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DEVELOPMENT OF REHABILITATION TECHNIQUES TO RECLAIM TIN-MINED LANDS FOR LOW-COST HOUSING IN MALAYSIA

by

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CHAPTER ONE

INTRODUCTION

Problem Synopsis

Since the discovery of tin ore along the alluvial beds of Larut district in 1874, tin mining has been one of the major mining operations in Malaysia. In fact, the early economic development of Malaysia was based almost entirely on the developments of its tin mining industry (Gungwu,1974). However, the expansion of the tin industry has been solely focused on economic gains with little attention to the effects of the mining operations on the land and environment. Most of the mined lands were severely disturbed and usually left abandoned for nature to restore back to their "natural" state.

During the last twenty years, Malaysia entered into the transitional phase of development. This occurs when rapid economic growth creates urban expansion especially along the west coast of the nation. The economic opportunities in the urban areas resulted in intense urban-migration from the rural population. As a result, the land in the urban areas became scarce and was considered a limited asset to the nation. Therefore, there seems to be a need for the government to understand and develop the program of land conservation and rehabilitation. This is especially true for the tin mined lands. It is estimated that there are about 520,000 acres of tin mined lands in Malaysia which are undeveloped (Kitching,1982). Thus there is a real need for a rehabilitation program to reclaim the tin mined lands for public uses, particularly housing development.

Statement of Problem

Like most developing countries, urban-migration has been one of the most serious socio-economic problems faced by Malaysia. Modernization and the search for a better standard of living have attracted more and more Malaysians to the urban areas. This phenomenon has led to an increase in the demand for housing, employment opportunities and recreational facilities. It is estimated that about 337,000 housing units are required in the urban centers during the 1981-85 period (Department of Statistics, Malaysia, 1983). The government has developed low-cost housing to accommodate the poor, but still the supply is far less than the demand. Thus, the rural immigrants concentrated in the slum areas and squatted illegally around the cities. By the latest count about a third of the population of Kuala Lumpur (the capitol) and a quarter of the population of Ipoh (third largest town in Malaysia) are "squatters". As a result of these social demands, land has become a significant asset within the urban areas. With the social demands on the rise and land as a limited resource, planners will soon be forced to develop comprehensive land conservation and rehabilitation programs. Tin mined lands should be included in the rehabilitation program because most of the undeveloped sites within the urban areas are mined over lands.

In the past, with lack of understanding of land use planning and little concern among the miners for the future usage of the mined lands, little or no reclamation work has been carried out. The mined lands have been left abandoned with hopes that nature would restore the devastated landforms years later. It was not until recently that rehabilitation programs for mined-over lands, especially those close to the urban areas, were considered to be of significance. Experimentation and actual projects for future land use have been carried out with about an equal amount of success and failure. Financially it would be very expensive, in most cases, to carry out such a project unlesa proper planning procedures and practices were first taken into consideration. It is the purpose of this study to look into potential planning procedures and practices in rehabilitation of tin mined lands.

This study focuses on the development of low-cost housing on tin mined lands near the urban areas in Malaysia. This type of development will lessen the problem of housing shortage in the urban areas. It will also provide an appropriate solution to land use on rehabilitated tin mined lands. However, proper planning is needed for such a development to be successful.

Objectives

The primary objectives of this study are as follows:

1. To study the existing site conditions of tin mined lands in Malaysia.
2. To identify appropriate types of housing development on tin-mined lands near urban areas.
3. To develop the planning procedures and practices for rehabilitating tin-mined lands for low-cost housing development.

Scope of Study

This study will deal with the development of rehabilitation techniques to reclaim tin mined lands for low-cost housing in Malaysia.

This study will not deal with:

* political, and cultural factors that can influence the housing development
* financial and marketing factors of housing
* aspect of obtaining land for housing development
* variables other than those in the criteria for selection of study sites

The major concerns of this study will be:

* to study the site conditions of tin mined lands
* to study the socio-economic factors of the squatters in the urban areas
* to develop the site improvement methods for tin-mined lands
* to determine the foundation work for proposed housing
* to develop a site development plan for the study sites

Methodology

I. Literature Search

A. To determine the history and role of the tin industry to the socio-economic conditions of Malaysia.

B. To understand the administrative system of the tin industry.

C. To understand the mining operations and the disturbance that the operations have done to the land and environment.

D. To investigate the current rehabilitation practices on tin-mined lands.

E. To determine the condition and need of housing in Malaysia.

II. Site Selection

A study site is needed in order to develop a rehabilitation program for housing development on the tin-mined land. The study site should have the following characteristics:

A. Proximity to an urban area which has a high demand for housing.

B. Undeveloped and mined by the major mining methods.

C. Accessible to the urban population.

III. Data Collection - Site Visit

A. Documentation of socio-economic factors of the low-income population of the study site.

B. Gathering of information on site characteristics:

- inventorying the study site
- refering from research reports and maps
- interviewing with authorized personnel

IV. Analysis of Data

The data is analyzed through basic landscape architecture suitability processes:

A. Suitability matrix

B. Overlay technique

C. Composite overlay

V. Synthesis

Development of a land use schematic map that shows the relationship and locations of the land use areas on the study site.

VI. Implementation

The planning and designing of the land use areas in the study site involved the following developments:

A. Site Development Map

B. Reclamation Process

VII. Conclusions and Recommendations

A. The overall findings and usefulness of the study.

B. The changes in the regulations and practices of tin industry that will facilitate the rehabilitation practices.

C. Suggestions for future research.

CHAPTER TWO: LITERATURE REVIEW

Section One

HISTORY AND ROLE OF THE TIN INDUSTRY IN MALAYSIA

Tin industry has played an important role in the development and growth of Malaysia. In fact, the existence and prosperity of many towns in Malaysia was a result of the presence of tin in their vicinity. Tin is one of the major exports of Malaysia since the establishment of the British rule in 1874. This chapter explains the historical background and the role of the industry in the economical growth of Malaysia. Later, the properties and usage of tin will be discussed to illustrate the importance of tin as a metallic element.

Historical Background

A. Early Development of Tin Industry

The development of the tin industry in Malaysia flourished in the nineteenth century with the establishment of the British rule in 1874 (Wong, 1965). The discovery of rich tin deposits in the Klang Valley in Selangor and Kinta Valley in Perak led to the rapid development of the industry in the nineteenth century. It was Malaysia's wealth in tin that caused the British to bring in Chinese immigrants to work in the mines. Panning was the only method at that time. Basically, this method is similar to gold panning and is carried out by individual workers. The miner used an 18 inch diameter wooden pan and separated the tin ore from the soil by swirling the pan in water. This was a laborious method which employed many workers. By the end of nineteenth century, Malaysia became the largest exporter of tin in the world, with an output of 53,000 tons per year (Mohdzain, 1981).

During the early twentieth century there were some significant changes in mining techniques. Western technologists developed the dredging and gravel pumping techniques which can mine large amounts of tin ore using few workers. Dredging was a large-scale operation in tin mining and these mines were primarily owned by European mining companies. Gravel pumping was a smaller mining operation and operated mostly by Chinese miners. Both techniques resulted in a tremendous increases in the production of the tin ores. However, in early 1930's there was a slump in the world tin industry. This was caused partly by a temporary decline in demand due to the Great Depression and by vastly increased world production during the late 1920's. In Malaysia the increased production had come chiefly from European-owned mines. As a result the average tin price in 1931 fell to one-third its level in the boom year of 1926 (Gungwu, 1964). Further decline in the tin price was prevented by drastic export control among the principal producers in the world in the form of the International Tin Agreement in 1931. An artificial tin price was thus maintained until the outbreak of the Second World War.

B. Post War Developments

After the Second World War, there was a rapid growth in the tin industry. This growth was partly the result of financial assistance offered by the Malaysian government for rehabilitation of the mines. Many mines were destroyed during the Japanese occupation between 1942 and 1945. The progress of the industry was also the result of the high tin price which culminated during the Korean War of 1951-1952 (Gungwu, 1964). The average tin price was twice that of 1946 and nearly three times that of 1939 (Wong, 1965).

An important influence on the post-war tin market has been the United States' strategic stockpiling policy. The United States, which has no tin resources of its own, began stockpiling tin for strategic purposes in 1939 but continued with the policy even after the War. After 1956, the United States substantially reduced its purchase of tin. But even before that, it had become clear that the high post-war tin price was only temporary. As soon as the United States had achieved its stockpile target a world tin surplus similar to that of 1930's would emerge. Consequently in 1956, the International Tin Agreement was revived in an attempt to artificially maintain the high tin price through export control. The Malaysian tin industry was affected by the export control and the production of tin fell about 40 per cent, employment fell more than one-third and about 40 per cent of the mines were put out of operation (Gungwu, 1964).

At present, the production of tin in Malaysia is expected to decline because of a shortage of reserves and a marked decline in the grade of ore mined. In 1983, the demand for tin from most of the leading tin consuming countries, namely Japan, European Economics Community countries and the United States, reached its peak. Although the decline of tin production has had some impact on the Malaysian economy, tin still plays an important role in the current economy. At the end of 1982, tin and tin concentrates were the fifth major export of Malaysia and accounted for M$1,484 million dollars (Ministry of Labor, 1982). .

Properties and Uaage of Tin

Tin is a soft, silver-white, metallic element which has the lowest melting point among the major metals. It is also extremely malleable and ductile, shows unusual resistance to corrosion and fatigue, and ia non-toxic (Mohdzain, 1982). Tin alloys readily with many other metals and has a low coefficent of friction. In addition, tin has been used in many chemical compounds.

Manufacture of tinplate represents the single largest use of tin metal, with most of the plate being used to produce food and beverage containers - the ubiquitous tin can. In 1980, 71,700 tons of tin, composing 40.9 percent of that year's world conaumption of primarly tin metal, were used in the manufacture of tinplate (Baldwin, 1983). The second largest use of tin is in aolder, accounting for 25 per cent of world output of tin metal in recent years. Solder is commomly used for jointing, especially in electrical components. About five per cent of the total usage of tin is in the production of bronze. Bronze is produced by the combination of copper and tin and is used for casting statues, bella and pieces of artillery.

Some minor uses of tin are in (1) tinning of electrical wires, (2) polyvinyl plastics , and (3) tin organic chemicals and other minor chemical products for industrial fungicides and disinfectants. Among the uses of tin in its pure form are the making of organ pipes and pewter. Pewter is used for manufacture of a wide range of household utensils and wine measures.

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Section Two

ADMINISTRATION OF TIN INDUSTRY IN MALAYSIA

Government policies and actions are among the important factors influencing the structure of the tin mining industry in Malaysia. It is necessary to understand the administration system of the tin industry because the system influences the progress of rehabilitation practices on the mined lands. It is the intent of this section to discuss the administrative system of the tin mining industry in Malaysia. This discussion will include the governing of the industry by governmental agencies in the administration, leasehold and taxation systems.

Levels of Administration

Mining in Malaysia is conducted in eight states and in the Federal Territory of Kuala Lumpur. Federal and state laws are applied in these nine jurisdictions creating a considerable complexity in the legal conditions (Zen, 1982).

At the federal level, there are two main agencies directly involved in the administration of the tin industry. The Federal Ministry of Primary Industries is the highest authority. In addition to monitoring the interest of the industry as a whole, the Ministry also has the power to regulate the mining operations. Regulation is done by the Mines Department of the Ministry. The task of this department is to check the safety of working conditions at the mines. The Department is empowered by the Mining Enactment (F.M.S. Cap.147) 1934 which is presently the only law that governa the mining operations. The Ministry of Primary Industries is aware that its powers over the mining industry are very limited by the constraints of laws and constitution (Zen, 1982). Most of its efforts in changing the mining code are opposed by the state governments. This is because the state governments do not want to lose the privileges permitted in the old enactment. In actuality, the Federal Ministry authority seems powerless to implement solutions to mining problems. The Ministry's officers can only advise the directors of the State's Mines Department as to action that should be taken.

There are several Federal Ministries that have indirect links with mining operations in the country. The Ministry of Land and Regional Development (MLRD) seems to be most involved. This Ministry is solely responsible for the control of all regional development. The state government can be made to surrender a considerable amount of its power so as not to hamper the regional authorities within the development regions. One of the positive steps taken by this ministry in land use planning is to identify the tin-bearing areas. The law requires that all economic mineral deposits be extracted before the land is developed for other uses (Zen, 1982). But there are no regulations as to what should be done after the land haa been mined. Although the MLRD has the authority to effect amendments to the National Land Code, the State governments could still choose to ignore the amendments when they feel that their interests are adversely affected. The National Land Code (Act 56 of 1965) is based upon the Malay custom that the ultimate owner of all land is the Sultan (King) of the state. Persons might use the land, but they pay the Sultan for the right to do so and the Sultan holds the eventual reversionary interest. This means that the Sultan can, if he wishes, revoke the right to use land for any reason.

At the state level, the agencies that have the most direct influence on the tin industry are the State Executive Committee and the Land and Mines Department. The former is actually a cabinet of the political power at the state level. These committee members advise the Sultan on mining matters, especially mining leases. Many of the decisions made by the Sultan do not agree with the advice of the environmental experts from the Ministry of Science, Technology and Environment. The task of this Federal agency is to assure that the mining activities follow the conditions in the Environmental Quality Act of 1974. This situation usually results in a tremendous number of environmental hazards (See Environmental Impact of Tin Mining, Section Three).

The State's Land and Mines Department has the most wide-ranging power in the mining industry. The inspectors of the department are empowered to suspend the mining operations if the miners are found in violation of the lease regulations. The department can also impose additional regulations while the actual mining work is in progress and could stop the mining operation if the regulations are not followed. The department can increase or decrease the lease fees, and filling and levelling bond if the lease is to be renewed.

Leasehold and Taxation Systems

I. Mining Lease

A mining lease is the right to mine a site. On large dredging properties, it is granted for periods of 15 to 21 years. Gravel pump mining leases are granted for periods of about three to five years. The lease applicant must pay a lease fee, present a plan showing the final appearance of the mine site and post a "filling and levelling" bond. The principal reclamation requirement which a lease holder has to fulfill on the completion of mining is to fill and level his property to a grade which does not exceed 5 per cent, leaving an unfilled space (final mine hole) of a size approved under an "escape clause" in the "express conditions" attached to the mining lease.

Under the term of the mining lease, the only agricultural activity which is permitted on the property is the growing of crops to feed the workers. The mine operator is thus prevented from farming or performing general agricultural reclamation. Once a mining lease expires, the mining land is surrendered to the state. It may be leased out again under a new mining lease or under a Temporary Occupation License (T.O.L) for agricultural activity.

The mining lease can expire in two ways. The first is that the date of expiry of the lease is reached, whether the mineral extraction is completed or not. Secondly, the lease expires when it is proven by the miner that all the minerals have been extracted before the actual stipulated date of expiration is reached. In the case of renewal of mining lease, the law requires the lessee to apply for renewal at least one year before expiration of the lease. The purpose of this is to enable the State government to process and come to a decision before the lease expires. There have been instances where decisions on such applications have not been made within the the specified period (Mohd Salleh, 1977). Although, as a partial solution, continuation of mining operations on the expired lease has been allowed on a year to year basis after the expiration date, constituting an irregularity under the law, creating difficulties for the enforcement officers of the Department of Mines and insecurity for the miner.

II. <u>Taxation System and Problems</u>

The principle that taxes must be paid by the mining industry to compensate the State or the Nation for minerals extracted and to contribute towards national development and maintenance is indisputable. There is a general agreement that about 70 per cent of Malaysian tin mining profit is absorbed in taxes, making the tin industry the most heavily taxed industry in the country (Jaffar, 1977). The main taxes levied on the industry are the import duty, royalty or export duty, income tax and tin profit tax. The federal government receives 90 per cent of the proceeds, leaving only 10 per cent to the State Governments. This results in no incentive on behalf of the State Governments to do reclamation work on the mined lands.

In addition to the heavy taxes imposed by the government, the miners are also faced with problems of inequitable taxation. The government charges the same rate of royalty on the production of tin ore without regard to the tin concentration in the ground.

This system imposes a heavy burden on marginal miners who are working on low-grade ground. Thus the miners try to avoid mining the low-grade ground and ignore reclamation ideas when the mining activities terminate.

