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Land Reclamation: Its World-wide Status

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Abstract : On Earth three of four parts of surface is surrounded by water while there is only one part of land. Since ancient times people have been interested to be settled near coastal areas due to better weather and easy transportation to go to other countries. Again world population is increasing gradually while existing land is reducing due to rise in sea level. So to tackle the scarcity of land in coastal area, we need to create new land from the sea preserving the ecosystem in sea water.

Keywords: Coastal Area, Ecosystem, Filling, Artificial Land, Reclamation, Sea

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1. Introduction:

Despite the world having large areas of land, most are not available for human settlement due to extreme weather because these lands were either in very cold regions or in extremely hot and dry regions. When a city needs more space to build on or better defenses from coastal erosion, land reclamation can provide a solution. There are some areas such as hilly regions, which cannot be accessed easily due to weak communication. So, people always prefer the regions having good weather and easy transportation.

In this world most popular megacities such as New York, Tokyo, London, Sydney, Seoul, Manila, Yangon, Jakarta, Shanghai, Mumbai, Bangkok, Kolkata etc. has been set up near the sea shore or river since other countries can be linked easily through waterway of rivers, seas and oceans.

Again the global population has been increasing rapidly and is projected to reach 8.5 billion in 2030, and

to increase further to 9.7 billion in 2050 and 10.4 billion by 2100 [1]. Such populations demand broadening of land which can be utilized for agricultural, residential and industrial purposes as well as for constructing airports. Land reclamation is often used for the construction or expansion of ports, airports and residential, commercial complexes or agriculture. It can also be used for beach replenishment, shore and dune replacements and restoring islands. Reclamation is very much well known in Asia, Europe and Africa [2]. Reclaimed areas among the famous cities are mainly used for setting up airport, followed by residential/commercial and industrial purposes.

2. Methods and Materials:

Land reclamation is a technique of creating new land from the sea, desert or near desert.

The methods and materials used for land reclamation depend on the type of land, its intended use and other factors.

a. Sand Spreading: Sand is spread throughout the area to raise the land's level if the soil is soft or the seabed is shallow [3].

b. Filling with heavy rock and cement: Huge amounts of cement and big size rock is dumped to cover the lower region. After that the upper region is filled with earth and clay up to a prescribed height.

c. Hydraulic fill reclamation: Earth is dredged from a borrow area and pumped to the reclamation site. Here loose medium grained quartz sand is used as common fill material [3][4].

d. Poldering: Land is drained and surrounded by dikes to keep water out [5][6].

e. Draining submerged wetlands: Submerged wetlands are drained to reclaim land. This method is applied for agricultural purpose.

Land reclamation method is nothing but simply dumping the region by huge amounts of big rock with cement, thereafter filling with pebbles, soil, clay until the prescribed depth is achieved. Sometimes land is reclaimed from submerged wetlands by draining water for agricultural purposes. Hoover is utilized across a large area of the sea floor, pommeled to make along lasting base. Huge amounts of boulder, rock, sand, mud, brought from distant area, has been used in many engineering projects to set up offshore concrete walls. Hydraulic reclamation is a process, specially used to build airports, recreational sites, and to recover beaches, in which filling materials mixed with water are dumped in the reclamation site.

Significant land reclamation requires large volumes of fill material, such as sand, clay and rock. The two main methods of procuring the fill material, one is to dredge the material from the ocean/seafloor, or the harbor/bay bottom, the other main source of material is to import the material via upland location sites.

The preferred fill material needed to create a large land reclamation project would be sandy soils, and rock due to their near immediate consolidation. Clay is the least preferred fill material as it requires some type of geotechnical improvements to prevent future settlement issues prior to construction of upland structures including cargo yards. Sand can be found in abundance on sea/ocean floors, as well as harbor/bay bottoms at some depth. Poor quality sediments may sit atop the sandy soils, but with proper site selection they can be accessed easily with a hydraulic dredging operation. Sandy soil borrow pits are extremely common, but trucking, transportation, and placement costs compared to a large-scale dredging operation can be significantly more.

