety was identified by all informant groups as one of the important benefits of capital dredging. Before dredging, limited depth created greater navigational risk because vessels had to operate under more restrictive depth and tidal conditions. The thesis notes the potential for navigation disturbance and grounding risk if draft and tidal conditions were not properly considered. After dredging, the greater available depth provided more maneuvering space and improved the safety of vessel entry, departure, and movement along the channel.

The safety improvement also contributes to service quality. A port that can provide predictable and safe access is more likely to gain the confidence of shipping operators. However, the study does not interpret dredging as a complete safety solution. Safe navigation still requires navigation aids, appropriate

operating procedures, competent personnel, and effective port-management systems. This qualification is consistent with the stakeholder recommendation that navigation facilities and safety systems continue to be developed.

Safety was the most frequently cited benefit across stakeholder groups :
"Risiko kandas berkurang." (IS4, PT Meratus)
"Pengerukan telah meningkatkan kedalaman alur secara signifikan. Kondisi ini memberikan ruang gerak yang lebih aman bagi kapal yang keluar dan masuk pelabuhan serta mengurangi risiko kandas." (IS2, PT CMA CGM)
"Pengerukan sangat berpengaruh terhadap kelancaran keluar-masuk kapal karena kedalaman alur yang lebih memadai memberikan ruang gerak yang lebih aman." (IA1, KUPP Molawe)

Triangulation: Bathymetric contour mapping (Figure 3.4) identified areas with depths shallower than −12 mLWS that pose navigational risk; these areas were reduced after dredging.

Interpretation: Safety functions as both an operational outcome and a service-quality attribute that informs port choice.

4.7 Logistics Efficiency
The research identifies an indirect positive effect on logistics efficiency. Reduced waiting time lowers time-related operating burdens. Increased vessel capacity can allow more cargo to be transported per voyage. Better schedule reliability can reduce uncertainty in the supply chain. The thesis therefore concludes that capital dredging contributes to lower logistics cost, although the study does not provide a controlled numerical before-and-after estimate.

The concept of economies of scale is relevant to this finding. When a larger vessel carries more cargo on a voyage, some voyage-related costs can be distributed over a larger cargo volume. The competitive benefit is therefore generated through a combination of access, capacity, and time efficiency rather than through the physical depth of the channel alone.

Informants linked dredging to indirect logistics cost reduction and increased confidence :
"Pengerukan membantu menekan biaya operasional kapal karena waktu tunggu berkurang, penggunaan bahan bakar menjadi lebih efisien." (IS2, PT CMA CGM)
"Biaya demurrage cenderung menurun setelah pengerukan dilakukan." (IS4, PT Meratus)
"Pengerukan meningkatkan kepercayaan principal, mengurangi waiting time kapal, menekan biaya operasional, mempercepat pelayanan kapal, serta meningkatkan daya tarik Pelabuhan Muara Sampara sebagai pelabuhan tujuan." (IS6, PT Philhua)

Interpretation: User confidence is a perceptual outcome that mediates between physical infrastructure and port choice. Informants explicitly framed accessibility as a criterion for selecting Muara Sampara over alternative ports.

4.8 Service Quality and User Confidence
The interviews indicate that user confidence increased after the channel improvement. PT Philhua Shipping Agency emphasized increased principal confidence, reduced waiting time, lower operating cost, faster vessel service, and greater attractiveness of Muara Sampara as a destination. These outcomes demonstrate how an infrastructure change can influence perceived service quality.

4.9 Stakeholder Perspectives

The stakeholder evidence reveals strong convergence while retaining different emphases. KUPP Molawe emphasizes navigation safety, smooth vessel traffic, operational efficiency, and the need for continued channel maintenance. PT Pelayaran Bahtera Adhiguna emphasizes increased vessel-service capacity, operational efficiency, and competitiveness, while also stressing maintenance dredging and

good operational management. These perspectives represent the regulatory and agency dimensions of the infrastructure improvement.

From the shipping-company perspective, PT CMA CGM Indonesia views capital dredging as having a very positive effect on service capacity, operational efficiency, service quality, and port attractiveness. PT Merpati Abadi Shipping reports smoother vessel access, more efficient service, and greater operational reliability. PT Meratus emphasizes navigation safety, vessel traffic, and operational efficiency but also points to the need for berth and facility development. These differences demonstrate that competitive advantage is multidimensional: the same channel improvement affects safety, service, capacity, and infrastructure adequacy simultaneously.

PT Mitra Pelayaran Nasional highlights increased vessel capacity, smoother vessel flow, greater operational efficiency, lower logistics cost, and a stronger role for Muara Sampara as a supporting port for regional industrial and trade activities. PT Philhua Shipping Agency emphasizes principal confidence, waiting-time reduction, lower operating cost, faster service, and destination attractiveness. Together, these perspectives show a consistent pattern from infrastructure improvement to user value and competitive positioning.

