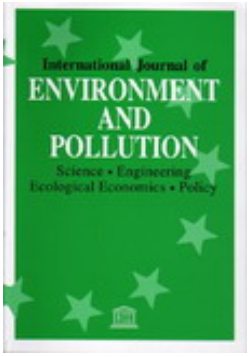

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Combating illegal sand pumping: enforcement challenges and policy mechanisms in Taiwan's EEZ

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Combating illegal sand pumping: enforcement challenges and policy mechanisms in Taiwan's EEZ

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Abstract: In Taiwan, the exclusive economic zone (EEZ), which overlaps with those of neighbouring coastal countries, has become a hotspot for illegal sand pumping by cross-border fleets. These activities have drawn significant criticism from the public and media for contributing to weaknesses in marine law enforcement, environmental degradation, and habitat destruction. In response, legislative, administrative, and civil society actors have demanded stronger enforcement and effective countermeasures – including legal reforms, enhanced marine resource conservation, and increased enforcement to demonstrate the Taiwanese government's commitment. This study evaluates Taiwan's inter-ministerial coordination strategies and proposes enforcement and management recommendations based on strengths, weaknesses, opportunities, threats (SWOT) and fishbone diagram analyses. The findings aim to inform future research and policy efforts, both domestically and in similarly affected coastal states.

Keywords: law enforcement; SWOT; strengths, weaknesses, opportunities, threats; sand pumping; EEZ; exclusive economic zone; Taiwan.

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1 Introduction

With the East China Sea to the north, the South China Sea to the south, the Taiwan Strait to the west, and the Pacific Ocean to the east, Taiwan is an island nation encircled by water. It has favourable natural conditions in its sea environment. By claiming a 12-nautical-mile territorial sea, a 12-nautical-mile contiguous zone, and a 200-nautical-mile exclusive economic zone (EEZ), Taiwan has greatly increased its jurisdiction over maritime areas since the Law on the Territorial Sea and the Contiguous Zone and the Law on the EEZ and the Continental Shelf were passed in 1997 (Tseng, 2021).

The combination of the Kuroshio tributaries and continental currents makes the Penghu seas a very prolific continental shelf fishery (Liu et al., 1992; Hsin et al., 2013). This dynamic oceanic environment supports a varied and profitable fishing industry. The Penghu Islands, which have a diverse distribution of fisheries species, are the greatest shallow rocky and coral reef fishing ground in the waters surrounding Taiwan.

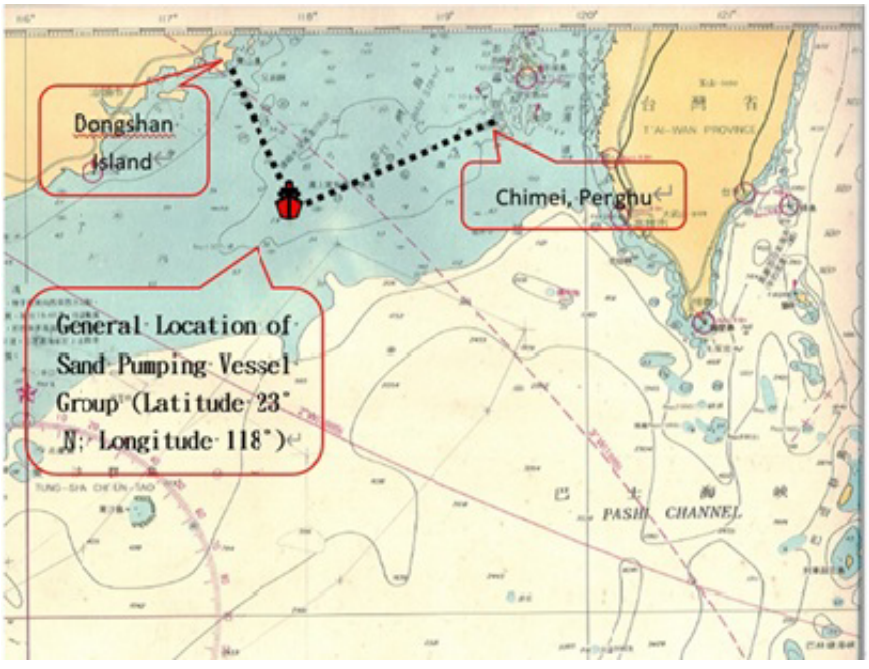
After arriving in the Penghu Islands, the Kuroshio tributary, which originates from the south with high temperatures and high salinity, weakens and can no longer reach most of the archipelago. In the meantime, the northern Chinese coastal current, which is low-temperature and low-salinity, also dissipates close to Penghu. Numerous migratory fish populations are supported by the steady year-round temperature created by this confluence of water masses, distinctive seabed morphology, and nutrient-rich waters. Furthermore, a range of fish habitats are supported by the region's high biodiversity, which naturally raises fishery production (Shih and Chiau, 2009; Shieh et al., 2007).

According to a survey by the Aquatic Products Laboratory of the Council of Agriculture, Executive Yuan, Penghu waters host at least 172 fish families and 1,230 species, comprising nearly 40% of Taiwan's fish species. Additionally, 22 crab families and 148 species have been recorded, accounting for 23.4% of Taiwan's crab population (Chen, 2004), indicating a high level of biodiversity.

Local fishermen have been fishing in the Taiwan Strait's Kinmen, Matsu, and Penghu waters for many years. Fishermen from Fujian, China, have regularly crossed maritime borders to fish in these areas because of their proximity and wealth of fishing opportunities.

The Taiwan Shoal, sometimes referred to as the Taiwan Bank, is situated southwest of Penghu and spans an area of over 8800 square kilometres, extending roughly 250 kilometres east to west and 130 kilometres north to south. With a shallowest point of just 8.6 m, its depth ranges from 30 m to 40 m in the west to less than 20 m in the east (as illustrated in Figure 1). Supporting many economically valuable species, the area is rich in a variety of fisheries resources and is a popular fishing destination for both Chinese and Taiwanese fishermen.

