CHAPTER 2 INVESTIGATION

2.1 Outline

Uniform investigation procedures for project planning are impracticable due to variation in scale and local conditions of the areas. As a first step, field reconnaissance is carried out to evaluate the area by classifying the existing depth of peat layer and acidity and evaluating the viability of various works such as water resources development, irrigation/drainage development, soil amendment and flood protection. In parallel with these works, the objective area is selected and a program is prepared for detailed investigation. After this, various works for plan formulation are carried out based on the program.

The final decision on project execution is made not only on the basis of detailed investigations but also with consideration of the application of the improvement works.

2.2 Basic Requirements for Survey

Before studying, the following maps are required.

- Topographical map
- Soil map
- Present land use map

2.3 Field Reconnaissance

Field investigation is carried out by using the above maps, in order to collect the following data and information.

- Natural conditions (topography, vegetation, meteorology/hydrology/ geology, groundwater, soil, water quality, flood damage, sea level, swamp, etc.)
- Socio-economic conditions (population, landholding, income, harvest, processing, storage, marketing, farmer organization, agricultural supporting services, etc.)
- Agricultural conditions (land use, cropping pattern, livestock, inland fishery, forestry, farming practices, farm products, etc.)
- Agricultural infrastructure (irrigation/drainage system, water management, groundwater, farm road, acidity damage in irrigation/drainage facilities, etc.)

- Rural environmental infrastructure (road network, rural electrification, water supply/water quality, etc.)

Collected data are reviewed and compiled for formulating development strategy.

2.4 Selection of Developing Area

Soil improvement/conversation area is selected by screening land characteristics based on the collected data and information. In this process, the following subjects are examined comprehensively.

(1) Social factor

- Development consciousness of farmers concerned.
- Necessity of new land reclamation for agricultural use.
- Agricultural conditions and marketing of agricultural products.
- Agricultural skills or farming techniques in surrounding area.
- Environmental problems with or without development

(2) Technical factor

- Difficulties in soil improvement and conservation.
- Possibility of drainage in line with surrounding irrigation and drainage system.
- Availability of water resources.
- Environmental impacts after development.

2.5 Detailed Investigation

Detailed investigation is carried out in the selected area and the followings are performed for plan formulation.

a) Preparation of map

- Topo-survey map is made for planning. Required specification is as follows.
  Scale : 1/5,000~1/10,000
  Contour : 1.0 meter interval
  (0.5 meter for flat land)
- Longitudinal profiling and cross sectioning for river/canal, if necessary.

b) Detailed survey and data collection

- Socio-economic conditions
- Agricultural conditions
- Agricultural infrastructure conditions
- Environmental conditions
- The following survey is essential for planning.
  - Seasonal pH value of soil and water
  - Seasonal variation of groundwater table

c) Soil survey

In order to get detailed information on soil and its distribution condition, soil survey is carried out. Required sites for survey are dependent on the characteristics of the area such as topography and soil. Basically, the survey by using boring stick is carried out at intervals of 500 m. In case of peat, however, it has to be done at smaller intervals as possible for the margin of peat soil. As an example, 200 m is recommended. A pit survey is basically conducted by an area of 100 ha. In this case, for the marginal place of soil distribution as mentioned above, survey has to be carried out intensively. Soil profile is sketched by this pit survey. Survey on thickness of peat layer is especially important for plan formulation. And, soil samples are taken from this pit for the following analyses in laboratory.

- Peat Soil
  1) Physical analysis
     Natural water content, Bulk density, Decomposition rate (Post method)
  2) Chemical analysis
     Moisture, pH (H_2O), pH (KCl), Electric conductivity (EC), Loss on ignition total nitrogen, Available phosphate, Cation exchange capacity, Exchangeable base, Base saturation, DTPA extractive copper, Zinc, SO_4, Amount of neutralization.

- Acid sulfate soil
  1) Physical analysis
     Natural water content, Bulk density, Particle-size distribution

2) Chemical analysis

Moisture, pH (H_2O), pH (KCl), pH(H_2O_2), Electric conductivity (EC), Total carbon, Total nitrogen, Available nitrogen, Available phosphate. Cation exchange capacity, Exchangeable base, Base saturation, 0.1N-HC1 soluble copper, Zinc, Manganese, SO_4, Amount of neutralization.

Some of them may not be required, depending on the given conditions.

[Reference] Buffer curve by oxidation using hydorogen peroxide(H_2O_2)

The principle of determination of the lime requirement is by the buffer curve.

At first, we treat by hydrogen peroxide [H_2O_2] for the oxidation of easily oxidizable sulfur in soil.

Secondly, after promoting the formation of sulfuric acid by oxidation, powered calcium hydroxide [$Ca(OH)_2$] is gradually added and let the solution is to rest for 24 hrs after which shaking is performed every 3 hrs.

Thirdly, after aeration and the equilibrium state with the atmosphere, the pH is measured by the glass electrode and the buffer curve is drawn and the lime requirement is determined.

The actual neutralizing ratio $CaCO_3$ / $Ca(OH)_2$=1.35, therefore the amount of calcium carbonate is 1.35 times.

CHAPTER 3 SOIL IMPROVEMENT/CONSERVATION MEASURES

3.1 Basic Concept

Soil improvement/conservation techniques are established in keeping close combination with all possible measures considered in various fields. Their techniques are applied in practical fields, taking account of the current agricultural skills, environmental conditions and economic viewpoints.

In this chapter, soil improvement/conservation measures are approached from technical viewpoints of three fields of soil amelioration, farming practice and structural improvement.

3.2 Soil Amelioration

3.2.1 Peat soil

Soil dressing and application of amendment materials (lime and nutrients) are the important aspects to consider. But before these treatments, drainage is essential, which will lower the water table and eventually prevent flooding.

(1) Burning and liming

Peat has a low mineral content and is acid in reaction. The pH at its natural state is usually less than 4.0. In order to neutralize natural peat with pH 3.6-3.8 into optimum level for crop growing, a tremendous amount of lime will be required. Burning increases soil pH, and makes some nutrients more available (better uptake of phosphate and potash) and partially neutralizes the soil. The benefits to the crops are immediate but the losses are irreversible. The accelerated loss due to burning should be strongly discouraged, as it has a great impact on peat conservation. A better way would be to assemble burning materials such as stumps and weed in separate place and to spread their ashes in farm after burning. This method, however, has a drawback that effects of pest control will be limited. The best alternative to burning is liming with calcium carbonate or wood ash which is a good source of neutralizing materials. The difficulty in obtaining wood ash limits its commercial application.

