Case study on land reclamation around the world - A Review

MUKESH PRAJAPAT[1], ADITYA RAJ[2], ASHISH KUMAR[3], MIHIR LAL[4]

[1] Final Year Student of B.tech Civil Engineering, Lovely Professional University, phagwara, Punjab (INDIA)

Email- mukeshkumarfarrod@gmail.com

[2] Final Year Student of B.tech Civil Engineering, Lovely Professional University, Phagwara, Punjab (INDIA)

Email- raj824027@gmail.com

[3] Final Year Student of B.tech Civil Engineering, Lovely Professional University, Phagwara, Punjab (INDIA)

Email- bittujhajharia1530@gmail.com

[4] Assistant Professor, School of Civil Engineering, Lovely Professional University, Phagwara, Punjab (INDIA)

Email- mihir.15800@lpu.co.in

Abstract: This review paper proposes about Land reclamation which is the idea of getting new land by filling process. It is usually done in coastal areas to enhance human resources. It is also done in areas like rivers, oceans and lakes. Usually, there is a natural process which fills such areas with sand, dirt and other materials. Land reclamation uses the same process of land filling, which is sped up. In some of the cases, this is done using dikes. In this paper the review of some case studies on land reclaimed in whole world.

Land reclamation from the sea has been occurring since ancient times, especially in harbors. Most of the the world's docks now occupy spaces that were once water and this heavily influences the coastal landscape. Japan has been one of the country's most needing to expand into the sea due to its topography and land requirements for agriculture, urbanization and, especially, industries and port facilities. Ninety per cent of Tokyo Bay's coastline is reclaimed land, which is almost 250 km2 of new land. In the 21st century, this disproportionate conquest of the sea has shifted to other countries. In the Persian Gulf, the coast has been indiscriminately occupied with artificial island projects for residential purposes. Some of them are finding some difficulties, such as “The Palms” and “The World” in Dubai, with a loss of sand, which is effect of currents and waves.

In China, due to economic expansion and export needs, industrial areas are spreading on the coast. Caofeidian (Bohai Bay) is the largest landfill island in the world with 150 km2, more than twice the sum of Dubai islands area. This disproportion of public works in Asia contrasts with the rest of the world. For example, the Bay of Algeciras (Spain-UK) is the largest container traffic Port in the Mediterranean with 2.5 km2 of reclaimed land, 100 times less than Tokyo Bay. A further problem associated with this practice is liquefaction, caused mainly by earthquakes, leading to ground subsidence in buildings, such as in Niigata (1964) or in San Francisco (1989), all on reclaimed land. This research paper aims to study land reclamation in the World with current statistics, geotechnical problems, the impact on the coastal landscape and future developments.

1. Introduction:

Land reclamation, the process of improving lands to make them suitable for a more intensive use. Reclamation efforts may be concerned with the improvement of rainfall-deficient areas by irrigation, the removal of detrimental constituents from salty or alkali lands, the diking and draining of tidal marshes, the smoothing and revegetation of strip-mine spoil areas, and similar activities.

Land reclamation is a specific technologic way to maintain favorable conditions of lands, natural resource that is critical for agriculture Land reclamation implies radical change of lands in the result of set of measures. Among various land reclamation forms, irrigation and drainage are the most common Land clearance operations (brushwood clearing, leveling of mole hills, etc.), chemical reclamation (liming and gypsum of soils), silvicultural reclamation, stabilization of loose sands, water and wind erosion control, etc. Land reclamation contributes to the maintenance and improvement of soil fertility, growth of crop capacity, rise of farming sustainability, mitigation of the effect of climate and weather fluctuations on production capacity. The scale of land reclamation expands; however, at the current stage the main focus is on enhancing its efficiency.

Three key land reclamation objectives are discerned as follows:

1.Improvement of the lands that are under adverse water regime conditions manifested in either excess moisture or its shortage as compared to the quantity that is deemed sufficient for efficient use of the area for economic purposes.