Figure 1 Map showing the marine localities of sand pumping ships in mainland China (see online version for colours)



The Penghu waters are ideal for trawling since they have large fishing grounds with mostly sandy seabeds. Cross-border fishing is common since mainland Chinese fishing vessels operate close to these waterways. According to Weng et al. (2020), the Spanish mackerel's breeding season runs from March to August. The Taiwan Shoal is the primary breeding area. According to historical records, the Pacific round herring, which is common in Penghu's fishing industry, and the lock tube fisheries account for up to 90% of the province's production. Their economy is based on this. The Taiwan shoal is a major breeding site for this species.

In addition to its significance for fishing, the Taiwan Shoal is rich in sand, which draws Chinese sand-pumping vessels. China uses this sand for large-scale projects. Even though the area is hotly contested, Chinese ships' repeated invasions have brought this issue back to the forefront in recent years. Chinese ships operating in the Kinmen and Matsu have frequently been confiscated by the Ocean Affairs Council (OAC) and Coast Guard Administration (CGA) (Li and Se, 2020; Huang, 2019). Additionally, sand dredging operations have been observed in the Taiwan Strait. This has turned out to be a significant enforcement problem.

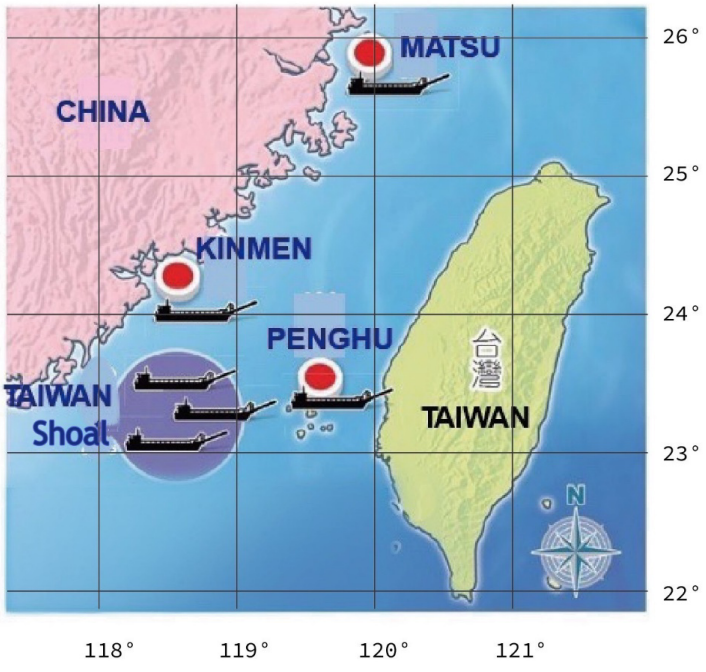
The Taiwanese government has pledged to address this unlawful sand dredging by amending the legislation to safeguard Taiwan's marine resources. This serious issue was the subject of an international moot in May 2023 in order to develop new and efficient policies (OAC, 2023).

After water, sand is the second most precious commodity that is exploited as a natural resource (Rangel-Buitrago et al., 2023; Rentier and Cammeraat, 2022; Bendixen et al., 2021; UNEP, 2002). The overuse of sand in coastal regions has an impact on the environment worldwide for societies in the 21st century. The monster of overpopulation,

which has resulted in widespread urbanisation, is the primary cause of this overuse of natural resources. The manufacture of building materials is necessary due to urbanisation.

Sand mines in Taiwan Shoal's coastal regions have recently been subject to Chinese controls. It is situated along the midway line of the Taiwan Strait's southernmost point. About 30 nautical miles southwest of Chimei, Penghu, is the exact location. It has shown itself to be the primary target of the Chinese ships' sand dredging operations. The CGA has responded by deploying patrol ships to enforce Taiwan's maritime regulations and disperse illicit sand dredging operations. However, a large number of Chinese sand-pumping vessels from the mainland frequently return to the Taiwan Shoal, where they unlawfully collect sand from Taiwan's EEZ while operating in the middle of the Taiwan Strait (Figure 2).

Figure 2 The illegally mined sand in Taiwan's EEZ (see online version for colours)



This illegal activity has resulted in significant losses of sand and gravel, leading to seabed topographical changes and causing severe damage to the marine ecosystem (Chen, 2020; Kao et al., 2017).

Between 2016 and 2020, 4669 sand-pumping vessels from mainland China were distributed, according to Coast Guard Administration statistics (CGA, 2023). There were 3991 of these vessels in 2020 alone, and 22,470 cubic metres of sand were extracted overall (Table 1). Sand-pumping and transport vessels have persisted in entering Taiwan's waterways for illicit extraction in spite of enforcement actions.

The CGA reported a startlingly high number of vessels dispersed in 2020 – nearly 4000. Kinmen, one of the most impacted regions, was the first to experience coastline erosion as a result of cross-border sand dredging. The Taiwan Shoal, which is situated along the Taiwan Strait's centreline near Penghu, has also developed into a popular

destination for sand-pumping boats. In addition to having abundant fisheries resources, this region is an important spawning place for species including neritic squid and Spanish mackerel.

Table 1 Statistics on the enforcement of illegal sand pumping vessels in China

Year	*Espel* (*vessel*)	*Detain* (*vessel*)	*No. of persons* (*vessel*)	*Confiscation* (*vessel*)	*Auction Price* (*Million NTD*)	*Illegal sand pumping* (*cubic metre*)
2016	0	2	11	2	0	1
2017	2	2	14	2	23.73	0.7
2018	71	2	13	2	4.19	1.3
2019	605	7	70	7	109.8	16.2
2020	3991	4	37	2	14.52	3.3
2021	665	0	0	1	131.21	0
2022	224	2	18	0	0	2.1
Total	4558	19	163	16	290	25

Scholars have raised concerns that sand extraction poses a severe threat to the seabed ecosystem and could have long-term ecological consequences (Lu and Chen, 2020).

The growing number of evictions shows that unlawful cross-border sand mining by mainland Chinese vessels continues to be profit-driven despite stringent law enforcement. The destruction of marine ecosystems in Penghu, Kinmen, and Matsu as a result of this continuous activity has put local livelihoods at risk and exacerbated coastal erosion (Wu and Chen, 2020).

The Taiwan Shoal has seen a rise in the number of mainland sand-pumping vessels operating there since China banned the excavation of coastal sand in 2018. The CGA uses high-pressure water cannons and huge patrol vessels to disperse these operations after they are detected. Moreover, under the Cross-Strait Joint Crime-Fighting and Judicial Mutual Assistance Agreement, CGA formally urged the Chinese authorities to restrict the illegal excavation of sand.