Table 3-2-1 listed out the various types of lime and their neutralizing values. Liming is to increase soil pH and to a certain extent increases the rate of mineralization, because of the increase in the microbial activities.

The lime requirement for neutralization depends on soil properties and cultivated crops. Lukes et al. (1975) showed that lime application of three (3)-eight(8) ton per ha is quite common. It is recommended to gradually increase soil pH through split applications rather than applying a very high level of lime at once because this may affect the availability of Ca, Mg and K.

Data on the suitable amount of application in Thailand are shown in Table 3-2-2. Lime should be applied once every four years and the amount applied for the second four (4) years period should be adjusted to get the pH suitable for the crop to be grown.

Tay and Wee (1972) showed that 4.5 ton per ha application of lime can maintain a pH value of 4.4 to 5.0 for 16 months in the top 46 cm of peat soil and has a good effect on pineapple.

It is interesting to note that there is a method using the soil power machine to inject 50% liming milk by high pressure (10-250 kg/cm^2) to a soil depth of 20-40 cm. This method is effective in soils with loose structure. And, the application of blast furnace slag including trace elements is also useful for neutralization.

(2) Soil dressing

This is the best way to correct some synthetically related problems found particularly in peat soils. The most available material is sandy soil from sand dune, but its poor nutrient content and loose structure make the mixing with fabric peat unsuitable. On the other hand, it is available for strengthening bearing capacity. It is reported that about 6 cm in thickness of sandy soil dressing was effective for upland crops. Ideally, the materials of soil dressing should include liming materials such as dolomite whose neutralizing power is very effective. But, dolomite is expensive, and the techniques of soil improvement using such materials should only be applied to intensive agricultural area.

Cheap soil dressing materials can be dug out from nearby swamps, located on the upland or foot of mountains. Prior to use of such materials, a quality analysis should be performed to determine the properties of materials and their suitability for soil dressing. A first hand information can be given by pH value. For example, the lateritic soil which is used to make roads has a high acidity (<pH4) and is unsuitable as a soil dressing material. If a good soil dressing material is available, a depth of 20 cm should be applied on the peat surface.

(3) Supplement of elements

The deficient elements in peat soils are phosphorus, potassium, calcium, magnesium as major elements (macronutrient) and copper, zinc, boron as minor elements, which have to be necessarily supplied. The application of major elements (P, K, Ca, Mg) and trace elements (Cu, Zn, Fe, B) in fertilizer form should be common on peat. Particularly, the requirement of potash and magnesium is high. Micronutrient deficiencies like Cu, Zn, Fe and B are also common on peat.

The general basal application of micronutrient in accordance with Abdul Rahman Haron (1992) is as follows:

Item		Amount (kg/ha)
Copper sulfate	;	20 -25
Borax	;	20
Zinc sulfate	;	20
Manganese sulfate	;	10
Ferrous sulfate	;	20 -30
Sodium molybdate	;	5

Foliar application of this fertilizer form is usually carried out whenever necessary. On paddy, fertilizers supplying silicate are necessary. From this consideration, the application of rice straw manure is useful because of its supply of potash and silicate.

3.2.2 Acid sulfate soils

(1) Potential acid sulfate soils

- Leaching and application of liming materials

Soil acidity can be reduced by flushing out soluble sulfate from topsoil and applying liming materials to the topsoil after this operation. The application of liming materials is the most convenient method to reduce soil acidity where inexpensive liming materials are available. A careful control of groundwater is essential to maintain the water table at shallower depth than the pyrites-rich substratum which exists in almost all acid sulfate soils. The most effective and available liming material in the province is the limedust from limestone in which calcium carbonate equivalent was determined as high as 70-90 percent.

- Supplement of elements

These soils are infertile, therefore, it is necessary to apply the major elements (P, K, Ca, Mg) and the trace elements, particularly, the application of phosphatic fertilizer is necessary to prevent aluminum toxicity. When it is fixed in a non-available form, a phosphatic fertilizer helps to make rock phosphate more available. Potassium is effective in mitigating excess damage by iron and its application can correct iron toxicity.

(2) Actual acid sulfate soils

- Leaching and neutralization

These measures are similar to those mentioned for the potential acid sulfate soils. Particularly, the action of leaching is most important in actual acid sulfate soils and the requirement of liming materials is greater than in the potential acid sulfate soils because acidic materials such as jarosite exist already in the substratum.

A leaching test in the laboratory was carried out by the Study Team, using Muno series soil. As a result of this test, as an example on leaching effect, the following is conducted for actual farming practices.

「The washing and mixing operation is necessary in paddy cultivation. This operation has to be repeated more than once for best results, if possible at least twice.」

As for leaching, field test in the Mu No-Koknai area was also conducted by the Study Team. As a result, the following is conducted.

「The pH of topsoil with 10 cm in depth could be neutralized from original value of 3.3 to 4.5. For this improvement, leaching water of 1,900 mm was required except for some loss such as evaporation and leakage. In this test, water is supplied continuously in the field to maintain standing water depth at 10 to 20 cm on the surface. And, in this operation, drainage was carried out every five (5) days. After drainage, land leveling with soil disturbance was carried out, and then water was supplied again. This cycle was repeated every five (5) days. Before first water supply, topsoil is plowed for accelerating oxidization of soil.]

The requirement of neutralization depends on the soil and type of crop to be grown. A suitable lime application is shown in Table 3-2-3. Peat soils require more lime than acid sulfate soils for same pH, because they have a strong buffer action. Lime application is necessary to adjust the pH at 5.0 and to save at least active aluminum. Because large amount of lime is required in any case, the washing of the soil is necessary before the application.

- Supplement of elements

The nutrient application is also similar to that described for the potential acid sulfate soils.

Various soil improvement techniques are summarized in Table 3-2-3, in relation with soil types.

3.3 Agricultural Development Measures

3.3.1 Crop selection

If the area is reclaimed for agricultural use, it is essential to cover with good vegetation as soon as possible in order to conserve soil and water. However, the choice of crops on reclaimed land is very limited due to poor soil quality. Then, many factors are examined for selection of pioneer crop. In this section, basic ideas for crop suitability are prepared based on the data and information given by DLD, as shown in Table 3-3-1. For final selection, marketing values of crops have to be examined.

(1) pH reaction

This is the most important factor for crop selection. If soil acidity would be neutralized for more than pH 4.5, some of crops might become possible for cropping. Then, the target of treatment may be set for pH value of 5.0, at which points alumina starts to dissolve in soil. Representative crops which can be grown in soil pH of around 5.0 are listed in Table 3-3-1.