2.Improvement of the lands that are under adverse physical and chemical properties of soil (heavy clay and muddy soils, saline, with higher acidity, etc.

3.Improvement of the lands that are liable to damaging physical impacts, ex. water and wind erosion consisting in the formation of ravines, development of landslides, soil scattering, and so on.

Depending on a concrete purpose, different types of reclamation are employed.

The reclamation oriented to remove excessive moisture from an area is called drainage reclamation. It is used, in addition to agriculture, in public utility, industrial, and road construction, peat extraction, when carrying out curative measures on swamp areas (wetlands), and other land development activities.

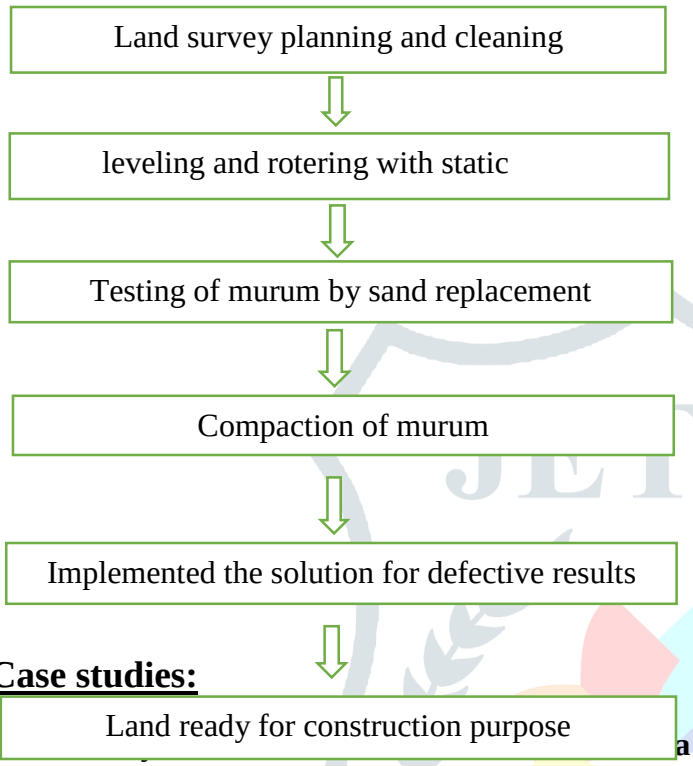
The reclamation intended to eliminate water shortage in the soil of agricultural fields is referred to as irrigation. Reclamation of lands with adverse physical properties is aimed at improving soil aeration, as well as increasing its porosity and permeability. To this effect, proper crop rotation practice is introduced, sand is applied to muddy soil, and mole drainage is performed which contributes to air and water permeability of deep soil layers. Reclamation of lands with adverse chemical properties consists in removing harmful salts by leaching, lowering soil acidity by applying lime, raising soil nutrient-supplying power by distributing fertilizers, and introduction of proper crop rotation with higher ratio of grass. Reclamation of lands liable to water and wind erosion generally includes the measures aimed at reducing the quantity and lowering the rate of running down surface water, raising soil resistivity to erosion and dispersion. These measures based on using a wide set of reafforesting, agrotechnical, and hydrotechnical means. in current conditions, in the majority of the areas subject to reclamation works, usually not one but several of the above-considered reclamation types are carried out depending on a combination of natural and economic conditions. For example, forest belts are planted, crop rotation is introduced on irrigated fields, fertilizers are applied, and leaching of saline land plots, etc. is carried out simultaneously with irrigation of the territory. All this, especially at large scale of reclamation construction in our country, makes land reclamation one of the major anthropogenic factors of transformation of nature as a whole and hydrological regime in particular Land reclamation is performed with the view of improving soil productivity and keeping viable farming, as well as ensuring guaranteed agricultural production based on maintaining and improving land fertility, as well as creating necessary conditions for drawing of unused and low-yield lands into agricultural production, formation of rational pattern of lands, integrated forest management, and conservation, reproduction, and efficient use of natural resources.

