

The Mitigation Strategies for Managing the Potential Environmental Risks Posed by Oil and Gas Development on Mangrove Ecosystems in the Coastal Communities

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Abstract

Guyana is an oil-producing country vulnerable to potential oil spills and the environmental risks posed by oil and gas exploration and production activities. Despite the technologically advanced equipment employed by Exxon-Mobil Guyana and affiliates, an oil spill could occur due to accidents, equipment failures, or sabotages. The selected coastal communities as the study areas in Region 1 and Region 2 could be adversely affected, particularly the mangrove ecosystems. Potential oil spill pollution will adversely impact mangrove ecosystems in Region 1 and Region 2. Mangroves offer significant benefits to coastal communities, such as coastal defence and carbon sequestration, which puts Guyana on the world map. The research aimed to investigate the mitigation strategies to manage the potential environmental risks on mangrove ecosystems in the coastal communities of Region 1 and Region 2. It followed a qualitative approach and conducted semi-structured interviews with the To-shaos of the selected coastal communities. The data analysis strategy was thematic analysis using the Nvivo software. The major themes included legal and policy frameworks, oil spill response strategies, community-based involvement, and monitoring and enforcement of regulations. The significant results included reviewing and updating the regulatory framework for mangrove

management and conservation; oil spills mitigation measures such as containment and shoreline protection and cleanup, cost recovery and compensation, and limited monitoring and law enforcement of mangrove management and conservation regulations by inter-agencies. The regulatory and institutional framework is outdated and needs to be amended. The agencies overseeing mangrove management and conservation have overlapping responsibilities and require more coordination. There should be greater collaboration among agencies for mangrove management and conservation and improved monitoring and enforcement programmes through institutional support.

Keywords

Enforcement, Monitoring, Oil Spill, Policy, Regulation

1. Introduction

The mangrove forests are vital coastal ecosystems and are one of the most prolific ecosystems. The coastal coverage of mangrove forests in Guyana comprises 22,632 ha of mangroves. Coastal Region 1 has the most range of 10,161 ha of mangroves, coastal Region 2 has 4000 ha, and coastal Region 6 has 4750 ha (Jai-kishun et al., 2017). The benefits of mangroves to coastal communities include the sequestration of carbon that helps to mitigate climate change (Nguyen et al., 2023), making mangroves in Guyana impact the world, decreasing wave energy and reducing non-storm waves, thus reducing erosion, fertility depletion, and general loss of soil quality (Ferreira et al., 2022); natural habitats for wildlife such as infantile fish, shrimps, and crabs and facilitate nesting for birds which can locate nests among the branches and leaves and source food among the roots (Li-Ying et al., 2022); recreational facilities, tourist attractions, and cultural heritage (Bimrah et al., 2022); tanning or staining to enhance the craftwork's beauty (Bimrah et al., 2022).

The oil and gas exploration and production have been precipitated by extreme levels of destruction, especially in cases where requisite care is not taken to ensure strict adherence to the required safety mechanisms. This is even more evident in coastal communities, which are particularly vulnerable to significant environmental risks, including oil spills resulting in potential negative impacts on the mangroves, socioeconomic fundamentals, and the daily lives of inhabitants and their well-being (Andrews et al., 2021; Booi et al., 2022; Henry et al., 2022) in coastal communities of Regions 1 and 2. Offshore oil and gas exploration and production have a terrible reputation for severe environmental risks, particularly oil spills caused by accidental discharges (Zhang et al., 2019), equipment malfunction, natural disasters, and deliberate sabotage. These incidents result in adverse impacts on marine habitats and communities. When oil spreads to the coastlines, the impacts are more devastating at the various system sites. Fingas (2018)

present that the coastlines offer a buffer between sea and land, chiefly mangroves and saltmarshes, which prevent erosion and floods. The coastlines provide habitats for people and animals that depend on natural resources. Therefore, oil spills may cause biodiversity loss and ecosystem service degradation in coastal communities, including mangrove ecosystems (Onyena & Sam, 2020). For instance, oil spilled on coastlines can cause severe habitat damage and living organisms within the habitats (Aa et al., 2022; Bhattacharjee & Dutta, 2022). The potential impacts of oil pollution on biota vary from species to species resulting in skin irritation and respiratory and digestive problems. Animals predominantly affected by oil include seabirds and turtles (Thakur & Koul, 2022; Shareefdeen & Bhojwani, 2022). The turtles hatch and nest on the coastline's beaches at Shell Beach Protected Areas in Region 1 and be smeared directly with oil.

Other oil and gas-related consequences, such as contaminants from pollution, will negatively impact human well-being to a considerable degree. Correspondingly, the mangrove ecosystems and related habitats will be demolished by the oil spill in the coastal communities in Regions 1 and 2 (Henry et al., 2022). The residents will experience health, social and cultural issues in coastal communities, which depend on its rich biodiversity and intricate mangrove ecosystems, farmlands, fresh water, and cultural heritage for their livelihoods and general sustenance (Henry et al., 2022). Additional challenges include local community resilience to spills and communication breaches, which impede and delay the remediation of oil spills. Therefore, deciding on the optimal mitigation and remediation strategies rely on the scientific knowledge of oil retrieval and operative monitoring procedures (Asif et al., 2022). This paper, therefore, seeks to address the research question:

- 1) What mitigation strategies will address the potential environmental risks posed by the oil and gas development on mangrove ecosystems in the coastal communities of Region 1 and Region 2?

2. Literature Review

2.1. Legal and Policy Frameworks for Mangrove Management and Conservation in Guyana

Guyana's legal and institutional frameworks consist of a multiplicity of legislative and policy tools that enable the management and conservation of mangroves and the facility of ecosystem services. However, there are severe challenges to satisfying the responsibilities of the framework (Johnson-Bhola, 2019). The Acts and Statutes are either disjointed or outdated and therefore are inappropriate for addressing some relevant issues. The Fisheries Act of 1957 is an example of this category. The issues include emerging coastal development projects such as oil and gas exploration and production, impacting the sustainable management and protection of mangrove forests and related ecosystems. These regulations do not articulate directly on mangroves, as such superimposing authority relating to mangrove management. There is apparent action of the

statutory duties of different agencies. Consequently, there are no discrete mandates and clear laws and regulations for mangrove management (Johnson-Bhola, 2019).

