Global Sustainability Research
https://doi.org/10.56556/gssr.v2i3.516
ISSN: 2833-986X

RESEARCH ARTICLE

Researching Offshore Facilities and Choosing an Appropriate Platform for Hydrate Extraction in the Bay of Bengal

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Received: 28 May, 2023, Accepted: 12 June, 2023, Published: 05 July, 2023

Abstract

Offshore buildings are used in various locations and sea depths for several reasons. Different equipment, platforms, and design techniques are needed depending on water depth, climatic conditions, structural arrangement, and new concepts. Offshore constructions usually generate and transport oil, gas, and other commodities. Bangladesh has yet to use the Bay of Bengal's hydrocarbon potential for oil and gas. Bangladesh lags behind India and Myanmar in maritime oil and gas discovery. In 50 years, Bangladesh's sea barriers have yielded no benefits. Bangladesh's economy is hindered by its high crude oil imports. Focus on offshore petroleum exploration to locate "black gold" now. Therefore, an offshore structure is needed. This thesis paper covers the fundamentals of all offshore systems, broadens the research, and recommends appropriate platforms for various sea-water depths, which those platforms are meant to be built for hydrates predicted in the Bay of Bengal. The paper uses the Bay of Bengal sedimentation and estimated water depth to choose offshore constructions. The country's maritime boundaries have 26 oil and gas blocks. There are 11 in shallow water and 15 in deep sea. According to statistics, the blocks are on the continental shelf and deep-water region. Five zones make up the Bay of Bengal continental shelf. They are shores A-B, B-C, C-D, D-E, and E-F after region F continental slope continues till the deep sea area. The continental slope zone C-D has 64-106 m water depth. Therefore, the Bay of Bengal continental shelf is suitable for all permanent offshore buildings except this zone. Only concrete gravity platforms fit this zone. We need the technology to search for oil and gas in water. It takes a lot of work to get foreign companies to work together. Thus, skilled people should work on it and encourage government or private businesses to develop oil and gas production technology.

Keywords: Offshore Structures; Hydrocarbon; Bay of Bengal; Continental Shelf; Sediment

Introduction

Offshore describes a location on water that is far from land. However, offshore construction entails erecting buildings and other infrastructure out at sea. Offshore structures are typically constructed and pre-commissioned on the ground. Offshore structures exposed to waves, seismic activity, wind, or a mix of these stressors exhibit non-linear, abrupt behavior. The ocean floor's topography is analyzed for petroleum reserves after seismic studies have been conducted. When the probability of finding hydrocarbons is high, the surveyor is prompted to dig deeper, and the quantity of hydrocarbon potential yields figures for the most cost-effective offshore building in the area. Oil and gas are being explored all over the planet. Onshore exploration refers to work done on land, while offshore research occurs in water. There is also a third zone, but it has a minor trade effect. Transition Zone Exploration is another name for this, though Shallow Water Exploration is more common. This includes areas with shallow water, such as coastal areas, waterway channels, and swamps. Exploration methods in such regions are often complex.

Offshore building projects have their own technical and monetary quirks. Offshore building projects rely heavily on the profits made from oil and gas extraction, which are directly linked to international finance and indirectly affected by oil price fluctuations. For instance, numerous offshore construction projects were initiated in 2008 as a direct consequence of the increase in global energy costs that year (Atreya et al., 2013)

Soon after Bangladesh became an independent country in 1971, oil was taken out of the ground for the third time (1971–1990). Six multinational companies, including ARCO, Ashland, and Union Oil Co., sank seven wells in the Bay of Bengal between 1974 and 1978 to investigate distant areas under Production Sharing Contracts with Petrobangla (the state oil company). Thus, the distant Kutubdia gasfield was discovered. One thousand nine hundred eighty all foreign energy companies had left Bangladesh, leaving only Petrobangla. A petroleum reservoir's porosity and permeability are crucial physical qualities when storing and transporting fluids. Both characteristics are essential when defining a reserve. Particle size and form, pore size, grain sorting, cementation, compression, packing fracture, and solution are significant in determining reservoir-scale porosity and permeability. However, aside from the work of a few undisclosed oil and gas companies in the Bengal Basin, no efforts have been made to quantitatively quantify core and log petrophysical characteristics and their potential governing variables (Ismail & Shamsuddin, 1991).

Bangladesh has relatively small hydrocarbon and lignite deposits, but its natural gas supplies could be huge. Most natural gas and petroleum oil come from Sylhet Division in the country's northeast, followed by Chittagong Division, Dhaka Division, and Barisal Division. Most people think that Bangladeshi natural gas is one of the cleanest in the world because it has a high methane content (95–99%) and almost no nitrogen content. Of the total 25,602 km2 that was in question, Bangladesh got 19,467 square kilometers (km) of territory in the sea from The Hague's Arbitral Tribunal, which presided over the maritime border dispute between Bangladesh and India in the Bay of Bengal. Therefore, the marine sector in Bangladesh holds excellent promise. The Bay of Bengal is home to numerous oceanic islands that may be highly mineral-rich. Furthermore, UNB reports that Bangladesh has discovered massive potential natural gas hydrate deposits in its Exclusive Zone, with estimates ranging from 0.11 to 0.73 TCF. It is equivalent to 17–103 trillion cubic feet (TCF) of natural gas (Shahjahan et al., 2002).