(2) Temperature

In general, after screening on pH reaction, suitability on temperature is examined. As an example, in Narathiwat, average maximum and minimum temperatures are 35°C and 20°C, respectively. Then, potato, onion, paper, tea, cabbage and chinese cabbage which are fond of lower temperature are likely to be unsuitable. If fertilizer application would be well managed on their crops, it could be impossible to raise their yields. In a borderline case, cropping season has to be determined by considering regional temperature in a year.

(3) Water requirement and rainfall

After the above considerations, suitability is examined in line with amount of water requirement and regional rainfall. If irrigation water is not available, data on successive no-rain days become important factor because there are some crops which are subject to drought damage.

(4) Wet endurance

Crops in swamp area are subject to wet injury. Therefore, cropping on high ridge is recommendable for root vegetables and deep rooting crops, considering annual variation of groundwater table. If soil porosity is less than 15%, the choice of crops is restricted to shallow rooting group.

(5) Suitability on groundwater table

Relation between depth of rooting zone and groundwater table is also important factor for low-lying land. In general, the more groundwater table becomes lower, the more rooting zone develops deeper. Root system of upland crops and vegetable is shallow. In tree crops, groundwater table has to be maintained at more than 50 cm below ground surface due to their deep rooting. In other submerged area, raised bed is built and banking for planting is made next on the bed in order to prevent root from rotting.

3.3.2 Major pioneer crops

Major crops and constraints for cropping are described below.

(1) Paddy rice

This is a representative crop which can be grown on peat/acid sulfate soils in this region. In cultivation, however, sterility is a crucial problem which would be caused by lack of copper resulting phenol in peat inactive.

(2) Baby corn, Sweet corn, Mungbean, Yardlong bean, Chili, Chinese kale, Cucumber

These crops are moderately acid tolerant and suitable for this regional climate. Timing of planting, however, has to be sought by considering submerged condition due to weak wet endurance. These crops are also subject to micronutrients deficiencies.

(3) Groundnut, Watermelon, Cassava, Sweet potato

Characteristics of these crops are the same as the above ones. Sandy soil with good drainage condition is suitable for cropping.

(4) Oil palm

This is one of the representative crops which can be grown moderately on peat due to shallow root system, acid tolerance and relatively low height growth. However, this cannot tolerate prolonged flooding.

(5) Pineapple

This is one of the pioneer crops in this region which can be planted immediately after land reclamation. Temperature and rainfall in this region are highly suitable for crop growing. It can be usually grown in an intercropping with other tree crops, because shade culture may be required for an area of which wind and sunshine is strong.

(6) Para rubber

This is a typical and attractive crop in this region. It has a high acid tolerance. Good drainage condition, however, is required because root rot may occur in an ill-drained soil. Annual rainfall requirement is more than 1,500 mm.

Special cares for farming

- High ridge culture is recommended for upland and tree crops on peat/acid sulfate soils. As for relation with groundwater, water table for upland crops has to be maintained at deeper than 50 cm below ground surface throughout a year, if possible. Even in rainy season, it is desirable to keep at least 30 cm below surface. For tree crops, required level becomes about 1.0 m, because tree is planted on raised bed which is made by further banking on original ground surface.

- Both of macro and micro nutrients deficiencies are common in peat/acid sulfate soil. When pH value will become lower than 5.0 due to lime deficiency, aluminum starts to resolve, which gives damage into crops. Especially, copper deficiency causes sterility of rice. Deficiencies of magnesia, boron, zinc, manglse, and iron also occur in vegetables. Therefore, in addition to lime, dolomite, copper sulfate, borax, zinc sulfate, manganous sulfate, ferrous sulfate, sodium molybdate are given as a basal application, if necessary. As for rice growing, it would be useful for sterility to release ponding water at the beginning stage of ripening period, besides fertilizing copper.

- If pH value becomes less than 5.0, phosphoric acid does not become available as a result of chemical reaction with aluminum, calcium and clay in soil. Therefore, phosphoric fertilizer requirement is much more than that on mineral soil.

- After harvesting, the crop field is plowed as a countermeasure against the capillary rise.

- Standard of fertilizer application is shown as following Table.

Crops	Fertilizer Application (kg/rai)			Remarks
	N	P_2O_5	K_2O	
Paddy	10	10	5	
Sweet corn	10	10	10	
Soybean	4.5	9	4.5	
Groundnut	4.5	9	4.5	
Green gram	4.5	9	4.5	
Yardlong bean	9	18	18	
Chili	15	15	15	
Cucumber	7.5	7.5	7.5	
Chinese kale	7.5	7.5	7.5	
Pineapple	15% of 50 - 100 kg/rai			
Oil palm	10% of unit requirement (*1)			
Para rubber	15% of unit requirement (*2)			

Note (*1) : Unit requirement is 1.0 kg per stump and increases gradually. It becomes 4.0 kg after four years growing.

(*2) : Unit requirement is 120 g per stump. It increases year by year and becomes 1.0 kg after seven years growing.

- All of phosphoric acid requirement is fertilized as a basal application. As for nitrogenous and potassic fertilizers, one-third or about half of their total requirements is fertilized as a basal application and the rest is applied during crop growing. As for tree crops, their applications are separated two times in a year.

- If fresh water is available, leaching is the most effective way for removal of acidity.

- Recycled agriculture is required for farming practices on peat/acid sulfate soil areas. As an example, farm animals can be raised by using grass, straw and bran of rice, residue of corn, and feces and urine produced from the animals can be used as a fertilizer for crops. In order to produce more feed for the animals, mixed cropping with pulse crop is recommended, in which seed is planted in a spacing of hill or ridge.

3.3.3 Inland fishery pond

Fish culture is one of the most important kind of land use planning in acid sulfate soil areas.

Typical fishes in this region are Catfish, Nile tilapia, Chinese carp, Silver carp, Tyicogaster heetoraria and Rohu, etc. Prevailing size of a pond is about 1.0 rai and management is cooperated with four families. It has to be well managed from environmental viewpoint. As for rearing, high protein feed which can be purchased from DOF is useful for catfish. For other fishes, however, rice bran and swamp cabbage may be supplied additionally for propagation of plankton.

3.3.4 Livestock

As for rearing of farm animal on peat/acid sulfate soil, fattening is not productive because nutrients of grass is generally deficient. Then, in order to raise it more productive, application of lime and fertilizer is required on a grass land. Cropping of homata, Luzi, Cori and Crisping are also useful for feeding.