The Forest Act of 2009 mandated the Guyana Forestry Commission (GFC) as the legal authority for the general management of state forests, while the National Forest Plan assigns the responsibility for advancing a national mangrove management plan (Johnson-Bhola, 2019). Other laws confer the responsibilities of several autonomous agencies that overlap in different aspects of mangrove management. The laws seek to address, including but not limited to, 1) the designated topographical space for the legitimate protection of mangroves, 2) conservation and protection of mangroves, 3) establishing authority over mangrove forests, and 4) community-based participation. However, the principal mangrove protection policy is absent (Johnson-Bhola, 2019).

Similarly, the National Mangrove Management Action Plan 2010-2012 indicates that disjointed legislation and forest policies do not directly govern mangroves. The administrative system engages various governmental institutions with overlapping responsibilities for coastal assets outside their interest. Officials from the Sea and River Defence Division have failed to regulate the extraction of mangroves due to constraints concerning inadequate human resources, lack of training, and a lack of knowledge in management best practices for the sustainable development of mangroves (Parliament of the Co-Operative Republic of Guyana, 2022).

The National Mangrove Management Plan (2010-2012) presents at least ten legislations regarding mangroves that have been identified, including the Guyana Forestry Commission (GFC), Sea and River Defence Department (S&RDD), Fisheries Department, Environmental Protection Agency (EPA), Guyana Lands and Surveys Commission, Georgetown Sewage and Water Commission, Ministry of Housing and Water, Hydrometeorological Service, National Drainage and Irrigation Board and the Regional Democratic (Parliament of the Co-Operative Republic of Guyana, 2022).

The primary agencies that have firsthand dealt with mangroves are the S&RDD, GFC, the EPA, and the Department of Fisheries. Nevertheless, the S&RDD and the GFC have daily participation in mangrove management. The Forests Act directs the Guyana Forestry Commission with the general administration of Guyana's State Forests. The National Forest Plan permits the GFC to develop a national mangrove management plan. The mangrove forests are habitats for feeding, breeding, and shelter grounds for many marine species (fishes, crabs, crustaceans, and mollusks). Thus, the Fisheries Department has an interest in mangroves. The Sea and River Defence Department is responsible for artificial and natural defenses. The Environmental Protection Agency coordinates the management of the coastal zone (Parliament of the Co-Operative Republic of Guyana, 2022). The principal legal framework that reinforces these tasks of the agencies includes:

- 1) Constitution of the Co-operative Republic of Guyana Act 1980
- 2) Forest Act 2009
- 3) Environmental Protection Agency (EPA) Act 1996
- 4) Sea Defence Act 1998
- 5) Fisheries Act 1957
- 6) Civil Act 1998
- 7) Local Democratic Organs Act 1988
- 8) Local Government Act Chapter 28:02

(Johnson-Bhola, 2019; Parliament of the Co-Operative Republic of Guyana, 2022; Parliament of the Co-Operative Republic of Guyana, 2022).

The National Agricultural Research and Extension Institute (NAREI) is the regulatory institution responsible for the protection and conservation of mangroves, in particular, monitoring and restoration of mangroves along the coastal regions (INEWS Guyana, 2021). The other agencies are the Guyana Forestry Commission (GFC), the Sea and River Defence Division (S&RDD), the Department of Fisheries, and the Environmental Protection Agency (EPA) (Conservation International, 2018; Johnson-Bhola, 2019). Further, the National Mangrove Management Action Plan also directs Guyana's mangrove management, Integrated Coastal Zone Management Plan (ICZM), the Regional Democratic Council (RDC), and Neighbourhood Democratic Council (NDC) (Johnson-Bhola, 2019).

In addition, at the global level, mangrove management is directed by the International Conventions and Protocols/Multilateral Environmental Agreements, to which Guyana is a signatory. These include United Nations Convention on Biodiversity (UNCBD) ratified in 1994; United Nations Framework Convention on Climate Change (UNFCCC) ratified in 1994; the International Convention for the Prevention of Pollution from Ships ratified in 1997; the International Convention on Oil Pollution Preparedness, Response and Cooperation ratified in 1997; the Cartagena Convention ratified in 2010; Kyoto Protocol ratified in 2016; and Paris Agreement ratified in 2016.

There needs to be more clarity between the policies and the legal framework to execute sustainable mangrove management practices (Johnson-Bhola, 2019). There are gaps in the policies that are similar to the gaps in the legislative framework regarding mangrove management, which affect the degree of execution. Excluding the Revised National Forest Policy Statement (NFPS) 2018, the following policy instruments the National Forest Policy 2018-2028, the National Forest Plan (NFP), the National Biodiversity Strategy and Action Plan (NBSAP) 2012-2020, the Code of Practice for Mangrove Harvesting (2011), and the Sea Defences Sector Mangrove Monitoring Protocols 2011, the policy instruments indirectly address mangrove conservation and management.

2.2. Guyana National Oil Spill Contingency Plan

The oil and gas exploration and production offshore Guyana's coast heightens

the environmental risks to the coastal ecosystems, including mangroves. The simulation models for Guyana indicate that oil spills are unlikely to occur due to extensive preventative measure equipment, the locations of the projects offshore, the warm water, and the crude oil's light characteristics (Blaha, 2017). Nevertheless, the literature presents evidence that regardless of the location of an oil project offshore, oil and gas production and transportation have numerous environmental risks linked with poisonous substances in the oil (Kho et al., 2022; Shahbaz et al., 2023). The recovery process, particularly the cleanup exercises, could adversely impact mangrove ecosystems (Aa et al., 2022).

The Civil Defence Commission (CDC), which is the Competent National Authority (CNA), is authorised by Cabinet Note CP (97)2:2 as the agency to manage oil spill occurrences in Guyana. The National Disaster Risk Management Policy and the National Multi-Hazard Preparedness and Response Plan guide the Director of the CDC, who is responsible for averting, preparing, and undertaking the toxic oil spills within the territory of Guyana and its Exclusive Economic Zone (Petroleum Management Programme, 2021).

The CDC and the National Oil Spill Committee Plan (NOSCP) will set up the Incident Command System structure to respond to any oil spill occurrences. The secretariat for the administration of this plan is the CDC which administers the secretariat for the administration of this plan and accommodates the National Emergency Operating Centre (NEOC) (Petroleum Management Programme, 2021).