3. Development:

From Twelfth Dynasty (c.2000–1800 BC) [7] land reclamation scheme was introduced for agricultural use. Later it was started for residential and industrial use at those regions where dense population prevails and where there is lack of flat land. Many airports like Hong Kong international and Kansai International in Osaka are its example. Also, artificial islands in Dubai of UAE are The Palm Island, Burj al-Arab hotel, The World etc. The Flevopolder in the Netherlands is an artificial island, which is the largest in the world. Beach restoration is also an example of land reclamation, which is executed by rebuilding the eroded beach by filling materials. It defends the coastal regions. In Mumbai a coastal road was reclaimed along the beach.

Some popular countries with largest reclaimed land are discussed below.

I. China:

Since 1949, China has carried out extensive land reclamation projects. It is on top of the countries in the world, which has created a major part of the artificial island during 1949 to 1990s. The total reclaimed land from the sea has crossed 13000 sq. kms [8]. Since 2000, coastlines around the world have been broadened by more than 2500 sq. kms. This area includes the 350 sq. kms Shanghai city, which is the biggest in China.

Followings are some major reclamation projects in China.

a. The Xuanmen Land: Reclamation project of Xuanmen Land in Zhejiang province is the single largest in Yuhuan County, started in the year 1975. Among three phases of this project, 2nd phase enclosed 53.3 sq. kms of area during 1999 to 2001 and 3rd phase enclosed approx. 45.3 sq. kms during the period 2006 to 2010.

b. Nanhui New City: This project was executed by the Shanghai government to acquire 133.3 sq.

kms of reclaimed land from the sea from 2003 to 2006 [9].

c. Caofeidian Land: This started In March 2005 and reclaimed 310 sq. kms near the Tangshan Island.

d. Subi Reef: China has reclaimed 4.2 sq. km of land at Subi Reef in the sea of South China. It started reclaiming in 2014 and by the end of 2015 had transformed it into an island [10].

Other major land reclamation projects are Shantou, Jiangsu, The Southern Chinese city in Shenzhen, The Cotai area in Macau, Haikou Bay etc.

II. Netherlands:

The Netherlands has reclaimed land from the sea since the 12th century, and till now up to 20% of the country's land is reclaimed.

Much of the Netherlands is below sea level, meaning coastal protection and flood prevention measures are high on the national agenda. About 17% of the total land of the country has been reclaimed from the sea, marshes, lakes and swamps.

a. Beemster: This reclaimed polder in the Netherlands executed between 1609 and 1612 from a lake, where windmills were used to remove water. Total area reclaimed is about 72.07 sq. kms.

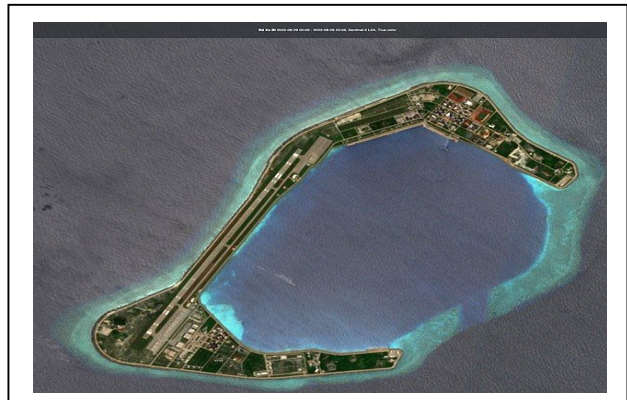
b. Haarlemmermeer: In the west Netherlands, this polder consists of 206.31 sq. kms artificial land recovered from water.

c. The Flevopolder: The Flevopolder is a largest island polder in the world forming the bulk of Flevoland. It was created from land reclamation having area 970 sq. km. In 1955, its northeastern part was depleted and the remainder i.e. the southwest part in 1968 [11].

Other reclaimed lands are Zuiderzee, Noordoostpolder etc.



Flevopolder, Netherland



Subi Reef (4.2 sq. kms), China

III. South Korea:

a. Saemangeum Seawall: South Korea's largest reclaimed land project is The Saemangeum Embankment Project. It started in 1991 and ended in 2006. As the longest embankment of the world, the project has a total embankment length of 33.9 km [12]. It reclaimed 400 sq. kms of land changing coastal tidelands, the main feeding areas for globally threatened birds into land for factories, golf courses and water treatment plants.

b. Seosan Reclamation Project: It was started in 1980 and ended in 1995. It was the first large-scale reclamation project of 154.09 sq. kms of land in South Korea.

c. Flood control Bank: 62.1 km bank was built to separate the Agricultural Science Site and Saemangeum Lake.