Although informants broadly agreed on the positive operational effects of dredging, they diverged on whether these effects alone constitute competitive advantage. Three qualifications emerged:

(a) Dredging is not sufficient without complementary facilities.

"Peningkatan daya saing pelabuhan juga perlu didukung dengan pengembangan fasilitas pelabuhan, kapasitas dermaga, serta peningkatan kualitas pelayanan secara berkelanjutan." (IS4, PT Meratus)

"Kemampuan pelayanan secara menyeluruh tetap harus didukung oleh kesiapan fasilitas pelabuhan lainnya seperti dermaga, peralatan bongkar muat, dan kolam pelabuhan." (IA1, KUPP Molaw)

(b) Dredging does not automatically create new routes.

"Pengerukan membantu kapal masuk dan keluar Pelabuhan dengan lebih lancar, tetapi tidak secara otomatis menambah rute pelayaran baru karena trafik kapal di Muara Sampara ditentukan oleh kebutuhan muatan dan pengguna jasa tertentu." (IS3, PT Merpati Abadi)

(c) Draft constraints persist under certain conditions.

"Masih terdapat pembatasan draft operasional sekitar 13–13,5 meter. Untuk kapal dengan draft mendekati batas tersebut, kegiatan keluar masuk pelabuhan umumnya dilakukan saat kondisi pasang tinggi." (IS5, PT Mitra Pelayaran Nusantara)

"Kendala tersebut masih dapat terjadi pada kondisi tertentu, terutama apabila terjadi sedimentasi kembali." (IA1, KUPP Molaw)

Interpretation: These qualifications do not negate the benefits of capital dredging, but they bound the competitive-advantage claim. The competitive value of dredging is contingent on lifecycle maintenance and complementary capability development. This finding is consistent with the analytical proposition that enabling conditions determine durability.

4.10 Cross-Stakeholder Synthesis

Stakeholder group	Primary benefit perceived	Operational meaning	Strategic meaning
Port authority (IA1)	Safety, smooth traffic, adequate channel	Fewer navigation constraints	More reliable port access
Shipping agency (IS3, IS6)	Lower waiting, faster service	Better coordination and vessel utilization	Higher service attractiveness
Shipping company – national (IS1, IS4, IS5)	Larger capacity, reliable access	More flexible vessel deployment	Stronger port choice
Shipping company – international (IS2)	Service capacity, quality, attractivenes	Improved operational efficiency	Strengthened competitive position

4.11 Competitive Advantage

The combined evidence indicates that capital dredging strengthens Muara Sampara's competitive advantage through improved infrastructure quality, higher vessel-service capacity, better operational efficiency, stronger user confidence, more reliable service, and increased attractiveness to shipping operators. The thesis identifies these dimensions as the principal expressions of improved competitiveness.

Capital Dredging → Navigational Accessibility → Vessel Capability and Operational Reliability → Logistics Efficiency and Service Quality → User Confidence → Port Competitive Advantage

Enabling conditions (identified inductively from informant qualifications): maintenance dredging, berth capacity, navigation facilities, digital systems, human resources, safety management, environmental management.

DISCUSSION

5.1 From Physical Capacity to Strategic Value

The principal finding of this study is that capital dredging creates competitive value through a chain of operational mechanisms. The physical intervention changes the constraints under which vessels operate. Improved channel access expands the feasible vessel-draft range and reduces dependence on tidal windows. This creates greater operational flexibility. The resulting flexibility affects waiting time, schedule reliability, safety, cargo capacity, and ultimately the value perceived by port users.

This finding supports the systems perspective of port performance. Infrastructure cannot be evaluated independently from the services it enables. In Muara Sampara, the channel improvement matters because it changes the conditions under which the port provides vessel services. The result is therefore consistent with the thesis argument that capital dredging should be understood as a strategic investment rather than simply a technical maintenance activity.

The findings support a systems perspective on port performance (Bichou & Gray, 2005): infrastructure becomes valuable when it enables services that users value. Informants perceived that channel depth matters not as an isolated physical measure, but because it changes the conditions under which vessel services are produced.

5.2 Vessel Size and Economies of Scale

A deeper channel expands the range of vessels that can potentially call at the port. This is strategically relevant because larger vessels can carry more cargo per voyage. The thesis explicitly connects greater vessel capacity with potential transport efficiency and lower cost per unit of cargo. The economic mechanism is economies of scale: voyage-related costs can be spread across a larger cargo volume when vessel capacity is efficiently utilized. However, the competitive effect should not be overstated. The availability of deeper water does not automatically guarantee that larger vessels will call at the port.