Bangladesh is rich in natural resources and spans an area of 147,610 square kilometers, stretching from north to south for 820 kilometers and from east to west for 600 kilometers. Regarding geography, the Bengal Basin can be found in an area characterized by exceptionally high levels of geological activity. A great number of dynamic geological features can be found within and all around the Bengal Basin. The region of the Indian Ocean, located to the northeast, is defined by the estuary of Bengal, the largest estuary in the globe. It is a triangular shape and is bordered on three sides by other countries: to the north by Bangladesh, to the east by Myanmar and the Andaman and Nicobar Islands, and to the west by India and Sri Lanka. The Bay of Bengal encompasses a total area of 2,172,000 km2 of land and water. To use a metaphor, the country of Bangladesh sits at the very tip of the Bay of Bengal. The length of the nation's exclusive economic zone is 370 kilometers (200 nautical miles), while the size of its territorial waterways is 12 nautical miles (22 kilometers). The land is reportedly subdivided into 26 separate sections, as stated by Petrobangla. The PSC district plan is presented in the following image. There are 11 sections from the coastal sea and 15 blocks from the deep sea. On the chart, far offshore is represented by a dark blue color, while shallow offshore is shown by a lighter blue color (Shahjahan et al., 2002).

Since the industrial revolution, energy demand has grown while supply has not. Bangladesh's power sector relies largely on fossil fuels since natural gas and coal are its main energy sources. Diesel, coal, heavy oil, and biofuels comprise the rest of Bangladesh's power generation. Bangladesh's energy field includes power, fuel products, natural gas, coal, biogas, and sun. Exploiting its abundant green energy sources may solve Bangladesh's power issue. The problem should be addressed by massively using ocean waves and the Bay of Bengal. Offshore buildings and energy use are the most effective way to use Bay of Bengal resources.

The following research and investigation objectives were set in light of the preceding discussion:

- Explore about offshore structures in detail in preparation for their use in the near future;
- Examining the potentiality of Bay of Bengal blocks for offshore constructions;
- Prediction of primary selection of offshore structures for those hydrocarbon potential area.

Literature Review

Detailed Study on Offshore Structures

Maritime and offshore structures must withstand harsh sea conditions for their plan spans. (50 to 75 years for ports and 25 years or more for offshore hydrocarbon platforms). Peak loads from storm gusts and waves wear loads from waves over the platform's lifespan and platform motion are essential to design aspects. Offshore buildings are built miles from shorelines in lakes, gulfs, and the open sea. These structures are made of mild to high-strength steel. The world's tallest artificial buildings are offshore towers. This chapter covers offshore building history, kinds, and loads that must be computed for design, plans and specs, production, installation, and environmental considerations (Ismail & Shamsuddin, 1991).