2. Methodology:

- Reclamation of arid land.
- Reclamation of salt-affected soils.
- Reclamation of swampy lands.

- Reclamation of coastal areas.
- Reclamation of mine spoils.
- Reclamation of eroded, infertile, and "new" lands.

2.1 Flowchart:



3. Case studies:

3.1 a

In this case of land reclaimed near mumbra station for new track construction which is located 400m away from mumbra railway station in Thane district and the nearby region of track has Cody or raw water which is constructed by INDIAN RAILWAYS (Mumbai urban transport project-MUTP) under D THAKKAR construction pvt. ltd. So to overcome this condition, as solution adopted for new construction is land reclamation or land filling. The objective of this project between Thane-Diva is expected to segregate the mail/express with the suburban traffic between LTT and Kalyan and increase the frequency of trains along central railway. In this project with the help of various senior engineers, site engineers and other officers we gathered all information (from the date of initiation) of reclaimed land by railway corporations. The major effort of this investigation is to know the various methods and tests carried out for land filling with its need for improving techniques.

3.2 The West Coast of Peninsular Malaysia

Seyedeh Belin Tavakoly Sany, ... Rosli Hashim, in World Seas: An Environmental Evaluation (Second Edition), 2019

Land reclamation for development activities (infrastructure, industrial, recreation, and tourism) often results an adverse impact on mudflats, mangroves, and fish stocks in WCPM. Land reclamation off Prai in Penang and Kuala Juru for industrial purposes has threatened cockle farming because of high levels of heavy metals and sedimentation. Mercury level in water has been found to be 2.30 ppm in these areas, which is 460 times higher than the permissible level in the United States. Based on the latest reports, 76 coastline reclamation projects covering 97,000 ha along the west coast of Malaysia, particularly large ones in Penang, Kedah, Perak, and Selangor, mean that there is an urgent need to assess the impact of land reclamation on the coastal and marine environment (Yusoff et al., 2006).

Keywords:

Peninsular Malaysia Natural environment Climate change Human activities Aquatic resources Management regimes

3.3 The Gulf of Mannar Marine Biosphere Reserve, Southern India

Nochyil S. Magesh, Subbiah Krishnakumar, in World Seas: An Environmental Evaluation (Second Edition), 2019

Land reclamation threatens the coastal habitats. Most of these coastal lands are used for dumping municipal waste, disposal of sewage, and for the construction of ports and fish landing centers. These activities are observed especially in the Tuticorin area, which is a fast growing industrial hub. The Tuticorin Port has changed the coastal configuration, thus modifying the oceanographic parameters, which has led to erosion. The Pandiyan and Punnaiyadi Islands were destroyed to construct Tuticorin Port. Its further expansion recently might have worsened the situation due to destruction of mangroves, tidal flats, and coastal sand dunes. Similar problems from land reclamation are noted in the construction of a new port in Kanyakumari (Enayam Port), where shoreline modifications are already seen. A few small-scale land reclamation works have also occurred for the construction of recreational centres, roads, hotels, and parks. The conversion of coastal land into saltpans may also disturb the coastal habitats by increasing the land salinity. More scientific studies on the effects of land reclamation may help to understand the effects of such activities on coastal erosion and change in physicochemical properties of soil and water.

Keywords:

South India reefsGulf of MannarPalk Bay plastic pollution Resource use.

3.4 Coastal Landform Changes: Coastal Erosion, Land Accretion and Subsidence

Bimal Kanti Paul, Harun Rashid, in Climatic Hazards in Coastal Bangladesh, 2017

Land reclamation by cross-dam construction started in coastal Bangladesh in 1957, with a 9.3-mile (14 km) cross-dam being built in the eastern branch of the Meghna River for the purpose of reclaiming land for agriculture. Cross-dams are closure structures between islands and the mainland, which are meant to accelerate the natural accretion process. A second 10.7-mile (16 km) cross-dam was built in 1964 in the same river branch, after two earlier unsuccessful attempts (World Bank, 2012). Although very slow, the natural process of accretion is giving rise to new chars (bars or islands) along major portions of the 475-mile (710 km) long Bangladesh coast. As noted, 2.4 billion tons of sediment passes to the Bay of Bengal each year through the Meghna estuary. Holding of the passing sediments will give rise to about 77 mi2 (200 km2) of land each year.