Shipping decisions also depend on cargo demand, berth availability, cargo-handling productivity, service quality, route economics, and connectivity. Therefore, dredging should be viewed as removing a physical constraint and creating an option for greater vessel capacity, while complementary capabilities determine whether the option is commercially realized.

A deeper channel expands the feasible vessel range. Informants linked larger vessel capacity to potential economies of scale. However, the study does not claim that dredging automatically attracts larger vessels; shipping decisions depend on cargo demand, berth availability, and route economics. Dredging removes a physical constraint and creates an option.

5.3 Waiting Time and Reliability
The reduction in waiting time is one of the most direct operational benefits identified by the research. Before dredging, tidal dependence introduced uncertainty into vessel scheduling. After dredging, stakeholders perceived shorter waiting and greater flexibility. This is strategically significant because logistics users value predictability as well as nominal capacity. A port that can provide reliable access can reduce uncertainty in vessel deployment and cargo planning. The result also illustrates why channel depth can become a service-quality variable. Although depth is a physical measure, its effect is experienced by users as a service outcome: faster access, fewer delays, and more predictable port calls. The competitive advantage therefore emerges at the interface between infrastructure and service delivery..

The reduction in waiting time was the most consistently reported operational benefit. Informants framed this as a service-quality outcome: faster access, fewer delays, more predictable port calls. The competitive advantage therefore emerges at the interface between infrastructure and service delivery. 5.4 Safety as a Competitive Attribute The stakeholder emphasis on safety demonstrates that port competitiveness is not based solely on speed and cost. A port must provide safe access under the operational conditions faced by vessels. The thesis identifies the reduction of grounding and navigation risks as an important consequence of improved depth. Greater maneuvering space also improves the perceived safety of entering and leaving the port.

Safety can influence port choice because shipping companies are exposed to financial and operational consequences when navigation is unreliable. Improved channel depth reduces one class of physical constraint, but it must be combined with navigation aids, procedures, competent personnel, and safety management. Thus, the dredging project should be viewed as a foundation for safe accessibility rather than as a substitute for a complete safety-management system.

Informants emphasised safety as a dimension of port competitiveness that is not reducible to speed or cost. Greater depth provides additional manoeuvring space and reduces grounding risk.

5.5 Logistics Cost and Supply-Chain Efficiency
The thesis identifies lower logistics cost as an indirect effect of capital dredging. The mechanism is consistent with the operational evidence: shorter waiting time reduces vessel time, while larger cargo capacity improves cargo-per-voyage efficiency. The study deliberately avoids presenting a numerical percentage reduction because the qualitative research did not establish a controlled cost dataset. Instead, the evidence supports a mechanism through which infrastructure improvement can lower the operating burden per unit of cargo. This distinction improves the validity of the conclusion. The research demonstrates how stakeholders experience the economic benefit, but it does not isolate dredging from other cost determinants such as fuel prices, cargo rates, berth productivity, or market conditions. Future quantitative research should therefore test the magnitude of the cost effect using longitudinal operational and financial data. Informants perceived lower logistics cost as an indirect effect. The mechanism is consistent: shorter waiting time reduces vessel time, while larger cargo capacity improves cargo-per-voyage efficiency. This study deliberately avoids presenting a numerical percentage reduction because the qualitative design did not establish a controlled cost dataset.

5.6 User Confidence and Port Choice
The interviews suggest that improved channel access strengthens confidence among principals and shipping operators. PT Philhua Shipping Agency reports higher principal confidence and greater destination attractiveness, while PT CMA CGM Indonesia emphasizes improved service capacity, efficiency, quality, and attractiveness. These findings indicate that physical infrastructure can influence the reputation of a port through the service outcomes it enables.

User confidence is strategically important because port competition involves choices among alternative facilities. When a port is perceived as safer, more reliable, and capable of serving larger vessels, it can become more attractive to operators and cargo interests. The competitive advantage therefore includes both measurable operational outcomes and perceptual outcomes such as trust and confidence.
User confidence emerged as a perceptual outcome that mediates between physical infrastructure and port choice. Informants from shipping agencies and international operators explicitly framed accessibility as a criterion for selecting Muara Sampara.

5.7 Regional Economic Implication
The thesis extends the effect of dredging beyond port operations to regional economic development. Muara Sampara supports industrial and trade activities in Southeast Sulawesi, including mining and nickel-processing activities. More efficient port access can support the movement of industrial inputs and outputs and potentially improve the attractiveness of the surrounding region for investment and economic activity. Muara Sampara supports nickel-processing and industrial activities in Southeast Sulawesi. More efficient port access can support the movement of industrial inputs and outputs. However, the study does not claim that dredging alone causes regional economic growth; it identifies the port as an enabling component of the regional logistics system.