2.3. National Regulations and Legislation

The national regulations and legislation that govern the GNOSP include the following:

- 1) Environmental Protection Act 1996
- 2) Petroleum (Exploration and Production) Act and Regulations 1986
- 3) Maritime Zones Act 2010
- 4) Coast Guard Act 1990
- 5) Guyana Energy Agency Act 2014
- 6) Environmental Protection (Hazardous Waste Management)
- 7) Regulations 2000 (Petroleum Management Programme, 2021)

2.4. Offshore and Onshore Oil Spill Response

The National Focal Point-Marine (NFP-M) will be the Maritime Administrative Department (MARAD) which will function as the Deputy Incident Commander in response to an offshore spill. All agencies must report marine oil spill occurrences to MARAD Georgetown Lighthouse in Georgetown. The National Focal Point-Land (NFP-L) will be the Guyana Energy Agency (GEA) which will function as the Deputy Incident Commander in response to an onshore spill. All agencies are mandated to report land oil spill occurrences to GEA (Petroleum Management Programme, 2021).

3. Materials and Methods

The research used qualitative data analysis methods to interpret and analyze mitigation strategies that will manage potential environmental risks posed by oil and gas exploration activities on mangrove ecosystems in Guyana's Region 1 and 2. The primary data collection involved face-to-face semi-structured interviews (Striepe, 2021) with seven Toshaos from coastal communities in the study areas of Regions 1 and 2. A purposive sampling approach was used to select participants who know the environment, management of mangroves, and socioeconomic issues emerging from oil and gas activities (Knott et al., 2022; Dunwoodie et al., 2023).

Trustworthiness was ensured through observation, triangulation, and follow-up interviews (Hull & Whittal, 2023). Relevant archival documents were also analysed. The qualitative data analysis using NVivo software (Castleberry & Nolen, 2018) was used to identify themes, and the findings were compared with other published works. The data collection included interpreting relevant archival and documents (Hintz & Quigley, 2022) relating to legislation, policies, government reports, and project documents that address the legislative framework for managing mangroves. Consent letters were obtained from community councils before conducting the study, and pseudonyms, Participants (P1) to P (7), were assigned to participants for privacy reasons.

The study areas were selected for researching the coastal communities in Regions 1 and 2. Region 1 has a population of almost 27,643 people living primarily in Amerindian settlements and is mainly forested highland, bordered north by a narrow strip of the low coastal plain. The study areas selected were Shell Beach, Santa Rosa, Waramuri, and Manawurin, located 5 to 10 km inland. Fishing and crabbing are predominantly done at the westernmost end of the Shell Beach Protected Area (Environmental Protection Agency, 2021; Blaha, 2017) (Figure 1).

This protected area is governed by the Protected Areas Commission under the Protected Areas Act 2011 to protect and conserve Guyana's natural resources. Shell Beach has significant biodiversity, including four endangered sea turtle species—Leatherback, Green, Hawks Bill, and Olive Ridley—which face extinction from human activities such as fishing, hunting, and plastic pollution. Shell Beach also has fifty-nine fish species. This protected area is a globally crucial birding area that nests more than 200 migratory bird species. It is the only coastal protected area supporting the communities' livelihoods (Environmental Protection Agency, 2021; Blaha, 2017).

The study areas selected were Akawini, Wakapau, and Kabakaburi (Figure 1). Region 2 (Pomeroon-Supenaam) comprises almost 46,810 people and comprises Amerindian settlements with recognized villages along the coast. The main economic activity is rice farming for local consumption and export (Blaha, 2017).

The selected communities in both regions depend on natural resource-based activities like agriculture, fishing, crabbing, shrimping, hunting, logging, and