In general, local variety of cattle in this region fattens 200 to 250 kg in weight after three to four years. Feed requirement for one cattle is 6 kg of dried grass per day. It is recommended that a family always raises three to four head and harvests or renews one head in a year.

Rearing of chicken is recommendable for getting not only hen egg and chicken meat, but also feces which is useful as a fertilizer on peat/acid sulfate soils.

3.4 Structural Measures

3.4.1 Peat soil

In the management of peat soil, there are two choices: development and undevelopment strategies. These choices depend on soil and topographical conditions of the specified area.

<u>Undevelopment strategy</u>

If undeveloping approach is chosen, peat soil area has to be kept undisturbed and submerged conditions for as long as possible to prevent peat wastage and to preserve ecosystem in peat soil. For this, some structures such as dike and check gate, are required.

Development strategy

If developing approach is applied into an area, a strategy to minimize soil disturbance has to be considered. For this approach, the followings are taken into consideration.

(1) Zoning

In general, there are a lot of risk to develop peat soil area from viewpoint of cost-benefit, because of many uncertain factors relating agricultural input and output, and environmental impacts. Then, in development approach, overall reclamation needs to be slow and gradual. Before reaching total development, the following concept of zoning is useful for gradual approach.

Development zone;

This zone is developed as a agricultural use area. Land is reclaimed and provided with canals and roads for farming. Irrigation water supply and drainage are carefully carried out.

Undevelopment zone;

This zone is not developed for the time being. Then, undisturbed approach is applied until the time when an attempt to reclaim would be justified based on outcome of the development zone.

In order to demarcate the zones clearly, dikes or roads are firstly required. Water control for the time being is done by different ways, depending on natural conditions.

(2) Water resources

If development option is chosen, water resources has to be prepared for agricultural use. To confirm the sources, the following subjects are taken into consideration

- Calculation of water requirement

In order to determine the scale of water resources required, water requirement is calculated based on the collected hydrological data. As a first step, consumptive use of proposed crops is estimated by using a series of data on evapotranspiration, crop factor and cropping calender. After this, water requirement is estimated based on rainfall and irrigation efficiency.

- Surface water development

  As a first choice, surface water development should be taken into consideration. If the area is located in a beneficial area served by other irrigation project, agricultural opportunity becomes high. Otherwise, water source and canal system have to be prepared in/around the area, based on the calculated water requirement. In this planning, pumping system should be avoided due to costly operation and maintenance.

- Groundwater development

  In order to definite a technical possibility, a lot of survey such as drilling of test well and pumping test, are needed. After this, volumes of recharge and withdrawal are also analyzed. In the initial development stage, there is a risk to develop from the point of cost-benefit. Besides, a practicable water use group has to be organized to share the costly operation and maintenance.

- Construction of irrigation pond

  As an alternative, pond of different size may be constructed in/around the area. Required scale is based on water requirement, however, capacity is generally large for agricultural use. Special cares for preventing acidity and unexpected subsidence have to be taken into consideration.

  In any case, water development will encounter many difficulties when analyzed in terms of cost-benefit, except for beneficial area designated by other irrigation project. If no water sources exist, area for agricultural use shall be limited to a small scale.

(3) Irrigation water supply

In development planning, water is supplied to rooting zone of crop by the following ways.

- Surface water supply

  Water with good quality is supplied by gravity from ground surface into rooting zone. It is the most effective way. It prevents capillary water with bad quality to move upward into root. A lot of amount of water, however, is required to work as a countermeasure against capillary rise, since peat has high permeability.

- Groundwater supply

  Water is supplied by capillary rise from shallow groundwater into rooting zone. In peat, however, acid water has to be neutralized before it reaches root. Liming is one of the ways for neutralization. There are two ways of liming ; one is putting lime in the topsoil, and the other is making lime gravel layer below plowing layer. But, in any ways, they have disadvantage that liming effect is limited. In this way, groundwater has to be maintained at required level for crop growing.

Supply method is determined by considering availability of water and other conditions.

(4) Drainage

In land reclamation, drainage is sufficiently needed to produce a certain bearing capacity and aeration of soil. But, rapid drainage and careless lowering of groundwater have to be avoided for preventing unequal subsidence, rapid decomposition of peat and undesirable acidification of lower soil.

For planning purpose, the area has to be put in comprehensive drainage system. Then, possibility of gravity drainage is studied, taking account of difference of elevations. Considering elevations at various sites, allowable subsidence has to be taken into consideration. In general, annual subsidence occurs a rate of around 3.0 to 5.0 cm under drainage condition.

As gravity system is economical, ungravitational drainage area should be designated as undevelopment area, where peat could be conserved by maintaining groundwater table as high as possible. Pumping system can be applied only where there is a strong demand for agricultural land.

(5) Canal system and water management

In both of developing and undeveloping areas, control of water level is essentially required throughout a year.

Developing area

Canal system is consisted of shallow ditch, collecting canal and weir or gate. At an early implementation stage, shallow ditch may be planned at a depth of 0.5 m to 1.0 m and at an interval of 20 m to 40 m, considering thickness of peat layer. Later on, their depth and interval may be readjusted and reconstructed as subsidence develops. In construction, excavated soil is spread on the field to make a moderate raising bed. These works, however, have to be abandon at the time when gravity drainage is no longer possible. Check gates and weirs can be installed at some points to control water table. For reference, a guideline for design of drainage canal applied in west region of Malaysia is shown as follows.

Canal	Depth (m)	Width (m)	Canal density
Main drainage	1.5	1.5	201×603 m (one block)
Lateral drainage	1.2	0.9	Three canals in a block
Farm drain	0.9	0.6	300 m in a block

Note : Slope is vertical, Source : Tay (1969)

After planting crops, water table has to be maintained at required level consistent with rooting development and capillary fringe which generally ranges from 10 to 15 cm in peat.

Undeveloping area

This area has to be kept in submerged condition throughout a year, because drying up following the wet season causes unexpected burning and destruction of ecosystem in swampy forest. For this, the area may be enclosed by dike with check structures. However, in planning, height of dike and scale of structures should be designed by considering ecological damage may be caused by standing water depth and its duration.

(6) Inland fishery pond

In peat soil area, inland fishery ponds are useful to get some additional income for farmers. In construction, some physical requirements are needed to secure good quality water and stable structural conditions.

As far as slope and bottom of pond covers with peat soil, it could be difficult to maintain good quality of water, due to easy run-off after neutralization by liming. Accordingly, replacement method may be adopted by using clayey soil.