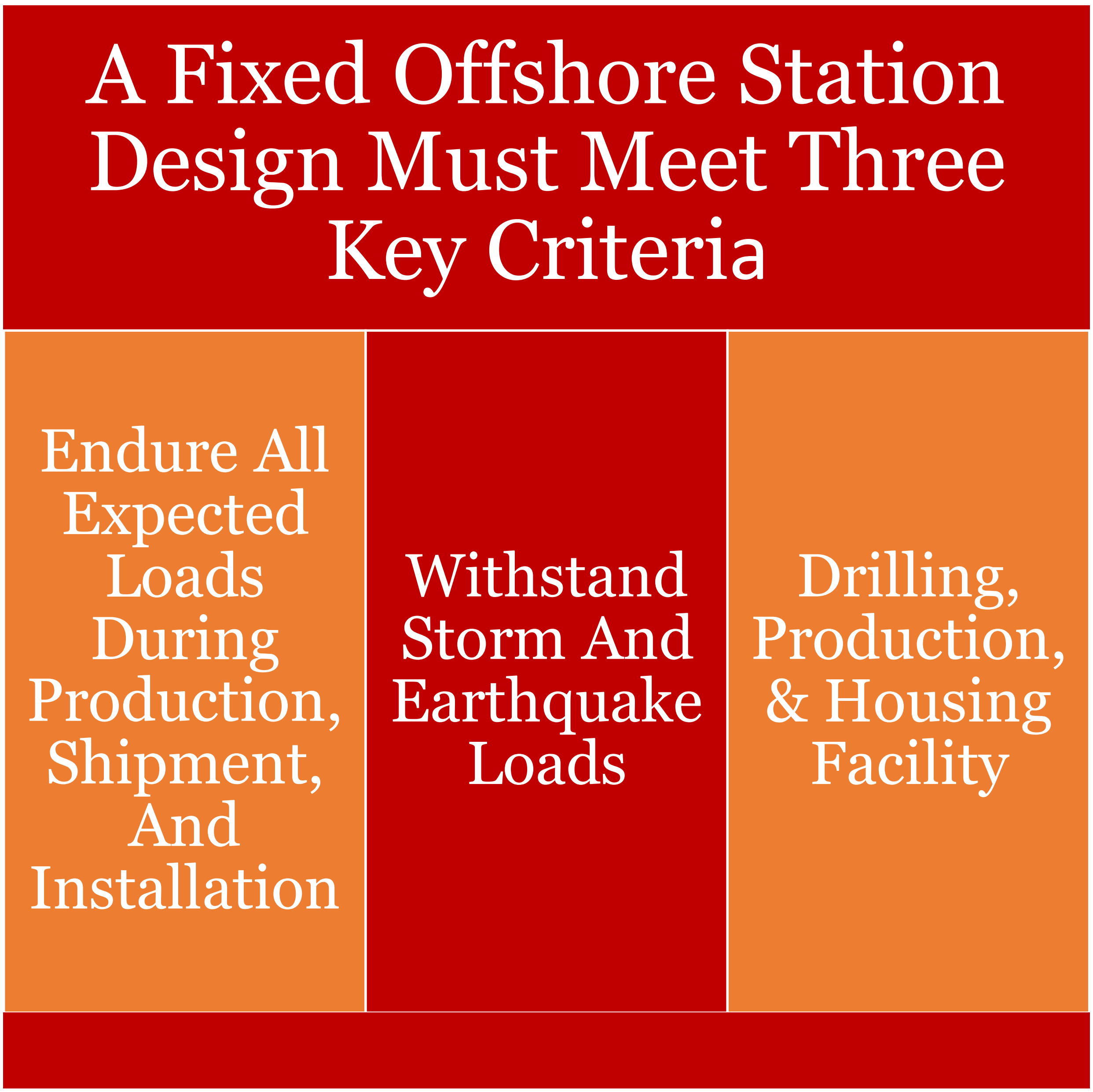

Figure 1. Three key criteria for offshore station design (Bhattacharya et al., 2006).

From 1909 to 1910, Louisiana dug wells. Timber derricks were raised on hastily built timber supports on woodpiles. Two main types of fixed platforms have evolved in the past 40 years: the concrete gravity type, built in the North Sea, and the steel template type, built in the Gulf of Mexico (GoM). Due to the need to dig deep water wells and build deepwater gas projects, the tension-leg platform was introduced as a third type. In 1976, Exxon built a 259-meter-deep platform in Santa Barbara. (850 ft.). The most widely used form of energy and liquid fuels is crude oil, and its use is likely to persist for decades (Dawood et al., 2013).