IV. United States:

In the United States, the most extensive reclamation activities are mainly related to irrigation. Major reclamation projects are Animas-La Plata Water, Boise, Boulder Canyon, Central Arizona, Central Valley, Columbia Basin, Gila, Huntly [13] and many more.

V. Bahrain:

Bahrain has been reclaiming land since the 1960s from the sea to create new islands and the process has continued to expand its territory for many years. Its land area has grown from 670 sq. kms in 1963 to over 777 sq. kms in 2021, making it slightly larger than Singapore.

Some of the major land reclamation projects include Al Madina Al Shamaliya, Diyar Al Muharraq, Durrat Al Bahrain [14] etc.

VI. Japan:

The third largest shut-off bay is the Tokyo Bay in Japan having 1380 sq. kms area. Almost 250 sq. kms of land from the Tokyo Bay was reclaimed till 2012, which is approximately 0.15 times the area of the original bay [15]. Other projects are-

a. The Hibiya Inlet: In 1592, This project, started in Tokyo was the first large-scale reclaimed site. Entry of this site is situated near famous area Shinbashi.

b. Dejima: In 1634, a man-made island was built in Nagasaki. During isolation period in Japan, it

was constructed.

c. Odaiba: The Tokyo city was saved from the tidal flow of the sea by some island forts built in Tokyo Bay. Land from the planed hills inTakanawa was used to build the forts.

Osaka Bay, Kobe City, Nagasaki Airport, Matsugaoka are other examples of reclaimed areas.

VII. United Arab Emirates:

The UAE's residential coastline is set to expand significantly as land is reclaimed to build islands for thousands for new waterfront homes and keep peace for people demanding luxury property. Between 2000 and 2021, The UAE reclaimed 119 sq. kms of land whereas 68 sq. kms of land, which is above 70% of the total reclaimed area in UAE, was reclaimed in Dubai. Abu Dhabi reclaimed 35 sq. kms [16].

The following are some notable land reclamation projects in UAE.

a. The Palm Jumeirah, Dubai: This project, looks like a giant palm tree spreading into the Persian Gulf, is world famous reclaimed site having 5.6 sq. kms area, bounded by an 11 km breakwater. It is clearly seeable from space and its own monorail is a special attraction totake the tourist around the man-made island group.