To develop enforcement methods, the OAC held interministerial talks in 2018. The goal of enforcement measures is to avoid confrontations because of the political sensitivity of cross-strait relations. Broadcasting warnings, deploying water cannons to ward off vessels, and gathering proof of legal infractions are currently examples of enforcement activities carried out under the Coast Guard Act. In extreme situations, vessels are seized and sent to the Penghu County Government and the Ministry of Economic Affairs (MOEA) for penalties and legal action. Future regulatory measures are still up in the air, though, as there is still no agreement on long-term sanctions or legal frameworks.

Large patrol boats are still used by the CGA to keep an eye on the Taiwan Shoal, regularly thwarting unauthorised sand-pumping vessels. But mainland ships keep coming back, lingering close to the middle line of the Taiwan Strait, waiting for sand mining to restart. Taiwan's marine resources may suffer serious ecological and environmental repercussions if these practices continue uncontrolled.

The Penghu County Government requested stronger enforcement and surveillance against Chinese illegal sand dredging at the Taiwan Shoal in a recent Executive Yuan petition. The mainland sand-pumping ships' grave ecological destruction is acknowledged by the Taiwanese government and is considering greater cooperation among the China Coast Guard, OAC, and CGA under the Cross-Strait Crime-Fighting Mechanism to prevent these activities (Penghu County Government, 2019).

2 Materials and methods

2.1 Study sites

The 8800 square kilometre Taiwan Shoal, which makes up over one-fourth of Taiwan's main island, is situated about 30 nautical miles southwest of Chimei, Penghu. Also known as the Taiwan Beach or Taiwan Shoal, the area is made up of several high and low shallow mounds. As seen in Figure 2, this study site is located in the marine area where mainland Chinese sand-pumping vessels commonly operate.

2.2 Methods

This study adopts qualitative analytical tools – strengths, weaknesses, opportunities, threats (SWOT) analysis and the fishbone (Ishikawa) diagram – to examine the challenges of enforcing laws against cross-border sand pumping by mainland Chinese vessels in Taiwan's EEZ.

The analytical approach aimed to evaluate both institutional and operational constraints in current marine enforcement practices, with an emphasis on identifying underlying structural issues affecting inter-agency coordination.

The construction of both the SWOT and fishbone analyses was based on a synthesis of multiple data sources. These included:

Academic literature on marine governance, maritime law enforcement, and transboundary resource management;

Government reports and statistical data issued by the CGA, the OAC, and relevant legislative evaluations;

Field-based insights and operational case studies documented in enforcement briefings were also reviewed to contextualise the data and support strategic interpretation.

Internal briefings and operational assessments provided by enforcement authorities involved in managing illegal sand pumping activities, such as the CGA and Penghu County Government.

This triangulated method ensured that the analysis reflected not only theoretical perspectives but also ground-level challenges and practical enforcement realities. By integrating insights from scholarly research and practical enforcement experience, the analyses aim to systematically identify institutional, legal, and operational barriers to effective marine law enforcement.

The SWOT framework was used to categorise internal capacities and external influences, while the fishbone diagram was applied to visualise root causes of inter-agency coordination challenges.

3 Results

3.1 Challenge in addressing cross-boundary sand pumping cases

3.1.1 Multiple authorities involved

The Ministry of the Interior (MOI) enforces the Law on the EEZ and the Continental Shelf of the Republic of China, the MOEA regulates the Sand and Gravel Excavation Act, the Mainland Affairs Council (MAC) administers the Act Governing Relations between the People of the Taiwan Area and the Mainland Area, the Ministry of Justice oversees the Criminal Code and the Administrative Penalty Act, the Immigration Agency of the MOI manages the Immigration Act, and local jurisdiction, under the Penghu County Government, makes handling cross-border sand pumping cases complicated.

3.1.2 The CGA's role as the principal law enforcement agency

As the principal law enforcement agency in charge of ensuring the safety, order, and interests of Taiwan's waters, the CGA is empowered by Articles 3 and 4 of the Coastal Guard Act to pursue, board, inspect, expel, arrest, seize, or detain vessels and other transportation that are deemed a threat, after which detained personnel and vessels are turned over to the relevant authority, either the Immigration Agency or the procuratorate.

3.1.3 Complex and sensitive cross-strait relations

Article 4 of the Law on the EEZ and the Continental Shelf of the Republic of China governs Taiwan's EEZ and continental shelf. When EEZs overlap with those of neighbouring or hostile nations, this provision requires discussions to draw a delimitation boundary. Additionally, it allows modus vivendi, or temporary agreements, to promote collaboration until a definitive delineation is established. Although the maritime region in question is within Taiwan's EEZ, it crosses over into mainland China's claims, which makes maritime law enforcement more difficult and raises the possibility of conflicts.

3.1.4 Insufficient manpower and budget

The detention of China's sand pumping vessels presents several practical challenges, including limited storage capacity, high detention costs, and increased enforcement burdens on the relevant authorities.

3.2 Impacts and challenges of sand pumping

Table 2 elaborates on the complex repercussions and allied issues of sand pumping. While considering both internal and external elements, this study uses SWOT analysis to methodically evaluate the issues experienced by Chinese vessels pumping sand across international borders.

3.2.1 Internal environment

Through a clear policy mandate, the agency's leadership has shown an internal commitment to enhancing patrol activities in the affected waters. This entails being ready to invest additional money if needed to prevent similar incidents from occurring in the future and to defend Taiwan's maritime interests and rights.

Table 2 SWOT analysis of the response to cross-boundary sand pumping cases by mainland china vessels

Internal environment	*S (strength)*	*W (weakness)*
	1 Policy Support for Heads of Organisations	1 The Coast Guard Administration is an enforcement agency
	2 There is sufficient law enforcement capacity in the Coast Guard Administration.	2 Limited detention space for crews and officers
External environment	*O (opportunity)*	*T (threat)*
	1 Supported by senior officials of the Executive Yuan	1 The number of authorities involved in the division of responsibilities
	2 Mainland Affairs Council advisory committee and the focus of the media attention	2 Cross-strait relations are complex and sensitive

Vessel crews and officers involved in sand pumping can be detained for a short time by an enforcement agency of the OAC, named the CGA. Therefore, effectively tackling illicit sand pumping necessitates coordination with other pertinent authorities, including local ocean affairs departments, the Fisheries Department, the navy, and port corporations. As such, the topic of sand pumping points out the link to the division of authority and service among different groups.