Realizing the huge potential for land reclamation, the Bangladesh Government has been pursuing a number of projects in the coastal areas of Bangladesh since 1977 to address the problems of coastal floods, tidal surges, and erosion and accretion of coastal areas. Land Reclamation Project (LRP), Meghna Estuary Studies (MES), Coastal Embankment Rehabilitation Project (CERP), Delta Development Project (DDP), Char Development and Settlement Projects (CDSP), Integrated Coastal Zone Management Project (ICZMP), and Estuary Development Program (EDP) are some of the coastal initiatives undertaken by the government (Alam and Uddin, 2013).

Keywords:

Climate Coastal landform Deposition Erosion Sea level rise Sediments.

3.5 Singapore: Threats to Sustainable Use of Resources

Loke M. Chou, ... Karenne Tun, in World Seas: An Environmental Evaluation (Second Edition), 2019

Land reclamation and coastal development pose a significant threat to Singapore's marine resources and these activities have been linked to the loss of live coral cover since the 1960s (Chou, 2016). Plans to reclaim more coastal shorelines and the merging of adjacent islands in the next decade have raised concerns that the coral reef would be at risk of further

habitat destruction. It is anticipated that more shorelines will be replaced by seawalls to adapt to sea-level rise and to reduce coastal erosion.

Apart from the impact of elevated sea surface temperature, another emerging threat includes the increasing frequency of harmful algal blooms. In 2014, 160 tons of farmed fish in the Johor Strait were killed by an algal bloom. Mass death of wild fish was also observed and resulted in shifts in community structure (Ng et al., 2017).

Keywords:

Singapore Artificial substrates Corals Mangroves Aquaculture.

3.6 Integrated Coastal and Estuarine Management in South and Southeast Asia

R. Ramesh, ... R. Purvaja, in Treatise on Estuarine and Coastal Science, 2011

Land reclamation which increased Singapore's land area by 17% has buried much of Singapore's coasts. Tan et al. (2007) reported that most of the natural sandy shores have been lost to reclamation (Tan et al., 2007). Construction of reservoirs by damming rivers and draining wetlands has also badly affected the habitats near river mouths and on intertidal shores. These have reduced coastal ecosystems drastically. Mangrove forest cover has been reduced from an estimated 13% in the 1820's to only 0.5% of the total land area. Many of the original 60 offshore islands and patch reefs around Singapore have been reclaimed. Some were merged into larger islands. Since 1986, most coral reefs in Singapore have lost up to 65% of their live coral cover.

The massive changes to the shoreline of Singapore means than many of the coastal areas are no longer complete ecosystems. The original habitats are fragmented and separated from one another. Animals at the top of the food chain have long since disappeared affecting the balance in the remaining habitats. High level of coastal activity (shipping, dredging, and continued reclamation and coastal construction) also contributes to sedimentation of coastal waters. Sediment in the water reduces the light penetration into the water, affecting photosynthesis by seagrasses and other plants, as well as corals that rely on their symbiotic algae for products of photosynthesis. As pointed by Tan et al. (2007), "Conservation of marine habitats still lags behind somewhat compared to the efforts on land, although this is not from want of trying. We have yet to establish a Marine Protected Area despite many attempts to do so. The main reason is that the southern shores, where most of the best reefs are located, are also the hub of our important shipping activities and our growing port facilities, Singapore being the world's busiest port." Singapore has undergone an almost complete transformation through land reclamation, construction of sea and airports and other structures, amalgamation of small islands into larger ones, removal of coastal vegetation and coral reefs, and the heavy use of coastal waters for port operations. The debate whether or not EIAs should remain discretionary or be made mandatory not just for projects that have high pollution potential, but also for those that may result in damage to ecologically sensitive areas, suggests that there is a growing concern on the part of an increasingly better-educated population that are environmentally aware (Chia, 1998).