Construction of the Palm Jumeirah in United

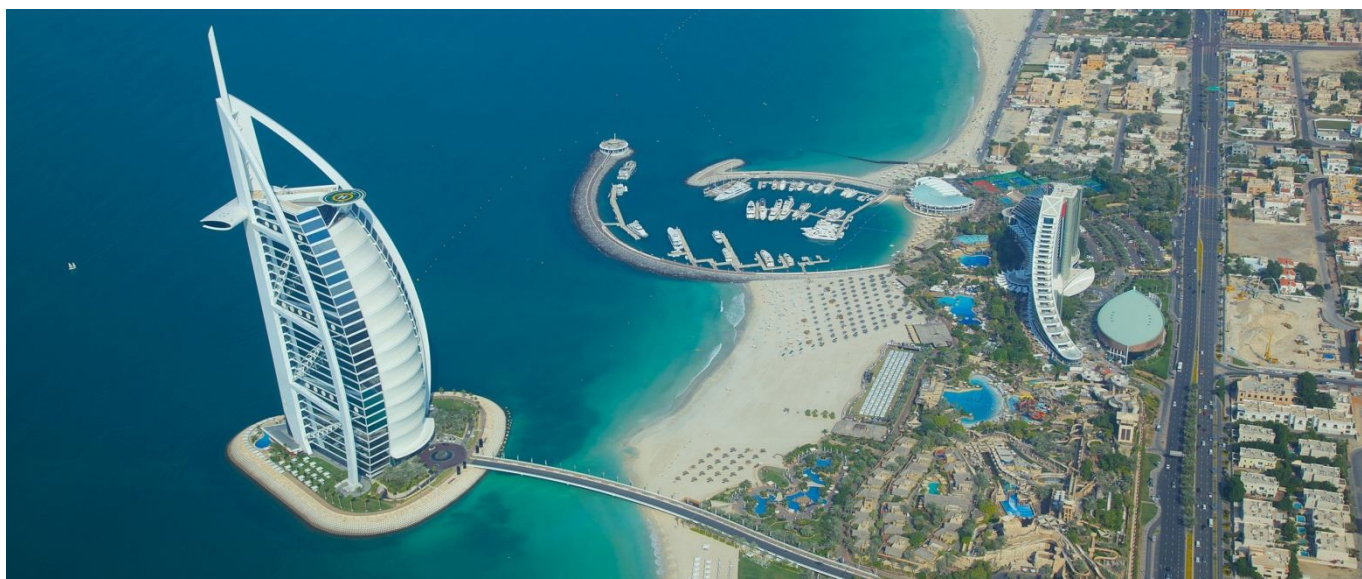


Palm Jumeirah, Dubai, United Arab Emirates,
photographed from the International Space Station, 2005.

Arab Emirates started in 2001. Buildings began in 2006, and the first residents arrived in 2007. More than 10,000 people lived in Palm Jumeirah in the second decade of the 21st century.

b. The World: Islands consisting of 300 islands, located in the water of Persian Gulf, off the coast of Dubai and formed in the shape of a world map. The whole area covers 6 by 9 kms and is bounded by an oval. Other offshore projects in Dubai are Palm Jebel Ali and Palm Deira. These are much larger than Palm Jumeirah but remain unfinished.

Other popular projects in UAE are The Dubai Marina, The Burj Al Arab, Al Reem Island, Yas Island, Al Lulu Island, Al Marjan Island, The Universe Islands and Port Rashid. Burj Al Arab luxury hotel in UAE and its neighbour the Palm Jumeriah.



Burj Al Arab luxury hotel in the United Arab Emirates and its neighbour the Palm Jumeirah

VIII. Singapore:

Singapore is well known for its land reclamation efforts to increase its usable land area. The country has used land reclamation to expand its size by almost 25% since 1960. It has expanded by a fifth over the decades from 581.5 sq. kms to 725.7 sq. kms between 1960 and 2019. The country aims to reach 766 sq. kms of landmass by 2030. Popular projects are-

a. East Coast: It added 15.25 sq. km of land along the island's southeastern coast. This is used now as habitats, business and a beach.

b. Marina Bay: Real estate businessmen in Singapore started focusing on creating waterfront projects by reclaiming land from sea in 1969 and was ended in the 2000s. The Marina Bay is a reclaimed project of 3.6 sq. kms area.

IX. Maldives:

The Maldives is one of the countries, most vulnerable to sea-level rise. The government in the island nation is adopting a strategy called 'land reclamation' to keep the country thriving. In December 2023, Maldives President Mohamed Muizzu had officially inaugurated 'Ras Male'[17][18], marking the commencement of the nation's most extensive land reclamation project ever undertaken. In March, 2024 he had announced the Felidhoo island's land reclamation project. On 11th April, 2024 he announced a reclamation project encompassing 0.3 sq. kms of land on L. Maavah island.

X. Nigeria:

Eko Atlantic City in Lagos having 10 sq. kms area combines coastal protection and city expansion,

mainly used for commercial and residential purpose. It provides housing for 250000 people. It has an 8.5 sq. kms long sea wall, dubbed the Great Wall of Lagos, protecting Nigeria's capital from sea levels and coastal erosion.

Many countries like Bangladesh, Hongkong, Australia, New Zealand, Qatar, Philippines, Macao, South Africa, Sri Lanka, India have also started many projects to create new land.

4. Challenges

Construction of an artificial island from sea is quite expensive and risky undertaking. The process of land reclamation could destroy coral reefs, seagrass, meadows, and natural barriers such as sand bars, mangroves and estuaries and marine habitats [21]. It can also harm the fishing and tourist industries. The effects of the projects under water are matter of concern. During dredging some particles of the silt, floating on the water, is dangerous to the underwater life since it can suffocate the corals, hampering the adequate supply of oxygen.

Due to high susceptibility to soil liquefaction, earthquake can intensify the amount of damage of the buildings and infrastructures on the reclaimed land. The research estimates that near about one fourth of the recent reclamation lands are potentially exposed to extreme sea level rise by 2100 and this threat to life is a big challenge to sustainable development at the coastal region.

Day by day sea level is rising and storm activity has increased. So creating new islands may be a risky undertaking. Still people are taking risk to create land for a sea view with blue water and to avoid the disturbance of traffic jam, noise, pollution from factory etc.

