Earthquake & Tsunami Emergency Support Project

ETESP

Pidie Kabupaten

- Meureudu
- Triang Gadeng
- Panteraja
- Simpang Tiga

Data Assessment &Soil Reclamation
(December 2005)
[maps updated April 2006]

SUMMARY

S.1 Locations

Within Kabupaten Pidie salinity survey was carried out in four kecamatan, in seven villages completing ten transect lines. The raw dataset collected during that survey was passed to ETESP in October 2005 to assist ETESP assess the condition of the soils.

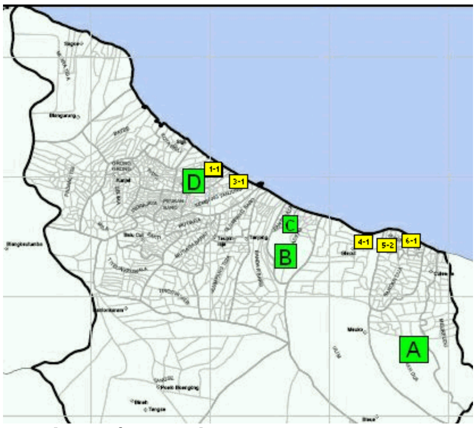
Table S.1 Coordinates of Locations

Name	Latitude	Longitude	Alt(m)	Description
2-1	5 21 27.2	95 58 28.6	21.0	Pidie, Simpang Tiga, Seukee, Site 2-1
1-1	5 21 32.0	95 58 30.9	13.1	Pidie, Simpang Tiga, Seukee, Sites 1-1 & 1-2
3-1	5 20 27.7	96 00 31.5	17.1	Pidie,Simpang Tiga, Cot JaJa (Tungoe), Site 3-1
4-1	5 15 25.8	96 11 03.4	0.0	Pidie, Triang Gadeng, Raya, Site 4-1
5-1	5 15 06.2	96 12 58.4	10.1	Pidie, Triang Gadeng, Cot Leue Rheng, Site 5-1
5-2	5 15 06.0	96 13 02.6	11.0	Pidie , Triang Gadeng, Cot Lueu Rheng,Site 5-2
6-1	5 15 33.1	96 15 00.9	14.9	Pidie, Meureudue, Meuraksa, Site 6-1

Altitudes from GPS and NOT reliable

Where a second traverse was done at virtually the same location as another the records were merged

Figure S.1 Locations



Coordinates for Site 7 lost

After study and manipulation of the dataset ETESP compiled draft reports and identified data of various types which were required to complete the assessments. Accordingly the sites were visited during December 2005 and additional data collected, these data included geographic coordinates for the sites (GPS), information on water table depths, texture of the soil, type and status of any irrigation and / or drainage systems plus rudimentary assessment of the husbandry inputs at the sites.

S.2 Site Features

At most of the sites it was established that pre-tsunami the favoured crop was normally padi during the wet season, sometimes double cropping, with a dry land, palawija crop in the dry season. Some of these sites did have drainage and irrigation systems and the existence of these systems seems to be critical in the present state of the individual site and the possibilities for reclamation.

Table S.2 Basic Features of the Sites

Kecamatan	Desa	Site	Sediment	Land Preparation	Present Landuse	Irrigation System	Drainage System	Notes
Meureudu	Meuraksa	6 – 1	7cm, mixed	N, P & OM	Sawah	Yes	Yes	50% yield and salinity falling to acceptable level
Triang Gadeng	Raya	4 – 1	7cm, mixed	N, P & K	Grazing	Yes	No	No crop post tsunami. Salinity low and good crops 100m away upslope
	Cot Leue Rheng	5 – 1	7cm, mixed	N, P & OM	None	Yes	Yes	Dead crop, flooded and close to fishponds. Salinity high
		5 - 2	7cm, mixed	N, P & OM	Puddled	Yes	Yes	Field puddled and farmer to try crop, salinity less than 5-1
Panteraja	Reudup	7 – 1	5cm, mixed	N & P	None	No	Yes, but blocked by road	Rice died and site 30% flooded. Salinity falling and almost OK
		7 – 2	5cm, mixed	N & P	As above	As above	As above	As above
Simpang Tiga	Seukee	1 – 1	5cm, mixed	N, P , K and OM	None	Yes	Not really	No effective drainage, high salinity and close to sea and fish ponds. 20% flood
		1 – 2	5cm, mixed	N, P , K and OM	As above	As above	As above	As above
	Seukee	2 – 1	3cm, mixed	N, P , K and OM	None	Yes, but with poor command	Yes	One poor chili crop post tsunami. High water table and moderate salinity. Close to sea and fish ponds
	Tungoe (Cot Jaja)	3 - 1	7cm, mixed	N, P , K and OM	None	Yes	No	60% flood, high salinity, close to sea and fish ponds. No hope without a major drain

S.3 Soil Salinity and Reclamation

Table S.3 Salinity of the Soils

Desa	Site	Overall soils salinity EM38 dS/m	Rhoades estimate O – 90cm EM38 dS/m	ETESP Average salinity EM38 dS/m	ETESP field salinity Dec 05 EM38	Conclusions and Recommendations
Meuraksa	6 – 1	4.90	4.60	5.20	1.04	This site has irrigation and drainage and salinity is falling and the farmer has had a crop (50% yield) Improve drainage to enhance full recovery Scenario 4 – reclaimable area
Raya	4 – 1	0.61	0.62	0.60	0.24	This site has irrigation supply but no real drainage but salinity has fallen to acceptable level and there are good crops close by Install drainage and enhance full reclamation Scenario 5 – land largely recovered
Cot Leue Rheng	5 – 1	10.04	10.47	9.60	7.26	Salinity is still high though site has irrigation and some drainage, but it is close to the sea, low lying and has fish ponds adjacent Seriously consider change in land use to fish ponds or other saline water use Scenario 4 – change land use area
	5 - 2	6.45	ND	5.50	2.20	Salinity has fallen and farmer has prepared land by puddling though salinity still too high to give acceptable yield. Refurbish or improve drainage and supply farmer with salt tolerant varieties to obtain acceptable yield until reclamation is completed Scenario 4 – reclaimable area
Reudup	7 – 1	1.61	1.92	1.30	1.47	Salinity has hardly changed as the site cannot drain and water is trapped on-site by the road., site is largely flooded. Install proper drainage system and discharge drainage water to Nipa area beyond road. Has irrigation but basically Scenario 1
	7 – 2	2.08	2.15	2.00	ND	Same as 7-1 above
Seukee	1 – 1	1.75	1.89	1.60	3.93	Salinity has worsened and this is mainly due to the position of the site – close to the sea and adjacent to fishponds – and the fact that there is no drainage system. Seriously consider change in land use to fish ponds or other saline water use Scenario 4 – change land use area
	1 – 2	1.22	1.13	1.30	ND	As 1-1 above
Seukee	2 – 1	0.34	0.17	0.50	2.61	Salinity has worsened and is now moderately high, there is a high water table, the site is low lying and close to the sea and fish ponds. Seriously consider change in land use to fish ponds or other saline water use Scenario 4 – change land use area
Tungoe (Cot Jaja)	3 - 1	0.46	0.51	0.40	10.70	Salinity has dramatically increased, the site is 60% flooded, has high salinity, is low lying, close to the sea and fish ponds Seriously consider change in land use to fish ponds or other saline water use Scenario 4 – change land use area

The overall salinity is the average of the Rhoades estimation and the ETESP estimate and Rhoades and ETESP value are explained in Appendix B
Dec 05 is data from site visit by ETESP in December 2005

If attempts were to be made to reclaim these areas the process would be through soil leaching after some civil engineering interventions to ensure there were functioning irrigation water supplies and, more importantly, a soil drainage system. The most important thing would be the soil drainage system since, if the saline water cannot be removed from the site the problem will never go away.

The volumes (depths) of water that have to pass though the soil at the various sites has been calculated and these volumes, plus the depth of water that has to be applied to the soil surface, are given in Table S.4. The leaching process is fully detailed in the Mobilisation Report prepared in October 2005 and basically consists of:

- Applying the calculated amount of water to the surface of the soil via flood irrigation in small basins or as overhead irrigation
- Irrigation has to be intermittent – that is there is a gap of 4–5 days between irrigations to allow the soil surface and upper layers to dry to some extent as this is proven practice in soil reclamation
- Irrigation gifts are 100mm in depth for each irrigation
- There has to be soil drainage that collects and removes the saline leachate from the bottom of the depth of soil being reclaimed and then totally removed from the site and location

It is recommended that the initial reclamation is done during the dry season since water tables are at their lowest level due to lack of rainfall and it is then possible to have soil drainage. It is also suggested that, no matter what the long term planned use of the land is – padi, palawija or tree crops, raised beds are prepared with deep furrows between them. The furrows would act as part of the drainage system and help collect and remove saline leachate. Cropping can normally start after a few reclamation irrigations as the immediate root zone will be desalinsed very quickly and the deeper soil will be desalinsed whilst the crop grows and roots start to exploit the deeper soil.

The system of suggested raised beds and drainage are shown as sketches in the various scenarios appended to this summary.

Reclamation leaching can and does use a lot of water as the data in Table S.4 shows. Economic analysis would be required before proceeding with civil works and leaching at any site that could not be reclaimed by the farmer himself.

Table S.4 Number of Estimated Irrigations for Reclamation

Kecamatan	Location	Site	Existing Salinity (dS/m) Dec 05	Soil depth to be recovered (mm)	Depth of water table (mm)	Soil Text Class	Depth leaching water required (mm)	No of "Gifts"	Depth of water to be applied (mm)
Meureudu	Meuraksa	6 – 1	1.0	600	750	H	208	6 – 7	650
Triang Gadeng	Raya	4 – 1	0.2	600	750	H	120	5 – 6	550
Triang Gadeng	Cot Leue Rheng	5 - 1	7.3	600	750	H	726	18 – 19	1850
Triang Gadeng	Cot Leue Rheng	5 - 2	2.2	600	750	H	220	6 – 7	650
Panteraja	Reudup	7 – 1	1.5	600	750	H	735	18	1800
Panteraja	Reudup	7 – 2	1.7	600	750	H	850	20 – 21	2050
Simpang Tiga	Seukee	1 – 1	3.9	600	750	H	393	10 – 11	1050
Simpang Tiga	Seukee	1 – 2	3.9	600	750	H	393	10 – 11	1050
Simpang Tiga	Seukee	2 – 1	2.6	600	750	H	261	7 – 8	750
Simpang Tiga	Tungoe	3 - 1	10.7	600	750	M	1070	25	2500

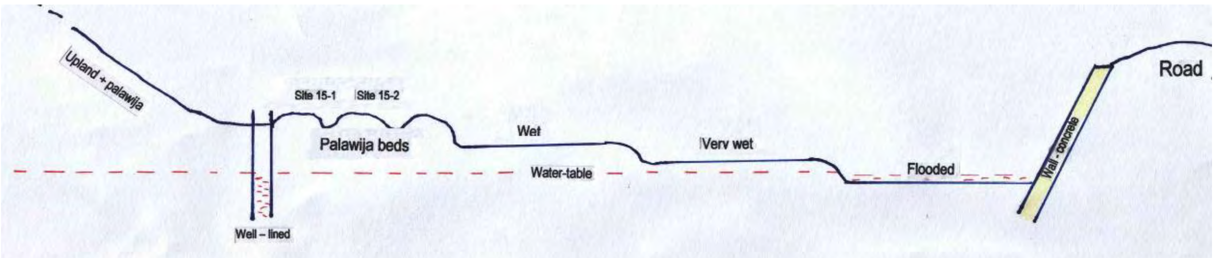
"Gifts" refer to irrigation gifts of 100mm each.