3.4.2 Acid sulfate soils

In management of acid soil, there are two choices of strategy if the area is developed or undeveloped. Their strategies are determined by considering severity of acidity, hydrology, availability of irrigation water and social factors such as demand for land and availability of financial inputs.

Undevelopment strategy

If undevelopment choice is selected in the area, an approach for improvement and conservation is necessary to keep the soil undisturbed and saturated for as long as possible based on the existence of pyrites and jarosite. Acidity produced during prolonged dry weather is washed off by following flooding, so that acid water has to be assembled and drained into surroundings without damage. For this purpose, structural measures should be taken into consideration.

Development strategy

If development choice is selected in the area, there are many courses of approach, depending on social and physical conditions. Cheapest strategy, however, should be applied to deal with acid sulfate soil.

(1) Water resources

Water resources development planning is carried out, as described in 3.4.1.

(2) Drainage

Drainage problem is studied by putting the area into a comprehensive drainage system. Basic approach is the same as the case of peat soil area.

(3) Soil dressing

To ameliorate acid condition for agricultural use, this is a simplest way in which mineral soil is transported into the area to make bed for crop growing. This choice, however, can be applied at which maintenance of groundwater and flooding are impracticable and demand for land is high and financial input is available.

(4) Leaching

Leaching is the most effective way for soil improvement as a first step before cropping and liming, if fresh water is available. If the area receives a higher intensive rainfall during wet season, it is used as a leaching water. Then, before heavy rain season, the fields may be started to plow the topsoil for further developing oxidization occurred during former dry season. When fresh water such as rainfall or irrigation water becomes available, periodic flushing is given into the topsoil. As a result, accumulated acid is washed off and drained through ditch and canal into river. This cycle is repeated until the topsoil is improved to some extent and saturated enough to grow crops.

(5) Canal system

In order to maintain groundwater table and to conduct effective leaching, canal system is required precisely. Severity of acidity varies at the depth where acidic layer exists and the nearer surface acidity occurs, the more intensive ditch system is required. In general, cropping fields are enclosed by ditch of which dimension is given at 20 to 40 m in interval and 0.5 to 1.0 m in depth. Their ditches may be required more intensively according to the severity and introduced crops. Excavated soils are used to make raising bed which is effective to remove accumulated acidity from field to ditch. These ditches are connected with main canal leading to sea. Weir and check gate are also constructed at some points to control water flow. If water is not enough to wash out acidity and to maintain groundwater table in these intensive ditches, the situation might worsen with further acidification by soil disturbance.

As a precise water control system, underdrainage system with pipe drain may be considered. In case of heavy clay with low permeability, however, some extra works like plowing might be required. In some situations, it may be also impracticable because the pyrites above water table changes into jarosite. In this case, economic viability must be taken into consideration.

(6) Water management

Water table should be maintained at different levels in different parts, based on the depth where acidic layer exists.

Groundwater table has to be maintained at required level as possible throughout a year, in order to prevent further development of oxidization. But, in general, maintenance becomes more difficult as dry season progresses. Water table comes down gradually and it becomes ultimately impossible to keep at required level and oxidization is accelerated. To avoid such condition, water management to minimize acidity shall be required. Normally, water table should be maintained at about 60 cm down from ground surface.

(7) Inland fishery pond

Inland fishery ponds may be developed in the areas. They may be constructed by excavating acidic layer and building a enclosed dike. Before fish growing, their bottoms and slopes are fertilized by liming. Amount of lime requirement is reported to be average 6 to 8 ton per rai at the initial stage, depending on the soil acidity. After the first year of growing, its requirement be decreased at an average of 3.5 ton per rai and may be reduced in progression.

Table 3-2-1 Sources of lime and Their Neutralizing Values in $CaCO_3$ Equivalent

Material	Primary ingredients	Neutralizing value
Burned Lime	CaO	179
Hydrated Lime	$Ca(OH)_2$	136
Dolomite	$CaMg(CO_3)_2$	109
Calcic	$CaCO_3$	100
Basic Slag	$CaSiO_3$	86

Source : Kamarudin,1988

Table 3-2-2 Suitable lime Application by Soil Series

Soil Series	Mapping unit/ Symbols		Application of lime(ton/ha)	
			pH 5.0	pH 6.5
Narathiwat	22	Nw-oi/d1&d2,m,a3	25	30
〃	25	Nw-oi/d3,m,a1&a2	28	38
〃	26	Nw-mk-oi/bs,a4	30	44
Munoh	19	Mu-ly/a4	20	30
Rangae	33	Ra-ly/a2	12	15
〃	34	Ra-ly/a3	16	20
〃	35	Ra-m, sub-ly/a2	12	15
Kab Daeng	14	Kd-oi/a3	20	35
Thon Sai	49	Ts-ly/a3	12	14

Source ; DLD

Remark ;1)Total neutralizing power in limestone is about 80%.

;2)Lime requirement is estimated by Woodruff method.

Table 3-2-3 Application of Soil Impreovement Techniques

Depth of peat (cm)	Depth of pyrite (cm)	Existing of jarosite	Soil series	Soil Improvement Techniques					
				Burning	Soil dressing	Leaching	Application		Drainage
							Lime	Fertilizer	
0 ～40	non	non	Bang Nara etc (Alluvial)				○	○	
	0～50	non	Chain Yai				○	○	○
		exist	Muno			○	○	○	○
	50～100	non	Range				○	○	○
		exist	Muno			○	○	○	○
	100 ～150	non	Range				○	○	○
		exist	Muno			○	○	○	○
	more than 150	non	Range				○	○	○
40～100	non	-	Kab Daeng	○	○		○	○	
	40 ～100	-	Kab Daeng	○	○		○	○	○
	100 ～150	-	Kab Daeng	○	○		○	○	○
	more than 150	-	Kab Daeng	○	○		○	○	○
100 ～200	non	-	Narathiwat	○	○		○	○	
	100 ～200	-	Narathiwat	○	○		○	○	○
	more than 200	-	Narathiwat	○	○		○	○	○
200 以上	non	-	Narathiwat	○	○		○	○	
	more than 200	-	Narathiwat	○	○		○	○	○

Remarks: Fertilizer includes trace elements and manure.