3.7 Land Disturbance and Reclamation after Mining

In Environmental Impacts of Coal Mining & Utilization, 1987

3.7.1 Framework of Land Reclamation Requirements

In recent years many countries have developed and adopted laws, national programmers and specific policies for environmental protection. The basis of most laws applicable to the mining industry and its effect on land seeks to control land management, protect resources and regulate land reclamation and landscape restoration. Although these laws are often specific to activities of the mining industry, they constitute an integral part of national efforts to optimize living conditions for man. The costs involved in environmental improvement are borne, in the first place, by those responsible for the mining activity. There is no doubt that legal provisions of this kind contribute to rises in production costs.

The Constitution of the USSR provides that land and its resources are owned by the Soviet society. Since the national economy is planned, the country has all prerequisites for genuinely integrated and rational use of natural resources. Article 18 of the Constitution emphasizes the importance of natural resource protection in the interests of present and future generations.

All land reclaiming activity in the country is controlled by a series of legal Acts. The fundamentals of land reclamation are decreed in Fundamentals of Land Legislation, the land codes of the Union Republics and other legislation. For example, Article II of the Fundamentals of Land Legislation makes it mandatory to reclaim the lands allocated for surface and underground mining of minerals; to bring disturbed cultivable lands and forests into a usable state; to do everything possible to restore agricultural land to a usable state in parallel with the production process, and if this is impossible to do, carry out the necessary reclamation no later than a year after production has been completed; to remove and store fertile soil layers in any work which involves soil disturbance so that it can be reused during reclamation.

An increasing concentration of disturbed land in mining areas of the USSR has made the problem of land reclamation the most important long-term program of the nation in the field of natural resource management. The Special Degree of the Council of Ministers of the Soviet Union of 2 June 1976–On the Reclamation of Lands, Preservation and Rational Use of Fertile Soil Layers in Mining Materials and Peat, Exploration Surveys, Construction and Other Works—provides that the reclamation of the areas where minerals have been already extracted shall be funded by the state from special allocations, and industries with active mines shall reclaim disturbed lands at their own expense, all the costs involved being covered from production costs. The research institutes of the Ministry of Agriculture of the USSR are assigned the task of developing reclamation programs. State control of the program's implementation is exercised through local authorities and land management offices.

This logical sequence of laws and codes of practice in the field of land reclamation envisages a high rate of recovery of disturbed lands and during the ninth 5-year plan by 1975, the areas of reclaimed lands increased two and a half times compared with 1971. The proportion of the lands returned to agriculture increased considerably. For the Ukraine and Steppe region of the RSFSR it reached 70–75%. This high rate of reclamation is a result of setting up special land reclamation divisions within coal production associations. Within the Ministry of Coal Industry there is a division for the protection of nature with its own research institute. The institute conducts comprehensive studies on problems related to reclamation of land disturbed by coal mining.

3.7.2 in the German Democratic Republic (GDR), land reclamation was first officially endorsed in 1951 in the law on the Restoration of Economic Value of Territory Occupied by the Mining Industry, Including Waste Storage. At the present time various codes of practice in the GDR strictly define the rights and obligations of production units whose activity causes land disturbance. Legislation determines the procedures to be followed if damage to former users occurs, including the procedure for reimbursement of losses by farmers' co-operatives when the disturbed area is greater than 20 % (Motorina and Zabelina, 1968)**.**

3.7.3 In Czechoslovakia (CSSR), laws concerning the use of natural resources (1957), protection of land resources (1976), forest law (1977) and building code (1976), the obligations of industrial establishments in relation to soil, landscaping, water regimes and other subjects are specified. Legislation requires long-term plans for the reclamation of lands in the large industrial areas of the country. For example, the master plan for the restoration of the North Czech brown coal area contained detailed maps and calculations of the total land-use up to 1980. Projects provide for parks and green zones around industrial establishments. The costs involved in reclamation activity in the CSSR are borne by the mining industry**.**