Scenario 1 Sloping land with no irrigation or drainage

The soil is considered slightly to moderately damaged with salinity levels of 2-4dS/m (Salinity Class SC1) with reclamation normally being attempted by the farmer without guidance. But, the farmers are only having limited success and that is normally only on the highest parts of their farm. The main problem with such sites is a high water table and restricted drainage. Water tables at highest part of farm are at 50-75cm with salinity of 0.25-0.50dS/m (Class C2) and the water table is usually at the surface on the lower parts of the farm.

The water on and in the land just cannot escape from the site as there is no active drainage system and the natural stream lines have been blocked, often by man-made structures such as roads and concrete irrigation channels.

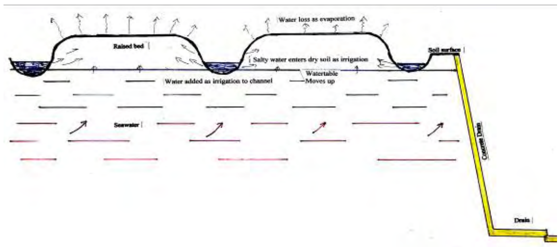
Cross Section of typical location



Problems

1. High water table which gets closer to the surface as the level of the land falls towards the natural stream lines
2. The land in the lower-slope positions is flooded since the water table is actually at the surface
3. Man-made structures, such as roads, urban and agricultural drainage ditches and irrigation channels, acting as dams and blocking the drainage
4. Inappropriate, surface flow irrigation methods are being utilised and these are perpetuating the salinity
5. No in-field or on-farm drainage and natural stream lines are no longer active

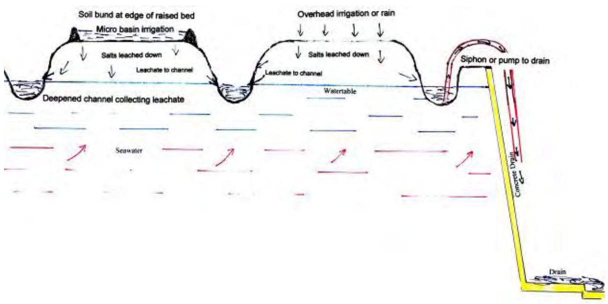
Surface Irrigation Perpetuating Salinity



Immediate actions

1. Install in-field & on-farm drainage, these can be farmer-installed with guidance and instruction
2. Clear, unblock and restore natural drainage lines and ensure they connect to the local river or drain
3. Deepen in-field furrows so they can act as drains to remove any saline leachate produced – the farmer can implement this
4. Apply irrigation as overhead and not surface-flow, this will better enable soil leaching – use watering cans or appropriate, low-cost technology with piped or pumped supply
5. Use salt tolerant varieties and, for the immediate future, only grow palawija on raised beds with overhead irrigation techniques.

Overhead Irrigation Giving Desalinisation



A palawija cycle must be built into the cropping calendar to allow annual leaching and desalinisation

Possible reclamation problems and effects

1. Engineering difficulties bypassing man-made structures requiring minor to medium civil engineering inputs
2. Increasing salinity and flooding downstream as the saline leachate is removed from the sites and drained to local rivers
3. Development of soil acidity under palawija cropping, this is a known problem with some of the soils of the region and soil pH must be monitored. Soils with this possible problem should have large amounts of organic matter (FYM, compost) added to assist remove the aluminium from the soil and hence reduce the acidity. Liming materials may also be required. These soils will revert to neutral when flooded for padi in future.
4. Farmers might show some resistance to having to grow palawija rather than padi but, with selection of high value, marketable crops income generation could be considerably enhanced

Conclusions and Recommendations

These soils can be easily and rapidly reclaimed and brought back into production with relatively low costs and most of the intervention done by the farmer.
In puts such as seed and fertilizer should not be supplied, or applied to the farm, until the salinity level is lowered via the above actions. Even then, salt tolerant varieties of crop should be utilised and, if palawija, soil pH must be monitored.

Scenario 2 Level, low lying close to the coast and still flooded with drainage

The soil is considered to be moderately to heavily damaged and still flooded. Surface water salinity of 1.5-2.0dS/m (Class 3) and surface soil salinity of 4.63dS/m (SC2). However, previous irrigation systems are now acting as drainage systems and could be utilised to drain and reclaim this land if some refurbishment was done, channels cleaned and deepened to improve the outflow of the main drains or channels into the sea plus preventing or reducing tidal effects.

Typical site previously used for padi

Problems

1. High water table and flooding by very saline water which is influenced by tidal action via the existing channel
2. Deep sediments deposited by the tsunami which, to date, have not yet been mixed in with the original soil due to flooding restricting access to the land
3. High salinity surface water and moderately salinised surface soil giving unsuitable environment for cropping
4. No current cultivation and cannot be any cultivation until the land is drained and salt tolerant seed is made available

Sites like this are on almost flat alluvial plains with no obvious high points, still totally or partially flooded, no cropping at all and covered in grasses which are being browsed by buffalo etc. and are close to the coast. But, at least one location, there was an operational drainage channel. Refer the photos below. However, local information was that this was, in fact, a previous irrigation system. The in-field water-flow in this channel was fairly fast and there was an outlet into a major channel which was obviously linked to the sea. This drain or channel was flowing - but very slowly. This drainage system was governed by tidal movement and the local estimate was that there is presently between 50-100cm of sludge, sediment and rubbish in the channel or drain.

Existing badly silted-up channel

Drainage entering main channel

Immediate Actions

Deepen and clear all existing channels on, around and above the site, ensure all sediment and garbage is removed. Much of this can be done by the farmers under supervision and within the "cash-for-work" scheme.

Cut tidal effects in the main channel by clearing the river / channel mouth and install flood gates to protect the channel. These activities will NOT be low cost and will involve major civil engineering.

Restore irrigation water supply with an upgraded distribution system. This task will not be low cost and will involve civil engineering expertise – but could be incorporated into the ETESP irrigation programme.

Use highly saline tolerant rice varieties as such sites will probably be at risk of re-salinisation from sea-water ingression.

Possible reclamation problems

Sea level continues to rise and inundation could well be an on-going problem, even if tidal gates are installed.

If highly salt tolerant varieties cannot be located locally for immediate use then they must be located and imported before any planting is done (Thailand has knowledge).

Conclusions and Recommendations

These sites can be reclaimed but at considerable cost due to relatively major civil engineering interventions.

If reclamation proves too expensive then a change of land-use is indicated and the immediately obvious use is to construct fish pods

No seed, fertilizer or other inputs should be supplied or applied until reclamation has been completed. If reclamation is not to be attempted then a change in land use has to be made or the land abandoned to agricultural cropping.

Scenario 3 Rain fed area with no active drainage though drainage installed

Level areas previously used for rain-fed rice but out-of-command of local irrigation systems and having the remnants of a soil drainage system. Soil salinity level about 4-6dS/m (SC2) and water table at 30-50cm with salinity level of 0.3-0.6ds/m (C2). Farmers have tried cropping but crops failed and sites now abandoned. Such sites can be quite badly damaged with the surface water virtually stagnant with algae etc growing and water is not passing into the existing drainage canal.

Raised bund above the soil drain

Problems

High soil salinity that, if anything, is getting worse due to evaporation of the saline water from the surface concentrating the salts.

High water table that should not be there since there is a soil drain at the edge of the field but it is NOT collecting and removing water from the field.

Surface water all over the site gives an unacceptable, anaerobic root zone for palawija and the site is far too saline for padi. The site is so wet and stagnant that algae and other water plants are growing.
Water is not entering the existing drain and it is suspected that there might be a plough pan formed over years of puddling with oxen.

Immediate Actions

Clear the drain that passes through the site and also ensure it is cleared down-stream so that any effluent collected can be removed from the site. At the same time deepen the drain to below the rooting depth for palawija (50-60cm). Most of the on-farm work can be done by the farmers under guidance and through the "cash-for-work" scheme.
Refurbish the full length of the drain where it leaves the farmland and until any effluent that it carries can be safely and environmentally acceptably be removed from the area and into a local, natural stream line or functioning, large drain.
Establish, by digging, examining, describing and sampling soil profile pits in several locations within the site to establish if there is a restriction to drainage due to a plough pan. If there is a restriction deep plough or rip to at least 50cm depth to break or rupture any pan or restriction.
Construct palawija beds and follow Scenario 1 using palawija cropping with overhead irrigation, when required, as the cropping system until salinity is reduced.
Much of the damage to such drains is not due to tsunami effects but is due to long-term neglect and lack of maintenance of the drain.

Badly damaged and blocked drain

Refurbishment will be mainly a civil engineering task and relatively expensive to implement but very necessary if not essential – not only for agriculture but also for social reasons.

Possible reclamation problems

Civil engineering inputs will have to be used to ensure that the drainage is safely disposed of and does not flood other areas and create problems downstream if the drain begins to flow carrying saline leachate.
It may not be economically possible to refurbish the full length of the drain due to expense or lack of relevant civil engineering skills and availability. Similarly, if safe disposal of the saline leachate cannot be guaranteed then the work should not proceed.
Inability to install / supply irrigation water could be a problem, but the ground-water can be used and the quality of the ground-water should improve with time as the salinity of the area is reduced. Also, the rainfall is relatively good (about 1700mm/annum) and, in the past, was good enough for rain-fed rice to be grown.