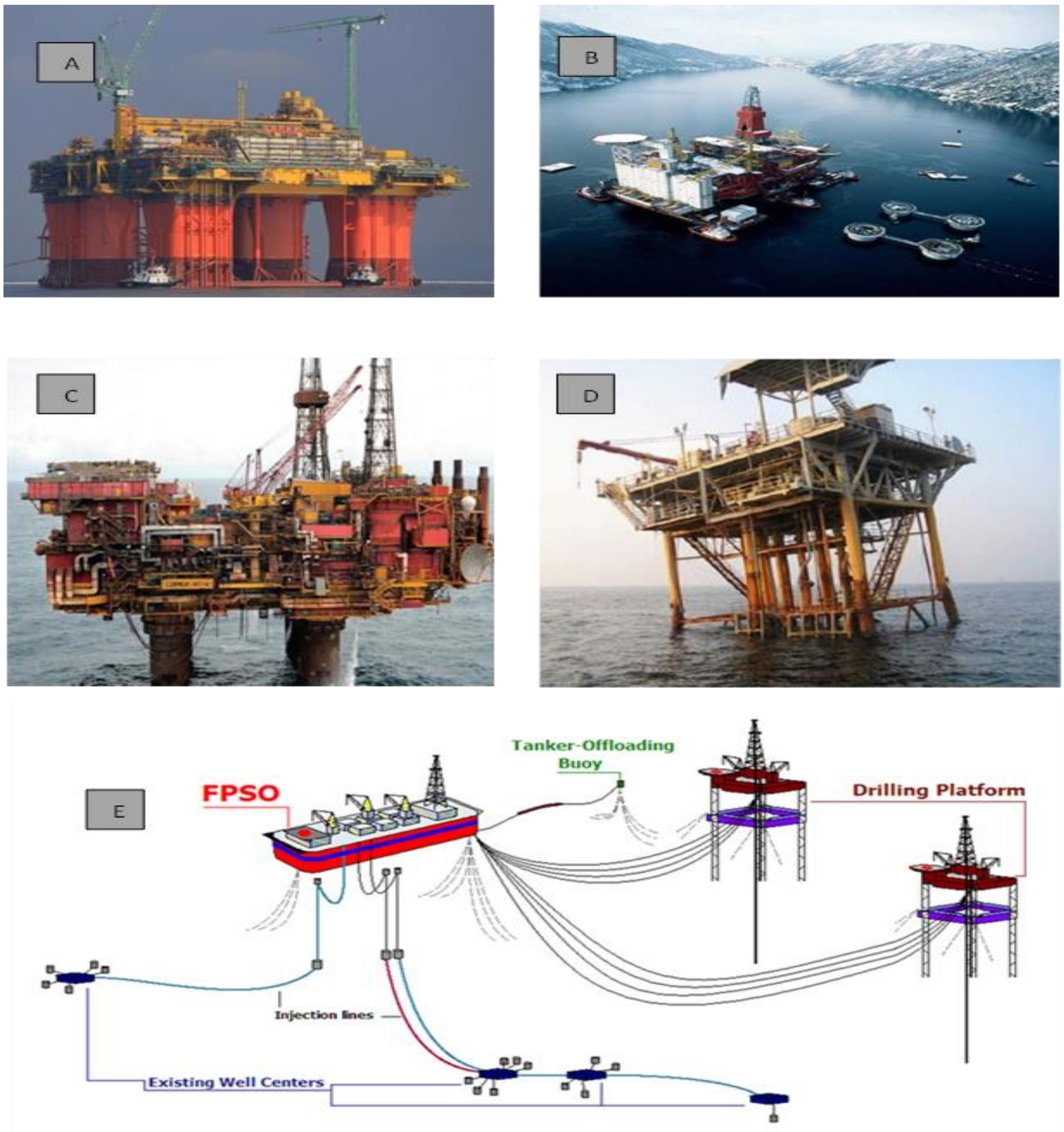

Figure 2. Offshore Structures. (A) Floating Production System; (B) Concrete Gravity Platform; (C) Complaint Tower; (D) Fixed Steel Template Structure; (E) Process of Floating, Production, Storage and Offloading (Dewangan et al., 2010).

About 1950, BP conducted similar studies in Abu Dhabi. Persian Gulf The activity has grown steadily in water less than 30 meters (100 feet). In the 1960s, GoM hurricanes damaged the station, forcing a redesign. Hurricane Hilda in 1964 destroyed 13 platforms with 13-meter waves and 89-meter-per-second winds. The following year, typhoon Betsy, a 100-year storm, injured several stations and destroyed three. Designers began planning for 100-year storm repeat periods instead of 25 and 50 years.

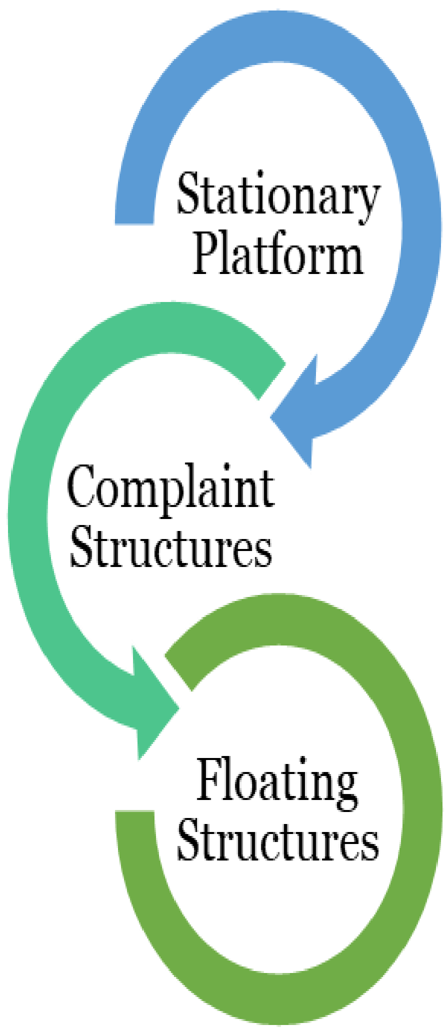

Figure 3. Types of Offshore Structures (Bhattacharya et al., 2006)

The region of the Indian Ocean, located to the northeast, is defined by the estuary of Bengal, the largest estuary in the globe. It is a triangular shape and is bordered on three sides by other countries: to the north by Bangladesh, to the east by Myanmar and the Andaman and Nicobar Islands, and to the west by India and Sri Lanka. The Bay of Bengal encompasses a total area of 2,172,000 km2 of land and water. To use a metaphor, the country of Bangladesh sits at the very tip of the Bay of Bengal (Maurin & Rangin, 2009). The nation's exclusive economic zone is 370 kilometers (200 nautical miles), while its territorial waterways are 12 nautical miles (22 kilometers). The land is reportedly subdivided into 26 separate sections, as stated by Petrobangla. The PSC district plan is presented in the following image. There are 11 parts from the coastal sea and 15 blocks from the deep sea. On the chart, far offshore is represented by a dark blue color, while shallow offshore is shown by a lighter blue color (Solomon, 2020).