3.2.2 External environment: opportunities

3.2.2.1 Endorsement by senior officials of the Executive Yuan

Senior Executive Yuan officials have authorised Legislative changes to stop mining vessels from illicitly pumping sand, including two steps of auctioning seized ships and bringing operators to justice (Xie, 2020). A commitment is made coordinating with the Ministry of Justice, the Ministry of National Defense, and the MOI to increase law enforcement, enhance patrols and defence in high-risk locations, and protect marine environments, resources, and national security (Hsieh, 2020)..

3.2.2.2 Advisory Committee of the Mainland Affairs Council and media attention

Sand has been illegally pumped by Chinese ships. The sea environment, social safety, land erosion, and fishing resources are all negatively impacted by this. This urgent issue has been taken up by the mainstream media and the MAC's advisory committee (Mainland Affairs Council, 2021). There is no doubt that this problem requires an extensive solution.

3.2.3 External environment: threats

3.2.3.1 Multifaceted authority involvement

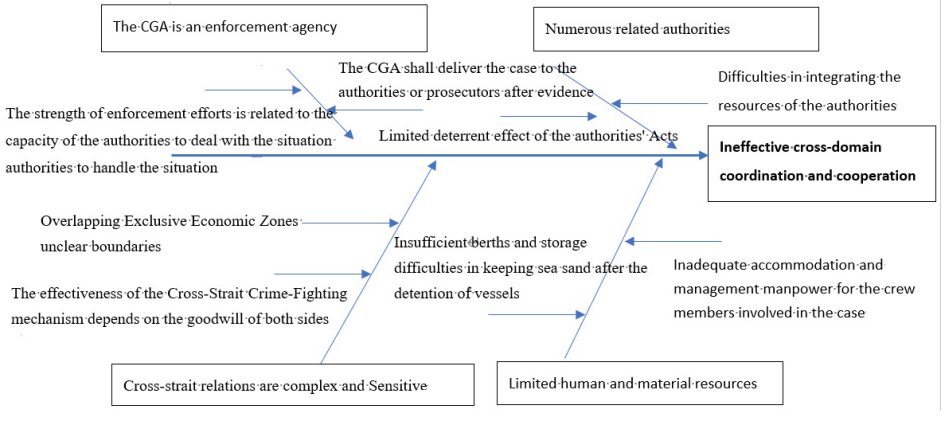
The interference of many regulatory bodies has been impeding efforts to stop unauthorised sand pumping intrusions. The government has jurisdiction over mainland ships' unlawful invasions. This is a complicated issue that requires teamwork and a broad approach. The problem will not be resolved until a comprehensive approach is implemented. To overcome this urgent problem of unethical and illegal pumping, interagency cooperation must be strengthened.

3.2.3.2 Complex of cross-strait relations

One of the main issues is the cross-strait problems. Both Taiwan and mainland China claim a portion of the EEZ, which includes the sand pumping area. In order for the Cross-Strait Crime-Fighting mechanism to be effective, both sides must be willing to work together on law enforcement, which calls for cooperation and goodwill on both sides – an extremely challenging task. This dynamic makes it harder to make decisions unilaterally and makes addressing sand pumping in the area even more difficult.

An in-depth examination of this problem is given by a fishbone diagram (Figure 3), which pinpoints 'ineffective cross-boundary coordination and cooperation' as the primary obstacle behind the challenges in controlling Chinese vessels' cross-border sand pumping. There are four main contributing causes to this fundamental problem.

Figure 3 A fishbone diagram is shown to the right to analyse the problems (see online version for colours)



3.2.4 Threats and challenges

This section synthesises the institutional and structural challenges identified earlier, providing a consolidated view of enforcement bottlenecks and coordination issues. Table 2 and Figure 3 serve as visual tools to support this analysis, each offering unique insights into the enforcement dynamics surrounding illegal sand pumping.

3.2.4.1 Multifarious authorities and resource integration

As shown in Table 2, a significant external threat identified is the involvement of multiple agencies with overlapping responsibilities. These include the MOI, the MOEA, the Mainland Affairs Council (MAC), the Ministry of Justice (MOJ), the Immigration Agency, and local governments such as the Penghu County Government. The fragmented governance framework creates institutional silos and inefficiencies in coordination. Figure 3 further illustrates this through one of the key fishbone branches labelled 'Division of Responsibilities', emphasising how unclear jurisdictional boundaries undermine unified responses to enforcement.

To address this, a more unified interagency strategy is needed. Mechanisms for real-time information exchange and standardised procedures for joint operations are essential. Without procedural blueprints or legal mandates for coordination, response times and enforcement effectiveness remain limited.

3.2.4.2 Inadequate deterrent measures

Another weakness indicated in Table 2 is the inadequacy of current legal deterrents. Penalties under earlier versions of the EEZ legislation were not proportionate to the profit incentives behind illegal sand mining. This weakness is mirrored in Figure 3's identification of 'Weak Legal Frameworks' as a core causal factor. The lack of stringent punishment enables recidivism and fails to discourage transboundary offenses. Enhancing legal tools – such as increased fines, more extended detention periods, and asset forfeiture – is essential to improve deterrence.

3.2.4.3 Role and capacity of the Coast Guard Administration (CGA)

Table 2 identifies the CGA as strength in enforcement, recognising its legal authority and operational capabilities. However, its effectiveness is conditional on inter-agency coordination and logistical capacity. Figure 3 highlights the 'Limited Resources and Manpower' issue, showing how CGA's operational load is compounded when other agencies fail to provide timely support. Therefore, institutional capacity-building must include better resource allocation, technical upgrades, and support for CGA-led multi-agency operations.

3.2.4.4 Transfer of cases to competent authorities

Another challenge arises from the procedural bottleneck surrounding case transfers. As the fishbone diagram indicates, under the 'Coordination Challenges' branch, transferring cases to the appropriate legal or immigration authorities involves delays and inconsistencies due to fragmented mandates. Defining agency responsibilities more clearly, along with establishing inter-agency liaison units, can improve both the speed and transparency of legal proceedings.