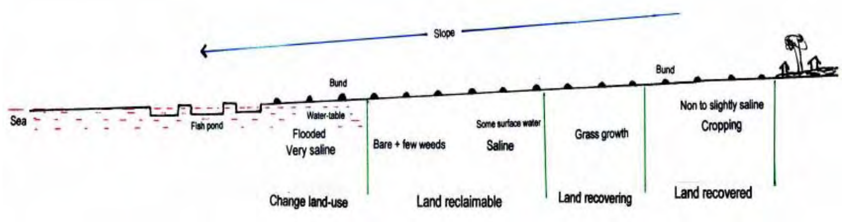
Conclusions and Recommendations

There are no insurmountable reasons as to why such sites cannot be reclaimed and brought back into production. However, the reasons for the present lack of flow from the fields to the existing drains must be established and remedial measures taken.
No seed, fertilizer or other inputs should be supplied or applied until reclamation has been completed or at least underway. After reclamation it is strongly recommended that saline tolerant varieties of crops should be ustilised to ensure there is no future crop yield reduction or failure due to any salinity build up – this is possible if the deep subsoil is also salinised to some extent and capillary rise can resalinise the topsoil.

Scenario 4 Lower slopes of irrigation schemes, close to fish ponds

This scenario is found mainly in the Pidie and Bireuen areas and is associated with the lower slope positions of irrigation schemes, near the coast and where fish ponds already exist.

Cross section from village on high ground to fish ponds and the sea



Drainage Ditch / Collector Drain

The irrigation schemes have an operational water supply system and some basic drainage channels – though what the farmers call drainage is really overflow systems that remove excess irrigation water from one irrigated field to the next field down-slope.

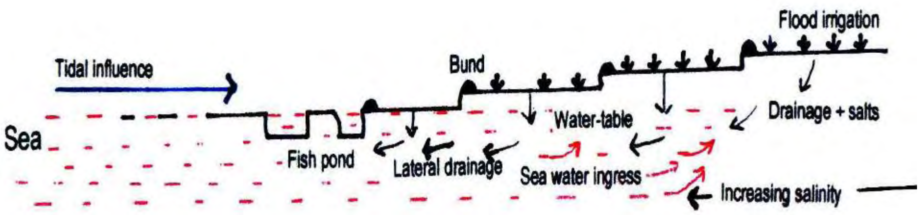
However, there is often a larger drainage channel running directly down-slope at the opposite side of the field from the inlet for the irrigation water, hence there is some drainage of the land.

Problems

There is a progression of salinity increase down-slope with the soils at the top of the slope already back in production (Scenario 5) and the soils at the lowest points being badly flooded and very saline. There are at least two possible reasons for the salinity of these lower slope sites:

- Tidal influence and sea water ingress via the water-table, and
- Accumulation of salts in the lower slopes due to the sub-surface, lateral or sideways drainage of the soils further upslope. This is a natural phenomenon and is to be expected in any irrigation scheme, in particular where there has been inadequate provision of soil drainage

Salinisation of low lying site from the sea and irrigation



Salinisation is happening from the sea plus from the land and, for the worst affected areas, there is probably no way to reclaim the land and land-use should probably be changed to construction of fish ponds.

Immediate actions

A decision has to be made as to where the land-use should be changed to construction of fish-ponds and where reclamation should be carried out. One indicator or guideline should be the severity of the flooding on the surface and, also, if there is tidal influence – that is, does the flood increase and decrease with the tide? If there is obvious tidal influence then the land-use should be changed.

Where there is no tidal influence, but the land may still be flooded, then the drainage should be increased immediately – this can be done by installing drainage ditches across the slope (on the contour) and ensuring any drainage collected is discharged into the collector drain down the edge (down-slope) of the irrigated area leading to the fish ponds and the sea.

In the areas further upslope, where the land is recovering and grasses are starting to grow, the drainage should be increased as suggested above and this will speed up the recovery process. Diagrams are presented in Scenario 5 of such drains.

Possible reclamation problems and effects

With the installation of drains there will be an immediate increase in the amount of water, mainly saline, draining off the land trying to find its way to the sea. All channels downstream and the outlet to the sea must be unrestricted or increased flooding at the shoreline will happen.

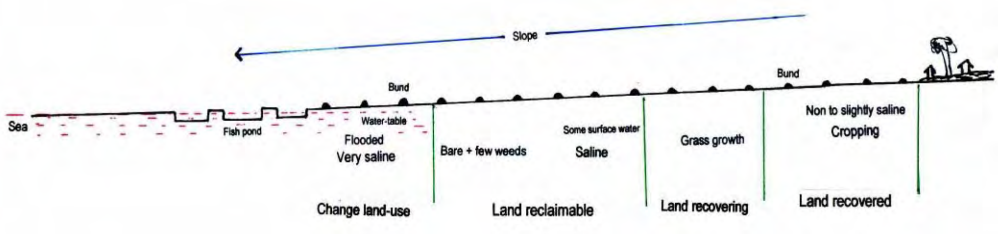
Conclusions and Recommendations

The services of an experienced soil / land drainage engineer should be used to design and oversee the installation of the suggested drains and, in the worst effected areas, no seed, fertilizer or other inputs should be supplied or applied until reclamation has been completed or at least underway.

Scenario 5 Flat to very gently sloping wetland-rice areas within irrigation

This scenario is found mainly in Bireuen plus other places where there are large, well established irrigation systems. Cropping has re-commenced in these areas and the combination of irrigation and even minimal drainage has lead to leaching of the salts and reclamation of the land. Farmers are monitoring the recovery themselves and start to cultivate when there is strong, green growth of natural grasses on their fields.

Cross section from village on high ground down-slope through padi area



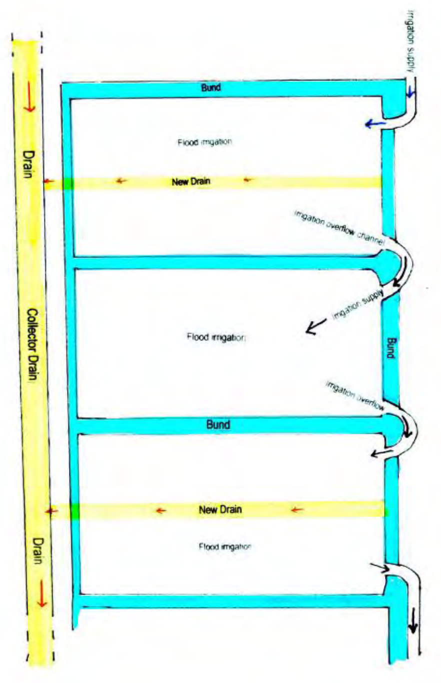
The situation of this scenario is depicted on the right hand side of the diagram where the lower captions read "land recovered" and "Land recovering".

Very little intervention is now needed on this scenario but, if there had been a more comprehensive drainage system, this land could have been back in production much sooner.

Problems

Land is this category no longer has a problem of any great significance, but there is an increase in salinity as one progresses down-slope away from the village on the high ground – this is because the first land to be leached would be the highest land and the saline leachate would have drained laterally down slope and added to the salinity of the lower slope sites. As long as there is sufficient rainfall plus continued application of irrigation water the land will continue to recover as the salts are leached out further and further down the slope.

New field and existing collector drains



Immediate actions

Consideration should be given to improving the existing drainage system to ensure there is no future build-up of salinity through normal irrigation of the land. In addition, a study of the water management and irrigation applications should be carried out to ensure that sufficient water is applied to ensure that there is an adequate "leaching fraction" being applied to ensure leaching occurs. If there were ever to be another disastrous tsunami and vast amounts of salt water were again dumped on the field the improved drainage system would speed up the recovery process.

Additional drains should be installed on the contour; right across the width of the padi fields and disgorge into the existing collector drain. The field drains should be deep enough to ensure that the bottom of the drain is below the maximum rooting depth of the crop (rice) being grown and, generally should be somewhere between 60 – 75cm deep, whilst the existing collector drains are already about 100cm deep.

Possible reclamation problems and effects

With the installation of drains there will be an immediate increase in the amount of water, some of it possibly saline, draining off these upper slope sites and trying to find its way down-slope to the sea. All channels downstream and the outlet to the sea must be unrestricted or increased flooding at the shoreline will happen.

Field Drain

Drainage Ditch / Collector Drain

Conclusions and Recommendations

Although land falling into this category is largely recovered, or recovering, improving the drainage network system can only be of benefit for the immediate and long-term future and will help ensure there is little or no build-up of salinity with continuing irrigated agriculture – however, good water management will also be important. Land in this category should receive all available inputs, especially improved seed, as soon as possible to help boost agricultural output.

Contents

CHAPTER 1 INTRODUCTION

1.1 Introduction

The Tsunami of 26 December 2004 inundated the Pidie area and dumped vast amounts of sea-water plus sediments and debris on the land as well as virtually totally destroying a large proportion of the infrastructure - social and agricultural. The ADB Grant Number 0002-INO: Earthquake and Tsunami Emergency Support Project (ETESP) was set-up to assess the situation and propose remedial measures to assist the area recover from this natural disaster. Uniconsult International Limited (UCIL) was awarded Package 3 – Agriculture Component and UCIL staff mobilised in early September 2005 to commence work.

Figure 1.1 NAD Kabupaten

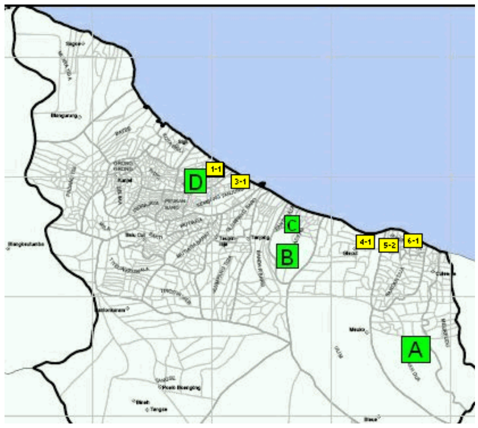
The Desalinisation and Soil Improvement Specialist was tasked with assessing the situation with respect to soil damage and designing remedial interventions to enable the reclamation of the soil and farmland to enable agriculture to resume as quickly as possible.

All the Kabupaten within the immediate study area are shown in Figure 1.1 and Pidie is labeled 09 on the north coast of Sumatra and lies to the east of Banda Aceh and Aceh Besar Kabupatens. Several sites from various Kecamatan, with available soils and salinity data, within Pidie are reported here.

1.2 Kecamatan

In Figure 1.2 the relevant kecamatan have been coded:

Figure 1.2 Kabupaten Pidie and Kecamatan



A Kec No 20 Meureudu

B Kec No 50 Triang Gadeng

C Kec No 51 Panteraja

D Kec No 190 Simpang Tiga

The map shown as Figure 1.2 was extracted from the ADB collection and geo-registered in the GPS software Ozi Explorer. The sites visited for data collection are shown in yellow with site numbers attached. It should be noted that some error in geo-registration exists since the sites do not always fall within the mapped kecamatan. No attempt is made here to explain this anomaly.