Table 3-3-1 Crop Suitability in Swampy Area

Acid-tolerance	Temperature	Water requirement and Annual rainfall	Wet Endurance	Effective Soil Depth	Groundwater table
Highly suitable crop in soil PH arround 5.0 Pineapple Tea Cashew nut Mulberry Oil palm Sugar cane Para Rubber Pasture Upland Rice Moderate crops in soil PH more than 5.0 Paddy Rice Garlic Corn Tomato Sorghum Pepper Cassava Cotton Potato Kanaf Taro Coffee(Arabica) Ginger Coffee(Robusta) Soy Bean Tobacco Groundnut (Verginia etc.) Mungbean Okra Sesame Kale Coconut Sweet potato Citrus Watermelon Mango Japanese radish Longan Cabbage Lichee Chinese cabbage Rambutan Nanking shallot Durian Carrot Mangosteen Cucumber Lansa Broccoli Tamarind Yardlong bean Onion Marginal crops in soil PH 5.0 Chilli Lettuce	Suitability in the range of 20 to 35°C Highly suitable crops Pineapple Coconut Cashew nut Citrus Mulberry Mango Oil palm Rambutan Sugar cane Durian Para Rubber Mangosteen Pasture Lansa Upland Rice Tamarind Paddy Rice Chilli Corn Cotton Sorghum Kenaf Cassava Coffee(Robusta) Taro Tobacco Ginger (Verginia etc.) Soy Bean Okra Groundnut Kale Mungbean Sweet potato Sesame Watermelon Nanking shallot Moderately suitable crops (This range is a little high for crop growing) Longan Peper Lichee Tea Garlic Tomato Coffee(Arabica) Marginal crops (This range is too high for crop growing) Potato Cabbage Lettuce Onion Chinese cabbage	· Tree crops can be grown under annual rainfall of 1,500 to 2,000mm. · For upland crops, minimum requirement of rainfall for about four months for crop growing is about 500mm. · Crops with low drought resistance Upland Rice Cucumber Broccoli Potato Taro Ginger Soy Bean Onion Corn	The following crops are subject to wet injury. Sweet potato Watermelon Japanese radish Cabbage Chinese cabbage Nanking shallot Carrot Corn Sorghum Cassava Potato Ginger Soy Bean Groundnut Mungbean Tea Tobacco Tree & Fruit Soil porosity more than 18% is most suitable. Minimum requirement is 15%.	Minimum requirement of depth More than 15cm Paddy Rice Pasture Mungbean Onion More than 20cm Upland Rice Groundnut Tomato Tobacco Pineapple More than 25cm Corn Sugar cane Sorghum Garlic Cassava Chilli Taro Pepper Soy bean Cotton Sesame Kanaf More than 30cm Potato Ginger More than 50cm Oil palm Durian Coconut Mangosteen Citrus Lansa Mango Tamarind Longan Tea Lichee Coffee Rambutan Para Rubber	Suitable position of water table below ground surface Less than 15cm Mungbean Less than 20cm Groundnut Tobacco Less than 25cm Corn Sorghum Cassava Soy bean Pineapple Sugar cane Pepper Kanaf Less than 30cm Onion Less than 50cm Ginger Durian Oil palm Mangosteen Coconut Lansa Citrus Garlic Mango Cotton Longan Coffee Lichee Para Rubber Rambutan Less than 100cm Tamarind

CHAPTER 4 PLAN FORMULATION

4.1 Approach to Plan Formulation

In this chapter, technical guideline is prepared for agricultural development planner facing with difficulty in development strategy on problem soils. Procedure for approaching is as follows.

- The area is characterized by soil, water resources and drainage conditions.
- Development strategy is prepared by the characterized area.

(1) Land classification by soil

In general, land and soil classification is carried out based on many studied data in the area. For planning purpose, however, the area could be classified by using simplest factors directed to the development. Then, thickness of peat layer, depth of pyrites and severity of acidity are adopted as their factors. As a result, the classification is prepared for formulating development plan, as follows.

Classified Number	Depth of Peat (cm)	Depth of Pyrite (cm)	Present status of Jarosite
1	0~40	non	non-existing
2	0~40	0~50	non-existing
3	0~40	0~50	existing
4	0~40	50~100	non-existing
5	0~40	50~100	existing
6	0~40	100~150	non-existing
7	0~40	100~150	existing
8	0~40	more than 150	non-existing
9	40~100	non	
10	40~100	40~100	
11	40~100	100~150	
12	40~100	more than 150	
13	100~200	non	
14	100~200	100~200	
15	100~200	more than 150	
16	more than 200	non	
17	more than 200	more than 200	

This classification is based on the soil series defined by DLD. In practice, there are many way of classification, depending of studied and analyzed soil items and local conditions. For reference, the following standard used by other project is shown as an example.

Standard for land classification in the Karang Agun Project

(NEDECO) (Matondang, 1979)

1) Standard for paddy field

Thickness of peat layer is less than 90 cm, electric conductivity in 25°C is less than 8 mmho/cm, exchangeable sodium is less than 20%, n value of index for soil maturing is less than 2.0 and land slope is less than 5%.

If the land satisfies the above requirements, it is judged as a suitable land for paddy. After this, the land is divided into the three classes as shown in below table.

2) Standard for upland crops

Thickness of peat layer is less than 200 cm, no pyrites exists beneath the peat layer, electric conductivity in 25°C is less than 8 mmho/cm, exchangeable sodium is less than 15% and n value is less than 1.4.

If the land satisfies the above requirements, it is judged as a suitable land for upland crops. After this, the land is divided into the following three classes.

	Suitability		
	High	Medium	Low
Paddy			
Depth of pyrite layer (cm)	>100	50~100	<50
Depth of peat layer (cm)	<40	40~90	40~90
		(Organic matter is 18 to 38%)	(Organic matter is more than 38%)
Upland crop			
Depth of pyrite layer (cm)	>100	50~100 (pyrite<2%)	50~100 (pyrite<2%)
Depth of peat layer (cm) (Organic matter is more than 38%)	<40	40~90	90~200

Matondang pointed out some problems about the viability of the above standard.

(2) Availability of water resources

Water resource is one of the factors when development strategy is considered. Agricultural opportunity and soil improvement depend on its availability. Then, the area is classified as follows.

I-I; The area is supposed to be supplied irrigation water under relevant project. Therefore, there is no need to develop water resources.

I-II; The area has no water resources at present. However, facilities required for new water resources could be constructed in/around the area for the near future if financial input is available.

I-III; The area has no water resources at present. In addition, facilities could hardly constructed in future, from physical and financial viewpoints.

(3) Possibility of drainage

Peat/acid sulfate soils are distributed generally in low-lying land. Accordingly, most of areas are suffer from severe flooding. Then, the level of drainage is an important factor for developing strategy. Therefore, the area is classified according to the drainage conditions, as follows.