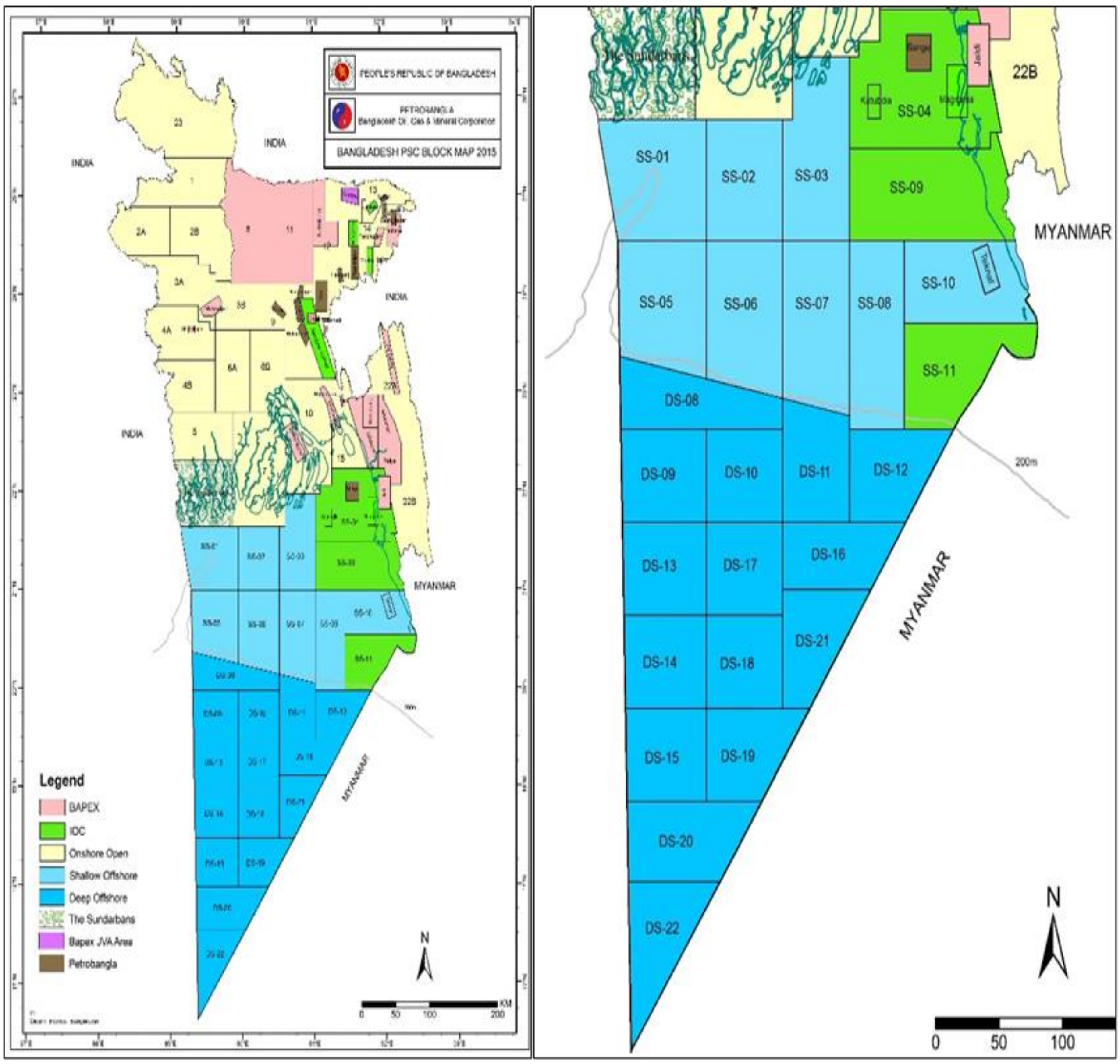

Figure 4. Shallow Offshore and Deep Offshore Blocks. Working Blocks (Shahjahan, et al., 2002).

Offshore Section Resources

Bangladesh produces the 15th most natural gas in Asia. Bangladesh's northeast, east, southeast, and south corridors yielded natural gas. Sangu is Bangladesh's only offshore gas field. Sylhet's Haripur contains natural oil, but the region's only oil well produces too little. Bangladesh is behind other nations in oil and gas research because the energy sector has yet to help the economy as much as expected. Bangladesh's oil and gas assets are hard to estimate due to a lack of exploration data and ocean digging. This paper summarises the Bay of Bengal and Bangladesh marine petroleum scenario. The Bengal Basin provides gas and a few liquid fuels (mainly condensates and light oil). In the Bengal Basin, Oligo-Miocene sediments are source rocks, and Miocene-Pliocene sediments are storage rocks. Most studies of the Bengal basin's parent rocks have focused on middle Miocene strata dug from depths greater than 4 kilometers (Ismail et al., 2014). The Surma Group unconformably overlies the Paleogene turbidites, and the submerged fan complex appears to have persisted into the upper deep water. Deep-marine facies connections of abundant petroleum deposits have gotten the least attention (Dasgupta, 2004).