As and when the 1:50,000 scale topographic maps are located the sites will be shown on those topographic maps. As can be seen the sites were not clustered too close to each other and were distributed along the coast of the Kabupaten.

1.3 Background

At the time the Inception Report was prepared very little data had been located with respect to the soils, salinity and sediment problems brought about by the tsunami. However, there was limited information and data available relating to the aerial extent and degree of damages inflicted by the tsunami – most of this data being available in the ADB GIS Mapframe system – this data has been consulted and used. Limited climatic data were reported in the Interim Report and these data have been used for further analysis and manipulation.

Other data were made available through BPTP (Balai Pengkajian Teknologi Pertanian) for use by ETESP, this included the raw data for a salinity survey done using an EP38 salinity probe and, in addition, it is hoped that some traditional soil analysis being undertaken in support of the EM38 survey will be available for inclusion soon. This dataset was compiled by the Soil Research Institute, Bogor 16123, Indonesia from a survey carried out by the institute and funded by the Australian Centre for International Agricultural Research (ACIAR). Transects were done in four Kecamatan at 7 locations with 10 transects being completed in total. Most of these sites were re-visited in early December 2005 by ETESP.

1.4 Sites or Locations

The format of this report is that material, such as climate, common to all areas, Kecamatan or transects, is contained in this chapter and a separate Chapter is devoted to each of the Kecamatan with data from each individual location in separate sections.

Table 1.1 Kecamatan Reported for Pidie

No	Name	Features	Location / Desa	Site	Days flood	Sediment (cm)	Landuse
20	Meureudu	Very little exposure to the ocean as very narrow strip on the coast. Most of the Kecamatan lies inland	Meuraksa	6 – 1	5	7 Mixed	Sawah Cropping pale, patchy, poor to good
50	Triang Gadeng	Slightly to the SE of the middle of the Kabupaten on the cost with large exposure to the ocean	Raya	4 – 1	3	7 Mixed	Palawija Ground nuts Crop patchy, pale but moderate
			Cot Leue Rheng	5 – 1 5 – 2	5	7 Mixed	Sawah 5 – 1 dead 5 – 2 good crop
51	Panteraja	Very small Kecamatan abutting Triang Gadeng on the coast with large exposure to the ocean	Reudup	7 – 1 7 – 2	15	5 Mixed	Sawah Rice died planned for Ground Nuts
190	Simpang Tiga	On the coast slightly to the NW of Panteraja and possibly with some shelter from the ocean from promontory lying some km to the NW	Seukee	1 – 1 1 – 2	3	5 Mixed	Palawija Tomato & cucumber Tomato good but pale & patchy. Cucumber moderate
			Seukee	2 – 1	3	3 Mixed	Palawija Cauliflower Good crop but pale
			Tungoe (Cot Jaja)	3 - 1	3	7	Palawija Onions Good but pale colour

The Kecamatan are presented by kecamatan number and not in alphabetical, size or perceived order of importance.

Table 1.2 Geographic Coordinates of the Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
1-1	5	21	32.0	95	58	13.1	13	Pidie, Simpang Tiga, Seukee
2-1	5	21	27.2	95	58	21.0	21	Pidie, Simpang Tiga, Seukee
3-1	5	20	27.7	96	00	17.1	17	Pidie, Simpang Tiga, Cot Jaja (Tungoe)
4-1	5	15	25.8	96	11	00.0	0	Pidie, Triang Gadeng, Raya
5-1	5	15	6.2	96	12	10.1	10	Pidie, Triang Gadeng, Cot Lueu Rheng
5-2	5	15	6.0	96	13	11.0	11	Pidie, Triang Gadeng, Cot Lueu Rheng
6-1	5	15	33.1	96	15	14.9	15	Pidie, Meureudu, Meuraksa

NB Altitudes from GPS unit and not to be taken as anything like accurate, must be found from topographical map
NB Where a second traverse was done at virtually the same location as another the records were merged

1.5 Climate

The climatic data that are available are presented more fully in Appendix A and only salient features are presented in this section. The distribution of the long term rainfall is shown diagrammatically in Figure 1.3 and as Table 1.2

1.5.1 Rainfall in Pidie

The annual rainfall, or precipitation, for the area is taken as almost 1900 mm and the monthly distribution, as seen in Figure 1.3, appears to suggest there are two main peaks – February with over 340mm and September with close to 350mm.

1.5.2 Use of Rainfall Data

The monthly rainfall data have already been built into one of the main "reclamation" tools which is an MS Excel spreadsheet (Leaching Water Requirements.XLS) for calculating the depth (mm) and volume (cubic metres per hectare) required to leach soils of various textural class with salinised horizons of various depths.

On the assumption that:

- the data are reasonably accurate
- reclamation was done during January and February, two of the highest rainfall months
- it rained every three days

then, on average, there would be something like 27mm of rain every 3 days. This could be a large boost towards reclamation and would save irrigation water, if there was an irrigation supply. However, this calculation is very basic and proper computer modeling would be required to get more accurate figures of possible rainfall.

Figure 1.3 Rainfall Distribution in Pidie

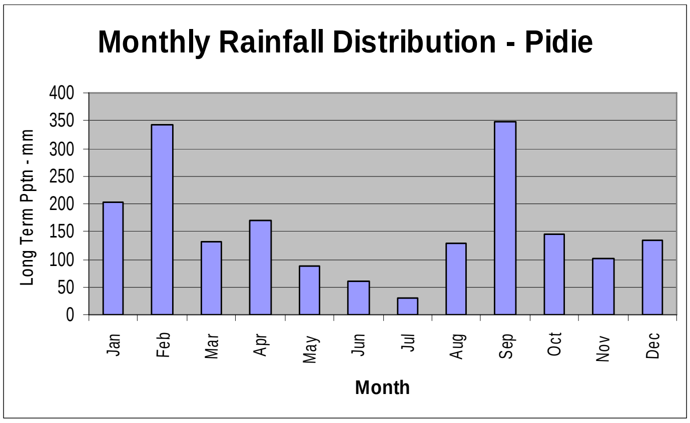


Table 1.3 Rainfall Distribution in Pidie

	Kabupaten No 9 Pidie	Distribution
	mm	*%*
Jan	204	11
Feb	342	18
Mar	132	7
Apr	170	9
May	89	5
Jun	60	3
Jul	31	2
Aug	129	7
Sep	348	18
Oct	146	8
Nov	103	5
Dec	135	7
Total - LT	1889	

LT = Long-term precipitation / rainfall

Table 1.4 Recent Site Data

Name	Location / Desa	Transect	Water-table depth (cm)	Soil PSC	Drainage System	Irrigation	Land-use
Meureudu	Meuraksa	6-1	0	H	Yes, +/- OK	Yes, good	Padi, poor
Triang Gadeng	Raya Cot Leue Rheng	4-1 5-1 5-2	0 – 5 0 0	H V H	None Yes, flowing Yes, flowing	Yes Yes, good Yes	Grazing None Puddled
Panteraja	Reudup	7-1 7-2	20	H/V	Yes, slow	No	None
Simpang Tiga	Suekee Suekee Tungoe (Cot Jaja)	1-1 1-2 2-1 3-1	10 10 0	V V M	Not really Previously None	Yes Yes Yes	None None None

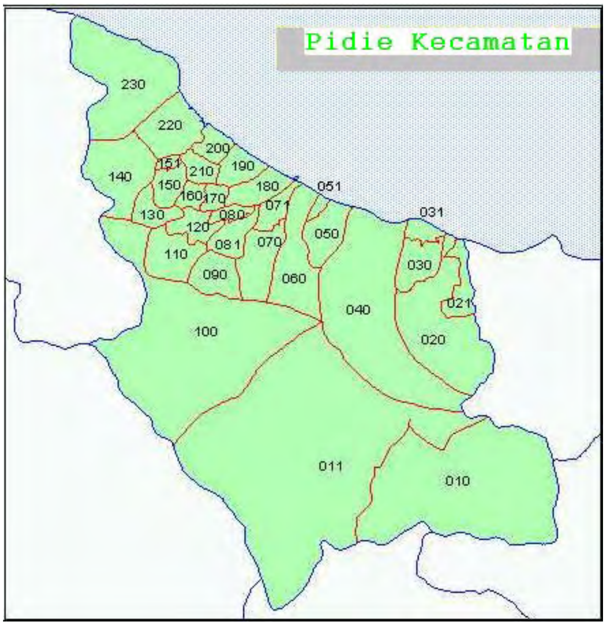
PSC Particle Size Class leaching progress: M = medium, H = heavy (clays)

CHAPTER 2 MEUREUDU

2.1 Introduction

Kecamatan Meureudu is, as previously noted, lies on the eastern side of Kabupaten Pidie located on the north coast of Sumatra and labeled as 020 in Figure 2.1 below. Only one location within the kecamatan was subjected to a salinity survey and this was in Meuraksa where one transect was done with the EM38 salinity device

Figure 2.1 Kabupaten Pidie



The coordinates of the site were taken by ETESP in December 2005 and are shown in Table 2.1. Some salient facts about the sites are presented in Table 2.1, which has been compiled form study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

2.2 Salinity Survey

Only one transect, number 6 – 1, was done in Meuraksa and can be seen below as being very close to the shore-line.

Figure 2.2 Location

The GPS data was dropped onto sheet 0521-12 of the 1:50,000 scale topographic map and an extract of this map shows the location right on the map sheet edge in the top left corner.

Table 2.1 Geographic Coordinates of the Site

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
6-1	5	15	33.1	96	15	14.9	15	Pidie, Meureudu, Meuraksa

NB Altitudes from GPS unit and not to be taken as anything like accurate, must be found from topographical map

Table 2.2 Transect Information

Name	Site	Days flood	Sediment (cm)	No	EM38 Points	Sediment	Land use / Crop	Fertiliser	Notes
Meureudu	Meuraksa	5	7	6 – 1	7	Mixed with soil	Sawah Crop patchy, pale and poor to good within survey area	N, P & OM	Field wet due to irrigation or rainfall

2.3 Site Description

This site description was compiled after the ETESP visit in December 2005.

Site 6-1 lies on a flat alluvial plain situated just below a slightly raised area with the village and kelalpa (Figure 2.3) , next to fishponds, which are close to the ocean. A rice crop had recently been harvested but yield was about 50% of what was obtained pre-tsunami when, the farmer reported, only padi was grown. Cropping was obviously planned again as the field to the left (Figure 2.4) had been puddled whilst the rice stubble can be seen on the right.