3.2.4.5 Resource constraints

Figure 3 underscores 'Resource Limitations' as a foundational cause, echoing Table 2's mention of weak internal capacity. Limited detention space for personnel, lack of dockage for seized vessels, and insufficient funds for legal processing collectively hinder

long-term enforcement sustainability. A comprehensive budgeting and infrastructure plan must accompany legal reforms to enable effective execution.

3.2.4.6 Complex cross-strait relations and unresolved EEZ demarcation

Both Table 2 and Figure 3 emphasise the sensitive and unresolved nature of cross-strait relations as a persistent threat. The lack of an agreed-upon maritime boundary and the weak operationalisation of the Cross-Strait Crime-Fighting Mechanism limit Taiwan's capacity to resolve disputes bilaterally. This is a systemic challenge that needs diplomatic engagement alongside enforcement. Building mutual trust and operational channels for communication with mainland Chinese authorities is essential to support the maritime rule of law.

3.3 The challenge of addressing sand pumping cases by mainland china vessels

3.3.1 Multifarious authorities involved

Preventing and stopping the illicit sand pumping by Chinese mainland vessels is the main responsibility of the nation's state agencies, according to their duties and jurisdictions. These agencies are the MOI, the MOEA, the MAC, the Ministry of Justice (MOJ), charged with administrative punishment and criminal prosecution, Immigration Agencies, charged with enforcing the Immigration Act, and the Penghu County Government, charged with local surveillance.

The complexity of solving this issue has become more difficult because of the main requirement of coordination and transfers between different departments. To prepare a uniform and proper response, good communication between all the concerned departments is significant. This requirement is used to discuss procedures, coordinate tactics, and discuss resources to apply a well-enforced regime.

It is necessary to amend laws and policies and make proper availability guidelines for transferring data and evidence between different organisations for collaborative operations. These are the needs to solve the issues of the illicit mining of sand, and establish a good and high involvement of different organisations.

3.3.2 Role of the Coastal Guard Administration (CGA)

The CGA is the leading agency administering maritime law in the oceans. Articles 3 and 4 of the Coast Guard Act state that CGA has the power to pursue, board, search, and dispose of the ships that are involved in such activities, while the ships are on navigable waters and jeopardise security and oceanic tranquility. Also in these types of situations, CGA can arrest, seize, or detain those vessels. In case of arrest, the crew members and ships should be delivered to a respective entity, the immigration Bureau, or prosecuting agencies for further processing.

The efficacy of CGA relies on strong coordination and associations with other entities for maintaining maritime compliance. The jurisdictional scope and ability of these associated bodies are usually taken into consideration when making enforcement proceeding decisions. The result is that a good and effective approach to handling cases of sand extraction is dependent upon smooth coordination.

3.3.3 Complex and sensitive cross-strait relations

The complex cross-strait relationship makes the battle against illicit sand mining complicated. Under Article 4 of the Republic of China Law on the EEZ and the Continental Shelf, boundary disputes with adjacent or neighbouring countries should be solved by equitable agreements.

Jurisdictional issues arising from the indefinite EEZs overlapping between Taiwan and China are the reason that strict laws against pumping sand cannot be enacted effectively. Indeterminate border also generates diplomatic and legal problems regarding the issue.

Furthermore, institutions like the Cross-Strait Crime-Fighting mechanism, which can foster cooperative law enforcement, are based on mutual trust between Taiwan and mainland China. Mutual exchange of evidence on mainland China vessels engaging in crimes or a mutual agreement on cooperative maritime enforcement are the most significant challenges. These challenges underscore the necessity of two-way cooperation and the delicate balance that must be struck between the cross-strait to facilitate effective regional governance.

3.3.4 Resource constraints

The authorities are also faced with a serious resource-based problem of holding sand-pumping boats, for example, a lack of docking space, costly detention, and logistical problems caused by detained boats. These problems put a tremendous burden on the agencies handling cases of illegal sand mining.

The unavailability of berthing space renders it hard to accommodate seized vessels, particularly where forfeiture orders require that they be held under detention indefinitely. Detention fees, such as provision, monitoring, and interim storage, are a costly burden on these services' operational and financial budgets.

Besides, storing and handling the seized sea sand becomes more difficult when these ships are detained. There are budgetary limitations fuelled by a lack of storage capacity as well as the complexity involved in handling seized goods, making it much more difficult to pursue enforcement action.

4 Discussion

4.1 Proposed solution mechanisms

An examination of a 'leftward fishbone diagram' (Figure 4) is employed in suggesting a solution in the form of 'developing a framework for inter-regional coordination and cooperation'. The solution attempts to address the root problem of 'weak inter-regional coordination and cooperation' in attempting to address the complex problem of cross-border sand extraction by mainland Chinese ships.

4.2 Leftward fishbone diagram

The suggested approach to tackle cross-border sand extraction by mainland Chinese vessels comprises the following essential elements:

Improved inter-agency coordination: Apply the improved process and practices that guarantee inter-agency cooperation and exchange of information. This ensures efficient and coordinated action against illegal sand mining activities.

Strengthening legal frameworks: Reform and modernise existing law to make for a more effective deterrent and impose harsher penalties. A stronger deterrent to sand-pumping offenses can be created by aligning penalties with the incentives behind illegal conduct.

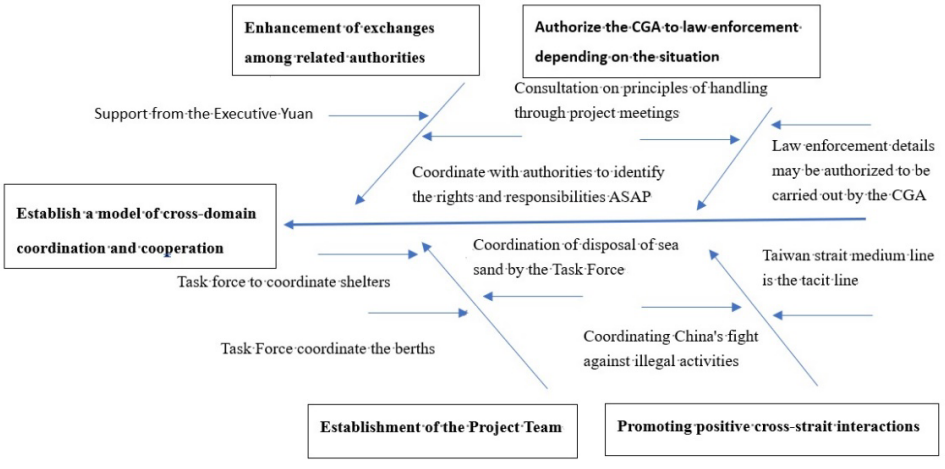
Resource support: Supply more resources and funds to manage imprisoned individuals and vessels effectively. This entails addressing material concerns such as dock space, short-term accommodation, and storage of sea sand.