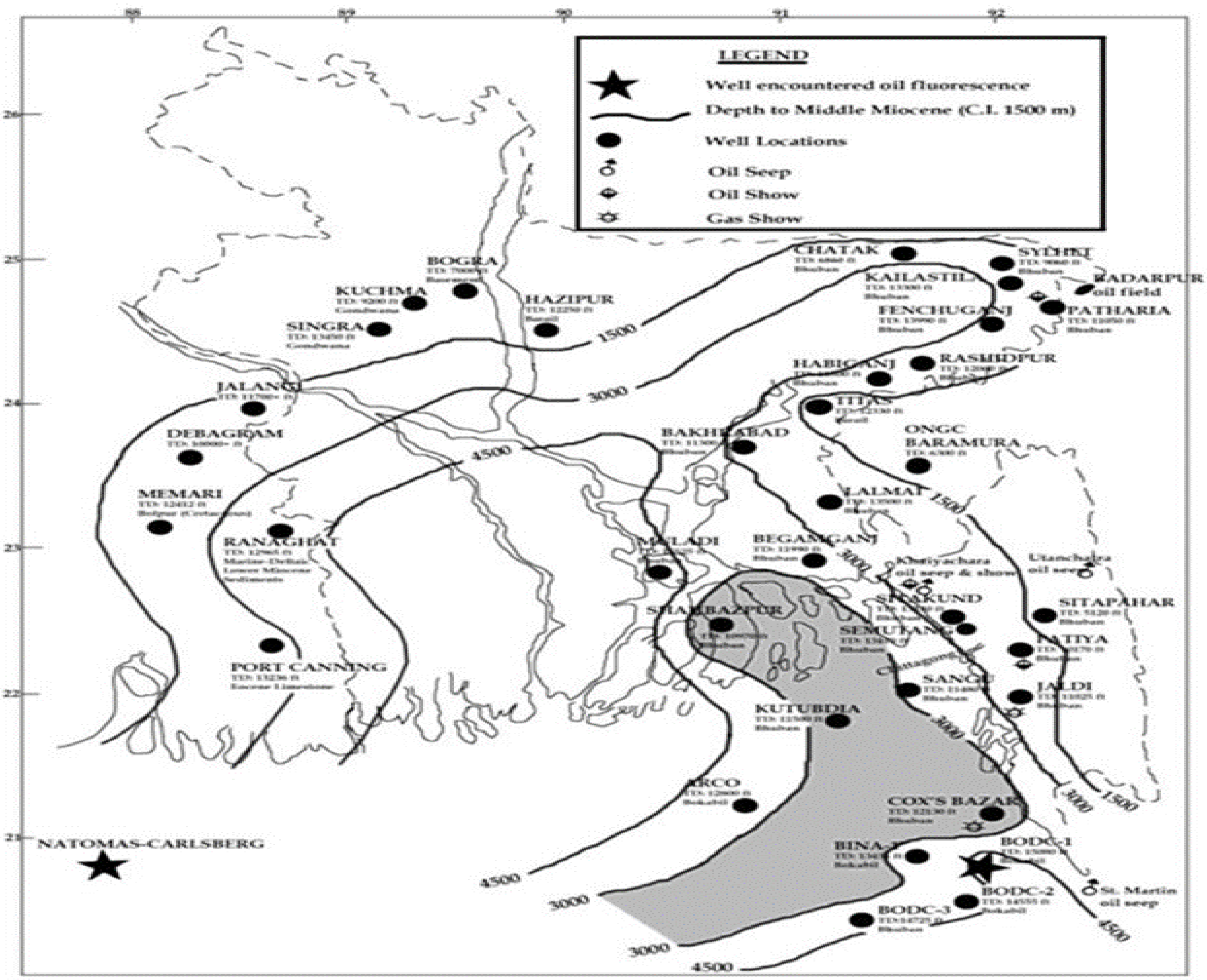

Figure 5. Hatia depression and the ocean area are depicted on a contour depth map, the mid-Miocene strata that lie within it serving as a petroleum reserve (Dasgupta, 2004).

The Bhuban Formation formed the offshore Bengal Basin Hatia Petroleum System. Beyond the Surma basin to the south and southeast, oil and condensate are isotopically denser (-24.5 to -26.6%) with negative canonical features, indicating marine or marine-influenced source rocks from type-II or type-II/III kerogen. The oil output window is between 5400 m and 10000 m because sands with low vitrinite absorption bury quickly. Methane carbon isotope rates indicate that Miocene and Pliocene pools contained old parent rock (Roybarman, 1987). A study of the source rock potential of chosen cores from the Muladi-1 well in Bangladesh found that extractable organic material linked to carbon content rises with depth in shale samples, suggesting age and source oil. Oil leaks at Hararganj, Sitakund, Utan Chatra, and the Patharia indicate that mature source rocks produced liquid petroleum during the oil production window. Except for the lower Miocene gas-prone source rocks, the horizons of the Oligocene, upper Eocene, and Paleocene show fair to excellent oil source potential, with an oil window maturity zone between 5000 m and 8000 m in the deeper basin. Geochemical and source rock palynological data from West Bengal, India, suggests that the mature source rocks of the Paleogene-Early Neogene series may be located at the Eocene slope break (Hasan & Qasim, 2017). Wet gas is more common in cores from the MND-2 well in the offshore Mahanadi basin below 3300 meters, while mature source rocks for oil are at 2500 meters (Basal Miocene). Due to its continuous fracturing and delta build-up, the Jenum Formation of the Oligocene Barail Group, the main source rock in Assam and the Surma basin is widely regarded as the offshore Bengal Basin source rock. Geologists believe Bengal Basin deposits are source rock and top rock. These sands aided hydrocarbon capture.

The ocean area has folded and inverted crustal segments. Find extremely high buildings (Saiful et al., 2011). Younger bending and reversal between paleode and neode formation fronts are usually minor and straightforward. Inversion zones may acquire tiny, hidden bends. Controlled faulting and structural closures are likely. Hydrocarbon migrates vertically through cracks and laterally up-dip over pale slopes, making the offshore Bengal Basin ideal for hydrocarbon capture at 4-6 km. Channels filled with mud and sand, channel sands, incised valleys where heavy channeling happened, and pro-delta clays that move up-dip to delta-front sand wedges are ideal petroleum traps (Greaves et al., 2017).

Table 1. Offshore Suitability Regarding Water Depth of the 26 blocks of Bay of Bengal (Ismail & Shamsuddin, 1991).