Figure 2.3 Kelapa in Village above Fishponds

Figure 2.4 Rice Stubble and Recent Puddling

This site would fit the ETESP Scenario 4 situation since it is low lying, still flooded to some degree, close to the coast and abuts fishponds whilst there is irrigation supply. The main visible problems at this site are high water table, risk of inundation or intrusion with / by saline water from the sea and fish ponds plus lack of adequate soil drainage.

2.4 Site Information from the EM38 Survey and ETESP

Table 2.3 Land Preparation Post-tsunami

Site	Land Use Type	Crop or land preparation	Soil	Notes
6–1	Sawah	N: 60 kg/5000 m^2, before planting and 21 days after planting P: 20 kg/5000 m^2, before planting OM: 1 ton/ha, Applied before planting	Wet	Recently irrigated or flooded by rainfall

Table 2.4 Soil and Site features December 2005

Site	PSC 0-25 cm	Soil Texture	Soil ECe 0 -25 dS/m	PSC 25 – 50 dS/m	Soil Texture	Soil ECe 25 – 50 dS/m	Soil Depth cm	WT Depth cm	WT EC dS/m
6-1	H/M	vfSCl / Sl	0.96	H	Cl	1.11	ND	0	0.19

Since the site was flooded the water-table depth is recorded as being at 0cm and the soil depth is not recorded, but if anything but wet land rice was to be grown the soil depth would be taken as 0cm since there would not be an acceptable root zone for a dry-land crop.

2.5 Problems

Farming had resumed, though with disappointing results since the yield was about 50% of that obtained pre-tsunami. The problems that still remain do not seem to insurmountable and this land can be recovered and good yields again obtained – use of salt tolerant rice could be an immediate solution. In time, normal rice growth may be possible as salinity is already quite low. The present high water table could be reduced if drainage in and around the fishponds is improved. The sediment has obviously not caused any major problem since it was mixed-in.

2.6 Soil Salinity

The raw data from a salinity survey carried out on the site was passed to ETESP for use in soil reclamation studies. The basic findings of what the data reveals is presented as simply as possible in this section without going into the theories or the processes of data-manipulation used. Table 2.5 below is a presentation showing a few facts that the data reveal, these facts are revealed by all EM38 datasets and are standard procedure.

Table 2.6 contains the actual salinities determined from the EM38 data.

- Starting in the right hand column of Table 2.5 it states "Reading OK" – this has been determined from carrying out a check of some of the ratios of the various data items and is a standard procedure with the EM38. The data can be classified as "false" if an unacceptable ratio is found and would be caused by the presence of metallic objects in the soil – such as metal poles etc.
- Similarly, another check of another ratio of some of the data items reveals if the soil salinity sits in the topsoil (referred to "inverted" in the literature) or if it has been "leached " downwards to some extent. Sites 6–1 shows as leached, meaning that the topsoil has lower salinity than the subsoil, but in this site the deep subsoil also has low salinity
- The coloured coded column is the ETESP assessment of the degree of problem that the original depth of sediment presented – the key is shown as Figure 2.5. The coding is also used for salinity as shown in Table 2.5. As can be seen this site was rated as having a negligible problem from the depth of sediment.

Figure 2.5 ETESP Problem Rating Key

ECe dS/m	PROBLEM RANKING	Sediment cm
0 - 1.9	None	0 - 0.9
2 - 3.9	Negligible	1 - 1.9
4 - 5.9	Very Slight	2 - 4.9
6 - 7.9	Slight	5 - 9.9
8 - 11.9	Moderate	10 - 14.9
12 - 15.9	Moderately Big	15 - 19.9
16 - 23 9	Big	20 - 29.9
>24	Very Big	>30

Table 2.5 Assessment of the EM38 Dataset for Site 6 - 1

Kabupaten	Kecamatan	Location	Site	mS/cm EMv	mS/cm EMh	mS/cm Average	Samples No	Sediment Cm	Flood Days	Status	Check
Pidie	Meureudu	Meuraksa	6 - 1	223	183	203	7	7	5	Leached	Reading OK

The salinity data in Table 2.6 reveals that, based on the average values, the salinity problem was negligible for the upper 30cm and the lower 60–90cm of this site (colour code green) but was higher in the 30–60cm layer and coded blue. This indicates that there had certainly been some leaching and the salts were concentrated in the second layer. The various determinations of the overall salinity fell into Salinity Class SC2 (International System) and estimates ranged from 4.6 from the Rhoades formula to 5.2 dS/m. from ETESP These values were above what one would accept for cropping and some reclamation leaching would be required.

Table 2.6 Salinity Measurements for Site 6–1

			Rhoades			Rhoades	ETESP Lookup			Salinity Class	
Kecamatan	Location	Site	ECe 0 - 30cm dS/m	ECe 30 -60cm dS/m	ECe 60 -90cm dS/m	ECe 0 - 90cm dS/m	ECe EMv dS/m	ECe EMh dS/m	ECe EMav dS/m	Rhoades	ETESP
Averages											
Meureudu	Meuraksa	6 - 1	3.66	6.71	3.42	4.60	5.9	4.6	5.2	SC2	SC2
Maximums											
Meureudu	Meuraksa	6 - 1	10.11	-0.38	10.64	6.79	7.7	7.7	7.7	SC2	SC2
Minimums											
Meureudu	Meuraksa	6 - 1	-0.05	2.68	1.71	1.45	4.3	2.7	3.5	SC1	SC1

***Rhoades** (1989) = Traditional estimate of salinity from EM38, **ETESP** = project estimate.*
Values shown in red above are suspect and excluded from manipulation

If the maximum values are studied it can be seen that the overall determinations still fell into Salinity Class SC2 with values ranging from 6.79 Rhoades – 7.7dS/m from ETESP. However, the maximum salinity values in the 0–30 layer and the 60–90 layer were both much higher and were classified as Salinity Class SC3 – the maximum data for the 30–60 layer cannot be commented upon as the data were suspect. The minimum values, as would be expected, fell into the SC1 class with values ranging up to 4.3dS/m.

In other words this site did have a salinity problem and would benefit from further investigation and reclamation leaching.

2.7 Sediment Depth

Table 2.3 noted that the sediment depth deposited on the soil at the site was considered to be a “negligible” problem. As the local cultivation of this site has been less than successful through “mixing” the sediment with the native soil and that the salinity of the top layer was less than the underlying layer it appears that there was no longer a problem from the sediment – the problems would appear to be coming from salinity lower down the profile.

2.8 Conclusions & Recommendations

In summary, the data would appear to be reliable and there was a salinity problem on this site. However, the recent ETESP checks in early December indicate that the situation has improved, the various salinity values are listed in Table 2.5 below. An overall salinity figure from the EM38 data was calculated by taking the average of the:

- ECe for 0 – 90cm by the Rhoades equations and
- ETESP estimate of the average salinity

Table 2.7 Comparison of Salinities from EM38 Survey and December 05

Location	Site	Overall EM38 dS/m	Rhoades 0–90cm EM38 dS/m	ETESP average EM38 dS/m	Rhoades 0–30cm EM38 dS/m	Rhoades 30–60cm EM38 dS/m	ETESP EMh EM38 dS/m	ETESP 0–25cm Dec 05 dS/m	ETESP 25+cm Dec 05 dS/m
Meuraksa	6-1	4.9	4.6	5.2	3.66	6.71	4.6	0.96	1.11

The soil salinity at this site has fallen dramatically since the time of the EM38 survey and this is supported by the fact that the farmer has already had a crop of wetland rice from the land, albeit with a greatly reduced yield compared to pre-tsunami days. The farmer obviously has confidence that his land is improving since he has already started preparing the land for another crop by puddling the site.

This land will only ever be suitable for wetland rice due to the proximity to the ocean and fishponds, which mean that the water table will remain high. However, the fact that there is irrigation water entering the site means that soil leaching has happened and should continue to happen and hence salinity levels should fall further.

To ensure that crop yields are improved as quickly as possible all efforts should be made:

- to ensure that tidal effects are reduced as much as possible
- all drains from this site thorough the fishponds and toward the ocean should be kept clear, and
- salt tolerant varieties of rice should be made available for use as soon as possible – this latter action alone could mean improving yields to or above pre-tsunami levels.

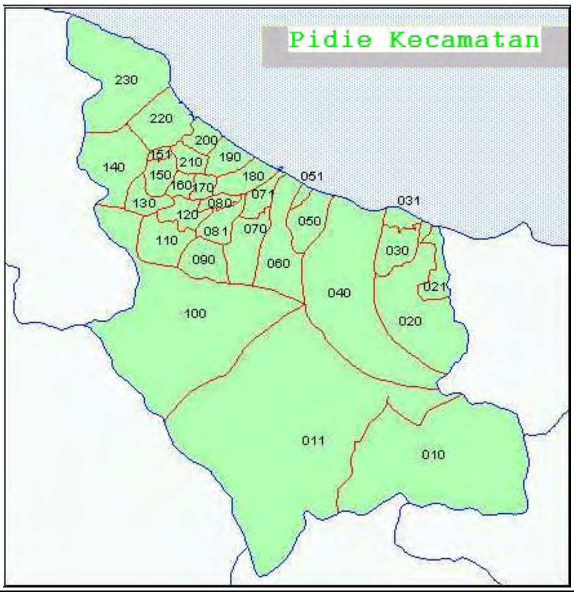
Otherwise very little intervention is required.

CHAPTER 3 TRIANG GADENG

3.1 Introduction

Kecamatan Triang Gadeng is, as previously noted, lies in the middle of the north coast section of Kabupaten Pidie and is labeled 050 in Figure 3.1 below. Two locations within the kecamatan were subjected to the salinity done with the EM38 salinity device.

Figure 3.1 Kabupaten Pidie



The coordinates of the site were collected by GPS by ETESP in December 2005 and are shown in Table 3.1. The GPS data were then downloaded onto sheet 0521-13 of the 1:50,000 topographic maps and an extract of that map is shown as Figure 3.2.

As can be seen, Site 4-1 is only a little over 100m from the shore-line whilst Sites 5-1 and 5-2 are only about 1 Km from the coast.