D-I; The area is located at which gravity system is possible even then subsidence will progress to some extent. On the other hand, it may be included in beneficiary area served by other drainage project. Also, flooding damage is not so severe that crops can tolerate.

D-II; It is judged that gravity drainage system is possible for a part of area, when the elevations of each canal system and thickness of peat layer are investigated. Also, flooding often obstructs crop growing at present.

D-III; The area is located in an extensive low-lying land. Judging from the site elevations of each canals, gravity system is impossible for whole area. Flooded water is always stagnant during wet season at present. Also, prolonged inundation often deprives farmers of agricultural opportunity.

4.2 Development Planning

Various choices are prepared for formulating development strategy, which are made by the cases defined based on the above mentioned classifications. Action is taken according to their characterized cases as shown in Table 4-1-1.

(1) The area can be developed with general agricultural skills on mineral soils. If peat remains in the area, it could be mixed with substratum soil.

(2) This is planned to be development area, if leaching could be carried out successfully. Much water and canal system are prepared for washing oxidized substance from field. Liming is also essential for crop growing. Irrigation water might be required for maintaining groundwater table.

(3) Development depends on severity of flooding damage. If acid water washed during rainy season could not but stagnant in field, choice of wet season crops would be limited due to acid damage. In a part of gravitational drainage area, approach is taken as same as the (2). Raising bed enclosed by intensive shallow canals is useful for leaching.

(4) This is planned to be development area. Leaching is firstly required to wash off acidity accumulated in topsoil. Liming is also applied according to acid reaction of soil. Groundwater table has to be maintained at required level by supplying water in dry season.

(5) Development depends on severity of flooding damage. Leaching and liming are required as same as the (4). Soil has to be kept saturated throughout a year. The choice of crop is dependent on flooding depth and duration. Dike and control gate might be provided against flooding, if necessary. Potentiality is higher than the (3).

(6) This area can be designated as development area. Potentiality is high. If topsoil is acidified, leaching or liming is required before crop planting. Groundwater table has to be maintained at shallower level than 100 cm below ground surface to protect oxidization in topsoil. General agricultural skills can be applied.

(7) Development strategy is same as the (6), depending on severity of flooding damage. In an area which is subjected to inundation, cropping schedule is planned based on inundation conditions.

(8) This can be planned as development area, if much amount of water is available for conducting leaching. After leaching, liming and soil saturation are required for crop growing. Then, potentiality is depending on availability of water resources. If its availability is low, a part of area is planned as soil undisturbance area.

(9) Development strategy is dependent on availability of water resources and severity of flooding damage. Raising bed and intensive canal system are effective for leaching. However, if prolonged inundation hinders to remove acid water from field, development may be abandoned and the area remains as a soil conservation area.

(10) This can be planned as development area, if much amount of water is available for conducting leaching. High groundwater table has to be maintained to prevent oxidization of pyrites layer. Developing area is dependent on availability of water resources developed newly.

(11) This area can be approached by same measures as the (10). In addition to an availability of water resources, flooding condition is one of key factors for development strategy. If it would be difficult to keep groundwater table shallow throughout a year, development might be small.

(12) This area could be designated as a development zone, if groundwater table could be maintained at shallower level than pyrites layer. As far as special cares for groundwater are taken, general agricultural techniques can be applied in this area. If acidity becomes active in topsoil, leaching water is required firstly. Potentiality depends on availability of water resources.

(13) Approach is almost same as the (12). If flooding damage is severe for crop growing, special measures such as dike and check gate, are taken into consideration.

(14) Development can be slow. If this area has heavy rain, it would be essential for soil improvement to repeat leaching by heavy rain and to prepare canal system. Liming is also required for crop growing. Choice of crops is very limited. If canal system could not be constructed, intensive agricultural development should be abandoned and the area should be conserved without soil disturbance.

(15) This area is planned to be undevelopment zone for the time being. But, in a gravitational drainage area, same approach as the (14) can be applied. In

general, water conservation measures are taken for preventing oxidization of topsoil.

(16) Development depends on severity of acidity in topsoil. If groundwater fall below pyrites layer during dry season and topsoil is oxidized, leaching has to be conducted by using rainwater. Then, soil disturbance is minimized.

(17) Development depends on severity of acidity and flooding condition. Approach is same as the (16). In an ungravitational area, raising bed is useful for crop growing and leaching. Groundwater table has to be maintained against raising acid substance from pyrites layer. And, soil disturbance is minimized.

(18) This area can be planned as a development zone, if groundwater table is maintained at higher level than 100 cm below ground surface throughout a year. In order to control water table, some facilities are constructed at some points. General agricultural skills can be applied, but, choice of crops is limited due to no water resources.

(19) Development approach is same as the (18). However, choice of crops is limited in a severe flooding area. Dike may be constructed to prevent inundation and conserve rainwater for as long as possible.

(20) This can be planned to be development area. Peat wastage and subsidence might be developed, considering existence of pyrites layer and overall drainage system. Canal system is constructed for controlling moisture condition of peat. Development potentiality is high.

(21) Development depends on severity of flooding damage In a gravitational drainage area, approach is same as the (20). Allowable depth of subsidence is determined based on surrounding canal system. Raising bed is effective for crop growing in an ungravitational drainage area. In this area, drainage should be carried out gradually to avoid overwastage of peat.

(22) In this area, agriculture could be developed by supplying water. However, much water is required for not only consumptive use of crop, but also preventing oxidization in pyrites layer. If substratum is sand with pyrites, leaching might be easy. But, if it is clayey with pyrites, subsidence has to be carried out gradually.

(23) Approach is almost same as the (22). Dike and raising bed are useful for ungravitational drainage area during flooding season.

(24) Scale of development depends on availability of water resources developed newly. Intensive agriculture could be done gradually with progress of subsidence. Acid water produced in the course of reclamation has to be drained without any damage in downstream area.

(25) Development depends on severity of flooding damage and availability of water resources. In a gravitational drainage area, approach is same as the (24). In an ungravity area, agriculture might be conducted without rapid subsidence. If flooding damage is severe, the area could be planned as a conservation area.

(26) Scale of development depends on availability of water resources developed. If its availability is sufficient for maintaining high groundwater table for crop growing, approach can be taken for development. Development area is determined by water availability.

(27) Approach is almost same as the (26). But, development area is limited according to the severity of flooding. If water is available even in dry season, planting area can be extended. Development should be conducted based on outcome of the (24).

(28) This area can be planned as development area. However, opportunity of crop growing is limited due to no water resources. Then, attempt to reclaim should be conducted gradually from an area with less peat. Water conservation is essential for this area to avoid peat wastage.