Some negatives sides of land reclamation on marine ecosystem in coastal areas include loss of biodiversity, disturbing the natural water flow, changing the shoreline mobility, disturbing habitat. This also removes the feeding and breeding areas for marine life, which has direct impact on fisheries.

5. Ongoing Projects

On 18th December, 2023 land reclamation of 11.53 sq. kms from Fushidhiggaru Lagoon [19] was started by the government of Maldives. It was a part of the Rasmale' Project. In its latest update on November, 2024, Maldives Transport and Contracting Company (MTCC) informed that 70% of the Thaa Kinbidhoo project was completed and total 0.25 sq. kms artificial land will be attached to the original land.

Construction of Ocean Flower Island in Hainan, China began in 2013 and was expected to be completed by 2022. But it is not yet completed. Macau International Airport in China will be expanded by 1.3 sq. kms as a reclaimed project.

Expansion of Lerwick Port Authority is a project to be reclaimed by 4 sq. kms in Scottish Shetland Islands. A large project of land reclamation, named Lantau Tomorrow Vision, is running to set up artificial islands of 18 sq. kms off the coast of Lantau Island.

In 2024, a plan was made by Jakarta which is in danger as quickest drowning city in the world, to handle the rising sea levels. It is named as The Great Garuda, started to construct 17 artificial islands, covering 12.5 sq. kms away from the north coast of the island. But only four was completed and other islands was rejected due to pollution.

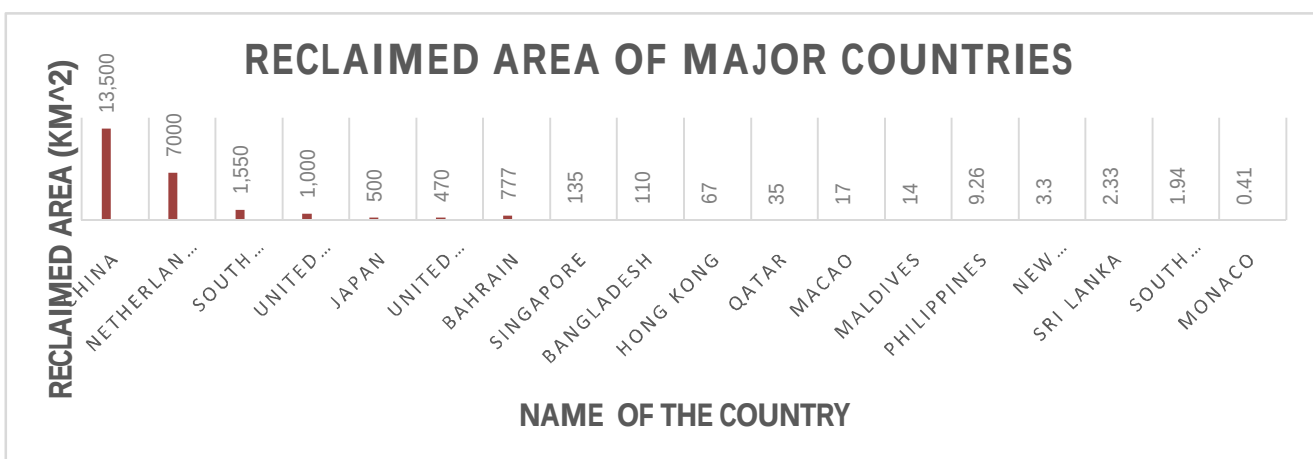
6. Proposed Projects

Singapore announced on 28th Nov' 2023 potential plans for a project on its east coast which would reclaim around 8 sq. kms of land - the size of over 1,000 football fields. A reclaimed project named Long Island [20] has been taken away from the East Coast for technical studies.



(Graphic: CNA/Rafa Estrada)

There have been proposals to reclaim land from the sea in Ajman, UAE. The expansion project of Macau International Airport, inaugurated by a ceremony on 22nd November, 2024, will add 1.3 sq. kms area.



Bar graph showing comparison of reclaimed Land among different countries

7. Conclusion

Artificial land creation is necessary due to increasing population in the world. Also Some countries like Maldives, Netherlands, Japan etc. as well as large number of cities in different countries are at high risk due to rising sea level. Most of the parts in Maldives are one meter above the sea level. But these countries need new lands. So, it is a challenging task to construct new land preserving the eco-system.

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