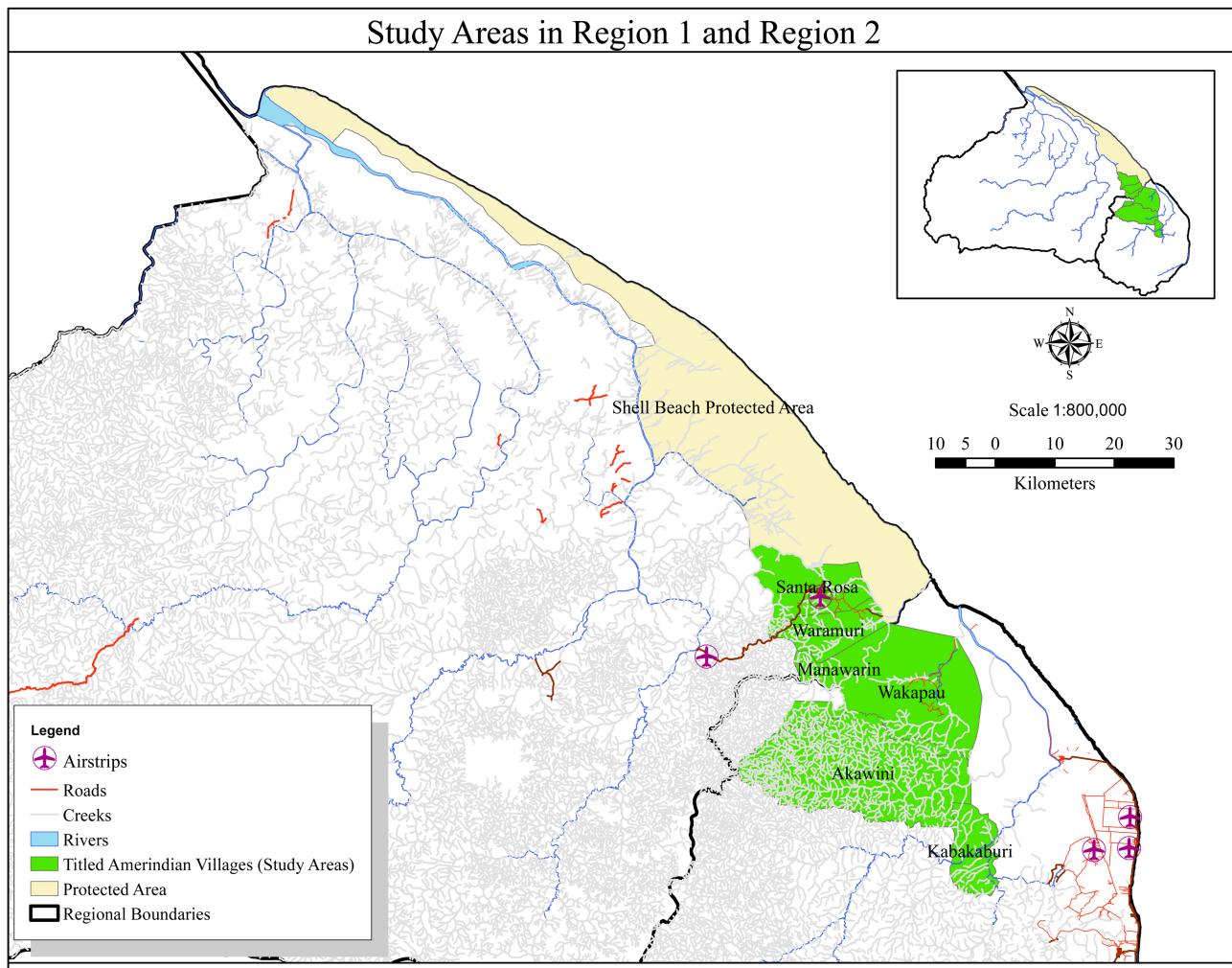


Figure 1. Study areas in Region 1 and Region 2.

mining for livelihoods. Potential oil spills reaching the coast will negatively impact the provisioning of resources like fish protein which are crucial for indigenous peoples' sustenance in oiled mangrove forests and swamps alongside the beach. Therefore, the research will underscore the coastal communities' environmental significance in protecting their diverse ecosystems through management interventions critical to conserving natural resources while promoting sustainable living practices among indigenous populations living along these coasts (Environmental Protection Agency, 2021; Blaha, 2017).

4. Data Analysis

Thematic analysis was employed as the data analysis strategy in this study. It enables the researchers to analyse vast amounts of data from several sources such as interviews, field notes, recordings, documents, and literature. The thematic analysis is an appropriate technique for retelling critical details of vast data and enables researchers to use a systematic style for data interpretation and results (Robinson, 2022). It systematically interprets data, theoretical views, and

participant explanations and provides a brief yet expressive interpretation of results. Further, thematic analysis can be used in qualitative research to analyze themes and interpret the meaning of the data obtained (Qin, 2022).

NVivo software version 20, adopted to aid in this process, assists researchers with their analyses by providing tools for organizing and sorting data efficiently. Researchers use the six-step process proposed by Clarke and Braun, which includes familiarization, coding process, generating themes, reviewing themes, naming themes, and reporting (Clarke & Braun, 2018; Fryer, 2022).

5. Results and Discussion

Several themes emerged from the response provided during the interviews and their analyses. The qualitative data analysis obtained six significant themes. The themes include legal and policy frameworks, oil spill response strategies, government collaboration with ExxonMobil Guyana and engaged local community members, community-based involvement, monitoring and monitoring enforcement of regulations, and training and education programmes. **Table 1** shows the summary of the major themes and sub-themes.

6. The Mitigation Strategies for Addressing the Potential Environmental Risks Posed by Oil and Gas Development on Mangrove Ecosystems

6.1. Legal and Policy Framework

The first theme was the legal and policy framework. The themes covered under this category include reviewing and updating the regulatory framework for mangrove management and conservation and reviewing and updating the institutional framework for mangrove management and conservation. Each team is discussed below:

Reviewing and updating the regulatory framework for mangrove management and conservation: The first theme under this category was that the government should regularly review and update the regulatory framework for mangrove management and conservation. This theme received support from all seven participants, who underscored that mangroves provided significant benefits to the livelihood of their communities and that the government should regularly review and update the regulations related to the management and conservation of the mangroves. All the participants shared similar views summarising the regulatory framework's significance in their responses. They alluded that the Acts are outdated, disjointed, and do not address environmental risks associated with oil spills in mangrove ecosystems. Therefore, they need to be updated.

Participants' observations on the need for the government of Guyana to regularly review and update its regulations on managing and conserving mangroves are supported by the literature. P5 states, "*There are many Acts for managing and conserving mangroves. However, these Acts are not directly related to mangrove management, are outdated, disjointed, and have several challenges. They do not*

Table 1. Summary of themes and sub-themes used for analysis.

Theme	Sub-theme
Legal and policy framework	Reviewing and updating the regulatory framework for mangrove management and conservation
	Reviewing and updating the institutional framework for mangrove management and conservation
Oil spill response strategies	Reviewing and updating Guyana's National Oil Spill Contingency Plan
	Oil spill preparedness
	Oil spill mitigation measures, including detection and monitoring, containment, shoreline protection and cleanup, cost recovery, and compensation)
Government collaboration with ExxonMobil Guyana and engaged local community members.	Government collaboration through Environmental Protection Agency, Civil Defence Commission, and Guyana Forestry Commission, with ExxonMobil Guyana and engaging the local community members
Community-based involvement	Community-based involvement in mangrove management and conservation
	Mangrove management action plan needs the voice of the local community's members.
Monitoring and law enforcement of regulations	Limited monitoring and enforcement of mangrove management and conservation regulations by inter-agencies due to insufficient funds.
	Absence of coastal defence plan
Training and education programmes	Education programmes should include the importance and protection of mangroves against oil spills and related environmental risks

address environmental risks from oil spills in mangrove ecosystems.” Guyana does not have definite legislation for managing and conserving mangroves. However, several Acts associated with the forest, coastal sea defence, and development projects comprise the legislative framework for mangroves (Johnson-Bhola, 2019). The regulations do not directly address mangroves' environmental risks and management problems. This resulted in overlying authority relating to mangrove management because there appeared to be no distinct line of demarcation of various agencies' statutory duties and responsibilities. Consequently, no clear mangrove management regulations (Johnson-Bhola, 2019).

For instance, Johnson-Bhola (2019) suggests:

1) Sea Defence Act of 1998—Sec.13 (1 Sec. 14, 15 and Sec. 16 (b) (a) (b) Sec, 26 states that a person who encroaches on any sections of the Act will be ac-

countable on summary conviction of twenty-two thousand five hundred Guyana Dollars (GYD \$22,500). The sum corresponds to one hundred and nine United States Dollars (USD \$109).

The summary conviction of the sum specified is compassionate and would not deter the perpetrators (Johnson-Bhola, 2019).

2) Forest Act of 2009—Part 3.31 forbids the cutting and destruction or conducting of any prohibited undertaking in a State forest and inhabiting land in a State forest.

This Act could be amended to contain “protected species on private freehold lands,” in line with the governmental decree that protects mangroves (Johnson-Bhola, 2019: p. 36).