(29) Development is possible for a part of gravitational drainage area. But, development should be slow. Thickness of peat layer and allowable depth of gravity system are the key factors for development approach. If drainage condition is severely bad, this area is designated as a conservation area

(30) Development depends on possibility of water management. As far as water conservation and management is successful throughout a year, a part of area could be reclaimed. However, choice of crops is very limited due to no water resources. Development should be slow.

(31) Approach is almost same as the (30), except for where flooding damage is severe. If the area is subjected to inundation damage every year, it is

planned as an undevelopment zone and peat is conserved until the time when every conditions are prepared.

(32) This area is planned as a development zone. However, approach should be slow, considering existence of thick peat. Reclamation works might be launched from the area where drainage is easy and peat layer is relatively thinner.

(33) Approach is almost same as the (32), however, reclamation is limited in a small area. Development should be conducted based on the outcomes of other peat area. Drainage has to be controlled to prevent peat wastage.

(34) Development should be slow based on the results of the (32). Agricultural use of peat is limited. Reclamation might be conducted from where peat layer is relatively thinner.

(35) Most of area should be planned as an undevelopment area. Much water is needed for maintaining high groundwater table to prevent peat wastage. Agricultural use of this area is very limited, even if reclamation can be attempted.

(36) Development strategy is the same as the (35). Some facilities such as dike and check gate are required for maintaining high groundwater table during dry season and for minimizing peat wastage.

(37) This area is planned as a conservation area. In order to control groundwater table and alleviate flooding damage, proper water management facilities are required.

(38) (39) (40) (41) (42) (43)
This area is planned as a conservation area for the time being. Practical recommendation is given for maintaining groundwater table throughout a year. Peat soil should be kept undisturbed condition compatible with ecosystem and plant community in this area until the time when every conditions are prepared.

Table 4-1-1 Index Number for Plan Formulation

<table>
<tr><th rowspan="3">Thickness of peat layer (cm)</th><th rowspan="3">Existence of pyrite layer (cm)</th><th colspan="2" rowspan="2">Existence of jarosite</th><th colspan="18">Index Number for Development Strategy Formulation</th></tr>
<tr><th colspan="6">I - I</th><th colspan="6">I - II</th><th colspan="6">I - III</th></tr>
<tr><th>with</th><th>without</th><th colspan="2">D - I</th><th colspan="2">D - II</th><th colspan="2">D - III</th><th colspan="2">D - I</th><th colspan="2">D - II</th><th colspan="2">D - III</th><th colspan="2">D - I</th><th colspan="2">D - II</th><th colspan="2">D - III</th></tr>
<tr><td rowspan="8">0 ~40</td><td>-</td><td>-</td><td>○</td><td colspan="18">(1)</td></tr>
<tr><td rowspan="2">0 ~ 50</td><td>-</td><td>○</td><td colspan="3" rowspan="2">(2)</td><td colspan="3" rowspan="2">(3)</td><td colspan="3" rowspan="2">(8)</td><td colspan="3" rowspan="2">(9)</td><td colspan="3" rowspan="2">(14)</td><td colspan="3" rowspan="2">(15)</td></tr>
<tr><td>○</td><td>-</td></tr>
<tr><td rowspan="2">50 ~100</td><td>-</td><td>○</td><td colspan="3" rowspan="2">(4)</td><td colspan="3" rowspan="2">(5)</td><td colspan="3" rowspan="2">(10)</td><td colspan="3" rowspan="2">(11)</td><td colspan="3" rowspan="2">(16)</td><td colspan="3" rowspan="2">(17)</td></tr>
<tr><td>○</td><td>-</td></tr>
<tr><td rowspan="2">100 ~150</td><td>-</td><td>○</td><td colspan="3" rowspan="3">(6)</td><td colspan="3" rowspan="3">(7)</td><td colspan="3" rowspan="3">(12)</td><td colspan="3" rowspan="3">(13)</td><td colspan="3" rowspan="3">(18)</td><td colspan="3" rowspan="3">(19)</td></tr>
<tr><td>○</td><td>-</td></tr>
<tr><td>150 ></td><td>-</td><td>○</td></tr>
<tr><td rowspan="4">40 ~100</td><td>-</td><td></td><td></td><td colspan="3">(20)</td><td colspan="3">(21)</td><td colspan="3">(24)</td><td colspan="3">(25)</td><td colspan="3">(28)</td><td colspan="3">(29)</td></tr>
<tr><td>40 ~100</td><td></td><td></td><td colspan="3" rowspan="2">(22)</td><td colspan="3" rowspan="2">(23)</td><td colspan="3" rowspan="2">(26)</td><td colspan="3" rowspan="2">(27)</td><td colspan="3" rowspan="2">(30)</td><td colspan="3" rowspan="2">(31)</td></tr>
<tr><td>100 ~150</td><td></td><td></td></tr>
<tr><td>150 ></td><td></td><td></td><td colspan="3">(20)</td><td colspan="3">(21)</td><td colspan="3">(24)</td><td colspan="3">(25)</td><td colspan="3">(28)</td><td colspan="3">(29)</td></tr>
<tr><td rowspan="3">100 ~200</td><td>-</td><td></td><td></td><td colspan="3" rowspan="3">(32)</td><td colspan="3" rowspan="3">(33)</td><td colspan="3" rowspan="3">(34)</td><td colspan="3" rowspan="3">(35)</td><td colspan="3" rowspan="3">(36)</td><td colspan="3" rowspan="3">(37)</td></tr>
<tr><td>100 ~200</td><td></td><td></td></tr>
<tr><td>200 ></td><td></td><td></td></tr>
<tr><td rowspan="2">200 ></td><td>-</td><td></td><td></td><td colspan="3" rowspan="2">(38)</td><td colspan="3" rowspan="2">(39)</td><td colspan="3" rowspan="2">(40)</td><td colspan="3" rowspan="2">(41)</td><td colspan="3" rowspan="2">(42)</td><td colspan="3" rowspan="2">(43)</td></tr>
<tr><td>200 ></td><td></td><td></td></tr>
</table>

Note

Availability of water resources

I - Ⅰ; Sufficient water is supplied from relevant project.
I - Ⅱ; No water resources at present. But, it can be constructed in future.
I - Ⅲ; No water resources. And, it can not also be constructed in future.

Possibility of drainage

D - Ⅰ; Gravity system is possible.
D - Ⅱ; Gravity system is possible partially.
D - Ⅲ; Gravity system is impossible.

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