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Section Three

TIN MINING OPERATIONS

It is important to investigate and understand the operational characteristics of the tin industry before a rehabilitation program can be developed. This is because the disturbance of the land depends to a great extent on the characteristics of the mining operation used in mining the tin ore. Thus the purpose of this section is to explain the origin of tin deposition and the methods used to mine the tin ore from the deposition areas.

Geographical Setting of Tin

Most of the known tin deposits lie in the western belt of Malaysia which is about 400 miles long and 50 miles wide. Figure 2.1 illustrates the tin deposition pattern in Malaysia. Kinta Valley in Perak and Klang Valley in Selangor are the dominant producing regions. The Kinta Valley has proven to be the richest tin mining area in the world and has been actively exploited over the last 80 years (CRNET, 1977). The state of Perak produces about 55 per cent of the total Malaysian tin output while Selangor produces about thirty per cent (Mohdzain, 1981). The remaining percentage is produced by the States of Pahang, Negeri Sembilan and Johor. All production in the western belt is from

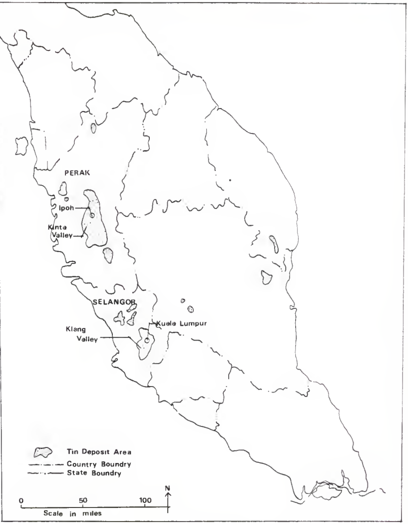


Figure 2.1 Tin Deposition Pattern in Malaysia
Source: Japan International Cooperation Agency, 1981

alluvial deposition.

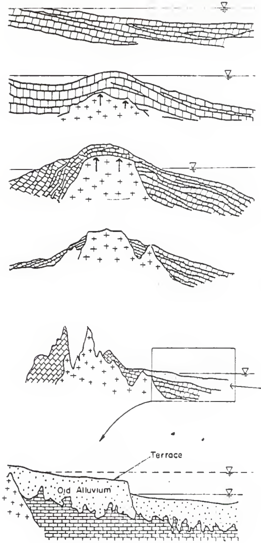
Origin of Tin Ore

In Malaysia the origin of tin ore is known to be associated with the geological process of granitization, which produces the present-day granite backbone of the Malay Peninsula. The sequences in the geological formation of tin ore deposits are illustrated by Figure 2.2.

Granite magma containing tin bearing fluids were first intruded into older rocks such as limestone and schist during the Mesozoic Age (about 100 million years ago) (JICA, 1981). In this process the tin bearing mineral called cassiterite (SnO_2) was formed within the granite itself. As some of the tin bearing fluid penetrated into the older, adjacent rocks, cassiterite also formed in them.

Subsequent to the granitic intrusion, the granitic rocks were broken down by weathering and erosion. The eroded cassiterites were transported by runoff and deposited in areas where the speed of water was not sufficent to carry the eroded materials. As deposition continued, the deposits gradually formed alluvial plains. Later erosion of the alluvial plains formed terraces. Terrace deposit material, called old alluvium, is the main tin deposit in Malaysia.

Before the deposition of alluvial terrace deposits, the bedrock in these areas had been weathered and eroded. The erosion of limestone bedrock typically yields karst features which are pinnacles, troughs and deep solution channels. This complex topography formed a series of natural riffles which retained and



Formation of Older Rocks.

Intrusion of Granite

Formatian of Mountain Range

Weathering and Erosion

Deposition of Alluvial Deposits

Terrace Formation (Old Alluvium)

Figure 2.2 Geological Development of Tin Ore Deposits
Source: Japan International Cooperation Agency, 1981

concentrated the heavy grains of cassiterite (Figure 2.3). This is one of the reasons that most of the tin mines are found in areas with limestone bedrock.

This formation process had two advantages for the Malaysian tin industry. First, the ore-containing medium is loose alluvium which is easy and cheap to excavate. The second reason is that the ore has become sifted and concentrated by the limestone riffles which acted as a natural sluice.

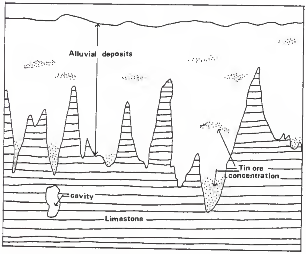


Figure 2.3. Tin ore location in alluvial deposits
Source: Japan International Cooperation Agency, 1981

Methods of Mining

The two basic types of tin mining methods are open-cast and load mining. Load mining is done underground and thus not likely to produce significant disturbance on the surface. This study will focus on the open-cast mining method which operates mostly on the alluvial plains. The extraction techniques used to obtain the tin ore include dredging and gravel pumping.

About 95 per cent of Malaysian tin is mined from alluvial deposits by dredging and gravel pumping methods. Table 2.1 shows the number of mining methods from 1973 to 1983. About 60,000 workers are directly employed in the industry. Both of the methods use water to extract the tin ore from the ground. Tin is a high specific gravity metal which can be gathered by relatively

Year	Dredging	Gravel pumping	Others	Total
1973	58	873	31	962
1974	56	932	28	1016
1975	55	810	33	898
1976	51	724	24	799
1977	53	784	24	861
1978	53	833	27	913
1979	54	772	25	851
1980	54	746	25	825
1981	60	593	25	678
1982	57	576	25	658
1983	43	521	24	588

Table 2.1. Number of Mining Methods
Source: Japan International Cooperation Agency, 1981

simple wet gravity concentration methods. The abundance of water in the country has greatly facilitated exploitation of the resource on such a large scale. Thus water is used to separate the tin ore from soil particles and other minerals.

I. Dredging

A dredge is a floating excavating machine and ore treatment plant weighing as much as 6,000 tons. It is rectangular in shape and operates in a continually advancing artifical pond which it creates itself (Figure 2.4). The tin ore recovery process is as follows:

A. The ore bearing earth is excavated from depths up to 200 feet and conveyed to the dredge platform by means of a chain bucket excavator at the front of the dredge. The bucket capacity ranges from 10 to 24 cubic feet (Curren, 1974).

B. Cassiterite is recovered from the excavated material on the dredge by washing using jigs and tables. The cassiterite crude concentrate so produced has a tin content of 25-30 per cent (Kitching, 1982). This concentrate is transferred to an on-land metals dressing facility "tin shed" where it is further washed to produce a concentrate containing approximately 75 per cent tin for dispatch to the smelter.

C. Waste materials, termed as tailings, are ejected into the water by chute at the rear of the dredge. The stones and sand fractions of these tailings immediately sink to the bottom of the pond while the silt and clay (slime) fractions remain in suspension. A high capacity centrifugal pump, located 200 feet behind the dredge, is used to get rid of the slime. It draws water and suspended solids from 10 to 15 feet below the surface and delivers them to slime retention areas in the dredge channel at some distance back from the dredge. The liquid effluent from these slime ponds flows back to the dredge through the dredge channel, further settling out the solids. Starting at the upper end of the channel where dredging commenced, low bunds are often erected in the dredge channel to restrict the rate of flow of a certain amount of water to the dredge pond and further refine it.

When dredging is completed, therefore, the tailings area consists of 1000 feet wide level strips of slime tailings (clay and silt fractions) underlain by stone and sand fractions and divided by sand strips; and a rather large rectangular pond or ponds where sections of the dredging operations have ceased.

From the explanation, it can be seen that dredge mining is a closed circuit system. All water requirements are recycled and outside water is seldom added. Due to the level nature of the tailings and their location in low-lying areas, there is seldom any erosion or runoff to adjacent land and watercourses (Kitching 1982).

II. <u>Gravel Pumping</u>

This method is currently the most commonly used in tin mining in Malaysia, accounting for more than 50 per cent of the production. Kitching (1982) has estimated that at least 70 per cent of the total tin tailings area in Malaysia are the result of gravel pumping operations (Figure 2.5).

The gravel pump mining process is summarized as follows:

A. Water from centrifugal pumps at a pressure of approximately 100 psi, delivered through 2 inch jets (monitors) is used to break down the ore bearing ground. A mining unit generally consists of 3 to 4 monitors supplied by a 350-480 horsepower pump delivering 3000 to 6000 gallons per minute.

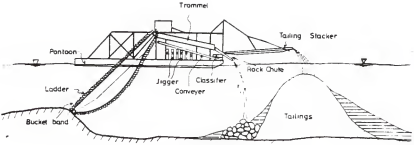


Figure 2.4 Typical Dredging Method
Source: JICA, 1981

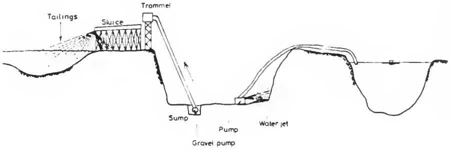


Figure 2.5 Typical Gravel Pumping Method
Source: JICA, 1981

B. The resulting slurry, containing 10 to 18 per cent solids, is pumped from the mining pit to a recovery plant which possesses a screen (trommel) that separates the slurry from stone and gravel.

C. The slurry is allowed to flow along sluice boxes (palong) with baffles that trap the heavier tin ores. When sufficent amount of tin ore has been trapped, the concentrates are cleaned by jigs and the products are taken to a treatment plant for final dressing.

D. Tailings from the palong are either pumped or flow by gravity into bunded areas or old mine pits.

E. In these tailings areas, the solids settle out and the water is pumped back to feed the monitors.

It can been seen from the explanation that this is basically a "closed" system where all water is recycled. But in many instances, the miners discharge the tailings into natural water courses when bunded areas or old mine pits fill. During heavy rainfall, the bunds break down and the tailings flow to nearby stream or river. This results in degrading water quality and siltation of water courses.

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Section Four

SITE CHARACTERISTICS OF MINED LANDS

The characteristics of pre-mined lands are quite different from the lands that have been mined. This section will discuss the characteristics of mining lands before and after the mining operations. This will show the effects of mining activities to the land and the environment.

Site Characteriatics Prior to Mining Operation

The discussion of the origin of tin ore in Section Three points out that most of the tin deposits lie in the alluvial plains along the western belt of Malaysia. These areas usually range from undulating landforms to relatively flat coastal plaina with isolated limestone hills (Mohdzain, 1982).

Soil types within these areas vary from sedimentary soils to alluvial soils. The alluvial soils are distributed over the coastal plains and river valleys. The sedimentary soils generally cover the foothills and the undulating areas of the region. The fact that most of these soils are relatively suitable for agriculture has generated conflicts between miners and farmers. However, a recent government policy allows an area to be cleared for agriculture development only after the Mines Department and Geological Survey Department have jointly certified that no economic minerals exist in the area (Ooi, 1976).

The natural vegetation of this region consists of lowland tropical rain forest. This forest is composed of a canopy layer, intermediate layer and dense undergrowth (Figure 2.6). The dominant tree species are from the Diptrocarpaceae family. Mangrove forests dominate the coastal areas. A large percentage of the forest has been cleared for agriculture purposes. Rubber and oil palm are the economic crops planted by the farmers when the forest lands are cleared. Agricultural crops such as rice and vegetables are found mainly on the flat coastal plains.

Figure 2.6. Profile of Lowlsnd Tropical Rain Forest
Source: Zen, 1982

Site Charscteristics After Mining Operstions

Considering the fsct thst there sre several methods of mining being employed, it should be expected thst the chsrscteristics of the mined lsnds differ from one site to another. The conditions of the surfsce snd subsurface festures are sffected by the method of mining employed, composition of the soil, snd the msnner in which the tsilings are deposited. This study will discuss the effect of the dredging snd gravel pumping methods spplied to the mining sress. The effect to the site chsrscteristics of the mining lands csn be discussed in three categories; physicsl lsndscspe, soils, snd vegetation.

A. Physicsl Lsndscspe

Generally, tin-mined lsnds sre classified as tin tailing lsnds or disturbed lsnds. The lsnds are msde up of ssnd, slime and clsy tailings which sre left by the mining operations. On lands where gravel pumping was used the landscape consists of a series of abandoned mining pits filled with water. The pits are often illegally used by farmers for breeding fresh-water fish. Another landscape feature of the disturbed land is the fan-shaped tailings (Mohdzain, 1981). This feature is usually found in areas around the recovery plant. The recovery plant was usually erected at a raised level and sloped toward the discharge area. The fan-shaped feature is the result of a continuous discharge of tin tailings from the upper level of the recovery unit. The tailings area has a continuous gradation from gravel and coarse sand at the top to fine sand and clay at the lower end.

The dredging operations usually resulted in landscape features consisting of a series of small, flat terraces. Excess water and slime from the dredge paddock was usually pumped out into one or more of the abandoned enclosures (made from the overburden) which became slime retention areas. Here, the fine suspended soil particles settled down. Water from the enclosure was allowed to escape over a spillway into the nearest natural watercourse. When the water dried out from the retention area, the slime eventually turned to hard clay. As the clay dried, it eventually shrank and cracked into semi-permanent masses which slowly weathered down. These retention areas were repeatedly flooded with fresh slime until the enclosure became more or less flat land. Coarser materials such as gravel, stone, and sand were discharged by the dredge into the paddock. Sometimes sand was heaped into parallel ridges which formed extensive sand piles (Mohdzain, 1981).

B. Soils

A very large proportion of the soil left behind on the mined lands consists of coarse particles almost totally devoid of humus. Most of the essential nutrients for plants were removed in the process of mining and later leached by erosive agents after the mining operation ceased. However, Meane (1980) classified the tin tailings into four types based on agricultural characteristics. The types of tailings are (1) sand, (2) slime, (3) mixture of sand and slime, and (4) mixture of sand, slime and overburden. In Meane's study, it was determined that all the tailings are uneconomical for agricultural uses unless extensive soil additives are utilized. As far as chemical composition is concerned, sand tailings are almost devoid of nutrients that could support plant growth. Nitrogen and other base nutrients are almost completely leached from the soil (Zen, 1982). In a report by Mitchell (1959) potash and phosphate are weathered from the base mineral rocks, but are quickly leached by rain water before they are available for the plants. However, he discovered that the fertility of the soil increased slowly after years of abandonment. He noted that the nitrogen content of the soil improved from 0.01 percent at the end of the first year to 0.09 percent after twenty years.

In 1981, Japan International Cooperation Agency investigated the tin-mined lands and then classified the lands into five types based on engineering characteristics. The five types are: (1) loose sand, (2) loose sand and soft clay, (3) soft clay and loose sand, (4) soft clay, and (5) water and soft clay/loose sand. The purpose of the investigation was to study the structure of the soil and its ability to support residential development. A detailed explanation of the soil classification will be discussed in Chapter Four.

C. Vegetation

Pallanappian (1972), in his study of the plant communities in the tin tailings areas, divided plant communities into four categories: (1) sand, (2) slime, (3) shrub, and (4) forest communities.

The sand communities are found on the dry sandy tailings on both flat or sand-pile areas. Vegetation consists of mainly herbaceous weeds including Borreria setidens, Tricholaena rosea and Ischaemum muticum. These plant species occur in the groove-like depressions among the sand mounds and are scattered over flat, sandy tailings areas.

The locations of the slime communities are either on the unsettled slime retention areas or in the ponds. These areas are usually filled with slime and rain water and remain wet throughout the year. The substratum is usually very soft and unsettled. Among the plant species found here are the Laersia hexandria and Nelumbium nelumbro plus other species that prefer wet sites.

The shrub communities are found on settled and relatively drier slime retention areas. Mitchell (1959) noted that Melestoma malabathricum is the pioneer shrub able to grow on the tailings areas. Then other species such as Cyclosonus aridus, Minuosa sepiaria and Spathogolottis plicata condensed within the areas and formed dense communities.

The final plant community is the forest community which is usually found on the older slime retention areas. There are variable types of forest communities, ranging from the impenetrable thickets of *Mikania sp.*, *Istracera sp.* and *Eugenia macaranga* to the passable but dense formation of tree species with cleared understory and closed canopy (Mohdzain, 1981). Trees such as *Premna corybusa*, *Fragea cremulata*, *Macaranga griffitheana* and *Ericiliona nemontosa* dominate slime tailings after period of 25 years (Pallanappian, 1972). He also observed that there has been no extensive formation of pure forest on tin tailings at any site. The Pallanappian (1972) study concluded that it takes more than 30 years for the plant succession to reach the final stage of the forest community.