3.7.4 In Poland, planned reclamation started in 1961 when the Economic Committee of the Council of Ministers made it mandatory, by a special decree for the Ministry of Mining Industry and Power, to reclaim disturbed lands. Further, a considerable effect on land reclamation activity was produced by the 1966 Act of the Council of Ministers and the 1971 Law on the Conservation of Agricultural and Forestry land and its Recultivation. This legislation made land reclamation obligatory during mining operations, specified necessary procedures, and dealt with legal and financial considerations. Reclamation work is carried out by the coal producers as a cost to them**.**

3.7.5 Land reclamation is legislated for in Bulgaria, Hungary, Romania and Yugoslavia. Although there are differences in organization and management, a number of common principles can be discerned:

- land reclamation activity is included in national plans and constitutes a part of natural resource management.

- objectives and methods of reclamation must be determined at the design stage of the mine; mining plans must incorporate land reclamation as an integral part of production processes.
- before reclamation plans are drawn up a comprehensive study is carried out.

3.7.6 In the United States of America the National Environmental Policy Act of 1969 covers a wide area of national policy in relation to environmental problems. The Act requires the preparation of a document to be used by the federal authorities in their decision process for all major federal actions that significantly affect the environment. The federal authorities must take into account:

- the environmental impact of the proposed action.
- any adverse environmental effects which cannot be avoided should the proposal be implemented.
- alternatives to the proposed action.
- the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.
- any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Such a document is required wherever federal action is involved in the mining process, either direct or indirect (for example, the federal licensing of a related activity).

Until 1977, individual states in the USA exercised primary jurisdiction over the restoration of mined lands. State legislation usually authorized a state agency to issue permits to mines on receipt of details on the mine site, mining and reclamation plans, and a bond or other security to cover the restoration.

Surface and mineral rights are owned separately and diversified ownership among private individuals, the federal government and the state governments exists. Until 1976 it had been the policy of the federal government to allow the individual states to act for it where federally owned coal was being mined, but this was changed by the 1977 federal Surface Mining Control and Reclamation Act. This created overall regulations for coal mine reclamation and established minimum reclamation performance standards. The standards include restoration to the approximate original contour, segregation and replacement of topsoil, establishment of vegetation comparable to pre-mining conditions, and protection from adverse hydrological effects. Operators must take responsibility for successful revegetation for 5 years after seeding (for 10 years where mean annual precipitation is less than 66 cm).

Thus, since 1977, reclamation of surface-mined land for coal is initially the responsibility of the Office of Surface Mining within the US Department of the Interior, but individual states are allowed to take this over where they develop state programmers that comply with the procedures in the Surface Mining Act and enforce permanent standards at least as stringent as the federal ones. If state programmers are not developed, they have no regulatory authority over the reclamation of coal-mined land. The Surface Mining Act placed a levy per ton on all coal produced in the USA. This fund can be used to finance the restoration of areas that were not reclaimed in the past and other action needed to alleviate off-site impacts of the unreclaimed areas.

From 1981 a new consideration has been given to the Surface Mining Control and Reclamation Act. Without amending the Act, it is intended that the rules should be streamlined to reduce federal involvement in the Act's enforcement and increase the discretion of state authorities in interpreting the law according to regional conditions. It will probably result in a reduction in site inspection by the federal agencies and remove certain specific requirements such as those relating to the grading of coal haulage roads and the method of treating mining water runoff. Regulations relating to the planting density of forest trees on reclaimed forest land may also be relaxed in the light of local conditions.