3) Fisheries Act of 1957—Part 8 Marine Reserves and Fishing Priority Areas, Section 21. (1). (a) provides for more excellent defence of flora and fauna of the specified areas and defends and conserves the marine and wildfire habitats. (2) states that anyone who removes or damages flora and fauna other than fish in the marine reserve without permission granted under subsection 3 (b) is guilty of an offence.

Part 8 should contain “protected species.” (Johnson-Bhola, 2019: p. 36).

4) Local Government Act, Part IV sec 51 states that cutting trees will have specific fees.

Part IV should stipulate that mangroves are exempted from cutting (Johnson-Bhola, 2019).

Reviewing and updating the institutional framework for the mangrove management and conservation of mangroves. The second theme under this category was that the government should regularly review and update the institutional framework for mangrove management and conservation. This theme received support from all seven participants, who underscored the importance of national policies and plans that involve several agencies in diverse sectors to help coordinate and collaborate project undertakings and circumvent policy conflicts. For instance, P1, P4, P6, and P7 shared similar views on the need to review and update the policy instruments, including a plan and strategy framework that strengthens institutions and improves collaboration among agencies for mangrove management conservation in the coastal zones. They collectively state: “*There was a need to update the National Mangrove Management Action Plan (NMMAP) 2010-2012 and Integrated Coastal Zone Management Action Plan (ICZMAP 2000).*”

The NMMAP 2010-2012, which highlighted the institutional and legal framework for mangrove management and conservation, still needs to be updated since 2012. The EPA is responsible for the coastal zone management and the execution of the Integrated Coastal Zone Management Action Plan (ICZMAP) and the Shore Zone Monitoring Programme (SZMP). The ICZMAP identifies the coastal zone as a significant part of Guyana but does not delineate the coastal zone for integrated coastal zone management and resource use. The Integrated

Coastal Zone Management Committee (ICZMC) was established due to a policy decision. The ICZMP and ICZM Committee, established in 2000, have been non-operational for several years (Guyana Chronicle Staff Reporter, 2022). The related policies and plans must be updated to reinforce the agency's role in coastal zone management. Moreover, the policies must be relevant and in line with the current developments in Guyana's oil and gas sector. The oil and gas exploration and production activities could impact mangroves (Johnson-Bhola, 2019).

There are disjointed policies that do not directly address mangrove management and conservation. The institutional system involves various governmental agencies with overlapping responsibilities for coastal assets, which aligns differently from their interests. Therefore, there is no comprehensive policy or strategy for mangrove management and conservation because of the absence of a clear mandate (Parliament of the Co-Operative Republic of Guyana, 2022). Consequently, reviewing and updating these policy instruments must address the gaps. Furthermore, there needs to be more clarity between the policies and the legal framework to execute sustainable mangrove management activities.

6.2. Oil Spill Response Strategies

The second theme was oil spill response strategies. The themes covered under this category include reviewing and updating Guyana's National Oil Spill Contingency Plan, detection and monitoring, oil spill preparedness, and oil spill mitigation measures, including containment, shoreline protection, cleanup, and cost recovery and compensation. Each team is discussed below:

Reviewing and updating Guyana's National Oil Spill Contingency Plan: The first theme under this category was reviewing and updating Guyana's National Oil Spill Contingency Plan. All seven participants supported this theme and shared similar perspectives that regular review and update of Guyana's National Oil Spill Contingency Plan should be done by the CDC, which is the competent authority responsible for both onshore and offshore oil spills. P1 states, "CDC coordinates oil spill response and mitigation activities." Similarly, P3 stated that CDC was responsible for preparing the Guyana National Oil Spill Contingency Plan and reviewing and updating it, as well as training and exercises of responders. P4 also stated that the national oil spill contingency plan offered coordinated response efforts and training for oil spills.

The purpose of an OSCP is to guide a synchronized response to oil spills. Collaboration between industry and government usually prepares the OSCP (Little, 2018). The CDC prepares, reviews, and updates NOSCP every three years. The amendments are based on the current operating and legal environment, the decisions arising from training and exercises, and, more importantly, actual oil spill occurrences. The main body of the plan may only be revised by agreement with justification. All members of the National Oil Spill Committee (NOSC) should be involved in the amendments with justifications and subsequent ap-

proval by the Cabinet.

Oil spill preparedness. The second theme under this category was oil spill preparedness. All seven participants supported this theme and shared similar perspectives that all relevant agencies should be prepared for oil spills and prioritise capacity building and coordinated responses to oil spills. For instance, P1, P2, P4, P5 and P7 collectively state:

“The national oil spill contingency plan should be updated and relevant. The response equipment and human capital should be sufficient, competent, and compatible to deal with oil spill issues. It is necessary to test the deployment of the response emergency equipment by exercises to practice the response procedure and staff mobilisation.”

There is a legislative framework that governs oil spill operations in Guyana. These include the Environmental Protection Act 1996, the Guyana Shipping Act 2006, Public Health Act 1934, and the GEA Act 2014. The National Oil Spill Contingency Plan is the authority that contains the measures and procedures for the management of oil spills in Guyana. The plan is reviewed and updated based on continuous data gathering and risk assessments. It is tested by exercises and training of all response staff, emergency response equipment deployment, and personnel mobilization.

The Civil Defence Commission and the United States (US) Coast Guard conducted various virtual and practical onshore and offshore exercises with more than 30 agencies and over 231 persons, both males, and females. The specific training areas included fundamentals of remote sensing, oil spill response and the on-scene commander role, oil spill risk assessments, shoreline cleanup, assessment techniques, and oil wildlife management. The Civil Defence Commission’s Preparedness and Response Manager stated that the exercise had prepared Guyana to detect oil spill impacts and respond to the incidents effectively (Department of Public Information, 2022).

Oil spill mitigation measures. The third theme under this category was oil spill mitigation measures. All seven participants supported this theme and shared similar perspectives that all relevant agencies should work together to reduce the impact of oil spills on the environment, especially the mangrove ecosystems, wildlife, and the community’s well-being. They alluded to mitigation measures, including detection and monitoring, containment, shoreline protection, cleanup, cost recovery, and compensation. Each measure is discussed below.