3.2 Salinity Survey

The sites were in:

- Raya - Site 4–1 with one transect of 7 sample points, and
- Cot Leue Rheng - Sites 5–1 and 5–2 with 25 and 20 samples points respectively

Some salient facts about the sites are presented in Table 3.2, which has been compiled form study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

Figure 3.2 Locations

Table 3.1 Geographic Coordinates of the Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
4-1	5	15	25.8	96	11	00.0	0	Pidie, Triang Gadeng, Raya
5-1	5	15	6.2	96	12	10.1	10	Pidie, Triang Gadeng, Cot Lueu Rheng
5-2	5	15	6.0	96	13	11.0	11	Pidie, Triang Gadeng, Cot Lueu Rheng

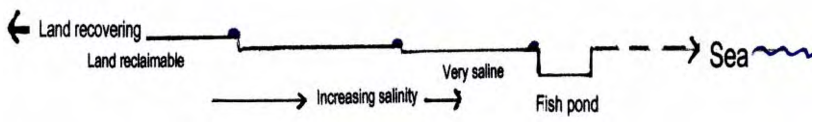
NB Altitudes from GPS unit and not to be taken as anything like accurate, must be found from topographical map
NB Where a second traverse was done at virtually the same location as another the records were merged

3.3 Site Descriptions

Site descriptions were compiled after the ETESP visit in December 2005. **Site 4-1** is on an almost flat alluvial plain at the edge of the village of Raya and is only hundred metres or so form the ocean. There is an active irrigation supply and there appears to be natural drainage of the soil. Present land use is grazing only but, about 100m away, there are good horticultural crops growing. The pre-tsunami crop cycle was padi and palawija and yields were reportedly good. Only one traverse was done at this site during the EM38 survey.

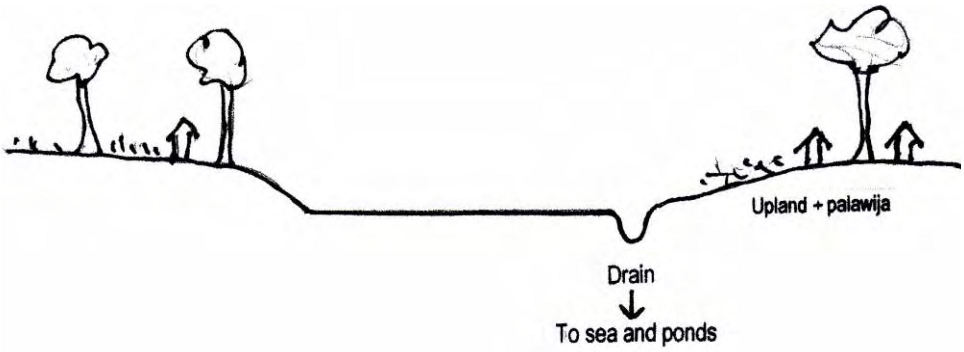
Sites 5-1 and **5-2** at Cot Leue Rheng are on a gently sloping, alluvial fill / plain with fishponds at the lower end (Figure 3.3) abutting Site 5-1 whilst 5-2 is slightly upslope from 5-1. There is a relatively large collector drain flowing down one side of these sites, the drain disgorges near the fishponds.

Figure 3.3 Down Valley Section



Site 5-1 is badly flooded and there is no crop and has not been any crop since the tsunami

Figure 3.4 Cross Valley Section



Site 5-2, although valley from 5-1, is flooded with no cro since the inund However, 200m f up-valley the field NOT flooded

Village settlement palawija cropping upland areas which the sides or edges flat alluvial fill or (Figure 3.4).

Figure 3.5 Collector Drain

The drain at this site in Cot Leue Rheng is fully operational with a good flow and is obviously draining the fields or land further up the valley.

However, the same drain could well be adding to the flooding and salinity at the sites at the lower end of the valley. The process involved is described in the ETESP paper "Scenarios".

Figure 3.6 Flooded Site

Table 3.2 Soil and Site Features December 2005

Site	PSC 0-25 cm	Soil Texture	Soil ECe 0 -25 cm	PSC 25 – 50 cm	Soil Texture	Soil ECe 25 – 50 cm	Soil Depth cm	WT Depth cm	WT EC dS/m
4-1	H	fsCl / Cl	0.21	H/V	Cl	0.26	0	0	0
5-1	V	C	8.55	V	C	5.97	0	0	4.13
5-2	H	fsCl	4.29	V	Cl / C	0.11	0	0	0.43

Notes: Soil depth is noted as 0 (zero) as there is no depth of soil that could be considered an acceptable root zone for dry land crops or leached without improved in-field drainage

WT (water table) EC as noted above is actually the EC of the flood water covering the site

3.4 Site Information from the EM38 Survey

No additional soil analytical or laboratory data have yet been located for this site but soil and water salinities were measured in the field during the ETESP visit when additional data were collected in order that a more considered assessment of the situation could be presented.

The information previously collected is summarized in Table 3.3. It can be said that the application of fertilisers to site 5-1 at about the time of the survey was ill advised and the inputs were wasted, this situation could have been avoided by rapid feedback to the farmer that his field was far too saline to grow anything.

Table 3.3 Transect Information from EM38 Survey

Name	Site	Days flood	Sediment (cm)	EM38 Points	Sediment Treatment	Landuse / Crop	Fertiliser	Notes
Raya	4 – 1	3	7	7	Mixed with soil	Palawija Ground Nuts Patchy but moderate crop	N, P & K	Irrigation broken
Cot Leue Rheng	5 – 1	5	7	25	Mixed with soil	Sawah Rice dead	N, P & OM	
Cot Leue Rheng	5 - 2	5	7	20	Mixed with soil	Sawah Good crop	N, P & OM	15cm of water on the field

The limited data available about the land preparation and cropping of the sites are detailed below.

Table 3.4 Land Preparation and Crops – Raya and Cot Leue Rheng

Site	Land Use Type	Crop or land preparation	Soil	Notes
4–1	Lowland rain fed	Ground nuts N: 100 kg/ha before planting and 21 days after planting P: 50 kg/ha before planting OM: 25 kg/ha 21 days after planting Medium crop	Dry	Soil very dry
5–1	Sawah	Rice N: 60 kg/ha before planting and 21 days after planting P: 20 kg/ha before planting OM: 1 ton/ha Applied before planting Crop dead	Wet	Near 5–2 where the crop was OK
5-2	Sawah	Rice N: 60 kg/ha before planting and 21 days after planting P: 20 kg/ha before planting OM: 1 ton/ha Applied before planting Crop good	Wet	Field flooded to 15cm depth and good crop.

The only significant conditions noted for these sites was the lack of water at Site 4 and the crop at 5–1 failed whilst at Site 5–2 the crop was growing well

3.5 Problems

The problems, or otherwise, of these sites can be summarized as follows

Site 4-1 has a good irrigation supply and is revering naturally and little or no problem now exists apart from a possibly slightly too high water table but the natural drainage seems to be coping.

The conditions at Sites 5-1 and 5-2 are quite different.

Site 5-1 is very low lying and abuts land that has been developed as fish ponds, at present there is a brickworks with clay being excavated and it is assumed that this" pit" will become a new fishpond. The water table will remain very high, there will be tidal influence and sea-water ingression will quite possibly increase as the sea level rises – as it is doing and expected to continue doing. Also, the ETESP hypothesis is that saline water being leached from the land upslope is being added to this area via the operational drain that is described above. Present rapid, field determination of salinity show the site to be very saline.

Site 5-2 is not as low lying as 5-1 but it is still badly flooded even though it lies up-valley or upslope of 5-1 and there is no current cropping, though the EM38 survey indicated a rice crop. The ETESP rapid salinity check showed that the topsoil is still rather saline but that the subsoil appears to be much less so, suggesting that some leaching of the lower soil may well have happened. The flood water presently on the filed was not particularly saline and one immediate suggestion is to puddle the filed and drain off the surface-water as soon as the soil starts to settle – any salts dissolved in the puddling water might then be removed immediately from the site.

3.6 Soil Salinity

The raw data from a salinity survey carried out on the site was passed to ETESP for use in soil reclamation studies. The basic findings of what the data reveals are presented as simply as possible in this section without going into the theories or the processes of data-manipulation used. Table 3.5 below is a presentation showing a few facts that the data reveal, these facts are revealed by all EM38 datasets and are standard procedure. Table 3.6 contains the actual salinities determined from the EM38 data.

- Starting in the right hand column of Table 3.5 it states "Reading OK" – this has been determined from carrying out a check of some of the ratios of the various data items and is a standard procedure with the EM38. Data can be classified as "false" if an unacceptable ratio is found and would be caused by the presence of metallic objects in the soil – such as metal poles etc.
- Similarly, another check of another ratio of some of the data items reveals if the soil salinity sits in the topsoil (referred to "inverted" in the literature) or if it has been "leached " downwards to some extent. Sites 4–1 and 5–2 are noted as leached and 5-1 shows as having a saline topsoil, meaning that the topsoil has higher salinity than the subsoil and, if the salinity level were found to be high, would require leaching
- The coloured coded column in Table 3.5 is the ETESP assessment of the degree of problem that the original depth of sediment presented – the key is shown as Figure 3.7. The coding is also used for salinity as in Table 3.6

Figure 3.7 ETESP Problem Rating Key

ECe dS/m	PROBLEM RANKING	Sediment cm
0 - 1.9	None	0 - 0.9
2 - 3.9	Negligible	1 - 1.9
4 - 5.9	Very Slight	2 - 4.9
6 - 7.9	Slight	5 - 9.9
8 - 11.9	Moderate	10 - 14.9
12 - 15.9	Moderately Big	15 - 19.9
16 - 23 9	Big	20 - 29.9
>24	Very Big	>30

Table 3.5 Assessment of the EM38 Dataset for the Triang Gadeng Sites

Kabupaten	Kecamatan	Location	Site	mS/cm EMv	mS/cm EMh	mS/cm Average	Samples No	Sediment Cm	Flood Days	Status	Check
Pidie	Triang Gadeng	Raya	4 - 1	30	24	27	7	7	3	Leached	Reading OK
Pidie	Triang Gadeng	Cot Leue Rheng	5 - 1	272	432	348	25	7	5	Saline topsoil	Reading OK
Pidie	Triang Gadeng	Cot Leue Rheng	5 - 2	267	166	213	20	7	5	Leached	Reading OK

The salinity data in Table 3.6 reveals that, based on the average values, there is no salinity problem at all at the Raya site and all values are less then 1dS/m. All layers, apart from 30 – 60cm, of site 5–1 do have a salinity problem and the overall Salinity Classification for this site is SC3 – that is moderately saline and colour coded blue to mauve – whilst the topsoil has a ECe of 19dS/m which would place it in Salinity Class SC4 or highly saline (colour coded orange). There is no way that a rice crop could grow in these conditions and this is why the crop died. Salinities at site 5–2 are considerably less than at 5–1 and the site classifies as Salinity Class SC1 – SC2 with overall, average ECe of 1.69 – 7.4 though the topsoil salinity of this site cannot be commented-upon as the data was suspect and eliminated from manipulations.

When the maximum values are considered it is found that the Raya site would still classify as non-saline with values remaining below 1dS/m and no-colour coding being applied. The maximum value recorded at the Cot Leue Rheng site was the topsoil (0–30cm) with an ECe value of almost 23dS/m and falling in SC4 – highly saline whilst the other layers are also considerably more saline as compared to what the average figures indicate.