Environmental Impact of Tin Mining Operation

Like most mining operations, tin mining has had a devastating effect on land and the surrounding environment. In 1982, the devastated lands left by the mining operations amounted to 520,000 acres with an annual increase of 5,000 acres (Kitching, 1982). The disturbance of the mining operations can be classified into two major categories which are (1) water pollution, and (2) land disturbance.

1. Water Pollution

Bodies of water affected by mining activities are the natural watercourses such as streams and rivers. Pollution of this water may be caused by suspended solids and by chemicals released by the disturbed strata of the soil. Siltation of watercourses by the suspended solids such as sand, silt and clay has become a very serious problem. The suspended solids come from the mining activities and also sediment from erosion of exposed and loose soil. The impact of these activies includes pollution of drinking water, damage to rice fields, and formation of a clay crust, blocking of waterways and disrupting drainage patterns (CRENT, 1977). There is little documentation on the severity of chemical pollution which may include acid released from swamp environments or through the oxidation of the pyrite from certain soil horizons.

2. Land Disturbance

The nature of the disturbed land varies widely in topographic expression, percentage of area under water, drainage characteristics, soil structure and soil fertility. These variables are mainly due to the method of the mining operations and the physical and chemical properties of the soils.

The method of mining extracting the tin ore is the primary factor that results in different physical features of the disturbed land. The common feature of the mining process is that only a very small fraction of the total soil mass (tin cassterite) is removed. Therefore, the basic process consists of lifting the soil, extracting the tin cassterite and dumping the tailings. The extraction process utilizes large quantities of water and, because the mineral winning is by gravity process, the soil gets segregated into coarse and fine particles, and the soil nutrients are washed out (CRNET, 1977). Where land has been worked by dredging, the resultant landscape consists of a series of small, flat terraces of varying levels and ponds filled with water or slime. The surface area of such mined-out land is likely to consist of 60 percent dried out slime crust, 20 percent sand and overburden and 20 percent water (CRNET, 1977). The result of gravel pumping operations is a scene of great disarray of various sizes and shapes of tailing dumps with different soil characteristics and with the final mine hole eventually filled with water. The final mined-out surface of this operation usually consists of 20 percent sand, 60 percent mixture of sand, clay and silt and 20 percent ponded water (CRNET, 1977).

From the viewpoint of utilization of these mined lands for residential use, the soil is generally of very low strength and tends to settle differentially on account of its heterogeneity (CRNET, 1977). Foundation costs for this soil, even for single-story houses, are higher than on undisturbed soil. Construction of high rise buildings require the use of piles; in most cases driven to the bedrock, though the pinnacled bedrock poses problems for secure anchoring (Teh, 1974).

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Section Five

HOUSING SITUATION IN MALAYSIA

Like most developing countries, urban-migration has been one of the main socio-economic problems faced by Malaysia. Modernization and the search for a better standard of living have attracted more and more Malaysians to urban areas. During the period from 1971 to 1980, urban-migration has resulted in a rapid growth of squatter settlements which were characterized by high dwelling density and poor and inadequate amenities. The squatters can be categorized as urban poor or low income group in the urban society. During this period, the government has taken some action to help the urban poor. Low-cost housing projects were set up in several cities including Kuala Lumpur, Ipoh, Penang and Johor Baru. But most of the housing projects were not fully successful and the shortage of low-cost housing has been increasing each year. Therefore, the purpose of this section is to illustrate the housing situation in the urban areas of Malaysia. First, this section will explain the occurrence of the squatter settlement which led to high demand for low-cost housing in the urban areas. Later, a discussion of the government policy and action to solve the shortage of such housing will be introduced.

The Occurrence of Squatter Settlements

Examination of historical records reveal that squatters have been in evidence in many urban centers, particularly in Kuala Lumpur, Ipoh and Johor Baru, since the early 1930's. However, most observers agree that it was the combined effects of the Japanese occupation (1942-1945) and war-induced food shortages that resulted in the first rapid expansion of squatter settlements in the urban centers (Johnstone, 1983). During the last two decades, the squatters have increased markedly in the urban areas. This was caused by the rapid economic growth and social development in the urban areas. In Kuala Lumpur, where reliable data was available from 1969, the squatter population has increased about 3,000 each year (Smith, 1977). In 1976, there were approximately 146,000 squatters in the city. Figure 2.7 illustrates the percentage of housing types in Malaysia.

The main reason that the urban poor (low income) built unconventional housing is because they could not afford to buy the high-priced houses built by private developers. In Malaysia, the urban poor people are classified as those whose monthly income is less than M$500 (US$ 220) (Ministry of Housing and Local Development, 1982). With the small income, they illegally build houses on land for which they have no title. This housing type allows the owner to select forms of land use, building standards and density levels which are less restrictive than those governing the conventional sector (Johnstone, 1983). Futhermore, the unconventional housing allows them greater flexibility in the use of income than does conventional housing. The unconventional form can result in a more highly personalized form of construction where the owner-occupier is often the builder.

Problems of Unconventional Housing

Due to the ever-increasing squatter settlements, the government has taken action to investigate the conditions and problems arising from the illegal settlements. In 1970, a committee of the National Operations Council on Squatter Rehousing and Resettlement was established and it summarized the problem created by the squatters in the following manner:

A. Squatting results in an increase in crime, juvenile delinquency and a wide variety of social problems;

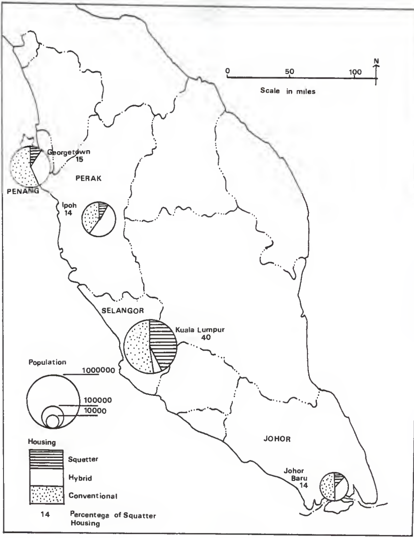

Figure 2.7 Housing Types in Malaysia
Source: Ministry of Housing and Local Development, 1982

B. Squatting results in the loss of substantial revenue in the form of assessment rates and taxes to the government;

C. Squatter areas are the seedbeds for thugs, secret societies and other racketeers in which to operate their activities;

D. Squatting not only affects the physical development of the town, but also its economic, social and political stability; and,

E. Squatting dwellings are generally fire hazards as well as a menace to the public health.

Government Policy and Action

The findings on the problems created by squatters have resulted in governmental action considering the provision of public housing as a part of social welfare. The government realizes that the improvement and growth of the housing sectors affects the economic expansion in the urban areas. Thus, the government formulated several low-cost housing projects for the urban poor people. The importance of the low-cost housing provision has gained impetus through three Malaysian development plans. These are called Second, Third and Fourth Malaysia Plans.

In the period from 1970 to 1975, the government formed the Second Malaysia Plan (SMP) which put emphasis on the provision of low-cost housing in the urban and rural areas. The total housing need was estimated at 345,000 units with 60 percent of the units required in the urban areas. Only half of the SMP target was achieved which left the remaining deficit to the Third

Malaysia Plan (TMP) 1976-1980 (Johnstone, 1983). The TMP highlighted more incentives on behalf of the government to provide more financial support for low-cost housing programs. Private developers were encouraged by the government to provide more low-cost housing units. Special benefits and arrangements were given to private developers who would build low-cost housing. Such arrangements included reductions in taxation and provision of cheap serviced land to private developers who would construct in particular localities or build in joint ventures with the government. By the end of 1980, only 70 percent of the TMP goal had been met and, futhermore, only a small proportion of the dwellings being built were considered as low-cost units with a unit price below M$10,000 (Johnstone, 1983). Thus, the remaining burden was brought forward to the Fourth Malaysia Plan (FMP) which was launched in 1981-1985. During the FMP, the urban requirement for low-cost housing was estimated at 337,000 units. Therefore, it is clear that the provision of low-cost housing in urban areas is not fully achieved and results in shortages of housing from one year to another.

Among the reasons that caused the failure to provide adequate low-cost housing to the urban poor in the urban areas are increased in land prices, technical difficulties, bureaucratic and organizational delays and, sometimes, material or labor shortage (Johnstone, 1983). The escalating increase of land prices in the urban areas constitutes the major reason for the failure. For example, land in Petaling Jaya (a satellite of Kuala Lumpur) cost about M$70,000 an acre in 1976, and in 1980 increased to M$150,000. As a result, in the same period the average house prices increased by 20-25 percent per annum (Smith,1981). In conjunction with the increased price of the land, one of the FMP objectives was to use the land in the optimum way and enhance the quality of life in the urban settings.

Possible Solution

To achieve a successful low-cost housing project, the government could develop on land that is less expensive. Tin-mined land is the best alternative, especially in cities where there is an abundance of vacant tin-mined land. Kuala Lumpur, Ipoh and Taiping were established and initially prosperous by the wealth of the tin-mined lands. Thus, they possess large areas of vacant mined lands that can be used for housing if the lands are properly rehabilitated.

As mentioned in Section Two, the mined lands are the property of the state government. Thus, the state government can use the lands for housing at no cost. The only cost involved will be the rehabilitation cost in order to prepare the land for suitable housing development. Therefore, the intent of this study is to develop a rehabilitation program for the tin-mined lands. The program will help provide cheap land for low-cost housing use and eventually help to solve the public low-cost housing shortage in the urban areas.

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Section Six

CURRENT REHABILITATION PRACTICES ON TIN MINED LANDS IN MALAYSIA

Even though tin mining had been in operation in Malaysia for more than a century, there was little concern for rehabilitation of the mined lands in the early history of the industry. Most of the reclamation experiments to date on the mined lands have been generally focused on future agricultural use. Today, with land being a limited asset especially within the urban areas, more diversified land utilization should be considered. This section is meant to discuss the role of the government and public in the initiation of a better rehabilitation program for tin mined lands. This section will also investigate the current approach to rehabilitation practice. The typea of rehabilitation projects that have been undertaken will also be discussed.

Criteria for Rehabilitation Activity

Bauer (1965), defines three criteria for any rehabilitation program of mined lands. The criteria are: (1) public pressure, (2) regulations, and (3) direct or indirect financial gain (land value). These criteria are applicable to tin mined lands in Malaysia. Each of these criteria will be discussed based on Malaysian socio-economic and political conditions.

A. Public Pressure

With the population expansion, land use developments are more intensified in the urban areas. The urban population demands more space for commercial and residential developments. In addition, the suburban areas are always being used for agriculture to grow crops such as vegetables to feed the urban population. Such a situation could be a positive step for a rehabilitation program for the tin-mined lands. Since much of the mined land is within the suburban areas, planners must develop a rehabilitation program to utilize the mined land in the most economical way.

Public concern for a better living environment may dictate the operational practice on land developments. Miners or other land developers should comply with the public's provision (through government regulations) to avoid any form of resentment. These provisions could be in relation to visual quality of involved areas and some means of water and air pollution prevention (Mohdzain, 1981). The public could also pressure the government to introduce more stringent federal regulations in relation to the operational practices and rehabilitation programs.

B. Regulations

Regulations can be described as the zoning techniques adopted by various levels of government that should be met before any permit is released for land development (Mohdzain, 1981). In conjunction with permitting tin-mining operations in specific areas, zoning regulations should define performance standards aimed at eliminating the creation of objectionable operational characteristics and desirable land forms (Bauer, 1965). The standards range from a requirement for a detailed restoration plan to simple slope stabilization. Also included in these performance standards are stockpiling methods, planting and screening plans, limitations on depth of excavation, and handling of topsoil. In most states in the United States, the standards include a provision requiring preservation and respreading of topsoil to the depth that originally existed (Bauer, 1965).

However, in Malaysia the requirements related to rehabilitation work on mined lands are not yet to be included in the existing Mining Enactment (Mohdzain, 1981). The Mining Enactment only covers the general operational practices of mining. There are some clauses in the Mining Enactment that would benefit any rehabilitation program. The clauses are:

1. All mined areas should be filled and leveled to a maximum of five percent slope, and
2. Disturbed lands or slopes should be stabilized through revegetation and construction of "silt traps".

No restoration or future land use plan of the area to be mined is required. The provision to preserve topsoil is not found in the Enactment. Topsoil contains the essential nutrients for plant growth. Thus, preservation of topsoil will help in the process of rehabilitation of disturbed lands and, in particular, revegetation.

As mentioned in Section Two, the miner has to pay a "filling and leveling" bond before the land is leased for mining operation. This measure assures that the miner fills and levels the mined areas when mining operations terminate. The bond will be forfeited if the miner neglects to fill and level the mined sites. Considering the expenditure required to meet the government provisions, in filling and leveling the mined lands, most miners would take option to lose the bond. By doing so, the miners end up saving a lot of money since normally the cost for land filling and levelling would cost more than their bond.

C. Direct or Indirect Financial Gain (Land Value)

With land value on the rise proportionally with the demand, especially in urban settings, potential economic gain on rehabilitated land would become an attractive incentive for a proper rehabilitation program. Some rehabilitation projects, especially in Kuala Lumpur and Ipoh, have shown a significant increase in land value. It has been expressed by land developers that if they can "break even" or even take a slight loss on rehabilitation work, they have gained indirectly as long as their public image is improved, and gaining access to future sites (JICA, 1981).

Current Approach to Rehabilitation Practice

In many states in the United States, preplanning and progressive rehabilitation programs are required before mining operations. Thus, the rehabilitation programs are carried out simultaneously with mining operations. However, in Malaysia, due to lack of preplanning and rehabilitation regulations, rehabilitation of mined lands is carried out after mining operations have ended. This action results in high costs, especially in making the mined lands suitable for plant growth and stabilization of the disturbed areas. Another significant factor leading to slow and poor incentive toward rehabilitation practices could be the priorities set by the government in the utilization of the mined lands. The government policy is to remine the mined lands when new and more economical mining technology is developed. Thus, many mined lands are left vacant for years waiting for remining. Changes in such policy could help in the development of a better rehabilitation program for mined lands in Malaysia. The miners have very low incentive to rehabilitate the mined lands because of the heavy taxes imposed on the mining operations and the products.

Today, most of the rehabilitation practices of mined lands in Malaysia are focused toward agricultural uses. Among the few recommendations or suggestions by local soil scientists and agronomists in rehabilitating the lands is the improvement of the soil conditions through soil additives. Experiments have been conducted on the usage of various soil additives ranging from green manures to rubber and oil palm effluents. Sewage, peat, rice stalks and decomposed saw-dust were also tested. Most of these were successful in improving the soil structure, but it will be tremendously expensive to carry out such practice on a large scale (Mohdzain, 1982). In 1940, it was suggested that mined lands should be flooded periodically as a means of reconditioning. Periodic flooding on floodplains usually results in deposition of fertile alluvial soil which eventually improves the fertility of the land (Chamber of Mines, 1940). This method may be feasible on the low-lying dredged lands but to-date there has been little account of the actual result of such practice.

Current Rehabilitation Practices on Tin-Mined Land

Although rehabilitation of mined lands is not yet fully required by the government, several projects or field experiments have already been carried out on mined lands. There are four significant land development types on mined lands. These are: A) agricultural, B) residential, C) industrial, and D) recreational. The description of each development will be discussed as follows:

A. Agricultural

Since Malaysia is an agro-based nation, this could be the main reason that most of the rehabilitation projects are the agricultural type. These projects are carried out by several government and private individuals. The private individuals are usually farmers that illegally farm the tailings areas. A survey conducted by the Ministry of Lands and Regional Development indicates that approximately 266,000 acres of tailings area were being illegally used for farming. It is estimated that there are at least 25 percent of the nation's vegetables and fruits are produced on abandoned tailings areas (Kitching, 1982). In addition, the farmers raise fresh-water fish in the old mining ponds that produce about 80 percent of the nation's fresh-water fish supply.

Soil improvement has to be done on the tailings before they can be used for agricultural development. This is because the soil is usually deficient in essential nutrients for plant growth. The improvement techniques include the use of manure and fertilizer to improve the fertility and structure of the soil.

Many government agencies are investigating new and cheaper techniques of soil improvement to prepare the mined lands for more extensive agriculture uses.