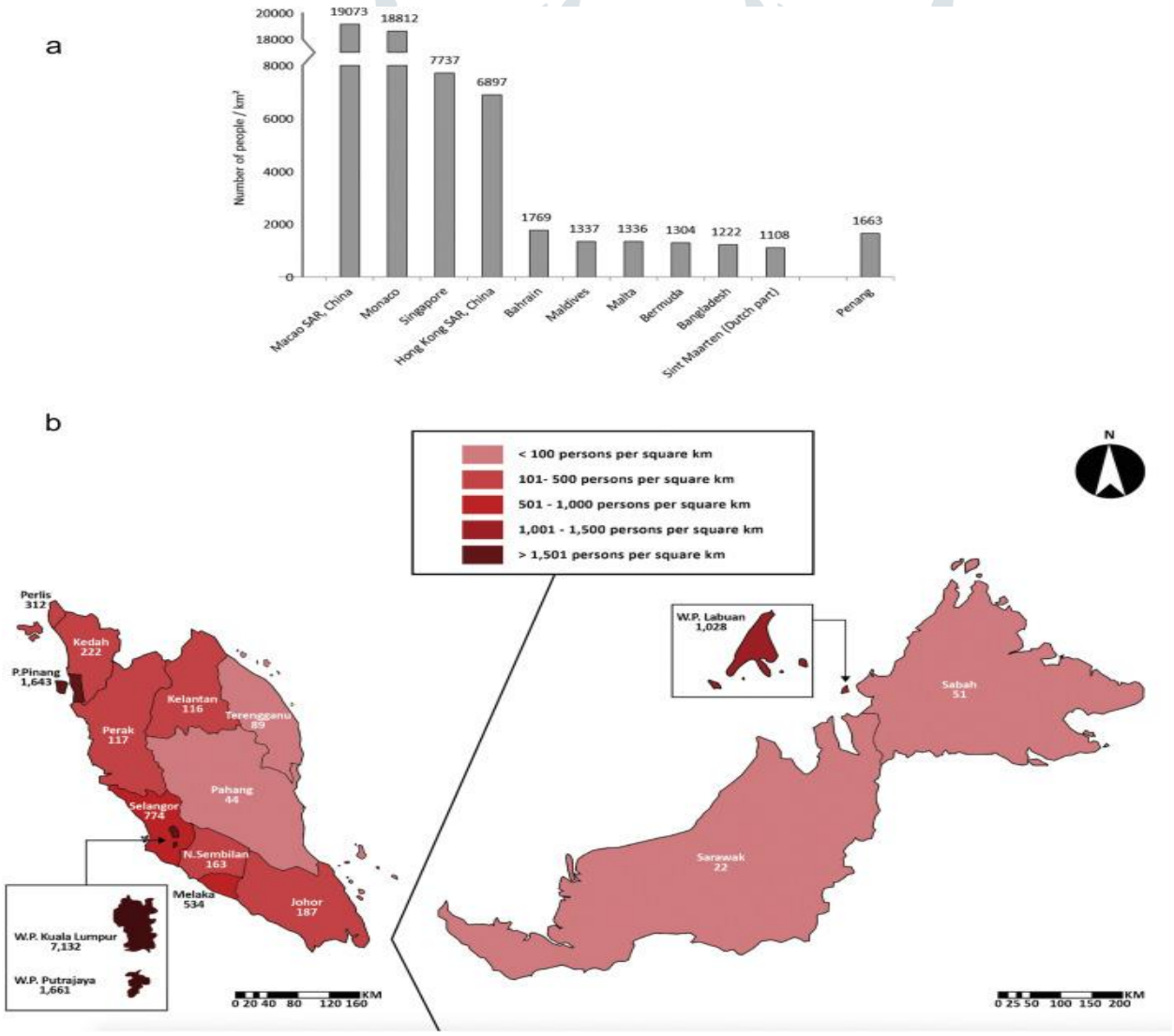
3.7.7 In the Federal Republic of Germany considerable preplanning of reclamation has occurred as coal mining has impinged on areas of intensive agriculture. As early as 1920, a law established an association to deal with regional planning in the Ruhr. The Regional Planning Act of 1962 made this body responsible for a development plan which includes refuse disposal planning and land utilization policy. Open space and amenity areas must be secured, often by the renewal of derelict areas. The location of tips is determined, suggestions for combining waste materials are made and landscaping plans and planting schemes approved. This provides integrated planning control for land restoration.