Blocks	Water depth	Area	Suitable platform
SS-01 to SS-08 SS-11	Up to approximate 200 m	Each have exploration area 4500 and 7700 sq. km.	Both concrete gravity and steel template platform
SS- 09, SS- 10	Up to approximate 200 m	Each have exploration area 4500 and 7700 sq. km.	Concrete Gravity
DS- 12, DS- 16, DS-21	Between 2000 to 2500 meters	Each have exploration area between 3200 and 3500 sq. km.	Larger TLP, SPAR platform, FPSO, Semi-submersible platform
DS- 08 to DS- 18	Between 2000 to 2500 meters	Not found	Larger TLP, SPAR platform, FPSO, Semi-submersible platform
DS-19	Between 2000 to 2500 meters	Approximate 11170 sq. km.	Larger TLP, SPAR platform, FPSO, Semi-submersible platform
DS-20	Between 2000 to 2500 meters	Approximate 12153 sq. km.	Larger TLP, SPAR platform, FPSO, Semi-submersible platform
DS-22	Between 2000 to 2500 meters	Approximate 12454 sq. km.	Larger TLP, SPAR platform, FPSO, Semi-submersible platform

The offshore Bengal Basin's Hatia Petroleum System began in the Bhuban Formation. Beyond the Surma basin to the south and southeast, oil and condensate are isotopically denser (-24.5 to -26.6%) with negative canonical features, indicating marine or marine-influenced source rocks made from type-II or type-II/III kerogen. Since layers with low vitrinite absorption bury quickly, the oil output window is expanded between 5400 m and 10000 m (Shahjahan et al., 2002). The parent rock in Miocene and Pliocene pools was old based on methane carbon isotope ratios. According to a study of the source rock potential of chosen cores from Bangladesh's Muladi-1 well, extractable organic material linked to carbon content rises with depth in shale samples, suggesting age and source oil [9]. The Patharia well's oil show and leaks at Hararganj, Sitakund, and Utan Chatra suggest that mature source rocks produced liquid petroleum during the oil production window. Except for the lower Miocene gas-prone source rocks, the horizons of the Oligocene, upper Eocene, and Paleocene show fair to excellent oil source potential, with an oil window maturity zone between 5000 m and 8000 m in the deeper basin. Geochemical and source rock palynological data from West Bengal, India, suggests that the mature source rocks of the Paleogene-Early Neogene series may be located on the Eocene slope break (Imam & Hussain, 2002). According to studies of cores retrieved from the MND-2 well in the offshore Mahanadi basin, wet gas is more common in samples below 3300 meters, while mature source rocks for oil are at 2500 meters (Basal Miocene). The Jenum Formation of the Oligocene Barail Group, the primary source rock in Assam and the Surma Basin is widely regarded as the source rock in the offshore Bengal Basin due to its continuous fracturing and delta build-up. According to geologists, the Bengal Basin may contain source rock and cap rock deposits. These layers may have helped trap hydrocarbons. In the distant area, crustal segments show unique bending and inversion patterns. High-rise buildings may be found. Younger bending and reversal between the paleode formation and neode formation fronts is simple and tiny (Islam, 2010). Inversion zones can produce tiny, hidden bends. Structural openings with managed faulting are likely. The offshore Bengal Basin has favourable hydrocarbon capture at depths of 4-6 km because hydrocarbon migrates vertically via cracks and laterally up-dip over paleoslopes. Channels, channel sands, cut valleys, and pro-delta clays that move up-dip to delta-front sand wedges are ideal geological traps for hydrocarbons (Lafond, 1957).

Methodology

This is an observational study that required a lot of time spent behind a computer and in a library. Review study focused on whether or not floating structures in the Bay of Bengal would be safe to inhabit. Literatures pertinent to marine buildings that need to be reviewed include printed materials (books, journals, and periodicals), internet journal articles, and symposium papers. (Google Scholar, web of knowledge).

Results and discussions

The term "petroleum resources" refers to the estimated quantities of hydrocarbons on and below the planet's surface. The potential for a resource to be recovered and sold is estimated in both resource assessments and resource evaluations, while the latter focuses mainly on the latter. Bangladesh's considerable hydrocarbon potential has been the subject of several resource evaluations and publications, either independently by different government agencies or in partnership with Petrobangla. Bangladesh is a good location for numerous active petroleum systems since its potential source rocks span from the Cretaceous to the Miocene, which is old enough to enable hydrocarbon accumulation in any competent conventional trap. This article shows the accessible resources and a good platform for extracting hydrocarbons. However, there needs to be more knowledge to make educated judgments now. Both coastal and deep sea areas are included in the 26 oceanic regions. Building choices can only be made with a degree of certainty once we have a better understanding of the sedimentary composition of the area. The offshore basin was sedimented twice: first in the Triassic, when the Sibumasu terrane moved from Gondwanaland and produced the West Burma block, and again in the early Tertiary, when India collided with Eurasia, constructing the Himalaya (Dyanati & HuangQ, 2014).

The continental shelf at the head of the Bay of Bengal is as much as 100 miles wide but narrows to the south. The features of the continental shelf in this region are as follows:

- A width of approximately 25 miles.
- An average slope of 0 degrees and 15 minutes.

- A depth at the outer edge of around 100 fathoms.