Diplomatic measures: Employ diplomacy in achieving equitable settlements to resolve maritime boundary and territorial conflicts within EEZs.

Evidence sharing and cooperation in maritime enforcement can be enabled by the creation of confidence and cooperation within cross-strait exchanges.

Public awareness: Deter illegal involvement in sand pumping by making the public aware of how the environment is affected due to it and the ban imposed on it governments can effectively address the transboundary sand pumping challenges, secure maritime interests, and promote regional stability by applying these measures through an orderly arrangement of interregional coordination and cooperation. These complex issues may be resolved using the following alternatives, which are addressed below.

Figure 4 Analysis of alternatives using a left-oriented fishbone diagram (see online version for colours)



4.3 Strengthening inter-agency exchanges

4.3.1 Backing from the Executive Yuan

The establishment of an interministerial task force in the Executive Yuan is one of the key steps towards enhancing cross-border sand extraction management. To establish a more transparent and efficient enforcement policy, such a team would lead to an

accelerated alignment of resources and coordination among a number of government ministries.

A formal declaration through the media of plans to rewrite the law and raise penalties for illegal sand pumping would put the spotlight on this program and highlight the progressive nature of the government. This would act as a deterrent and a clear indication of the government's commitment to enforcing the law and bringing order to sea areas.

4.3.2 Clarification of rights and responsibilities

Increased public knowledge and media reports on cross-boundary sand dredging accidents provide a window of opportunity for government agencies to work more effectively in concert. By clearly defining the responsibility of each participating authority, the government can streamline procedures for the handling of detained persons, vessels, and confiscated sea sand. Such a proactive strategy accelerates enforcement action and reduces operational workload for the CGA, facilitating better use of resources in maritime law enforcement.

4.4 Delegating law enforcement to the CGA

4.4.1 Project-level consultation on handling principles

Having project meetings at the Executive Yuan level to formulate overall guidelines and procedures in handling cross-border sand mining cases can be of great assistance to improving enforcement efficiency before the gathering of evidence and the forwarding of cases to concerned authorities or prosecutors. The negotiations guarantee the government's commitment to providing a timely, efficient, and integrated response.

4.4.2 Flexible authorisation for law enforcement

The CGA may be assigned law enforcement details following project meetings that establish the general regulations. This delegation gives the CGA the freedom to utilise enforcement tools suitable to the conditions of the moment, i.e., weather, gravity of the case, and preliminary assessments of the local terrain. Giving the CGA this freedom allows for quicker and more efficient responses to cross-border sand extraction crimes. For example, fisheries resources, which were previously described in detail (e.g., Penghu's biodiversity and spawning grounds), now serve as justification for stronger enforcement, since degradation would threaten both ecological and economic stability.

4.5 Formation of a project team

4.5.1 Coordination of shelter

Establishment of a specialist project team within the relevant agencies following project meetings helps enhance the management of critical logistical issues. For the sake of effective and successful case management, such a team would take care of duties such as returning people to their original ships, arranging temporary housing, managing food and shelter delivery, and arranging for funds required.

4.5.2 Berth coordination

The project team may arrange for ships involved in such cases to be docked together and manage their disposal through channels such as auctions, conversion of assets, or other respective means after criminal seizure.

4.5.3 Management of sea sand disposal

Following a dispute, the project team can immediately determine the best way to dispose of the seized sea sand, ranging from options like reusing, auctions, or in-place backfilling. This ensures that the choice is made on the basis of expertise and according to procedures laid out.

Regional comparisons further underscore the importance of coordinated enforcement. For instance, the Philippines has strengthened its marine protection through joint patrols (Jabar et al., 2022; Monje, 2013; Eisma et al., 2005) and inter-agency task forces, particularly in response to illegal activities in its EEZ. Vietnam, likewise, has implemented strict vessel tracking systems and increased penalties to deter unauthorised sand mining and illegal fishing (Nguyen and Mai, 2018; Loan, 2010; Pomeroy et al., 2009). Drawing on such practices, Taiwan can enhance its enforcement framework by integrating regional insights, promoting cross-agency interoperability, and fostering real-time intelligence sharing among stakeholders.

4.6 Facilitating positive cross-strait interactions

4.6.1 Utilising the Taiwan strait median line

Upholding the Taiwan Strait Median Line as an informal dividing line is a practical step given the complexities of cross-strait interactions and the absence of a clearly defined boundary in overlapping EEZs. While formal agreements are being made, this temporary solution provides clarity and uniformity.

4.6.2 Strengthening coordination with mainland China

Effective settlement of cross-strait sand pumping incidents is based on the establishment and maintenance of the Cross-Straits Agreement on Combating Crime and Mutual Legal Assistance. The enforcement outcomes can be maximised by enhanced concerted efforts against transboundary crimes, such as sand pumping, within the Taiwan Strait. The cause is also aided by the enhancement of cooperative law enforcement via the Cross-Strait Crime-Fighting mechanism (Hsu, 2021). Regarding the Enforcement Statistics section, the CGA data (e.g., number of seized vessels, cubic metres of sand removed) is now clearly tied to the urgency of developing efficient inter-agency coordination mechanisms and enhanced deterrents.

4.7 Establishing an administrative coordination model

4.7.1 Formal cross-domain coordination mechanism

The Executive Yuan or the MOI may establish the Mainland China Ship Cross-Border Sand Pumping Response Task Force to further interagency coordination. Some of the

agencies whose administrative resources shall be centralised by this agency are the MOEA, the MAC, the Ministry of Justice, the Immigration Department, the CGA, the Procuratorate, and the Penghu County Government.