Detection and monitoring. The first oil spill mitigation measure was detection and monitoring. The Environmental Protection Agency declared it could detect and monitor oil spills and slicks in Guyana, offshore, onshore, and farther afield in South American waters. P1 states, “EPA has the technological capabilities to detect and monitor oil spills.” the Environmental Protection Agency has employed the service of MAXAR Technologies in Colorado to allow actual environmental monitoring of two offshore oil wells developed by ExxonMobil Guyana, Hess Corporation and China’s National Offshore Oil Corporation (CNOOC) (Wil-

kinson, 2023).

Furthermore, the agency has advanced field technology for monitoring and collecting data, including tablets and field phones with thermal-thermal sensors to detect and monitor radiation, water, air, and pollution. In addition, the agency has actual reporting of discharges of pollutants from the Liza 1 Floating Production Storage and Offloading (FPSO) vessel and the technology to trail marine vessels in the country's Exclusive Economic Zone (Kaieteur News, 2021).

Containment. The second oil spill mitigation measure was containment. P4 states: "It is important that the oil pollutant is contained and prevented from spreading to the shorelines, using booms." It is crucial to rapidly restrict the spill to reduce the risks and potential damage to public health, property, and natural resource, particularly mangroves. Booms are deployed to control the spread of oil to mitigate the pollution of shorelines and ecosystems and channel slicks along chosen paths where the slicks can be easily removed from the water surface (Bi et al., 2022). The booms may be deployed where skimmers can be positioned where the oil is gathered. Further, adsorbent barriers or chemical dispersants may be used to avert the spill from affecting protected or beneficial areas with water supply, beaches, and productive ecosystems. However, the Guyana Environmental Protection Agency will authorise the use of dispersants with the agreement of the public health officers (Petroleum Management Programme, 2021).

Shoreline protection and clean up. The third oil spill mitigation measure was shoreline protection and cleanup. P5 states: "Marine shoreline areas are critical ecological resources such as mangroves, wildlife, and various species habitats. Oil spills may threaten their livelihoods." It is necessary to safeguard the shorelines and conduct shoreline cleanup exercises. The survival of marine shoreline and freshwater ecological resources is at risk of accidental oil spill occurrences during oil offshore and onshore production, storage, and transportation operations. Response teams will exert their best efforts to contain spilled oil, which may sometimes reach the shorelines and delicate ecological habitats, such as the mangrove ecosystems (Bi et al., 2022). These fragile habitats will be at risk of oil pollution (Solo-Gabriele et al., 2021). Mangroves offer shoreline protection to local areas from strong storms and habitats for several animals, plants, birds, and algae fixed to the roots of trees (Iturbe-Espinoza et al., 2022). The oil clings to the visible surface and roots of mangrove trees when unprotected from the tidal waters' flow. The plants and animals affected by oil pollution cannot survive in the mangrove ecosystems, resulting in their demise (Duke, 2016). It is crucial to protect these resources from devastation and to preserve them for their survival, aesthetic value, and public recreational activities. Therefore, cleaning-up exercises are needed for oil spilled on the shorelines and land (Bi et al., 2022). P6 states, "There are various cleanup methods, including pressure washing, use of dispersants, in-situ and ex-situ methods." Various cleanup techniques may be used for oil recovery to circumvent the oil spill's impacts on the shoreline natural re-

sources. The shoreline protection and cleanup methods are discussed below:

1) Mechanical oil methods can eliminate much-oiled material and excavate oil slicks from the shoreline bedrock beaches (Pradhan et al., 2021). Pressure washing can be employed with low-pressure pumped water through hose pipes (Iskander et al., 2021). Mobile vacuum pumping units clean spilled oil in contaminated areas (Kurbangaleeva, 2022). Physical barriers such as fences and berms could be employed onshore to avoid spreading oil to delicate habits such as wetlands and mangroves and containing oil for removal (Lim et al., 2016).

2) Chemical methods include dispersants and surfacing washing agents. The dispersants can be used when oil is spilled at sea. They can be sprayed by aircraft and boats to reduce the droplets' size to boost the oil's thinning and dispersion to lessen the toxicity level (White & Karras, 2021; Feng et al., 2021). The surface washing agents with the flushing technique can be applied together to remove spilled oil effectively (Feng et al., 2021; Bi et al., 2021).

3) Biological methods such as bioremediation protect shorelines (Ellis et al., 2022; Wenning et al., 2018). Bioremediation is a slow process that can be applied to delicate shorelines after treatment with other methods. The application of nitrates and phosphates can fast-track the natural biodegradation process or bio-stimulation

4) Oil and combustible materials (e.g., vegetation and substrates) can be controllably burned on the shorelines (Fingas, 2018). Thus, reducing vast quantities of oil and facilitating vegetation recovery faster than natural processes alone (Iskander et al., 2021). This method is proper when heavy oil is in-situ and cannot be removed with physical or other methods (Fingas, 2018). The ex-situ method includes scraping the polluted sediments and oiled vegetation, mitigating the risk of oil reassembling (Taneez et al., 2018).

The Guyana National Oil Spill Contingency Plan contains the methods above to mitigate damage by recovering spilled oil and removing oiled debris in an eco-environmental friendly manner. Physical or mechanical will remove oiled debris on the shoreline by heavy machines, intensive manual labour, and vacuum units. Chemical dispersants will be considered based on the availability of chemical agents, logistical support, equipment, and knowledgeable personnel. Biodegradation of oil using certain chemicals and related biological additives will be considered. Burning is highly considered when the fire can be controlled and the losses to the fire are acceptable (Petroleum Management Programme, 2021).

Cost recovery and compensation: The fourth oil spill mitigation measure was cost recovery and compensation. P7 states: "Guyana can get compensation for cleanup and recovery operations through the international organisation for damage to the environment and economic loss due to oil spills."

ExxonMobil Guyana should be held accountable for likely oil spills. It should compensate farmers and other residents for any loss of properties, agriculture products and animals, tourist sites, and economic loss.

The compensation regimes comprise most international tanker spills' regulatory and compensatory frameworks. It consists of the International Conventions on Civil Liability for Oil Pollution Damage (CLC) 1969 and 1992, the conventions on the establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC) 1971 and 1992, and the 2005 Convention for the International Oil Pollution Compensation Supplementary Fund 2005. The CLC and its associated funds restrict the liability of oil tanker owners and offer up to US\$1.18 billion in reimbursement for cleanup and financial loss (Kiran & Krishna, 2010; International Maritime Organization (IMO), 2019).