As would be expected the minimum values are considerably less at all three sites but the Cot Leue Rheng site still classifies as moderately to highly saline – Classes SC2 – SC3.

3.7 Sediment Depth

Table 3.5 notes that the sediment depths deposited on the soils at all three sites in Triang Gadeng are considered a "negligible" problem. This is supported by the fact that good crops were already being cultivated on site 4 where the salinity was low following "mixing" the sediment with the native soil. The problems at sites 5–1 and 5–2 would appear to be sourced from the salinity and not the sediment. Similar sites with this depth of sediment (7cm) should be treated the same way and the sediment mixed in via good ploughing with the application of fertilisers and organic manures.

Table 3.6 Salinity Measurements for the Site

Kabupaten	Kecamatan	Location	Site	Rhoades ECe 0 - 30cm dS/m	Rhoades ECe 30 -60cm dS/m	Rhoades ECe 60 -90cm dS/m	Rhoades ECe 0 - 90cm dS/m	ETESP Lookup ECe EMv dS/m	ETESP Lookup ECe EMh dS/m	ETESP Lookup ECe EMav dS/m	Salinity Class Rhoades	Salinity Class ETESP
Averages												
Pidie	Triang Gadeng	Raya	4 – 1	0.51	0.90	0.46	0.62	0.6	0.5	0.6	SC1	SC1
Pidie	Triang Gadeng	Cot Leue Rheng	5 – 1	19.00	2.59	9.81	10.47	7.5	11.8	9.6	SC3	SC3
			5 – 2	-0.88	3.53	2.43	1.69	7.4	4.2	5.5	SC1	SC2
Maximums												
Pidie	Triang Gadeng	Raya	4 – 2	1.50	-0.01	1.45	0.98	0.8	0.9	0.9	SC1	SC1
Pidie	Triang Gadeng	Cot Leue Rheng	5 – 1	22.93	2.97	12.33	12.74	9.4	14.9	11.4	SC3	SC3
			5 – 2	-1.24	4.38	3.05	2.07	9.4	5.4	7.5	SC1	SC2
Minimums												
Pidie	Triang Gadeng	Raya	4 - 2	0.50	-0.18	1.03	0.45	0.5	0.4	0.4	SC1	SC1
Pidie	Triang Gadeng	Cot Leue Rheng	5 - 1	15.10	3.57	3.12	7.26	2.5	8.6	5.2	SC2	SC3
			5 - 2	4.13	5.49	2.55	4.05	3.0	3.0	3.0	SC2	SC1

***Rhoades** (1989) = Traditional estimate of salinity from EM38,* ***ETESP** = project estimate.*
Values in red "suspect" and eliminated from manipulation

3.8 Conclusions & Recommendations

In summary, the data would appear to be reliable and there is no salinity problem on site 4 but there is a relatively serious salinity problem at site 5. The sediment depth deposited does not seem to have presented any real problem.

Reclamation leaching or a change in land use is required at Cot Leue Rheng – Site 5. However, the existing salinity, whether it exists at the surface (0–30cm), as in 5-2, or in the subsoil (60+cm), will NOT go away or reduce if:

- the sites do not have an operational drainage system to remove the saline water and leachate from the site once reclamation is started
- new saline water enters the site, whether this is from tidal effects, sea-water ingress through the subsoil or carried in the drainage from sites higher up the valley

If the addition of new saline water cannot be prevented then a change in Landuse has to be seriously considered.

Table 3.7 summarises the salinity values determined for these sites by both the EM38 survey and during the recent ETESP site visit. Overall salinity figures have been calculated by taking average of the:

- ECe for 0 – 90cm by the Rhoades equations, and
- ETESP estimate of the average salinity

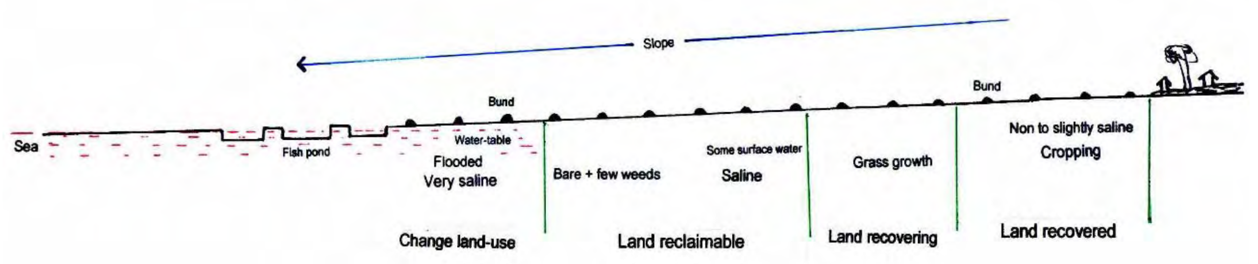
Table 3.7 Comparison of Salinities from EM38 Survey and Dec o5

Location	Site	Overall EM38 dS/m	Rhoades 0–90cm EM38 dS/m	ETESP average EM38 dS/m	Rhoades 0–30cm EM38 dS/m	Rhoades 30–60cm EM38 dS/m	ETESP EMh EM38 dS/m	ETESP 0–25cm Dec 05 dS/m	ETESP 25+cm Dec 05 dS/m
Raya	4-1	0.61	0.62	0.60	0.51	0.90	0.50	0.21	0.26
Cot Leue Rheng	5-1	10.04	10.47	9.60	19.00	2.59	11.80	8.55	5.97
	5-2	6.45	ND	5.50	ND	3.53	4.20	4.29	0.11

The soil at site 4-1 in Raya can be considered virtually fully reclaimed though it is possible that, in time the salinity could fall even lower. This situation has come about because there is an active irrigation system continually supply clean water to the land and, obviously, soil drainage is operating. Since the EM38 survey, the salinity has fallen by about 60% and even salt intolerant crops should grow and give satisfactory yields if the husbandry is good and all the necessary inputs are applied. No ETESP reclamation interventions would be required at this site – apart from inputs of seed, fertilisers and other agricultural commodities plus any appropriate farmer training.

However, the situation at Cot Leue Rheng is quite different and, although the salinity has fallen a great deal the levels at Site 5-1 are still well above acceptable levels for agriculture. This situation is recognized as ETSEP Scenario 4.

Figure 3.8 Idealised Cross Section from High Ground to Fishponds and the Sea



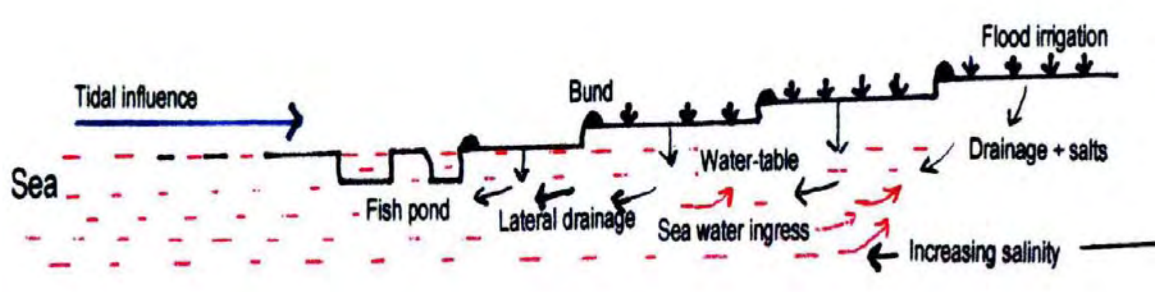
This area has an operational water supply system and some basic drainage channels – though what the farmers call drainage is really overflow systems that remove excess irrigation water from one irrigated field to the next field down-slope. However, there is a large drainage channel running directly down-slope at the opposite side of the field from the inlet for the irrigation water, hence there is some drainage of the land.

There is a progression of salinity increase down-slope with the soils at the top of the slope already back in production (ETESP Scenario 5) and the soils at the lowest points being badly flooded and very saline. There are at least two possible reasons for the salinity of these lower slope sites:

- Tidal influence and sea water ingress via the water-table, and
- Accumulation of salts in the lower slopes due to the sub-surface, lateral or sideways drainage of the soils further upslope. This is a natural phenomenon and is to be expected in any irrigation scheme, in particular where there has been inadequate provision of soil drainage

Salinisation is happening from the sea plus from the land and, for the worst affected areas, there is probably no way to reclaim the land and land-use should probably be changed to construction of fish ponds.

Figure 3.9 Salinisation of Low Lying Site from the Sea and Irrigation



A decision has to be made as to where the land-use should be changed to construction of fish-ponds and where reclamation should be carried out. Indicators or guidelines should be the severity of the flooding on the surface, soil and surface water salinity and, also, if there is tidal influence – that is, does the flood increase and decrease with the tide? If there is obvious tidal influence then the land-use should be changed and if the other indicators are present then serious thought should be given to a Landuse change.

Where there is no tidal influence, but the land still be flooded, then the drainage should be increased immediately – this can be done by installing drainage ditches across the slope (on the contour) and ensuring any drainage collected is discharged into the collector drain down the edge (down-slope) of the irrigated area leading to the fish ponds and the sea.

In the areas further upslope, where the land is recovering and grasses are starting to grow, the drainage should still be improved as suggested above and this will speed up the recovery process. Diagrams are presented in Scenario 5 of such drains.

With the installation of drains there will be an immediate increase in the amount of water, mainly saline, draining off the land trying to find its way to the sea. All channels downstream and the outlet to the sea must be unrestricted or increased flooding at the shoreline will happen.

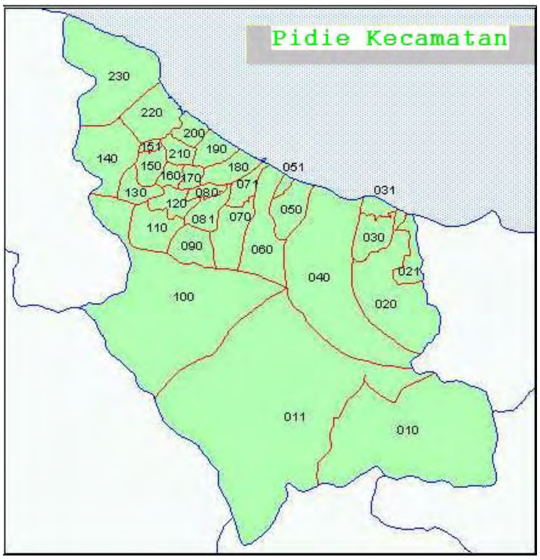
The services of an experienced soil / land drainage engineer should be used to design and oversee the installation of the suggested drains. In the worst effected areas where Landuse change is NOT to happen then no seed, fertilizer or other agricultural inputs should be supplied or applied until reclamation has been completed or at least underway.