3.7.8 In the Rhenish brown coal district of the Federal Republic of Germany a soft brown coal has been mined by surface methods since the 1950s. An integrated plan defines the limits of mining, the location of industry, agriculture and forestry and the reclamation schedule. This operational plan is approved by the Land parliament.

3.7.9 In the United Kingdom local government has had powers to acquire derelict land for restoration since 1944 (Town and Country Planning Act) and in 1951 the Mineral Workings Act provided for a fund for financing the restoration of land made derelict by surface mining by stripping. Various Acts made provision to meet the high cost of land restoration by making grants available. These have ranged from 50% to the total cost in special development, development, intermediate and derelict land clearance areas. Since 1974, as a result of an amendment to the Town and Country Planning General Development Order 1973, a county planning authority may require the National Coal Board to submit a scheme aimed at ensuring that waste material from deep mines is tipped in such a way as to facilitate subsequent landscaping and restoration to improve visual amenity. Strip-mining land restoration has been developed extremely successfully by the Opencast Executive of the National Coal Board.

3.7.10 In the People's Republic of China the Standing Committee of the Fifth National People's Congress approved the Environmental Protection Law in 1979 for trial implementation. In 1982 the Ministry of Urban and Rural Construction and Environment Protection was created which implements and supervises the carrying out of the national guidelines, policies, laws and acts relating to environmental protection. Land protection figures prominently in many of the articles of the law (Geping and Lee, 1984).

4. Chart:



5. Conclusion:

Abandoned mine land reclamation is a serious issue across the world. Increasingly, there has been an effort devoted to resolve, or minimize, the "environmental liabilities" of these sites. Abandoned mine land reclamation should be a phased process adapted to the conditions of each site. The methods and techniques applied in each case should depend on the objectives defined for the reclamation and should be based on a strategy designed to addressed both the diagnosed degradation and the intended end use of the site.

In a holistic approach, degraded mine reclamation may range from not excessively difficult to extraordinarily complex. Thus, in some cases (e.g., small mines) it may be acceptable to allow a regeneration process by spontaneous ecological colonization, taking advantage of the regional species pool and the biodiversity hosting capacity of the mine site. However, conducting effective environmental reclamation of a mine, treating the contaminated materials and observing the aptitudes of the site, is a more complex process that requires the participation of several scientific disciplines engineering (for the long-term geotechnical stability of mine site components and for reliable construction of covers and vegetation cap, etc.); physics (surface and groundwaters flow, air movement including fugitive dusting, etc.); chemistry (AMD generation, metal leaching, soil, water and air contamination, etc.); and biology and landscaping (vegetation and biosphere establishment, etc.). Therefore, the long-term success of a mine site reclamation requires a true multidisciplinary approach, with collaboration between geologists, hydrologists, chemists, biologists, soil scientists, agronomists, landscapers, engineers, economists, etc.

6. References:

1. Seyedeh Belin Tavakoly Sany, ... Rosli Hashim, in World Seas: An Environmental Evaluation (Second Edition), 2019
2. Nochyil S. Magesh, Subbiah Krishnakumar, in World Seas: An Environmental Evaluation (Second Edition), 2019
3. Bimal Kanti Paul, Harun Rashid, in Climatic Hazards in Coastal Bangladesh, 2017
4. Loke M. Chou, ... Karenne Tun, in World Seas: An Environmental Evaluation (Second Edition), 2019
5. R. Ramesh, ... R. Purvaja, in Treatise on Estuarine and Coastal Science, 2011
6. J.L. Stauber, ... S. Apte, in Marine Ecotoxicology, 2016
7. Paulo J.C. Favas, ... Majeti N.V. Prasad, in Bio-Geotechnologies for Mine Site Rehabilitation, 2018
8. Environmental Impacts of Coal Mining & Utilization A Complete Revision of Environmental Implications of Expanded Coal Utilization. Edited by: M.J. CHADWICK, N.H. HIGHTON and N. LINDMAN.