B. Residential

This type of development on reclaimed tin mined lands has been on a constant rise in recent years. One of the main reasons for such development is the increasing demand for housing, especially in urban areas like Kuala Lumpur, Ipoh and Taiping. Another reason may be the priority of the type of land development on reclaimed mined lands as set by the government. Residential development is placed second behind the top priority which is reservation for remining purposes.

Although this development may have been in progress for a number of years, it still has not received full support from the public sector. The public is still skeptical about this development since there have been incidents of land subsidence and cracking of infrastructure on earlier housing projects on these lands. Land subsidence on reclaimed mined lands could be the result of the nature of rehabilitation practice carried out and the materials used for improving the lands. Today, most of the housing developments on this land require piling structures for foundation. Based on observations of current housing development on mined lands, it is justifiable to state that, in common practice, site characteristics are not taken into consideration prior to development (Mohdzain, 1981). Potential usage of existing landscape features such as water, which may serve as an amenity in such development, are seldom taken into account. Generally, once mined land is released for housing development, most water features are drained and the area is filled with overburden.

The future of residential development should be good, especially with the high demand for housing in urban areas. Future development with proper planning and better utilization of existing site features could result in a more stable and lucrative venture.

C. Industrial

Since industrial sites require a large, open and relatively flat space, most tin-mined lands are appropriate for such development. Close proximity to urban areas is also one of the positive qualities of tin-mined lands which would be of advantage to most industrial developments. The best example of this development is the Tasek Industrial Estate in Ipoh which manufactures goods like cement, brick, rubber and plastic pipes, chemicals and mining machinery.

Based on the growing trend of industrialization in Malaysia, the future of this development on mined lands should be fairly good. However, this development is normally resticted by local zoning regulations.

D. Recreation

This is the least common type of land use development on reclaimed tin-mined lands. Previous lack of public support and demand for receational areas could be the reasons for the lack of such development. Today's trend, especially with the increase in population within the urban areas, means the demand for recreational areas is on the rise. In urban areas, where open spaces are limited, more and more abandoned mines are now being recognized by planners to be viable areas for recreational development. In Kuala Lumpur, for example, a number of mined lands have been reclaimed and converted into recreational areas with equal success and failure. Failure of some developments could be due to poor planning and site selection. Like other public developments, proper comprehension of the public desires and requests for the site and its potential uses are significant for the success of such development.

CHAPTER THREE

METHODOLOGY

Overview

As mentioned in Section Five of Chapter Two, there are high and increasing demands for low-cost housing in the urban areas. The urban migration of people from the rural areas is the primary reason for the high demand on such housing. The Ministry of Housing and Local Development has estimated that the urban requirement for low-cost housing in Malaysia for the period of 1981 to 1985 will be 337,000 units (Department of Statistics, 1982). The Ministry has allocated about M$1 billion for the development of this low-cost housing. This information indicates that the present demand for low-cost housing is high and will continue to increase if positive steps are not introduced to overcome the housing problem.

One possible approach to develop a successful low-cost housing project is to build the project on cheap land. Many low-cost housing projects failed to achieve their goals because of the drastic increase of land prices in the urban areas. The developers have to sell the dwellings at prices higher than M$10,000 which most urban poor cannot afford. Therefore, cheap land is a requirement for successful low-cost housing development.

Tin-mined land is the best choice for this purpose. Kitching (1982) estimated that there is 520,000 acres of undeveloped tin-mined land in Malaysia. The government can obtain this land for public housing development at no cost because the land is the property of the state government. The only land cost involved is the improvement cost necessary to prepare the ground suitable for housing development. Private developers have been encouraged by the government to construct low-cost housing and thus, they can purchase the tin-mined land at a very low price. Therefore, programs are needed to rehabilitate the mined land for the housing development.

The purpose of this chapter is to describe a methodology for the development of a rehabilitation program for the tin-mined land in Malaysia. The rehabilitation program will be a systematic program for a low-cost housing development on a selected tin-mined site. It is hoped that this study can become an example for residential projects developed on the tin-mined land in Malaysia. The methodolgy of this study will be carried out by the following processes:

A. Site Selection

B. Data Collection

C. Analysis of Data

D. Synthesis - Land Use Schematic Map

E. Implementation - Site Development Map

The relationships of the processes are illustrated in Figure 3.1. Each of these processes will be described in this section and the description will be used in Chapter Four.

Site Selection

A study site will be selected for the purpose of this study. There are three steps involved in this selection. The

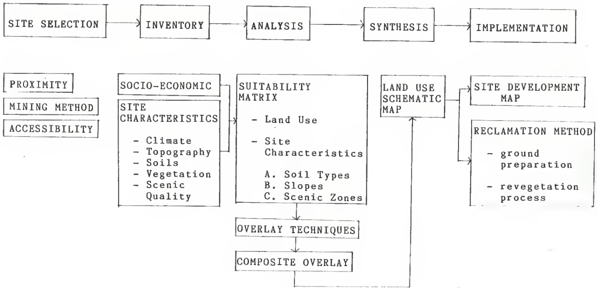


Figure 3.1 Flow Chart Of Rehabilitation Program

first step is to determine the dominant tin producing regions in Malaysia. Kinta Valley and Klang Valley are the dominant regions producing 90 percent of the tin in Malaysia. The next step is to select an urban area with a high demand for low-cost housing and an abundance of undeveloped tin-mined land. Selecting a study site in the vicinity of the selected urban area is the last step in the site selection process. The study site should have the following characteristics:

1. Proximity to an urban area which has a high demand for low-cost housing,
2. Undeveloped and mined by either gravel-pumping or dredging method, and
3. Accessible to the urban population.

Data Collection

The second process in the methodology is collecting information or data about the study site. There will be two categories of data, namely (1) socio-economic factors, and (2) site characteristics. The information will be gathered from maps, reports, personal inspections and interviews.

The socio-economic factors are factors that create the housing shortage in the selected urban area. The factors that are necessary to be inventoried are as follows:

1. The percentage or amount of squatter population.
2. The price for low-cost housing affordable by the urban poor.
3. The amount of undeveloped tin-mined land close to the urban area.

The information on these factors will be obtained from the reports by Ministry of Housing and Local Development and Department of Statistics, Malaysia.

The mining activities would likely to have disturbed many physical conditions of the land. Therefore, it is necessay to inventory the site characteristics of the mined land required for the development of the rehabilitation program. The characteristics will be divided into: (1) climate, (2) topograghy, (3) soils, (4) vegetation, and (5) scenic quality.

1. Climate

The temperature, precipitation and wind are the climatic factors that influence the physical conditions of the site. The mean annual temperature will be measured. The amount and distribution pattern of precipitation and the wind patterns that bring the precipitation will be also recorded. The information can be obtained from the Department of Meteorology, Malaysia.

2. Topography

Topography is the character of the landform of the site. The topographic features include the slopes, landform (hills and valleys) and infrastructure (roads and utility lines). All information gathered from the inventory should be located on a topographic map with a specific contour interval. The information will be obtained from reports by Mines Research Institute of Malaysia.

3. Soils

Soil is the major site characteristic that influences the development of a rehabilitation program on the mined land for low-cost housing. This is because the housing development requires a suitable soil capable of supporting the weight of the building. The mined soil should be classified into several types. The soil properties will be divided into two categories, namely (1) agronomic, and (2) engineering.

The agronomic properties of the soil are texture, composition, pH value and nutrient content. These properties will influence the plant growth necessary for residential related uses such as landscaping and farming. The properties should be inventoried and documented in a table. The information will be obtained from the reports by Mines Research Institute of Malaysia and an interview with the mining manager.

The engineering properties of the soil are bearing capacity and drainage. Bearing capacity is the ability of the soil to support the load placed on it. Thus, this soil's property is important for the housing development. Drainage is the soil property which measures the rate of water flow through the soil's profile. The properties should be inventoried and documented in an evaluation table. This information will be obtained from the reports by Mines Research Institute of Malaysia and Japan International Cooperation Agency.

4. <u>Vegetation</u>

Since the mined land has been disturbed by the mining activities, most of the vegetation has been destroyed during the excavation procesa. The plants that might grow on the disturbed soil can be classified as pioneer species because of their ability to initially grow and colonize the mined land. It is necessary to inventory the vegetation to know the plant species able to grow on the mined land. The information will be documented by classifying the vegetation in form of pioneer or secondary species and in form of tree, shrub or groundcover. The information will be obtained from reports by Mines Research Institute of Malaysia and personal inspection on the study site.

5. Scenic Quality

The primary objective in measuring the scenic quality of the study site is to determine those areas that possess high scenic quality (aesthetically pleasing) which will enhance the development of housing. The area with high scenic quality should be left for recreational development.

The scenic quality of a location in the site will be measured by using a scenic quality inventory and evaluation chart. The chart will be adapted from The Manual of Resource Management, Bureau of Land Management, United States. The adaptation is mainly because there is no visual resource inventory system in Malaysia. Six key factors such as landform, rockform, vegetation, water, color and disturbance will be inventoried and scenic values (score) will be given for each rating criteria. Some modifications of the rating criteria would be done to suit to the condition of the tin-mined lands. The values for each of the rating criteria are maximum and minimum scores only. It is possible to assign scores within these ranges. The scenic values of each location are added in a score table to determine the scenic quality zones.

Analysis of Data

The third process of the methodology is analysis of data. The function of analyzing the data is to determine the suitability of the study site for land use development, particularly low-cost housing. There will be two variables involved in this analysis; (1) dependent, and (2) independent. The site characteristics are the independent variables which will influence the dependent variables which are land uses. This suitability analysis will be carried out by the following steps: (1) suitability matrix, (2) overlay technique, and (3) composite overlay.

1. Suitability Matrix

The function of a suitability matrix is to demonstrate the degree of suitability between the dependent and independent variables. Three major site characteristics will be used in the matrix analysis. They are soil types, slopes, and scenic zones. The major land use will be the residential use (low-cost housing). Residential related uses such as recreational, commercial, institutional, agricultural and amenities are also included in the matrix. Each dependent variable will be evaluated on its suitability to each independent variable and the degree of suitability is ranked as low, moderate and high. The criteria of suitability will be illustrated in overlay maps..

Soils, slopes, and scenic zones are the site characteristics that have strong influences on the housing development of the tin-mined land. The soils will be divided into several types according to their engineering and agronomic properties. The slopes will be classified into four classes: (1) 0-5%, (2) 6-10%, (3) 11-15%, and (4) 16% and over. This is a slope classification used by the Ministry of Housing and Local Development, Malaysia. There will be three scenic zones in the suitability matrix. They are low, moderate and high scenic zones.

The evaluated information in the suitability matrix will be used in another step of suitability analysis called overlay technique.

2. Overlay Technique

This is a technique which involves maps of inventory information superimposed on one another to identify areas that provide, first, opportunities for particular land uses and, second, constraints (Steiner and Brooks, 1980). The interpretations for each site characteristic are recorded on separate sheets of transparent material. Each transparent sheet, commonly called an overlay, shares three common characteristics with the others in a set (Anderson, 1980). The characteristics are:

A. All overlays are drawn at the same scale to permit superimposing one upon the others.

B. All overlays are drawn with the same format; sheet size, placement of legend, title block, graphic media, and tonal assignment.

C. All overlays contain a common feature or features to assist in aligning the sheets when superimposed. Often these features are lines (such as roads), points (such as landmarks), or registration marks (crossticks) placed in the map border.

In this analysis, the overlay used is a matte acetate and shaded with rapidiograph pen to give the tonal values. Only the information of the residential uses will be drawn on the overlays. This is because the residential use is the major factor for the rehabilitation program of the mined land. If the information of other land uses such as recreation and agriculture are drawn on the overlays, the result will be a dark-shaded composite overlay. Thus it will be difficult to locate the areas suitable for residential uses. The darker the tonal value, the less suitable the area for residential use. Conversely, the lighter area, the better for residential development. Each site characteristic will be interpreted on the overlay map. Thus , there are three overlay maps which consist of soil types, slopes and acenic zones. The criteria used to evaluate these characteristics will be discussed for each map.

3. Composite Overlay

When the overlay maps have been drawn, they are superimposed on one another to derive a composite overlay map. The composite overlay map will show the areas that are suitable for the low-cost housing development. The darkest areas are the locations which are the most difficult to develop and would be undesirable. The lightest areas are locations best for development.

Synthesis - Land Uae Schematic Map

The findings from the analysis of data process will be used in the next process called synthesis. This is a process where the findings are integrated to form a land use schematic map. The function of the land use schematic map is to show the arrangement of the land use areas in the study site. The arrangement will be made after careful analysis of the composite overlay. Since the composite overlay illustrates the degree of suitability of the site for housing development in form of tonal values, the location boundary for such development can be delineated. The darkest areas are the locations which are the most difficult to develop for housing use and would be undesirable. The lighest areas are locations best for the development. Although the darkest areas are undesirable for residential use, they might be suitable for other land uses such as recreation and agriculture. Thus, the locations of the individual land use areas will be delineated in the schematic map. In addition, the circulation patterns, which include pedestrian and traffic, will also be delineated on the map. Figure 3.2 illustrates the interrelationships of the residential use with the related land uses.

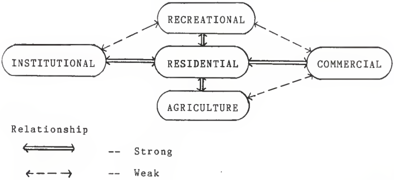


Figure 3.2. A Bubble Diagram Showing Interrelationship of Residential Use with Related Land Uses

Implementation - Site Development Map and Reclamation Process

Once the locations of the individual land use areas are delineated, the final process called "implementation" will be developed. This is a process which plans and designs the land use areas in the study site. There are two products involved in this process including site development map and reclamation process.

1. Site Development Map

The site development map indicates the whole structure and organization of land use developments in the site. The major land use will be the low-cost housing which will be developed on the lightly shaded areas. Therefore, this map will illustrate the layout, type and density of the housing units. The performance standards for the housing development will be adapted from the standards used by Ministry of Housing and Local Development. Commercial and institution (schools) uses will be developed in the vicinity of the residential developed areas. Some areas in the site will be used for agriculture uses such as planting vegetables and fruits, and raising fresh-water fish. Areas with slope 0 to 5% and moderate drainage soil will be used for the farming of the vegetables and fruits whereas old mining pond will be suitable for breeding of the fish. Recreation use will be developed on the darkly shaded areas which possess high scenic quality. In conjunction to the recreation use, the area will also be used for a practice called afforestation. This is a practice in which the vacant land is turned into forest by revegetating the land with valuable timber seedlings. There are several positive aspects of this practice such as financial gain from the timber, prevention of soil erosion, and enhancing the scenic quality of the recreational areas.

2. Reclamation Process

The physical and chemical properties of the mined soil have been disturbed by the mining activities. The soil structure is weak and unstable in supporting heavy loads. The essential nutrients that support plant have been washed away by the erosion agents. Therefore, soil improvement methods are required to prepare the soil suitable for the land use developments. The soil improvement methods can be classified into two types including, (a) improvement to support building load through soil compaction and foundation works and (b) improvement to support vegetation through revegetation processes.

CHAPTER FOUR

CASE STUDY - SEK MINING COMPANY

This case study is presented to illustrate the application of the discussed methodology to the development of a rehabilitation program on tin-mined land for low-cost housing development. This case study will cover all the processes in the methodology. It is the intention of this chapter to illustrate the application of the methodology in developing a rehabilitation program to reclaim tin-mined land for low-cost housing development.

Site Selection

As mentioned in the methodology, the first step in site selection is to identify a dominant tin producing regions in Malaysia. Kinta Valley and Klang Valley are the dominant regions which produce 90 percent of the tin in Malaysia (Figure 4.1). Kinta Valley has been chosen because of availability of mining information from the Mines Research Institute of Malaysia, located in Ipoh, which is the largest urban center in the valley.

When the dominant tin producing region has been selected, the next step is to select an urban area with high demand for low-cost housing and an abundance of undeveloped tin-mined land. Ipoh is the best choice because it has been burdened by low-cost housing shortages since the early 1960s (Johnstone, 1983). Its development and prosperity are dependent upon the wealth of the tin industry and it possesses many acres of undeveloped tin-mined land. The prosperity of the city has caused the urban migration of rural people to the urban center. Figure 2.7 shows that about

14 percent of the dwellings in Ipoh in 1982 were classified as squatter. In 1982, the Perak State Committee on Squatters has estimated that there are approximately 50,000 squatters in the city. The committee allocated 1212 acres of mined land to more than 1500 families since 1975 and the demand of such benefit has been increasing ever since that time (Department of Statistics, 1982). Therefore, Ipoh is faced with a shortage of low-cost housing and tin-mined land is the best site for such development.