In order to tackle issues, share perspectives, and settle connected challenges, these agencies may set up expert groups. Through teamwork, the approach is intended to eliminate barriers such as departmental silos, professional inclinations, and knowledge disparities, leading to a shared goal and enhanced inter-agency collaboration.

4.7.2 Informal cross-domain coordination mechanism

Informal inter-agency coordination can meet some operational needs beyond the formal structures. Political appointees can readily circumvent barriers through their wide-ranging powers. Budget issues, logistics off-loading, staff management, and other coordination needs can all be met faster by creating specialist communication channels. The flexible strategy ensures policy goals are sufficiently met by enhancing administrative flexibility in the government's public affairs department.

4.7.3 Administrative feasibility analysis

Cross-domain coordination is effectively maintained by both informal and formal instruments, but is not necessitated by today's laws. Informal interventions spur interaction among agency leaders and staff members, and formal ones entail the institution of expert staff units and interministerial task forces. The measures as a whole facilitate administrative performance, reduce such impediments as information gaps and departmentalism, and facilitate issues to be decided promptly.

The complexity of judicial jurisdiction across the Taiwan Strait, coupled with overlapping sovereignty over the EEZs and reliance on cross-strait crime-fighting mechanisms, presents clear strategic obstacles related to those discussed in the fishbone diagram and coordination plan.

The most daunting task in addressing mainland Chinese vessels' transboundary pumping of sand is the lack of functional cross-border coordination and cooperation. One of the main solutions concluded by this study is to provide a well-structured framework of cooperation between different organisations. Executive Yuan emphasised these main solutions, such as cooperation between entities, and enhancement of patrol and defence in the main and important areas of the marines. Additionally, the tenacious use of the Cross-Strait Crime-Fighting mechanism to implement law enforcement and investigate at sea suggests effective cooperation in solving sand pumping problems.

5 Conclusion

The OAC has played a crucial role in the formulation of marine legislation to improve Taiwan's maritime governance since its inception in 2018. Its primary aim is to formulate a strong legal framework that safeguards national maritime interests and ensures the sustainable use of ocean resources. This legislation protects Taiwan's sea rights, encourages the enforcement of sea laws, and prevents transboundary sand-pumping vessels from entering territorial waters and stealing sand and gravel.

Enforcement now hinges on implementing available legislation, observation of international practice, scrutiny of relevant legal regimes, and legislative revision within the jurisdiction of relevant authorities. Cross-strait collaboration in law enforcement is also up for discussion to control transboundary sand pumping boats and stop illicit operations in the territorial waters of Taiwan.

This study discovers a significant obstacle to the implementation of strategic management theory and policy analysis techniques, such as SWOT analysis and fishbone diagrams, in countering mainland Chinese vessels' transboundary sand pumping.

The biggest problem is that government-wide enforcement potential is limited by a management agenda within individual agencies and a lack of interdomain coordination.

In response to this challenge, the research suggests a practicable answer beyond the creation of inter-ministerial task forces as channels for the coordination of resources. In particular, it suggests two mechanisms that are required:

1 a Formal Interdisciplinary Coordination Mechanism with representatives from different departments

2 an Informal Interdisciplinary Coordination Mechanism to enable flexible inter-agency collaboration.

These mechanisms would be employed to coordinate different agencies into one interdisciplinary network with a common response.

This study aims to solidify Taiwan's actions in marine environmental protection, encourage cooperation, and improve the performance of the government by gathering relevant parties for a common goal. The research model of analysis and the suggested solutions are a useful reference for the government to handle such incidents in the future.

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Competing interest

The authors have declared that no competing interests exist.

Informed consent statement

All authors were aware of the publication of the paper and agreed to its publication.

References

Bendixen, M., Iversen, L., Best, J., Franks, D., Hackney, C., Latrubesse, E. and Tusting, L. (2021) 'Sand gravel, and UN sustainable development goals: conflicts, synergies, and pathways forward', *One Earth*, Vol. 4, No. 8, pp.1095–1111.

Cga (2023) *The Performance of the Enforcement on Illegal Sand Pumping Vessels*, Available at. https://www.cga.gov.tw/GipOpen/wSite/ct?xItem=139485& ctNode=11298& mp=marine (Accessed 12 June, 2024).

Chen, C-H. (2004) *Checklist of the Fishes of Penghu*, FRI Special Publication No. 4, Fisheries Research Institute, Council of Agriculture, Available at. https://ws.tfrin.gov.tw/Download.ashx?u=LzAwMS9VcGxvYWQvT2xkRmlsZS9wdWJsaWMvQXR0YWNobWVudC85NjE5MTAyNDgxMi5wZGY%3D & n=5r6O5rmW55Si6a2a6aGe5ZCN6YyELnBkZg%3D%3D (Accessed 2 February, 2025).

Chen, W-z. (2020) *Scholars Complete First Marine Ecology Record of "Taiwan Shoal", Urge Immediate Rescue to Prevent Damage by Chinese Sand Pumping Vessels*, Environmental Information Center, 5 July, https://e-info.org.tw/node/224456 (Accessed 1 September, 2025).

Eisma, R-L., Eisma, V., Christie, P. and Hershman, M. (2005) 'Legal issues affecting sustainability of integrated coastal management in the Philippines', *Ocean and Coastal Management*, Vol. 48, Nos. 3-6, pp.336–359, https://doi.org/10.1016/j.ocecoaman.2005.04.009

Hsieh, H-Y.J., Chen, C.A., Dai, C-F., Ou, W, Tsai, W-S. and Su, W-C. (2007) 'From the drawing board to the field: an example for establishing an MPA in Penghu, Taiwan', *Aquatic Conservation: Marine and Freshwater Ecosystems*, Vol. 17, No. 6, pp.551–657, https://doi.org/10.1002/aqc.826

Hsin, Y-C., Qiu, B., Chiang, T-L. and Wu, C-R. (2013) 'Seasonal to interannual variations in the intensity and central position of the surface', *Kuroshio East of Taiwan*, Vol. 118, No. 9, pp.4305–4316, https://doi.org/10.1002/jgrc.20323

Hsu, Y-C. (2021) *Chiu Tai-San Calls for Cross-Strait Fight Against Cross-Border Sand Pumping Vessels*, 10 November, Available at: https://www.Chinatimes.com/newspapers/20211110000419-260118?chdtv