5.8 Sustainability and Maintenance Dredging
The research emphasizes that capital dredging does not permanently eliminate sedimentation. The achieved depth can gradually decline if sediment accumulates. Consequently, maintenance dredging is essential for preserving the operational capability created by the capital project. Stakeholders explicitly identify periodic maintenance dredging as a requirement for sustaining competitive advantage. This finding leads to an important managerial interpretation. Competitive advantage from infrastructure should be managed over the asset lifecycle. The relevant management question is not simply whether the target depth was achieved during project completion, but whether the port can maintain sufficient effective depth under changing sedimentation and operational conditions. Lifecycle maintenance is therefore part of the competitive strategy. The findings emphasise that capital dredging does not permanently eliminate sedimentation. Maintenance dredging is essential for preserving the operational capability created by the capital project. This leads to a managerial interpretation: competitive advantage from infrastructure should be managed over the asset lifecycle.

5.9 Complementary Infrastructure
Several stakeholders caution that improved channel depth must be accompanied by berth development and other supporting facilities. PT Meratus, for example, emphasizes the need for berth and facility development, while the thesis recommendations include navigation facilities, digitalization, human-resource development, and safety and security systems. The implication is that dredging can create a capacity opportunity that the terminal system must be able to absorb. If channel capacity increases while berth capacity remains unchanged, the port may shift its bottleneck from navigational access to terminal service. A strategic investment program should therefore synchronize channel, berth, cargo-handling, storage, information, and hinterland capabilities.

5.10 Environmental Considerations
The thesis identifies potential environmental effects of dredging, including increased turbidity, disturbance of marine habitats, changes in water quality, and risks associated with disposal of dredged

material. These issues are recognized as management considerations, but the study does not provide quantitative environmental measurements. Therefore, the article does not claim a measured environmental impact; it recommends that environmental monitoring, mitigation, and regulatory compliance be integrated into dredging management.

5.11 Integrated Competitive-Advantage Model

The empirical findings support the following analytical model: Capital Dredging → Navigational Accessibility → Vessel Capability and Operational Reliability → Logistics Efficiency and Service Quality → User Confidence → Port Competitive Advantage. Maintenance dredging, berth capacity, navigation facilities, digital systems, human resources, safety, and environmental management act as enabling conditions that determine whether the competitive advantage can be sustained.

This model is the principal theoretical contribution of the study. It explains why a physical infrastructure project can generate a management outcome. The channel is not the final source of value; rather, it is the enabling resource through which better operational services are produced.

5.12 Comparison with Existing Theory

The findings are consistent with Bichou and Gray's systems view of ports, Talley's port-economic perspective, and Porter's value-based view of competitive advantage. The Muara Sampara evidence adds an empirical pathway linking these perspectives: infrastructure capability becomes valuable when it reduces operational constraints and creates user value. The findings therefore strengthen the argument that port competitiveness is multidimensional and should be managed through coordinated infrastructure and service capabilities. The findings are consistent with Bichou and Gray's systems view, Talley's port-economics perspective, and Porter's value-based view of competitive advantage. The Muara Sampara evidence adds an empirically grounded pathway linking these perspectives: infrastructure capability becomes valuable when it reduces operational constraints and creates user value.

CONCLUSIONS

This study concludes that capital dredging has a positive operational and strategic contribution to the competitive advantage of Muara Sampara Port. The most immediate benefit, as perceived by informants, is improved vessel accessibility. After the channel improvement, vessels can be served with greater flexibility and safety.The second conclusion is that capital dredging is perceived to reduce operational constraints. Informants reported shorter waiting time, smoother vessel movement, improved berth utilisation, and lower risk of schedule disruption. These effects were associated with improved operational reliability. Third, informants perceived that capital dredging contributes to safety. Greater depth provides additional navigational space and reduces dependence on restrictive tidal conditions.

Fourth, the study finds an indirect positive association with logistics efficiency. Larger cargo capacity and lower waiting time can reduce the operating burden per unit of cargo, although the magnitude of cost reduction was not statistically measured. Fifth, capital dredging is perceived to strengthen competitive positioning. Informants identified improved infrastructure quality, higher vessel-service capacity, better operational efficiency, stronger user confidence, and increased port attractiveness as the principal competitive outcomes. However, the study also found that dredging alone does not automatically generate new routes or fully eliminate draft constraints; complementary facilities and lifecycle maintenance are required.

Finally, the benefit is not self-sustaining. Maintenance dredging, berth development, navigation facilities, digitalization, human resources, and safety systems are required to preserve and extend the benefit. The strategic lesson is that capital dredging should be managed as a lifecycle infrastructure capability. Limitations and Future Research: This study is qualitative and does not establish statistical causality. Future research should test the magnitude of cost and efficiency effects using longitudinal operational and financial data.

DECLARATIONS

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