Selecting a study site in the vicinity of Ipoh is the last step in the site selection process. The author has visited two undeveloped tin-mined sites which have been mined by SEK Mining Company (Site A) and Mambang Di Awan Company (Site B). The site-selection characteristics for the sites were as follows:

1. Proximity to urban area :

   Site A is located about four miles from the central business district of Ipoh and site B is six miles away (Figure 4.2).

2. Method of mining:

   Site A is mined by gravel pumping method and site B is mined by dredging method.

3. Accessibility:

   Site A is easily accessible to the urban population because there is a major highway along the northeast side.
   Site B is located three miles from the highway and was connected by a dirt-mining road. Thus this site is less accessible to the urban population than site A.

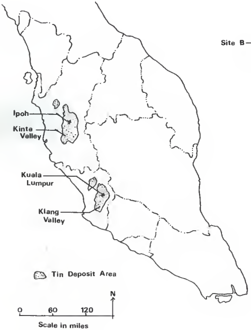


Figure 4.1 Tin Producing Regions In Malaysia

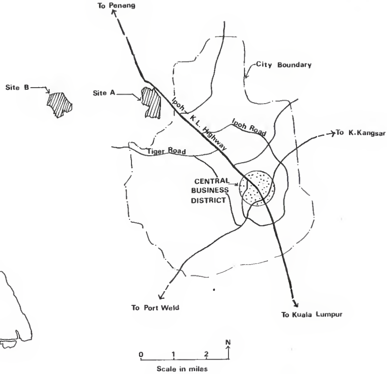


Figure 4.2 City of Ipoh

Site A is chosen as the study site because it is more accessible to the urban population than site B. Site A, formerly mined by SEK mining Company, has a total area of 450 acres and has been left vacant for about five years. Thus site A is inventoried to gather information on its physical conditions.

Data Collection and Documentation

The next process after the site selection is the gathering of information or data about the site. Two categories of information have been gathered from the site. The first category includes socio-economic factors while the second provides site characteristics.

The major socio-economic factor that creates the shortage of low-cost housing in Ipoh is the squatter population. As stated above, there are about 50,000 squatters living in the city whose dwellings made up about 14 percent of the total dwellings in Ipoh in 1982. The Ministry of Housing and Local Development has reported that the price of low-cost housing affordable by the squatter in 1983 should not be greater than M$11,000. Therefore, the development of low-cost housing on the site should not be greater than the affordable price. There are about 18,500 acres of undeveloped tin-mined lands surrounding the city of Ipoh. Thus, there are plenty of undeveloped lands that can be used for development of low-cost housing.

The information on the site characteristics is divided into: (1) climate, (2) topography, (3) soils, (4) vegetation, and (5) scenic quality.

1. Climate

In general, the climate of the site is similar to that throughout the country. It is called an equatorial climate which is hot and humid throughout the year. The site receives about 100 inches of rainfall annually. The precipitation, brought by the southwest moonson winds, usually comes in the form of thunderstorms that occur primarily during the period between April and October. The mean temperature throughout the year is 83°F. The humidity of the site is extremely high during the day and night.

2. Topography

The topography of the site can be classified as undulating or rolling, formed by the sand and clay tailings left by the gravel pumping operations. Figure 4.3 shows the topographic features of the site. Physically, there are two distinct water areas with the largest at the northwest part of the site. These water areas are the old retaining ponds with depth varying from one point to another. The deepest point is about 40 feet deep. The total area of the water bodies is about 15 acres. The elevation of the land ranges from the lowest point of 658 feet to the highest point of 822 feet. Three low hills rise from the low-lying ground with a dominant hill located in the center of the site. These hills are made up of gravel and sand tailings. A relatively flat valley runs from the northeast to the central and continues to the southwest of the site. This valley is mostly covered with sand tailings.

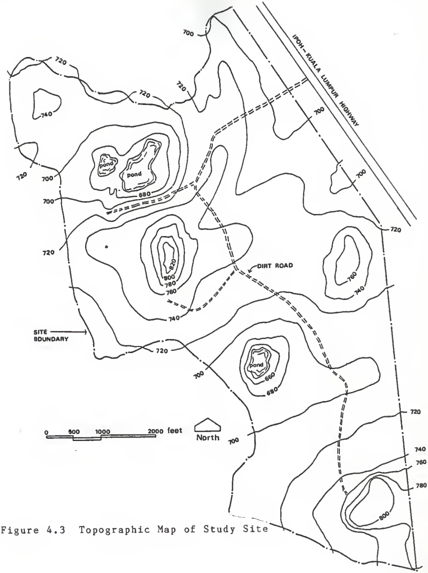


Figure 4.3 Topographic Map of Study Site

3. Soils

The soil structure of the tin-mined land is complex because of the disturbance by the mining activities. The description of soil information can be classified into two categories including: (A) agronomic, and (B) engineering.

A. Agronomic

In general, the soil consists of 67 percent sand, 31 percent mixture of sand, silt, and clay and 2 percent of water areas. Most of the site is well drained because of the high content of sand. The poorly-drained areas are close to the old mining ponds. The topsoil has been removed during the excavation of the overburden. The overburden has been used to fill the mining ponds and, therefore, is usually covered by sand or clay tailings. Most of the essential nutrients for plant growth have been leached by heavy rainfall. Table 4.1 shows the physical and chemical properties of the soil on the site. The soil is divided into two types including sand and slime (clay or silt). The acidity of the soil is about neutral which is mainly caused by the rapid leaching process. There are no toxic substances such as cadmium, mercury or arsenic contained in the soil. Some pioneer grass species are able to inhabit the soil particularly where there is a mixture of sand and clay. Once vegetation is established on a site, the soil fertility and structure is improved by the plant's humus.

B. Engineering

The Mines Research Institute of Malaysia (MRIM) and Japan International Cooperation Agency (JICA) have conducted several

Physical and Chemical Properties	Sand	Slime
Bulk Density	1.585	1.189
Total Pore Space (%)	40.20	55.11
Quick Drainage Pores (%)	36.85	1.35
Slow Drainage Pores (%)	1.41	5.13
Water Storage Pores (%)	1.66	9.09
pH	6.95	6.97
Nitrogen (%)	0.0155	0.0603
Carbon (%)	0.104	1.670
Calcium carbonate (%)	0.06	0.26
Phosphate (p.p.m)	3.5	10.5
Potash (p.p.m)	50.0	62.0
Exchangeable Magnesium (mEq/100g)	0.034	0.728
Exchangeable Calcium (mEq/100g)	0.635	10.203
Exchangeable Sodium (mEq/100g)	0.042	0.078
Exchangeable Potassium (mEq/100g)	0.064	0.224
Exchangeable Iron (mEq/100g)	0.144	0.235
Exchangeable Aluminium (mEq/100g)	0.314	0.334

Note : All measurements of pH and nutrient contents are obtained from soil depth 0-6 inches.

Table 4.1 Physical and Chemical Properties of the site soil
Source: Mines Research Institute of Malaysia, 1983

experiments on the soil structure of the tin-mined lands. JICA (1981) has classified the soil of the mined land into five engineering types. This classification is based on the ability of the soil to support the load of buildings. This classification has been used by MRIM to divide the soil of the study site. Table 4.3 shows the classification of the soil and area covered the soil types in the study site. The location of the soil types is shown in a soil map (Figure 4.4).

Since the mined soil is divided into five types, there are some differences in their properties. Therefore, it is important to evaluate the properties of the soils.The properties of the soils consist of bearing capacity, drainage and revegetation potential. Table 4.2 shows the evaluation of soil properties ranked as low, moderate and high.

Soil Types	Soil Properties			Score
	Bearing Capacity	Drainage	Revegetation Potential	
A	High	High	Low	High
B	High	Moderate	High	High
C	Moderate	Low	Moderate	Moderate
D	Low	Low	Moderate	Low
E	Low	Low	Low	Low

Table 4.2 Soil Types Evaluation
Source: Mines Research Institute of Malaysia, 1983, and Japan International Cooperation Agency, 1982

From the soil classification and evaluation tables it is found that soil Type A is composed of sandy soil left by the mining operations. This soil has high bearing capacity to support the building loads and no consolidation settlement will take place. It is a well-drained soil because of the high drainage value. Type B is composed of a soft clayey deposit

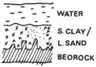
Soil Type	Profile	Area (acres)	Percentage	Bearing Capacity
A		604	67.1	High
B		118	13.1	High
C		120	13.3	Moderate
D		43	4.8	Low
E		15	1.7	Low

Table 4.3 Soil Classification of the Study Site
Source: Mines Research Institute of Malaysia, 1983

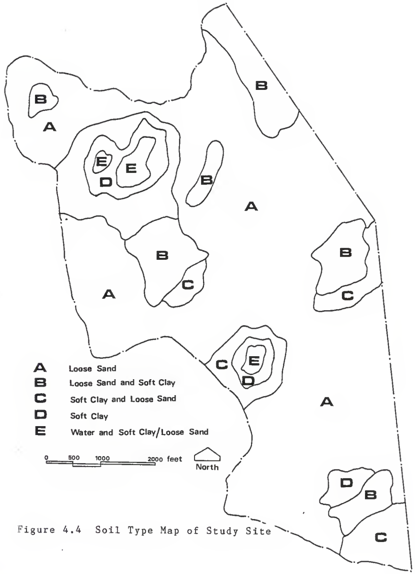


Figure 4.4 Soil Type Map of Study Site

covered with sand. Although it has high bearing capacity, some consolidation settlement might take place due to the clay deposit. Type C is comprised of sandy soil deposits covered with soft clay and consolidation settlement is high. It has a low drainage value indicating the soil is poorly-drained. But soil Type C is superior to those of Type D because the term of consolidation is shorter. Type D is a mining pond filled with soft clay. This type of soil requires a substantial amount of fill and the term of settlement is long. Lastly, Type E is a mining pond that has been unfilled with soil materials and usually filled with water. This soil is very soft and will only support structures after being filled with a large amount of soil (JICA, 1981).

The revegetation potential is the soil property which indicates the ability of the soil to support plant growth. This means that soil with high a revegetation potential value would support more plant than those with moderate and low values. This is because the high-value soil has more essential nutrients for plant growth than the moderate and low-value soils. Thus, soil Type B (high value) would be habitated by plants easier and faster than soil Type C and D (moderate value). Soil Type A and E have low revegetation potential value and would be difficult for the plant habitation unless the soils are treated with topsoil and fertilizers.

4. Vegetation

Since the site has been abandoned for five years, only sparse grass and shrub communities grow on the tailings. The tailings that initially support plant growth are the mixture of sand and clay. The grass communities are dominated by two species, Ischaemium muticum and Imperata cylindrica. Ischaemium muticum is the first colonizer of the site and grows to average height of 8 inches (Lim, 1984). Imperata cylindrica is a tall grass that can reach to 3 feet in height. It usually grows on sites that have been established by Ischaemium muticum. The shrub communities are composed of shrubs of heights ranging from 1.5 feet to 4.5 feet. The common species growing on the site are Melestoma malabathricum, Cyclosonus aridus, Minuosa separia and Spathogolottis plicata. They usually grow in dense form and possess long root systems to hold firmly to the loose sandy soil. Some hydrophytes are growing along the fringes of the mining ponds. The species include Eragrostis unioloides, Isachna globosa, Milcania cordata, Leersia hexandea, Typha augusta and Nymphia lotus.

5. Scenic Quality

The scenic quality of a location in the study site is measured by using a scenic quality inventory and evaluation chart (Figure 4.5). This chart is adapted from the Manual of Resource Management, Bureau of Land Management. This adaptation is mainly due to lack of a scenic quality inventory system in Malaysia. The scenic values of each location are added in a score table to determine the scenic quality zone. The score table and scenic quality zones are given below and an example of using the table is also illustrated (Table 4.4).

	High	Moderate	Low	
Landform	5	3	1	
Rockform	5	3	1	
Vegetation	5	3	1	
Water	5	3	1	
Color	5	3	1	
Disturbance	2	0	-4	
Total	5	6	2	= 13

Scenic Quality Zones:

Low = 0-11 Moderate = 12-18 High = 19-37

Table 4.4 Score and Scenic Quality Zone Table

The example in the table has a total score of 13 and therefore the location is classified as a moderate scenic quality zone. When scenic quality zones are obtained for the whole site, the information is illustrated in a map (Figure 4.6).

Analysis of Data

The gathered information is analyzed to determine the suitability of the study site for land use development. The major land use is low-cost housing for the squatters. This suitability analysis is carried out by the following steps: (1) suitability matrix, (2) overlay technique, and (3) composite overlay.

1. Suitability Matrix

There are two variables used in this matrix, including independent and dependent. The site characteristics represent

Key factors	Rating Criteria and Score		
Landform	Over 30 percent slopes which are dissected, uneven and large dominant features such hills of the tailings 5	10-30 percent slopes which are moderately dissected or rolling. 3	0-10 percent slopes which have little variety of landscape features. Slightly rolling or flat landform. 1
Rockform	Landscape distinctly seen and stand out from the landform. For example, limestone pinnacles in the ponds. 5	Features are common and obvious but not outstanding. For example, gravel and stone mounds form by the tailings. 3	Small to nonexisting features. No limestone outcrops. 1
Vegetation	Over 30 percent of the area cover with grass and shrub communities showing evidence of high potential to support plant growth. 5	10-30 percent of the area cover with grass and shrub communities showing evidence of moderate potential to support plant growth. 3	Less than 10 percent of the area covered with vegetation showing evidence of low potential to support plant growth. 1
Water	Distinct water features such as old mining ponds. Depth of pond of more than 30 feet and thus will not dry out. 5	Shallow pond or lake of depth less than 30 feet and filled with silt and clay and will dry out eventually. 3	Absence of water features. 1
Color	Rich color combination-high contrast of soil color from brown to white and variety of color of the vegetation 5	Moderate color combination of the soil and vegetation. 3	Subtle color variation-generally monotonous color. 1
Disturbance	Modifications add favorably to visual variety. 2	Visual quality is somewhat depreciated by inharmonious intrusions, but not so extensively that they are entirely negated or modifications add little or no visual variety to the area. 0	Modifications are so extensive that visual qualities are for the most part nullified or substantially reduced. -4

Figure 4.5 Scenic Quality Inventory and Evaluation Chart Adapted from Manual of Visual Resource Management, Bureau of Land Management, United States.

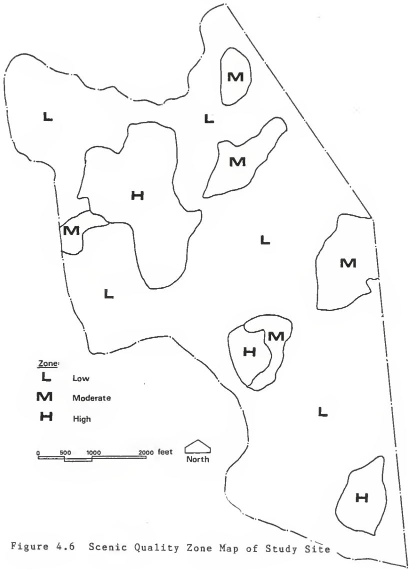


Figure 4.6 Scenic Quality Zone Map of Study Site

the independent variables which influence the dependent variables which are the land uses. The site characteristics are composed of soil types, slopes and scenic zones. Residential (low-cost housing) is the major land use but residential related uses such as recreation, commercial, institutional, agricultural and amenities are also included in the matrix. Figure 4.7 shows the suitability matrix which evaluates the suitability of the land uses to the site characteristics. The suitability of each land use is evaluated for each site characteristic and the suitability is ranked as values. The suitability of soil types and scenic quality are ranked as low, moderate and high, and the slopes are ranked in low, moderately low, moderately high and high values. The criteria of the values for each evaluation is explained for every overlay maps.

The evaluated information in the suitability matrix is used in the overlay technique for further evaluation.