Through the Ministry of Legal Affairs, the Competent National Authority (Civil Defence Commission) is responsible for initiating cost recovery arrangements with the polluter for the cost incurred for the response and recovery operations. The National Oil Spill Contingency Plan contains the procedures for the cost recovery and compensation from the polluter of oil spills. The polluter is responsible for the financial liability for the cleanup operations and the measures to mitigate the impacts of spilled oil on the environment. P7 states, "*The polluter (ExxonMobil Guyana) should be held accountable for oil spills. It should compensate farmers and other residents for any loss of properties, agriculture products and animals, tourist sites, and economic loss.*" The costs include loss of business at tourist sites, product loss, cleanup measures, restoration, and downtime due to interrupted passage of navigational channels. The National Response Agency (NRA), which comprises the Coast Guard (responsible for Maritime) and the Guyana Energy Agency (responsible for land), is tasked with recording documented logs to assess the pollution incidents effectively. The logs will validate government claims for compensation due to expenses incurred from evaluation, containment, and restoration of the environment (Petroleum Management Programme, 2021).

The NOSC committee is responsible, in line with legal regimes (such as the Civil Liability Convention 1992 and the International Oil Pollution Compensation Fund 1992, of which Guyana is a signatory), for the institution of the cost recovery strategy guiding principles. This NOSCP defines the cost recovery measures for both onshore and offshore oil spills, led by the Ministry of Legal Affairs (MoLA) and supported by all relevant national agencies (Petroleum Management Programme, 2021).

6.3. Government Collaboration with ExxonMobil Guyana and Engaged Local Community Members

The third theme was that the government collaborated with ExxonMobil Guyana and engaged with local community members. A significant theme covered under this category was Government collaboration through the Environmental Protection Agency, Civil Defence Commission, and Guyana Forestry Commission, with ExxonMobil Guyana and engaged the local community members. The primary stakeholder groups that emerged from the interviews were members of the local community, who are directly affected by oil spills. ExxonMobil Guyana

is conducting offshore oil and gas exploration and production operations that can result in potential oil spills, negatively impacting mangrove ecosystems. All seven participants responded that the government collaborated with ExxonMobil Guyana and engaged the local community well. P4 cited one incident where the government, through the Environmental Protection Agency, collaborated with ExxonMobil Guyana and conducted a consultation on the environmental impact assessment of one of the offshore oil and gas development projects. P4 states: “*The Environmental Protection Agency and ExxonMobil Guyana conducted consultations on the environmental impact assessment of one offshore oil and gas development project. Residents raised concerns of potential impacts on their community’s well-being and the mangrove ecosystems.*” P5 cited another case in which the government consulted with the local community members through the Environmental Protection Agency and ExxonMobil Guyana when discovering new oil wells. P5 states: “*Environmental Protection Agency and ExxonMobil Guyana held consultations when new oil wells were discovered. We raised concerns about accidental oil spills and equipment failure. If developed countries such as the USA with advanced technology experienced oil spills, Guyana is no exception.*” P6 cited another case where ExxonMobil Guyana and Civil Defence Commission conducted oil spill containment drills at Waini Point, Shell Beach. P6 states: “*Civil Defence Commission and ExxonMobil Guyana conducted an oil spill training exercise at Waini Point. The instructors used floating booms to demonstrate how to contain oil spills.*” P7 cited another case where the government, through the Guyana Forestry Commission and ExxonMobil Guyana, conducted Global Positioning System training with the local community, which included GPS principles and applications, navigation, tracking, mapping, and timing. P7 stated that the GPS training was timing and benefited the community members. It equipped them with the technical skills to navigate through the jungle, especially during hunting, and complemented their traditional knowledge of finding their way.

6.4. Community-Based Involvement

The fourth theme was community-based involvement. The themes covered under this category were community-based mangrove management and conservation involvement, and the mangrove management action plan needs the voice of the local community members. All seven participants supported this theme and shared similar perspectives that community-based involvement benefits the sharing of local and native knowledge and skills, which help in the decision-making process related to mangrove management and conservation.

Community-based mangrove management and conservation involvement:

The first theme under this category was community-based mangrove management and conservation involvement. Six participants supported this theme and shared similar perspectives. Community-based mangrove management entails the sustainable management and conservation of mangrove ecosystems. However,

this can be challenging for community-based mangrove management in economic and conservation zones. P2, P4, and P6 collectively state, “Coastal communities located next to mangrove ecosystems share the benefits of mangroves and, therefore, should participate in education programmes concerning the impact of oil spills on mangroves and their communities, with support from the local authorities.” Coastal communities next to the mangrove forest environment need education and awareness of sustainable resource management (de Oliveira & Bonetti, 2021). It is a strategy to advance the community’s biological and socioeconomic scopes (Basyuni et al., 2022), offering various amenities for people and the environment. These amenities, which are the ecosystems, are centered on community processes and collaborative efforts by local authorities. Coastal communities’ involvement is critical to managing the mangrove forests in coastal Regions 1 and 2. The communities should be educated on the benefits and protection of mangroves. The coastal inhabitants’ insufficient knowledge of mangrove ecosystems was their primary lack of participation in mangrove management and conservation activities. Nevertheless, they were keen on getting involved and improving their awareness of the significance of mangroves (Conservation International, 2018).

Mangrove management action plan needs the voice of the local community members: The second theme under this category was mangrove management action plan needs the voice of the local community members. Five participants supported this theme and shared similar perspectives. The mangrove management action plan needs the voice and participation of the local community members to succeed. All stakeholders of the mangrove environment should be motivated to participate in managing and conserving the mangrove ecosystems. In addition to nationwide awareness and education outreach, a community involvement program is required. (Parliament of the Co-Operative Republic of Guyana, 2022). P1, P3, P4, and P7 collectively state, “The Regional Democratic Council and Neighbourhood Democratic play an important role in coordinating community-based projects.” Community involvement should be centered on specific project sites. The communities that are in proximity to the sites will be actively involved in site development and monitoring. Community participant responsibilities will vary by site and comprise the required resources, continuous monitoring, and public education. An adequate budget is needed for such projects to offset community services that will benefit from their involvement. Furthermore, it is encouraged to develop good relationships with the regional authorities by conducting regional workshops on specific projects such as mangrove policies and legislations, monitoring and enforcement, and the community’s livelihoods (Parliament of the Co-Operative Republic of Guyana, 2022).