Huang, H-M. (2019) *Five People Were Arrested by the Kinmen Coast Guard for Illegal Sand Pumping*, 31, August, Available at. https://www.cna.com.tw/news/aloc/201908310139.aspx

Jabar, M., Valerio, M.A. and Ereneta, L. (2022) 'Role of sea patrols in marine environmental protection and conservation in the Philippines', *DLSU Research Congress 2022, De La Salle University*, 6–8 July, Manila, Philippines, Available at. https://www.dlsu.edu.ph/wp-content/uploads/pdf/conferences/research-congress-proceedings/2022/SEE-13.pdf

Kao, R-H., Hsu, C-H., Kao, J-C. and Yang, F-C. (2017) 'A study on the influence of the marine environmental deterioration and marine safety from carrying illegal sand mining in the sea area between Kinmen and Xiamen–the case of mainland China boats', *Transportation Planning Journal*, Vol. 46, No. 1, pp.51–84.

Li, P-R. and Ye, S-H. (2020) *Mainland Sand Pumping Vessels Surround Matsu The Coast Guard Dispatches the Xinbei Ship and the Special Task Force to Rush for Help and Drive Them Away*, Available at. https://www.Chinatimes.com/realtimenews/20201025002783-260407?chdtv

Liu, K-K., Gong, G-C., Shyu, C-Z., Pai, S-C., Wei, C-L. and Chao, S-Y. (1992) 'Response of kuroshio upwelling to the onset of the northeast monsoon in the sea north of Taiwan: observations and a numerical simulation', *Journal of Geophysical Research*, Vol. 97, No. C8, pp.12511–12526, https://doi.org/10.1029/92JC01179

Loan, N.T.P. (2010) *Problems of Law Enforcement in Vietnam: The Case of Wastewater Management in Can Tho City*, ZEF Working Paper Series, No. 53, University of Bonn, Center for Development Research (ZEF), Bonn.

Lu, P-L. and Chen, Q-H. (2020) *Kinmen Matsu Suffers From China's Transboundary Sand Pumping, Impacting Fisheries and Ecology*, 19 October. Available at. https://news.pts.org.tw/article/497584 (Retrieved 8 July, 2023)

Mainland Affairs Council (2021) *Highlights From the 30th Mainland Affairs Council Advisory Committee Meeting*, Available at. https://www.mac.gov.tw/News_Content.aspx?n=05B73310C5C3A632& sms=1A40B00E4C745211& s=34BEC04D6B289B90 (Retrieved 3 July, 2023).

Monje, T.G.R. (2013) *Maritime Enforcement in the Philippines: Issues and Challenges*, United Nations–Nippon Foundation Fellowship Programme 2012-2013, Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs, United Nations, Available at. https://www.un.org/oceancapacity/sites/www.un.org.oceancapacity/files/monje_-_un_nippon_paper_aprl_9_final.pdf

Nguyen, T.L.A. and Mai, N.H. (2018) 'Vietnam maritime law enforcement', *The Korean Journal of International and Comparative Law*, Vol. 6, No. 2, pp.172–198, https://doi.org/10.1163/22134484-12340111

Ocean Affairs Council (OAC) (2023) *International Conference on the Impact of Sand Dredging in the Sea*, Press Release, Available on: https://www.oac.gov.tw/ch/home.jsp?id=64& parentpath=0,6& mcustomize=activity_view.jsp & dataserno=202305150001

Penghu County Government (2019) *Lai Fengwei Calls on the Central Government to Investigate and Arrest China Vessels for Sand Pumping*, 30 August, Available on: https://www.penghu.gov.tw/general/home.jsp?id=191& act=view & dataserno=201908300002

Pomeroy, R., Nguyen, K.A.T. and Thong, H.X. (2009) 'Small-scale marine fisheries policy in Vietnam', *Marine Policy*, Vol. 33, No. 2, pp.419–428, https://doi.org/10.1016/j.marpol.2008.10.001

Rangel-Buitrago, N., Neal, W., Pilkey, O. and Longo, N. (2023) 'The global impact of sand mining on beaches and dunes', *Ocean and Coastal Management*, Vol. 235, p.106492, https://doi.org/10.1016/j.ocecoaman.2023.106492

Rentier, E.S. and Cammeraat, L.H. (2022) 'The environmental impacts of river sand mining', *Science of the Total Environment*, Vol. 838, p.155877, http://dx.doi.org/10.1016/j.scitotenv.2022.155877

Shih, Y-C. and Chiau, W-Y. (2009) 'Marine protected area planning experiences at Chinwan bay in Penghu, Taiwan', *Ocean and Coastal Management*, Vol. 52, No. 8, pp.433–438, https://doi.org/10.1016/j.ocecoaman.2009.06.002

Tseng, H-S. (2021) 'Maritime law enforcement on border-crossing fishing vessels: experience of Taiwan's practices under its unique political relationship', *Marine Policy*, Vol. 133, p.104749, https://doi.org/10.1016/j.marpol.2021.104749

UNEP (2002) *United Nations Environment Programme, UNEP Yearbook: Emerging Issues in Our Global Environment*, United Nations Environment Programme (UNEP), Nairobi, Kenya.

Weng, J-S., Yu, S-F., Lo, Y-S., Shiao, J-C., Lee, M-A., Liu, K-M., Huang, H-H., Wang, Y-C. and Wu, L-J. (2020) 'Reproductive biology of the narrow-barred Spanish mackerel (Scomberomorus commerson) in the central Taiwan strait, western pacific', *Deep Sea Research Part II: Topical Studies in Oceanography*, Vol. 175, p.104755, https://doi.org/10.1016/j.dsr2.2020.104755

Wu, S-Q. and Chen, H-M. (2020) *Evaluation Report on the Draft Amendment to Article 18 of the Law on the Exclusive Economic Zone and the Continental Shelf of the Republic of China*, Evaluation Report on the Bill of Legislative Research Bureau.

Xie, L-H. (2020) *The President of the Executive Yuan Declared: Auctioning of Illegal Sand Pumping Vessels and Transfer of Operators Bring to Justice*, 29 October, Available at. https://newtalk.tw/news/view/2020-10-29/486261 (Retrieved 28 June, 2023).