2. Overlay Technique

The values of suitability of land uses to site characteristics are transformed into tonal values on overlays. The tonal values are created by shading the overlays, which are matte acetate, using a rapidograph pen (No. 1). Low values are shaded the darkest and high values are left unshaded. Only the information relating the suitability of residential uses to the site characteristics is transformed into the overlays. This is because residential use is the major land use for this study. The darker the tonal value, the less suitable the area for residential (low-cost housing) use. Conversely, the lighter area,

Land Uses	Site Characteristics											
	Soil Types					Slopes				Scenic Zones		
	A	B	C	D	E	0-5%	6-10%	11-15%	16% and over	High	Moderate	Low
Residential	High	High	Mod.	Low	Low	High	Mod. High	Mod. Low	Low	Low	Mod.	High
Recreation	High	High	High	High	High	High	High	High	High	High	Mod.	Low
Commercial	High	High	Mod.	Low	Low	High	Mod. High	Mod. Low	Low	Low	Low	Mod.
Institutional	High	High	Mod.	Low	Low	High	Mod. High	Mod. Low	Low	Low	Low	Mod.
Agriculture	Low	High	Low	Low	High	High	Mod. High	Mod. Low	Low	Low	Low	Mod.
Amenities	High	High	Mod.	Low	Low	High	Mod. High	Mod. Low	Low	Low	Mod.	High

Figure 4.7 Suitability Matrix for Land Uses and Site Characteristics

the more desirable or better for residentail development. Every value in each characteristic is transformed into the overlay. Thus, there are three overlays being drawn including soil types, slopes and scenic zones (Appendix A). The criteria used to evaluate the suitability of residential use to the site characteristics are explained on a next page for each overlay.

All overlay maps are drawn at the same scale, same format such as sheet size (8.5 by 11 inches), placement of legend, title block, graphic media (matte acetate and black ink) and tonal value. The sheets are aligned by using a highway situated at northeast side of the site.

3. Composite Overlay

Later the overlay maps are superimposed on one another to derive a composite overlay map (Appendix A). The tonal values from each overlay are being overlapped over each other and thus produce a variation of tonal values. The darkest values represented the locations that are most difficult to develop for low-cost housing and would be undesirable. The lightest areas are best for housing development.

D. Synthesis - Land Use Schematic Map

The information produced by the composite overlay is used in a synthesis process. The location for each land use is delineated and integrated with other land uses in a land use schematic map (Figure 4.8). This map shows the arrangement of the land uses on the study site.

There are six land uses including residential, recreation,

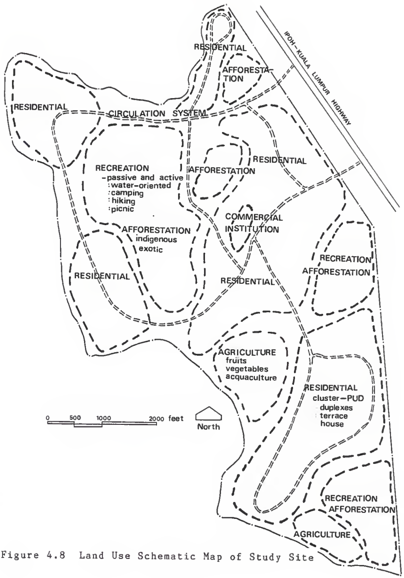


Figure 4.8 Land Use Schematic Map of Study Site

commercial, institution, agriculture and amenities shown on the schematic map. Residential is the major use and thus it used more land than the other uses. It is developed on the high suitability locations which are the lightest area shown on the composite overlay map. The soils of this location are majority of Type A and some of Type B. The slopes are in the range of 0 to 5 % and in low scenic quality zones. The residential development is classified as planned-unit development with low-cost housing being developed in cluster form. The detailed characteristics of the low-cost housing are discussed in the implementation process.

Areas with high scenic quality zones, slopes greater than 11% and soils Type D and E are used for recreation. These locations of these areas are the darkest shaded areas on the composite map. The recreation activities can be divided into two categories including passive and active. Along with the recreation development, the passive recreation areas are also used for afforestation development. The detailed description of recreation and afforestation uses are discussed in the implementation process.

Commercial and institution uses are located in the residential development areas. These uses will facilitate the residents by providing the products important for their domestic uses. Since most low-cost housing residents do not have private transportation, it is necessary to develop the shopping and educational centers close to the population.

Agriculture areas are also included in the study site. These are the areas where the residents can do mixed-used farming as a full-time or part-time work. The location of the farms are within the proximity of the residential areas. The farmers will grow food crops such as vegetables and fruit trees, and raising animals such as poultry and pigs and fish in the mining ponds. The detailed description of the mixed-farming is discussed in the implementation process. Most of agricultural uses are occupying the areas not suitable for residential such as areas with soil Type C, D and E, and slopes in range of 5% to 10%.

Amenities such as circulation and utility systems are located throughout the schematic map of the study site. The pedestrian and traffic circulation systems are provided to facilitate the movement of the residents of the low-cost housing. The roads are constructed in the residental, commercial and institution areas and connected to the Ipoh-Kuala Lumpur highway. They are also constructed along the recreation areas to provide access for the people to enjoy the aesthetic quality of the recreation site. The detailed description of the amenities are discussed in the implementation process.

E. Implementation - Site Development Map

The implementation process is developed after the location's of individual land use areas are delineated on the schematic map. The information from the schematic map is intrepreted further in the implementation process. Here, planning and designing of the land use areas are done and shown in a site development map (Figure 4.9). This map shows the whole structure and organization of land use developments in the site. The description of this process is divided into two parts; (I) land use development, and (II) revegetation process.

Figure 4.9 Site Development Map

I. Land Use Development

A. Residential Development

Description

The residential development is classified as planned-unit development with low-cost housing being developed in cluster form. A planned-unit development is a new way of designing residentail neighborhoods to provide a better environment for the people who live there while producing more profits for the developer and builder (De Chiara, 1975). Since the site has not been used as residential, it is possible to plan and design the whole site for planned-unit residential neighborhood. Some of the advantages for people living in a planned-unit development are :

1. Larger houses for less money
2. More choice of house types
3. Preservation of natural features like ponds and trees
4. Community recreation space
5. Safer pedestrian and vehicular circulation.
6. More conveniently located schools and shops

The type of buildings used for low-cost housing commonly built by Ministry of Housing and Local Development range from low-rise (one or two-story) to high-rise (18 story). High-rise buildings are usually built in city centers where the spaces for residential use are limited. This site has sufficient space for low-rise building construction while still fulfilling the building standards set by Ministry of Housing and Local Development. Thus, low-rise housing is being developed for this site. This housing type is commonly called terrace house in Malaysia which is a one-story building and having two or three rooms in each unit. The terrace houses are built in cluster form having two or more housing units in a group. This includes duplexes, quadraplexes and row houses (5-10 units). The housing density allowed by the Ministry of Housing and Local Development range from 14 to 43 units per acre. Information on housing type, floor and ground areas, cost and density of the low-cost housing to be developed on the site is illustrated in Table 4.5. These standards are adapted from the Design Book of low-Cost Housing published by the Ministry of Housing and Local Development. A typical plan of the low-cost housing is illustrated in Figure 4.10. Figure 4.11 shows a cross section of the housing area.

Table 4.5 shows that the floor areas of the low-cost housing ranges from 458 to 581 square feet. The floor area includes living room, bedrooms, kitchen/dining room and bathroom. The frontyard and backyard have a total area about 250 square feet for both the housing types. These open spaces can be used by the resident to plant vegetables and fruit trees and to do landscaping.

Minimum Building Standards For Low-Cost Housing

The minimum building standards for low-cost housing have being formulated by a committee from the Ministry of Housing and Local Development in 1967. The standard sought to:

1. Standardise low-cost housing design to which conventional and prefabrication construction methods are adaptable.
2. Formulate provisions of low-cost units, shortened

construction period, durability, weather resistance and housing style suited to Malaysians.

The minimum building standards are as follows:

1. The minimum sizes of rooms;
   living room : 120 square feet
   master bedroom : 120 square feet
   kitchen : 48 square feet
2. The minimum ceiling height : 8 feet
3. Building materials : maximum utilization of locallly produced materials
4. Communal facilities :
   a) Site for primary school of 1.5 acre per 1000 people
   b) 6 shops (7200 square feet) per 1000 people
   c) Medical clinic must be provided in commercial area
   d) Parking areas to accomodate cars, motorcycles and bicycles
   e) Cemetery ground : at least one space per one housing unit

The Ministry of Housing and Local Development also set up eligibility requirements to purchase the low-cost housing. The eligibility requirements are as follows:

1. Malaysians of twenty-one years or over who have lived in the city for five years or more.
2. Families with monthly income of less than M$ 500.
3. Family is defined as spouse, children and parents.

Housing Type	Description	Floor Area (sq. feet)	Ground Area (sq. feet)	Cost (M$)	Housing Density (units/acre)
A	2-room one-story	458	1624	9133	26
B	3-room one-story	581	1522	9825	28

Table 4.5 Low-Cost Housing Standards
Source: Ministry of Housing and Local Development, 1983

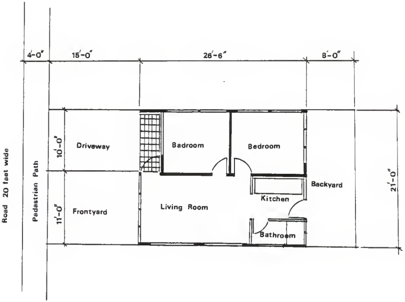
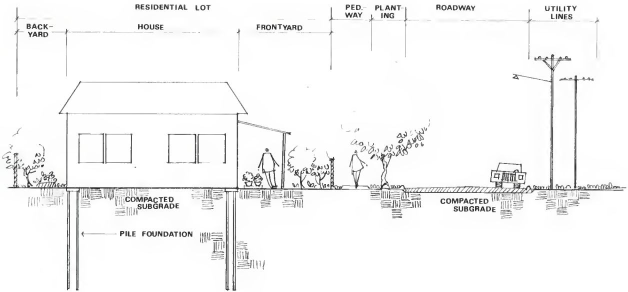


Figure 4.10 A Typical Plan for Low-Cost Housing
Source: Ministry of Housing and Local Development, 1982



Figuire 4.11 Cross Section of Low-Cost Housing Area

Ground Preparation Processes for Floor Area

The residential development is constructed on soil Type A which is loose sandy soil. Although this soil is suitable for low-cost housing development, some ground preparations are needed before the building can be constructed on it. The ground preparation can be divided into the following process:

1. Clearing and Leveling:

   The disturbed and uneven mined soil has to be cleared and leveled before the house can be built on it. The clearing and leveling process can be economically done by using bulldozer, scraper and grader.

2. Surface Compaction:

   The next process of ground preparation is surface compaction. Compaction is the process by which a mass of soil consisting of solid particles, air and water is reduced in volume by the momentary application of loads, such as rolling, tamping, or vibration. This process generally increases the soil strength, decreases its compressibility, and decreases its permeability (Hilf, 1975). For one-story building, this process is commonly done in Malaysia by smooth-three-wheel roller which weighs from 5 to 6 tons. The compacted lift thickness ranges from 6 to 8 inches. The loose and cohensionless sandy soil is compacted by this process and no settlement will occur when the building is placed on it.

3. Foundation Work:

The strength of the soil is further increased by the foundation process. Foundation is a process by which piles are planted into the soil structure by application of load. This process improves the strength of the soil and the soil will be able to support more load. Thus there will be no differential settlement to occur when the building is placed on the soil. Since the low-rise housing is considered as light building, only direct foundation is required for the housing construction. Direct foundation is done by using friction piles in which the piles are driven to the ground without reaching the bedrock. The friction strength developed between the pile surface and soil structure is sufficient to support the weight of the low-rise building. The common and economical piles used for low-rise building is wooden piles which consist of two kinds, including bakau piles and treated timber piles.

A. Bakau Piles

Bakau piles are logs of mangrove trees and typically 4 to 6 inches in diameter and 20 to 24 feet in length. They have an allowable load of about 1 ton per pile and driven with a 400 to 600 pound weight. These piles are closely spaced (about 1 foot) when driven into the ground. Figure 4.12 shows the foundation work using bakau piles.

B. Treated Timber Piles

These piles are made from the tropical timber and having dimensions of 5 by 5 inches. The timber is pressure treated with chemicals to prevent attacks from fungus and insects. They have allowable load of 14 tons per pile and are driven with a 2000 pound weight. Figure 4.13 shows the the foundation work using treated timber piles.

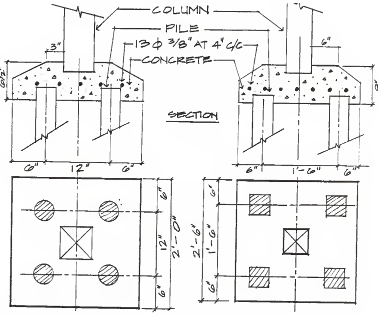


Figure 4.12 Bakau Pile Foundation

Figure 4.13 Treated Timber Pile Foundation

When the foundation work is completed, the ground is ready for the low-cost housing construction. In 1981, Japan International Cooperation Agency estimated the cost of the ground improvement. The total cost of the ground improvement is M$1.13 per square foot and is economical enough for low-cost housing development.

Ground Preparation Processes for the Yards

Since the mined soil lacks of essential nutrients to support plant growth, it is necessary to improve the condition of the soil. The preparation methods for the yards are discussed in revegetation process.

B. Recreation Development

Description

Recreation development is developed on areas not suitable for residential development. These areas have higher scenic quality, slopes greater than 11% and soil of Type D and E. Recreation is any form of experience or activity chosen by an individual for their personal enjoyment and satisfaction. The recreational activities can be divided into two categories including passive and active. Mohdzain (1981) has classified the recreational activities found in Malaysia. The classification is is shown in Table 4.6.

Active	Passive
Soccer	Fishing
Hockey	Picnicking
Badminton	Sight-seeing
Tennis	Walking
Basketball	Cultural shows
Sepak takraw	Boating
Cycling	Hiking
Jogging	Meditation
Swimming	

Table 4.6 Types of Recreational Activities in Malaysia
Source: Mohdzain, 1981

The area with two low hills and two old mining ponds is suitable for recreation development. The hills can be developed for passive recreational activities such as hiking, picnicking, sight seeing and meditation. The undulating area around the ponds can be used for passive activities such as picnicking, site-seeing and walking, and for active activities such as playing sport games especially sepak takraw, basketball and badminton, jogging and cycling. The pond can be used for water oriented activities such as swimming, fishing and boating. These recreational activities will provide enjoyment and satisfaction to the resident of the low-cost housing.

Ground Preparation Processes for Active Recreation

Active recreational activities such as sport games, jogging and cycling require hard surfaces. The hard surface can be made from concrete or asphalt for jogging, cycling trails and sport games. The ground preparation processes are as follows:

1. Clearing and leveling the ground using tractor with scraping blade.
2. Compacting the ground using tractor-drawn smooth-wheel roller that weighs 1 to 2 tons.
3. Laying of the construction materials such as concrete or aaphalt.

The ground preparation processes for recreational buildings are similar to the residential's processes.

Ground Preparation Processes for Passive Recreation

The passive recreational activities require are usually found in an environment made up of undulating ground surfaces and natural vegetation. Thus no levelling and compaction processes are needed for the ground preparation. But vegetation is required for the site for these activities. The ground preparation processes for the growing of vegetation are discussed in revegetation process.

C. Commercial Development

Description

Commercial facilities such as shops and medical clinics are required for the residents of the low-cost housing. The development of such facilities should be in the vicinity of the residential areas. This is because the residents of low-cost housing mostly depend on public transportation to go to the market.

The typical structure of the shop for low-cost housing communities is one-story building with average size of 1200 square feet. A community of 1000 residents needs at least six shops in the commercial area (Ministry of Housing and Local Development). A medical clinic is also required and ususally built in the commercial area. Parking areas for vehicles are also required in the commercial center.

Ground Preparation Processes for Commercial Area

Since the structure of the shop is one-story, the load per square feet placed on the ground is similar to the house. The ground preparation processes for the construction of the shops are similar to residential processes.

D. Institution Development

Description

Another basic requirement in the neighborhood is primary school for the children of the low-cost housing residents. A primary school is required for every 1000 residents. This educational center is usually located adjacent to the commercial area. A primary school needs a minimum of 1.5 acres of land for its development. A typical primary school is usually one- or two-story building surrounded by playground areas.