6.5. Monitoring and Enforcement of Regulations

The fifth theme was monitoring and law enforcement of regulations. The themes covered under this category were limited monitoring and enforcement of man-

grove management and conservation regulations by inter-agencies due to insufficient funds and the absence of a coastal defence plan.

Limited monitoring and enforcement of mangrove management and conservation regulations by inter-agencies due to insufficient funds: This theme received support from five participants. Participants faulted the government's ineffectiveness in monitoring and enforcing mangrove management and conservation regulations by inter-agencies due to insufficient funds, thus allowing the oil and gas company ExxonMobil Guyana to engage in activities that will likely result in oil spills. P1, P3, P4, and P5 shared similar views and collectively stated that there is "*Limited monitoring and enforcement of mangrove management conservation regulations by inter-agencies due to insufficient funds.*" Likewise, P2, P3, P4, P6, and P7 shared similar views and collectively stated that inter-agency monitoring and enforcement are absent of mangrove regulations, especially in the coastal regions more prone to the effects of oil spills. They state, "*There is a need for the relevant authorities to conduct interagency monitoring and enforcement of mangrove regulations in the coastal communities.*"

Absence of coastal defence plan: This theme received support from four participants. P5 indicated an absence of a coastal defence plan for the coastlines. The absence of the coastal defence plan outlining enforcement programmes, according to P5, implied there is no monitoring and enforcement plan for the oil company and other stakeholders associated with oil and gas exploration. As such, there is a need for the government to design a more effective monitoring and enforcement plan to ensure that oil company adheres to the regulations. P6 also supported P5's opinion regarding the absence of an effective coastal defence plan.

This study's findings indicate limited monitoring and enforcement of mangrove management and environmental conservation regulations. While there is a need for regularly reviewing and updating regulations (Tresiana et al., 2022), as recommended earlier, those policies may only be effective if the relevant agencies enforce them properly.

6.6. Training and Educational Programmes

The sixth theme was training and educational programmes. The central theme covered under this category was education programmes on the importance and protection of mangroves against oil spills. All seven participants contributed to this theme. Participants highlighted the need for the government to conduct training and education (Gamassa, 2022) with relevant stakeholders such as local community members, Guyana Forestry Commission, Regional Democratic Council, and ExxonMobil Guyana. For instance, P1 states: "*There is a need for education on the importance of mangroves involving the Regional Democratic Council and local community members.*" P3 shared similar perceptions as P4, stating that the government should "*educate the public, especially communities residing in the coastal communities, on the importance of mangroves like serving as natural habitats for wildlife and act as a shield against river bank erosion, and protection against oil spills.*" P4 further indicated that the educational programmes

should be entrenched into the curriculum from nursery through primary, secondary, and tertiary levels and should include mitigation strategies to manage environmental risks by oil spills on mangrove ecosystems.

P6 states: “*Government should train people from the agencies responsible for protecting and managing mangroves against environmental risks across the country.*” P7 shared similar views that the government should conduct inter-agency programmes to monitor and enforce the regulations and policies on mangrove management. Participants also indicated that the government should conduct inter-agencies education programmes across the country.

In addition, the participants underscored the need for the Ministry of Education to conduct a public education programme that should include academic curriculum development at the University of Guyana and the country’s educational institutions in Regions 1 and 2. The programme should also include awareness and the importance of mangroves. These education programmes should also be conducted on TV and radio. Further, inter-agencies staff engaged in mangrove management should participate in the training. These inter-agencies include the Guyana Forestry Commission, Sea and River Defence Department, Fisheries Department, Neighborhood Democratic Council, and community workers of Regions 1 and 2. From the outset, the Ministry of Education should also be involved in this campaign. Their involvement entails developing new curriculum content for the country’s educational institutions (Parliament of the Co-Operative Republic of Guyana, 2022).

6.7. Policy Implications

The jurisdiction over mangroves in Guyana depends on how they are defined as sea defence or forest resources in Guyana. It is essential to institute a clear law that defines mangroves and determines which ministry or institution is responsible for their management (Johnson-Bhola, 2019). Depending on how mangroves are defined (for example, sea defence or forest resource), different ministries or institutions, such as the Sea and River Defence Division or the Guyana Forestry Commission, should have jurisdiction over them. Many pieces of legislation used for mangrove management fall under the Sea and River Defence Act. Therefore, the recommendation is to place mangroves under the Sea and River Defence Division of the Ministry of Public Infrastructure (Johnson-Bhola, 2019).

The Sea and River Defence Division has updated its mandate to include Integrated Coastal Zone Management (ICZM). It plans to establish a department focused on research, collaboration, data analysis, and reporting based on policy directives. It must be considered that there is a need for clear definitions and jurisdiction regarding mangrove management in Guyana to ensure effective conservation practices (Johnson-Bhola, 2019).

7. Conclusion

This paper examined the mitigation strategies that could manage the potential environmental risks posed by oil and gas exploration activities in coastal Regions 1

and 2. The selected coastal communities are unique and vulnerable to potential oil spills due to their proximity to the coastline. These riverain coastal communities are remotely located and are not easily accessible. There were challenges to accessing these communities since the only affordable means of reaching them was by small wooden boats propelled by outboard engines, which took about five hours of the return journey.

It analysed the legal and policy frameworks that govern mangrove management and conservation, which have serious challenges. There is no demarcation of the legislative responsibilities of different agencies. Further, no specific laws and regulations exist for mangrove management. Consequently, there is a need to review and update outdated regulations.

Based on the interviews conducted, participants underscored a novel finding that regular reviewing and updating the policies and regulations to ensure there are no loopholes that ExxonMobil Guyana could use to evade environmental conservation responsibility.

The oil spill response strategies were methodically investigated, especially Guyana's National Oil Spill Contingency Plan. The National Oil Spill Contingency Plan is the authority that contains the measures and procedures for the management of oil spills in Guyana. The Civil Defence Commission is the competent authority mandated by Cabinet as the agency to manage oil spill occurrences in Guyana. It is responsible for preparing and reviewing the National Oil Spill Contingency Plan. It is tested by exercises involving training all response staff, emergency response equipment deployment, and personnel mobilization.

The relevant government agencies need adequate programmes for monitoring and enforcing mangrove management and conservation regulations. Therefore, there is a need for such programmes to ensure ExxonMobil Guyana adheres to these regulations to avoid environmental damage to the mangrove forest and loss of coastal communities' livelihood.

Declaration of Competing Interest

The authors have declared no conflict of interest.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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