A unique feature is that the shelf can be divided into five zones. Each has its own set of slopes and sediments. A sixth zone comprises the upper part of the continental slope. Each zone runs nearly parallel with the shore. The average widths, slopes, and depths of those zones are given below:

Table 2. Continental Shelf Zone

Zone	Width(mi)	Slope (Degrees)	Depth(fms)	Depth of zone
Shore A-B	2	0 degree 26 minute	0-15	0m to 27m
B-C	11	0 degree 4 minute	15-35	27m to 64m
C-D	6	0 degree 11 minute	35-58	64m to 106m
D-E	2	0 degree 35 minute	58-70	106m to 128m
E-F	2	1 degree 9 minute	70-112	128m to 205m

There is a lot of Globigerina ooze in the sediments of the deep Bay of Bengal basin, which is one of the things that sets them apart. The continental slope yields dark gray samples with a bluish tint and a pliable, soft texture. Several blocks in the DS series are located in an area with deep water: DS-12, DS-16, DS-21, DS-19, DS-20, and DS-22. Hydrocarbon source rocks are characterized by a high maturity level within the oil generation window for deeper sediments, consistent with a marine environment of deposition. Sites in deep water are typically situated in regions with thick sediment deposits on the continental slopes that slope gently into the abyssal plains. In these regions, the average slope of the seafloor is relatively shallow (less than 4 degrees).

Using buoy-measured data from February 2013 to December 2015 off Gopalpur at a depth of 15 meters, this article describes the spectral wave characteristics of the nearshore waters of the northwest Bay of Bengal. The southwest monsoon is associated with increased wave heights and more extended wave periods, as indicated by the seasonal mean significant wave height and mean wave period. A year's worth of waves between 138 degrees and 228 degrees accounts for 74% of the variation in sea level, with those between 48 degrees and 138 degrees accounting for 16%. The monthly average wave parameters show substantial interannual variability due to the occurrence of tropical cyclones. On October 12, 2013, a significant peak wave height of 6.7 meters was recorded due to the effects of Tropical Storm Phailin. On October 12, 2014, a significant peak wave height of 5.84 meters was recorded due to the effects of Tropical Storm Hudhud, whose track was 250 kilometers southwest of the study location. The analysis showed that a single tropical cyclone affected the annual maximum significant wave height, while the annual average value was nearly identical (1 m) in both 2014 and 2015. Western Bay of Bengal waves are affected by cyclones, swells from the Southern Ocean, and the southwest and northeast monsoons (Maurin & Rangin, 2009).

Table 3. Platforms According to Water Depth

Platforms	Required water depth
Concrete Gravity Platform	within 200 m and best from 100 m to 150 m, can be suited up to 350 m
steel template structure	Up to 500 m
Complaint Structures	Normally 300 m to 600 m
Larger TLP	Successfully has reached 1250 m
Spar Platform	Presently used up to 1000 m though technology can extend up to 2500 m (Deep water platform)
FPSO	Up to 2600 m
Semi-submersible	1800 m

Conclusion

Hydration study has resurfaced among experts worldwide due to several reasons. It could become the next generation's pure energy norm. Hydrates are abundant worldwide. The upstream offshore oil and gas value chain includes drilling rigs, research and support ships, platform building, production, and extraction. Downstream work includes refining and selling goods. Our energy supply, primarily natural gas and a potential new oil sector at sea, rests mainly on fossil fuels, which can be dug and handled. Bangladesh still needs to assess its marine petroleum potential. Bangladesh has 26 TCF of gas, but only 1 TCF is offshore. Up to 2014, 19 exploratory wells were dug in the Bay of Bengal, but only two gas finds—the Sangu and the Kutubdia—had minimal amounts. Sangu's 0.8

TCF stocks are gone, but Kutubdia's 0.04 TCF are not. The Magnama (3.5 Tcf) and Hatia (1.0 Tcf) have been dug but have not yielded marketable petroleum. Bangladeshi areas near Myanmar's gas deposits may have similar natural traits and gas or oil prospects. Thus, subsea structures for harvesting deposits and developing current structures are essential. Water depth and deck tools determine which level is best. Fixed platforms of steel template and concrete gravity fit Blocks SS-01, SS-02, SS-03, SS-04, SS-05, SS-06, SS-07, SS-08, and SS-11, which have ocean depths up to 200 m and layers without rock zones. Since SS-09 and SS-10 are in a rock zone, concrete gravity is best. The deep-sea rocks' geological knowledge is limited to their 2000–2500 m ocean level. We cannot specify a platform for those pieces. We can only recommend deep-water platforms like bigger TLPs, SPAR, FPSOs, and semi-submersible platforms.

A well-planned approach for finding oil and gas areas and deposits is needed to perform a multi-line scan in the Bay using cutting-edge technology. Whoever drills last is likely to pull not only their fair share of gas and hydrocarbon reserves but also those from across the boundary, so any delay in exploration could negate the opportunity to harness hydrocarbon resources, especially those (if any) located on either side of the maritime boundary (India and Myanmar). Extensive digging and research are needed to increase gas output. Petroleum extraction will require public-private cooperation to share data, information, tracking, best practices, assessment methods, and results. In order to predict resources for future use, the government should build a hydrate-stable map of the nation in the Bay of Bengal area.

• Little research was conducted on the distant regions, so scarce information was available.
• Since underwater building is so novel, there are few tools to draw from.
• The marine islands of Bangladesh have never been surveyed. This means that no information regarding the area's bathymetric shape exists.
• Tides, currents, ocean temperature, and other aspects of that marine region were poorly understood.

Acknowledgment: None

Funding: No funding received

Conflict of Interest: The authors shows no conflict of interest

Data availability: N/A

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