Ground Preparation Process for School Building

The load per square foot produced by the school building to the ground is more than the low-rise house. The ground preparation processes are slightly different than the residential processes. The clearing and leveling, and surface compaction processes are similar to those in the residential processes. In the foundation work, only treated timber piles are used to improve the strength of the loose sandy ground. The dimensions for the timber piles are 7 by 7 inches with length of 20 to 24 feet. The piles are driven by 2000 to 4000 tons weight from a height of 3 feet. The allowable load per pile is 27 tons. The piles are usually jointed with steel-sleeve joints and driven further down than the piles for residential construction.

Ground Preparation Process for School Playground

The common school playground consists of playfields for sport games such as soccer, sepak takraw and badminton, and trackfield, usually associated with soccer field. Thus the ground has to be cleared and then levelled to appropriate slope. The next process is the growing of grass on the playfields. This process is discussed in the revegetation process.

E. Agriculture Development

Agriculture is the major reclamation practice done on tin-mined land in Malaysia. Most of the lands are illegally farmed by the farmers in raising food crops such as vegetables and fruits. The old mining ponds are used for breeding of fresh-water fish. Thus, the farmers usually do mixed-used farming in growing cash crops, breeding fresh-water fish and raising livestock such as poultry and pigs. The fish culture is successful when operated in conjunction with the livestock where the effluent from animals seeps into the ponds and encourages the development of algae, plants and aquatic insects for the fish to feed on. Potential net annual income from a vegetable farm is estimated to be about M$ 1,780 per acre and the fish farm produced about M$ 1,300 per acre of pond area (Kitching, 1982).

The crops are grown on the sand and slime (clay and silt) tailings. The common crops that can grow on the tailings are listed in Table 4.7.

In the mining ponds the farmers usually raise several kinds of fish that possess complementary feeding habits. Among the most preferred combination is <u>Aristichterys nobilis</u> (big head carp) that feed on coarse plankton, <u>Puntius gonionorus</u> (lampan jawa) that feeds on macro-vegetation, <u>Ctenopharyisogodon idella</u> (grass carp) that feeds on fine plankton, and <u>Cyprius carpio</u> that feeds on bottom vegetation.

Sand Tailings

1. Grass and legume forage
2. Root crops - cassava, peanuts, onions
3. Vegetables - cabbage, pepper
4. Fruits - melons, papaya, pomelo, star fruit, coconut and cashew nut
5. Tobacco - Virginia type

Slime Tailings

1. Grass and legume forage
2. Upland rice
3. Corn
4. Soy bean
5. Vegetables - french bean, long bean, tomatoes, pepper
6. Fruits - banana, star fruit, pineapple, pomelo
7. Tobacco - Burley type

Table 4.7 Crops planted on Tin Tailings
Source: Kitching, 1982

Ground Preparation Process for Agriculture Use

The mined soils are lacking in topsoil and essential nutrients for plant growth. Therefore, the soils have to be improved for plants to grow. The preparation and improvement processes are discussed in the revegetation process.

F. Amenity Development

Description

Amenity development is included in residential development to facilitate and give convenience to the people in the neighborhood. The amenity development consists of two systems including circulation and utility. The circulation system facilitates the movement of the people in the community whereas the utility system provides the basic needs for the people such as electricity, water supply, telephone and sewage disposal. The construction of a utility system is usually in conjunction with the circulation system resulting in better efficiency in cost and appearance. Figure 4.14 illustrates the relationship and locations of the facilities in both systems commonly built in low-cost communities in Malaysia.

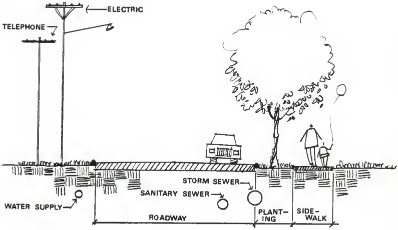


Figure 4.14 Street Cross Section
Source: Ministry of Housing and Local Development, Malaysia, 1983

Circulation System

The circulation system in planned-unit development neighborhood is divided into two parts; streets and pedestrian walks. The streets are separated from the pedestrian walks to provide more safety and convenience for the pedestrians.

1. Pedestrian walks:

A safe and convenient system for pedestrian walks is essential in the low-cost housing community. It should be functionally organized and follow the natural traffic patterns of pedestrians. Walks should be wide enough to accomodate two-way traffic with width ranging from 4 to 6 feet. The desirable maximum grade for walks is 4%.

2. Streets:

The overall street system for the housing development must conform to the circulation requirements of the community. It should provide maximum accessibility to all parts of the community and insure proper coordination with proposed circulation changes. Parking lots are included in the street system. The street classification is shown as follows:

Type	Width in feet
Arterial	32
Collector	24
Minor	20
Cul-de-sac	20
Alley	18

The horizontal alignment of the streets should provide a minimum of 200 feet clear sight distance. The desirable maximum grades for the streets range from 3% to 6%. When trees are planted between the curb and walks, the walks should be setback approximately 6 feet. If no trees are used, the setback should be 4 feet.

Utility System

This system consists of water supply, sanitary sewer, storm sewer, electricity and telephone. The location and interrelationship of all utility lines must be carefully studied for effiency and appearance.

1. Water Supply:

Water supply mains may be located under pedestrian walks, in planting strips, or under street. Minimum design requirements will locate it at 10 feet from the nearest sewer. If wells are used, they should be located at minimum distance of 100 feet from septic tanks and sewers.

2. Sanitary sewer:

The sanitary sewer mains are usually located on the center line of the road. The line is a clay tile pipe. It should be located below the water supply mains.

3. Storm Sewer:

Storm sewers are generally located one-third the distance from the curb to center of street. It should always located on the opposite side of the street from the waterline.

4. Electricity and telephone:

These are located in overhead lines over planting strip.

<u>Ground Preparation Process for the Pedestrian Walks</u>

The pedestrain walks are usually made from concrete. Since the mined soil is unstable for the walks, ground preparation and improvement processes have to be applied.

1. Clearing and Levelling:

The clearing and leveling of the ground is done by grader.

2. Surface Compaction:

The ground is compacted using smooth-wheel roller weighing 1 to 2 tons. This will encourage the loose sandy soil to become a compacted subgrade for the walks.

After the compaction process the ground is ready to be used for walk construction which must be conformed to the building standards of Department of Public Works, Malaysia.

Ground Preparation Process for Streets

Since the streets are being used for heavier loads than the walks, better ground preparation and improvements are applied. The common paving material for the street system in Malaysia is asphalt.

1. Clearing and Leveling:

   This process is usually done by the bulldozer, scraper and grader. The finish grade should be in range of 3% to 6%.

2. Surface compaction:

   The ground is compacted in two stages. The first stage is using sheepsfoot roller with load of 1.5 to 3 tons per linear foot of drum. The loose sandy soil has to be compacted in 4 to 6 coverages and compacted lift thickness ranging from 6 to 8 inches. Then the ground is further compacted by a smooth-wheel roller weighing 5 to 6 tons with lift thickness ranging from 6 to 8 inches. This process turns the loose sandy soil into a compacted subgrade that will support the traffic load.

After the compaction process, the ground is ready for the construction of paving material which is usually asphalt. The construction of the asphalt pavement should conform to the building standards of Department of Public Works, Malaysia.

II. Revegetation Process

The development of the residential, recreation, institution, agriculture and amenity uses are involved with the growing of vegetation in different aspects. Residential and institution uses require vegetation to be planted around the buildings. Recreation uses require vegetation to enhance and facilitate the aesthetic quality demanded by the users. Recreation areas in the study site are also used for afforestation uses which are totally involved with the growing of plants. It is obvious that agriculture areas are used for the planting of food crops. Lastly, trees and shrubs are planted along the street system to provide shade and beauty to the users. Thus vegetation has to be established on the study site to meet the needs of the land use developments. The establishment of the vegetation is through a revegetation process including the following aspects: (1) identification of revegetation problems, (2) ground preparation for vegetation, and (3) method of planting and species selection.

Identification of Revegetation Problems

Since the soil on the site has been disturbed by the mining activities, several revegetation problems will arise in growing of plants. The revegetation problems can be classified into physical, chemical and biological properties.

1. Physical Properties:

Problems encountered in revegetation process in the this tin-mined site include lack of topsoil, slope, erosion potential, particle-size distribution, color and drainage.

a. Lack of Topsoil

The topsoil of the mined land has been removed during the excavation process and used to fill the mining ponds or holes. Thus the ground is left with loose sand and clay soils derived from the mining tailings. These soils cannot support many varieties of plants because of the absence of topsoil which possesses the plant nutrients.

b. Slope and Erosion Potential

The soils on the low hills in the site are susceptible to erosion from the heavy tropical rainfall. Thus the soil particles and nutrients are leached out easily when the gradient of the slope is steep.

c. Particle-Size Distribution

Particle-size distribution refers to the amount and proportion of the various sizes of particles in the whole soil, including sand, silt, clay, and rock fragments (Law, 1984). The particle-size distribution of the soils is unevenly distributed by the mining activities. The structure of the soil is consisted of either loose sand layer or clay layer. Thus the sand particles and clay particles are not mixed together.

d. Color

The color of the sandy soil is generally white and the clay soil is light brown. Dark-colored soils absorb more heat from the sun than light-colored varieties (Law, 1984). Therefore, the clay soil is warmer than the sandy soil during the bright sunny day. The surface temperatures of dark-colored minesoils are lethal to seedlings.

e. Drainage

The sandy soil does not hold the water with a total pore space of 40.20%. Vegetation could not be easily grown because of a lack of water. On the other hand, clay soil holds water excessively with a total pore space of 55.11%. The clay particles are closely spaced and water could not flow through the soil structure resulting in water-logged condition and poor aeration. Thus this soil is also not suitable for revegetation.

2. Chemical Properties:

The only chemical problems that affect revegetation efforts on the site is nutrient deficiencies. The removal of topsoil and exposure of the mined soils to erosion agents have resulted to the leaching of the nutrients. After five years of exposure to erosion agents, particularly running water from rainfall, the soil of the site is almost devoid of essential nutrients for plant growth.

3. Biological Properties:

The prominent biological problems in the site are lack of organic matter and soil fuana.

a. Lack of Organic Matter

The lack of vegetative cover on the site has resulted in a lack of organic matter in the soil. Organic material is a major source of nitrogen which can be artifically added to the planting media (Law, 1984).

b. Soil Fuana

Since the lack of plants on the soils that provide food for the soil fuana in form of litter, the mined soils are devoid of soil fuana. Soil fauna such as worms, beetles, and insects dwell in the soil and are responsible for consuming and altering organic matter and mixing it with the soil.

Ground Preparation for Vegetation

The physical and chemical properties of the mined soil are improved through the following processes:

1. Mixing of Soil Fractions

The soil structure is to be broken up using tractor-drawn offset discs or chisel plows. This process will mix the sand and clay fractions of the soil and result in an even particle-size distribution of the soil. Several coverages must done to get an even particle-size distribution of soil. The finish slope of the ground should conform to the requirement for effluent application listed in Table 4.8 (Refer page 109). The process will also improve soil drainage and aeration.

2. Soil Conditioning

The next process after the soil fractions have been mixed is soil conditioning. The purpose of soil conditioning is to build up the organic matter in the mined soil by adding aoil conditioners. Soil organic matter binds together soil particles into aggregates between which there are large (non-capillary) pore space through which air can penetrate into the soil and through which surplus water can drain away. The benefits that the soil conditioners give to the soil can be summarized as follows:

a. Improve texture

b. Increase water-holding capacity

c. Protect against erosion

d. Supply plant nutrients especially nitrogen, phosphate and potassium

e. Increase biological activity in the soil

The soil nutrient requirements for the plant varies from one plant to another. The average nutrient requirements for tropical crops are as follow:

Nutrient	Requirement (pounds/acre)
Nitrogen	250-400
Phosphate	30-50
Potassium	100-200

There are four kinds of soil conditioners that can be used to improve the organic matter in the mined soils. They are: (A) rubber effluent, (B) palm oil effluent, (C) sewage effluent, and (D) animal manures.

A. Rubber and Palm Oil Effluents:

Rubber and palm oil effluents have been widely tested as soil conditioners to rehabilitate the tin-mined soils. The Rubber Research Institute of Malaysia (RRIM) and Malaysian Agricultural Research and Development Institute (MARDI) have done many experiments on the use of these effluents as soil conditioners in the mined soils. The results show much promise in improving the soil's organic matter and also fertility (Kitching, 1982). This is because the effluents are relatively cheap and contain considerable amount of essential nutrients for plant growth. The disposal of the rubber and palm oil effluents has been a serious problem by both industries. Thus the effluents can be purchased at very low price and could be economically utilized in rehabilitation of tin-mined soils. As indicated in Table 4.7 these materials contain considerable amount of plant nutrients. The

Constitutent	Effluents in Percentage Palm Oil	 Rubber
pH*	4.5	6.5
Total Solids	4.8	0.0015
B.O.D	2.0	1.35
C.O.D	6.0	3.1
Nitrogen	0.1	0.33
P	0.02	0.016
K	0.19	0.25
Mg	0.05	0.009
Ca	0.02	0.01
Mn	none	trace
Fe	none	trace
Zn	none	trace
Mo	none	trace
B	none	trace

* pH not measured in percentage

Table 4.7 Chemical Composition of Palm Oil and Rubber Effluent
Source: Malaysian Agricultural Research and Development Institute, 1982

palm oil effluent has a pH of 4.5 and has to be treated with lime (calcium carbonate) to neutralize the acidic compound in the effluent (MARDI, 1982). No treatment is needed for rubber effluent although its pH is 6.5 which is slightly acidic. The leaching process by the rainfall will neutralize the effluents when placed into the soil.

The effluents come in solid form and are mixed together before they are applied to the mined soils. The method of application, amount of effluent, suitable slope for the application for the effluents, and time lapse for planting are illustrated in Table 4.8.

B. Sewage Effluent:

The Malaysian Agricultural Research and Development Institute has also tested the use of sewage sludge as a soil conditioner on tin-mined soils. Sewage sludge is derived from the human wastes which are treated by municipal wastewater treatment plants. Sewage sludge improves the physical properties of soil and supplies nutrients long enough to establish plant growth (Walsh, 1976). The major nutrients supplied by the sludge are nitrogen (2.20%) and phosphate (0.60%). The sludge also contains minute amount of elements such as potassium, calcium, magnesium, sodium, iron, aluminium, zinc, cadmium and lead. Cadmium and lead are toxic elements that are hazardous to human and percaution has to be taken when using the sludge for food crops cultivation. The pH of the sludge may be slightly alkaline (7.9) which will be corrected by the leaching process after the material is placed into the soil.

Effluent	Application Characteristics
Rubber and Palm Oil	Method: Spread evenly on the ground using box spreader pulled by tractor or truck. Mixed into the soil by plowing or disking. Amount of effluent: 10 to 12 tons per acre in each application (two applications in interval of 6 months). Suitable slope: 2% to 4% Time lapse for planting: 4 to 6 weeks.
Sewage (liquid)	Method: Spread evenly on the ground using sprinkler system attached to tank wagon pulled by tractor or truck. Later the soil is plowed to mix the effluent evenly. Amount of effluent: 4 to 6 tons per acre in one application. Suitable slope: 0.5% to 1.5% Time lapse for planting: 10 to 15 weeks.
Sewage (solid)	Method: Spread evenly on the ground using box spreader pulled by tractor or truck. Mixed into the soil by plowing or disking. Amount of effluent: 4 to 6 tons per acre in one application. Suitable slope: 2% to 4%. Time lapse for planting: 15 to 20 weeks.

Table 4.8 Application Characteristics for the Effluents
Source: Malaysian Agricultural Research and Development Institute, 1982

This effluent comes in solid or liquid forms. The method of application, amount of effluent, suitable slope for application of the effluent, and time lapse for planting are also illustrated in Table 4.8.

D. Animal Manures:

The waste of poultry and cattle are often used by individual farmers to improve the soil structure and fertility of the mined land. This is possible only in mixed-used farming where the farmers grow vegetables and fruits, and raise poultry, cattle or pigs. The waste of the animals, except pigs, are used as manure in growing the food crops. The manures are rich in nutrients such as nitrogen and phophorus which are essential to plant growth. The manures are spread by hand broadcasting and mixed into the soil using simple farming tools such as a hoe and a spade.

Normally this soil conditioner is used on the soil which has been treated by rubber and palm oil effluents. The reason is to increase the fertility of soil for the growing of vegetables and fruit trees. The amount of material applied to the soil varies from one plant to another. Since the use of manure is usually done by individual farmer, the method of application revolves between the farmers and thus no reliable documents are available.

3. Planting Grass and Legume

After the improvement of soil properties by the soil conditioner, grasses and legumes are normally planted on the soil to further improve the nitrogen content in the soil, prevent erosion from heavy rainfall, and prevent the growing of weeds.

The common grass that is planted on the improved soil is Axonopus sp and Digitaria sp. Fast growing legumes such as Stylosanthes guyanensis and Pueraria javanica are planted on the improved soil. Experiments have shown that under tropical conditions the net gain in soil nitrogen from the grass and legume mixture can reach 400 pounds per acre per year (Kitching, 1982).

The planting of grass is needed in the residential yards, school playfields and recreation open spaces. Sometimes chemical fertilizers are added to the soil when there are signs of insufficient nutrients. The legumes are planted in agriculture areas, particulary around the fruit trees to provide additional nitrogen, preventing the loss of nutrients by soil erosion, and preventing the growth of weeds. The legumes are also necessary in afforestation areas because the tree seedlings need sufficient amount of nutrients and protection from the invasion of weeds.

The establishment of the grass and legume is done by seeding method. The common seeding method is broadcasting which uses equipment such as a fan seeder that blows seed out and away from the seeder in a circulation pattern. Hand broadcasting is also done in areas of rough terrain or on small parcels of land. The seeds of the plant should be uniformly distributed throughout the ground. The best time for seeding is just prior to the rainy period that is between April to October.

Planting Method and Species Selection

Agriculture and afforestation are the land uses most involved with the growing of vegetation. Thus it is important to describe the planting method and plant species selection for both practices.

1. Agriculture Practices

Mixed-used and intensive farming are usually done on the rehabilitated tin-mined lands. The farmers usually grow food crops such as vegetables and fruit trees, and also raise animals such as poultry and pigs. The wastes from the animals are used as manure in the vegetable beds and fruit tree planting holes. The crops that should be grown in the agriculture area are previously listed in Table 4.6. The farming is usually labor intensive using simple farming tools. The farmers usually use hoes to make the vegetable beds and water the plants using buckets carried on their shoulders. The fruit-tree seedlings are planted in a planting hole with treatment of rich topsoil and manure. Figure 4.15 illustrates the structure of a planting hole. The trees are planted in spacing of 15 to 20 feet apart. The necessary maintenance practice after the planting of the seedlings involves the clearing of the space around the seedlings from the legumes and weeds.

2. Afforestation Practices

Afforestation practice is necessary because more than 75% of tropical rain forest in Malaysia has been cut for agriculture, residential and urban developments. The trees that are suitable to grow on the improved mined soil and produce valuable timber should be planted in the afforestation areas. The recommended species and planting spaces for afforestation practice are illustrated in Table 4.9.

All the indigenous species include hardwood species that grow in the lowland areas. The maturity age for the lowland forest is about 75 to 100 years. Durio sp. is more preferable than the others because it produces valuable timber and also produces fruits that are very expensive in the market. The exotic species are softwood species which grow faster than the indigenous

Species	Planting Space
Indigenous:	(feet)
Shorea spp (Meranti)	25
Dipterocarpus spp (Keruing)	25
Artucarpus spp (Terap)	25
Durio spp (Durian)	25
Exotic:	
Pinus caribea	10
Pinus markussi	10
Causuarina equisefolia	15

Table 4.9 Tree Species for Afforestation Use

species. The usual growth rate to reach maturity is 20 to 30 years. But they are cheaper than the hardwood species in the market.

The tree seedlings are planted in planting hole similar to the fruit trees. But the hole for forest tree seedlings is deeper and larger than the fruit tree seedlings (Figure 4.16). The seedlings are planted in rows in the appropriate space as illustrated above. As in the case of fruit tree seedlings,

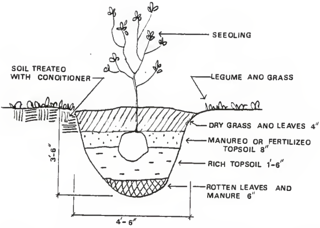


Figure 4.15 Planting Hole for Fruit Tree Seedling

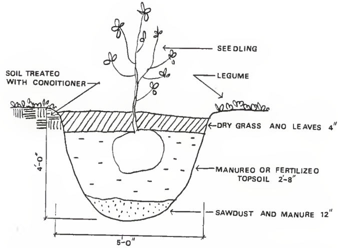


Figure 4.16 Planting Hole for Forest Tree Seedling

legumes and grasses are planted around the timber seedlings.

The afforestation use is incorporated with the recreation uses. The recreation uses that are permissible in the afforestation areas are the ones classified as passive recreation.

Summary

The study site can be used for land use developments when proper rehabilitation techniques are applied on the site. Selecting the suitable location on the mined land for a particular land use is a necessary process for a successful development. The mined soil structure and fertility have to be improved for the land use developments. Soil compaction and foundation are the necessary process to increase the soil strength to support the building loads. The deficiency in nutrient of the mined soils is corrected by revegetation process.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Utilization of Study

This study is of value to anyone looking for alternative usage of tin-mined lands. It can be specifically used by planners and designers in developing the mined lands for low-cost housing purposes in a systematic manner. It can also be applied by land developers and government agencies to evaluate the mined lands for social and economic enterprizes such as agriculture, commercial, institution and recreational. The planning process in this rehabilitation program will help land use developers to reclaim the mined lands in a systematic and economical way. This study also provides a significant contribution to the members of the Chamber of Mine's Research division as it can be employed to expand the search for a better utilization of reclaimed mined lands.

Concluaiona

Rehabilitation of tin-mined lands for land use developments is a relatively new practice in Malaysia. Most of the practices focus on agricultural developments which in many cases are done by farmers who illegally reclaimed and used the land for mixed-used farming. Other rehabilitation practices include residential and recreational developments.

The migration of rural people to urban areas in the Klang

Valley and Kinta Valley has resulted in a shortage of low-cost housing. This problem is expanded by the limited amount of cheap land in the urban areas. One possible solution to overcome this problem is to provide cheap land for the low-cost housing development. Undeveloped tin-mined lands, which are state property, are the best alternative because they can be acquired at no cost but must be reclaimed before development.

Tin-mined lands are feasible and economical for low-cost housing development and other land use developments after the lands have been reclaimed through a rehabilitation program. This rehabilitation program is developed through a landscape architectural planning process. The social-economic factors and physical characteristics of the mined land are the conditions and elements that influence the planning process. The social-economic factors of an urban area create the need for low-cost housing and other land uses that facilitate the housing development. The physical characteristics of the mined lands determine the possibility of implementing the land use developments. In the planning process, the information on physical characteristics is analyzed and synthetized to determine the utilization of the mined site for land use developments such as low-cost housing, recreation, commercial, institution, agriculture and amenities. The final outcome of the planning process is a site development plan which shows the location, arrangement and relationship of the land uses on the mined site. The physical conditions of the mined lands, particularly soil conditions, have to be improved to support the land use developments. The land use developments require a stable soil to support the buildings and infrastructure and fertile soil to support the vegetation. The soil conditions are improved through a reclamation process.

The reclamation process consisted of two parts including (A) compaction and foundation work, and (B) revegetation. The compaction and foundation work increases the soil strength and makes the soil strong enough to support the building load. The soil structure and fertility are improved by a revegetation process. This process consisted of three steps including (A) mixing of soil fractions, (B) soil conditioning, and (C) planting of grasses and legumes. After the reclamation process the mined aoil is made suitable to support plants which are being used in the agriculture, afforestation, recreation and residential areas.

It is important to acknowledge that the site characteristics of tin-mined land are complex and differ from one site to another. Thus it is necessary to thoroughly investigate the physical conditions of the mined land to obtain an effective and economical rehabilitation program. The direct application of the result of this study is limited in many ways to lands being mined by gravel pumping method. However, the results of this study do identify some general ideas of rehabilitation that are necessary in reclaiming the tin-mined lands in Malaysia. It is hoped that this study will initiate further research in rehabilitation of tin-mined lands in Malaysia for many land use developments.

Recommendations and Future Study

There are many directions that future studies could take related to this topic area. The basic concept of rehabilitation practices can be done on tin-mined land for further research and development of afforestation use. This development is important because more than 75% of the tropical rain forest in Malaysia has been harvested for timber and lands are used for agriculture and urban uses. Afforestation practices are necessary in Malaysia to have aufficient supply of timber in the future. Since there are about 520,000 acres of undeveloped tin-mined lands in the country, research on rehabilitating the mined lands for afforestation should be taken in the near future.

There should be some changes in the regulation of the tin industry. The federal government should create a policy at national level on rehabilitation of the mined lands. The federal government should offer financial support in terms of grants or loans to the states to do the rehabilitation work. The state government should make sure that the money derived from the forfeited levelling and filling bond is used for rehabilitation of the mined lands. The miners should be given privileges in longer leasehold so that they can have enough time to reclaim the site they have mined. The taxes on the miners have to be lowered to encourage the miners to do the reclamation work. If the miners fail to reclaim the land, then the mining authority should deduct the cost from their bonds. Bonds must be set high enough to cover the reclamation cost. The state government should also require the miners to submit plana of the dumping and storage of the overburden. The topsoil has to be preserved for reclamation uae after the land is mined.

To increase the production of food crops such as vegetables and fruits, and fresh water fish, the undeveloped tin-mined lands should be leased to farmers for reasonable period and lease rate. At present, the lease is called temporary occupation license (T.O.L) which lasts for one year. This period should be extended for 5 to 10 years to provide better confidence and security for the farmers to cultivate the mined lands. The government should rehabilitate the mined lands suitable for plant growth and later lease the lands to individual farmers.

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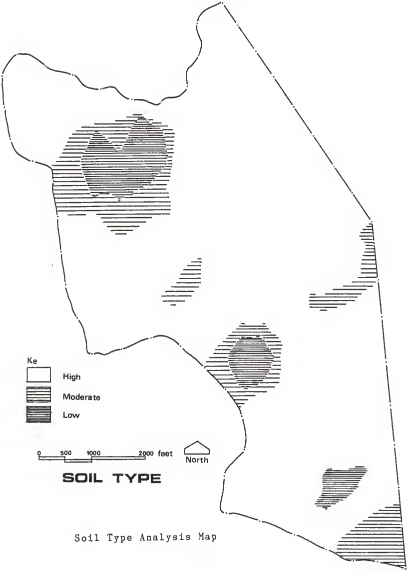


Soil Type Analysis Map

Soil Types

Criteria

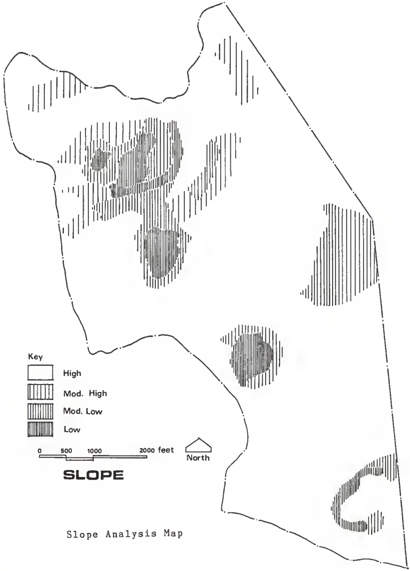
The primary objective of the soil analysis is to determine the areas that are adequate to support the development of low-cost housing. Information used to evaluate the soil was obtained from the Mines Research Institute of Malaysia and Japan International Cooperation Agency. Each soil was interpreted, based on engineering properties of the soil.

Key

Low - Soil not capable to support housing load because of low bearing capacity and high and long-term consolidation settlement.

Moderate - Soil not capable to support housing load because of moderate bearing capacity but low and short-term consolidation settlement.

High - Soil capable to support housing load because of high bearing capacity and no consoiilidation settlement.



Slope Analysis Map

Slopes

Criteria

The primary objective of this analysis is to determine the best areas that are suitable for housing development with minimum cost of earthwork. These values are derived from the topographic map of the study site.

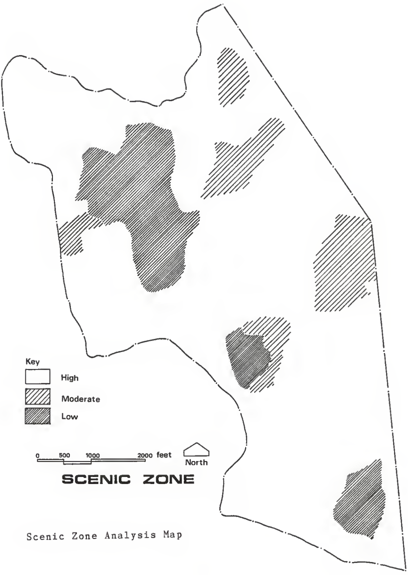
Key

High - Areas of 0-5% slope which would be best for housing development.

Moderately High - Areas of 6-10% slope which are satisfactory for housing development but would require some site work.

Moderately Low - Areas of 11-15% slope which are satisfactory for housing but would require large amount of site work.

Low - Areas with slopes of 16% and greater in which development would be costly and difficult with high erosion potential.



Scenic Zone Analysis Map

Scenic Zones

Criteria

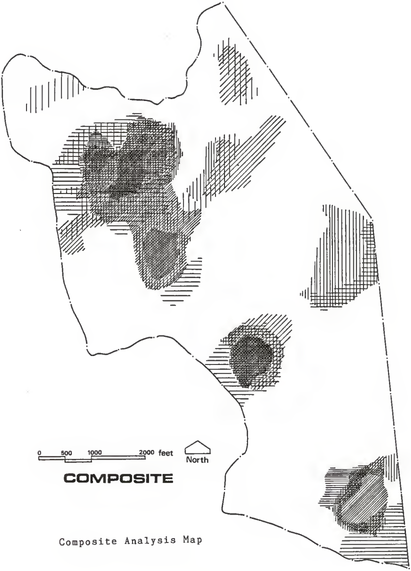
The primary objective of this analysis is to determine the areas with high scenic quality which would enhance the housing development. The areas with high scenic quality should be preserved for recreational use. Information used to evaluate the scenic zones was derived from the score table (Table 4.4) and scenic quality inventory and evaluation chart (Table 4.5). The darkest areas on the map are the least suitable areas for housing development. These are the areas with the lightest scenic quality score. The lightest areas are with the lowest scenic quality score and therefore would be best for the development.

Key

High - Areas with the score of 0-11.

Moderate - Areas with the score of 12-18.

Low - Areas with the score of 19-37.



Composite Analysis Map

Composite

This map shows all of the development values superimposed upon each other. The darkest areas are the locations which are the most difficult to develop for the low-cost housing use and would be undesirable. These areas would be suitable for other uses such as recreation and agriculture. The lightest areas are the locations best for the housing development.

DEVELOPMENT OF REHABILITATION TECHNIQUES TO RECLAIM TIN-MINED LANDS FOR LOW-COST HOUSING IN MALAYSIA

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

During the period from 1971 to 1980, many urban areas in Malaysia experienced rapid migration of rural people. Modernization and search for a better standard of living have attracted more and more Malaysians into the urban areas. The shortage of low-cost dwelling units, along with the high cost of limited land resulted in rapid expansion of squatter settlements in the urban areas. Providing low-cost housing for the squatters is the positive action to overcome the housing problems. One of the possible ways to accomplish this action is to provide cheap land for the low-cost housing development. Tin-mined land is the best alternative for this purpose because there are about 520,000 acres of undeveloped mined land in the country. Rehabilitation is a necessary action to reclaim the depleted lands near the urban areas for the housing development.

The purpose of this study is to develop a rehabilitation program which will help to reclaim the tin-mined lands near the urban areas for low-cost housing. The program is developed through the landscape architecture planning process.

The SEK Mine was chosen as a study site to illustrate the development of the rehabilitation program. The site was inventoried and analyzed with reference to three site characteristics including soils, slopes and scenic qualities. The land use deciaions were made based on the site characteristics and social needs. The final outcome of the program is a site development plan with reclamation methods. The plan shows the location and relationship of the low-cost housing areas with

other related uses such as recreational, commercial, institutional, agricultural and associated amenities. The reclamation methods improve the physical conditions of the mined land suitable for the land use developments.

The study shows that the tin-mined land is feasible and economical for the low-cost housing development after the land has been reclaimed by the rehabilitation process. The reclaimed land is relatively cheap and thus is a major part of the solution to overcome the housing shortage in the urban areas of Malaysia.