CHAPTER 4 PANTERAJA

4.1 Introduction

Kecamatan Panteraja is, as previously noted, abuts and lies to the west side of Kecamatan Triang Gadeng on the north coast of Sumatra labeled 051 in Figure 4.1

Figure 4.1 Kabupaten Pidie and Kecamatan

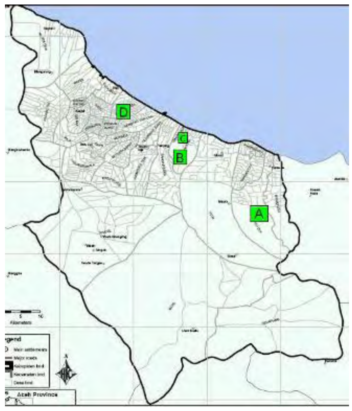


4.2 Salinity Survey

Only one location within the kecamatan was subjected to a salinity survey done with the EM38 salinity device. The location was:

- Reudup - Site 7 with two transects 7 – 1 with 17 samples points and 7 – 2 with 18 sample points

Figure 4.2 Location



Coordinates of the site were taken but since lost, the approximate position of Reudup, Site 7 is close to the green label 'C" in Figure 4.2. The site lies about 100m from the main highway from Bireuen to Banda Aceh within Reudup.

Two transects were done at this site but the exact locations cannot be shown as no geo-referencing data were included in the dataset passed to ETESP by BPTP and the ETESP coordinates have been lost. Some salient facts about the sites are presented in Table 4.1, which has been compiled form study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

Table 4.1 Transect Information

Name	Site	Days flood	Sediment (cm)	No	EM38 Points	Sed. Treat	Landuse / Crop	Fertiliser	Noted Problems
Panteraja	Reudup	15	5	7 - 1	17	Mixed	Sawah Died	N & P	Not planted since tsunami
	Reudup	15	5	7 - 2	18	Mixed	Sawah Died	N & P	Not planted since tsunami

4.3 Site Description

This site description was compiled after the ETESP site visit in December 2005.

Sites 7-1 and 7-2 lie on the south side of the main highway in Reudup on a virtually flat alluvial plain, only Site 7-1 had data collected from it as 7-2 was adjacent.

Pre-tsunami the main crop was padi but there has been no crop since the tsunami. When visited the site was 30-50% flooded with about soil depth above the water table of about 20cm in the non-flooded parts.

There was no official irrigation supply for the site but there were soil drains, as can be seen in figure 4.3

Figure 4.3 View over Site from the Highway

The water in this channel was flowing slowly towards the road where there was another channel or drain running parallel to the road.

However, there appeared to be no outlet or bypass to allow this water to get past the road and into the Nipa or mangrove area which lay on the north side of the road. If the field-drain was flowing more quickly and able to discharge to the mangrove area then desalinisation of Site 7-1 / 7-2 would be more efficient.

This site would more or less fit ETESP Scenario 1 even though there are channels acting as field drains.

Figure 4.4 Drain Running to the Road

4.4 Site Information from the EM 38 Survey and ETESP

The land was categorized as Sawah or lowland rain fed but the survey notes indicate that it has not been cultivated since the inundation, when the rice crop died, but was being considered for ground nut cultivation the recent ETESP visit established that the land was still flooded and not cultivated..

Table4.2 Land Preparation Post-tsunami – EM38 Survey

Site	Land Use Type	Crop or land preparation	Soil	Notes
7 – 1	Lowland rain fed / Sawah	Rice died and being planned for ground nuts N: Urea 150 kg/ha P: SP-36 50 kg/ha No crop in the ground	Dry	First tillage since tsunami Recent visit indicates NO cultivation
7 – 2	Lowland rain fed / Sawah	Rice died and being planned for ground nuts N: Urea 150 kg/ha P: SP-36 50 kg/ha No crop in the ground	Dry	First tillage since tsunami Recent visit indicates NO cultivation

Table 4.3 Soil and Site Features December 2005

Site	PSC 0-25 cm	Soil Texture	Soil ECe 0 -25 cm	PSC 25 – 50 cm	Soil Texture	Soil ECe 25 – 50 cm	Soil Depth cm	WT Depth cm	WT EC dS/m
7-1	H/V	SiCl	1.43	V	SiC / C	1.51	20	20	0.78
7-2	ND	ND	ND	ND	ND	ND	ND	ND	ND

No data from 7-2 as very close to 7-1 and in the same condition

4.5 Conditions and Problems

The significant conditions noted during the EM38 survey were the problems of:

- growing rice before the tsunami but the crop then died
- no current land use or cultivation but tillage in hand for ground nut cultivation – but all appearances are that this never happened
- shallow sediment deposition only
- irrigation or groundwater with salinity of 0.34dS/m

There is not an overly deep covering of sediment, initial study of the original salinity figures do not suggest a large salinity problem and this supposition is supported by the recent salinity determination. It is more likely that the lack of successful cultivation or cropping of the site is associated with the high water table plus the deleterious effects of the slight salinity that still remain.

4.6 Soil Salinity

The raw data from a salinity survey carried out on the site was passed to ETESP for use in soil reclamation studies. The basic findings of what the data reveals are presented as simply as possible in this section without going into the theories or the processes of data-manipulation used. Table 4.4 below is a presentation showing a few facts that the data reveal, these facts are revealed by all EM38 datasets and are standard procedure.

Table 4.5 contains the actual salinities determined from the EM38 data plus recently acquired "traditional" determination of the soil salinity from the site.

- Starting in the right hand column of Table 4.4 it states "Reading OK" – this has been determined from carrying out a check of some of the ratios of the various data items and is a standard procedure with the EM38. Data can be classified as "false" if an unacceptable ratio is found and would be caused by the presence of metallic objects in the soil – such as metal poles etc.
- Similarly, another check of another ratio of some of the data items reveals if the soil salinity sits in the topsoil (referred to "inverted" in the literature) or if it has been "leached " downwards to some extent. Both sites show there has been some leaching.
- The coloured coded column in Table 4.4 is the ETESP assessment of the degree of problem that the original depth of sediment presented – the key is shown as Figure 4.5. The coding is also used for salinity as in Table 4.5

Figure 4.5 ETESP Problem Rating Key

ECe dS/m	PROBLEM RANKING	Sediment cm
0 - 1.9	None	0 - 0.9
2 - 3.9	Negligible	1 - 1.9
4 - 5.9	Very Slight	2 - 4.9
6 - 7.9	Slight	5 - 9.9
8 - 11.9	Moderate	10 - 14.9
12 - 15.9	Moderately Big	15 - 19.9
16 - 23 9	Big	20 - 29.9
>24	Very Big	>30

Table 4. 4 Assessment of the EM38 Dataset for the Sites 7–1 and 7-2

				mS/cm	mS/cm	mS/cm	Samples	Sediment	Flood		
Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	No	Cm	Days	Status	Check
Pidie	Panteraja	Reudup	7 - 1	59	58	59	17	5	15	Leached	Reading OK
Pidie	Panteraja	Reudup	7 - 2	92	79	86	18	5	15	Leached	Reading OK

The salinity data in Table 4.5 reveals that, based on the average values, the salinity problem was non-existent to negligible for the surface (0–30cm) layer of the Reudup site (no colour coding or colour-code green, with SC1). The average determinations of salinity for the surface layers at the two sites is less than 2dS/m. These figures would be accepted as the site having being reclaimed and suitable to commence cropping.

However, as indicated above in Table 4.4, the soil has been leached to some extent and this is displayed by the fact that the second layer (30–60cm) was more saline than the topsoil and the salinity ranges from 2.6–3.1dS/m. These values fall in Salinity Class SC1, are a negligible problem and are colour-coded green.

The maximum values for these sites still presented no great problem as they also fell into SC1 whilst the minimum values are virtually non-saline.

Basically the sites at Reudup did not have a salinity problem, or only a very minor problem and all ECe values were classified as falling in the non-saline category or in Salinity Class SC1 and only minimal soil reclamation leaching might be required.

4.8 Sediment Depth

Table 4.4 notes that the sediment depths deposited on the soil at the Reudup sites are considered a "negligible" hazard or problem as the depth was only 5cm. Other sites with sediments of this depth and low salinities are already being cropped and there is no reason why this site cannot also be restored to productivity assuming there is a drainage system and water available for leaching and irrigation.

Table 4.5 Salinity Measurements for Sites 7–1 and 7-2

Kabupaten	Kecamatan	Location	Site	Rhoades				ETESP Lookup			Salinity Class	
				ECe 0 - 30cm dS/m	ECe 30 -60cm dS/m	ECe 60 -90cm dS/m	ECe 0 - 90cm dS/m	ECe EMv dS/m	ECe EMh dS/m	ECe EMav dS/m	Rhoades	ETESP
Averages												
Pidie	Panteraja	Reudup	7 - 1	1.94	2.60	1.21	1.92	1.4	1.3	1.3	SC1	SC1
			7 - 2	1.86	3.06	1.52	2.15	2.2	1.9	2.0	SC1	SC1
		Location mean		1.9	2.8	1.4	2.0	1.8	1.6	1.7	SC1	SC1
Maximums												
Pidie	Panteraja	Reudup	7 - 1	3.29	0.10	2.77	2.05	1.7	2.0	1.9	SC1	SC1
			7 - 2	2.24	3.74	1.87	2.62	2.8	2.3	2.4	SC1	SC1
		Location mean		2.77	1.92	2.32	2.34	2.26	2.18	2.15	SC1	SC1
Minimums												
Pidie	Panteraja	Reudup	7 - 1	0.93	1.59	0.80	1.11	1.1	0.9	1.0	SC1	SC1
			7 - 2	0.64	1.54	0.83	1.00	1.4	1.1	1.2	SC1	SC1
		Location mean		0.78	1.56	0.81	1.05	1.30	1.00	1.14	SC1	SC1

Rhoades *(1989) = Traditional estimate of salinity from EM38,* ***ETESP*** *= project estimate.*

4.9 Conclusions & Recommendations

In summary, the EM38 data would appear to be reliable and there was not a very large salinity problem on this site and what salinity there was seems to have been concentrated in the second layer indicating that some natural leaching had already taken place. The present situation suggests that the salinity is now much the same in the upper layers with no clear increase within the top 25 – 30cm.

The salinity problem was rated as "negligible" - colour coded green – for site 7-2 and some, minor reclamation leaching could have been envisaged if water-table conditions allowed. Site 7–1 was virtually non-saline at the time of the survey and the situation does not seem to have changed much up to the present.

An overall salinity figure of 1.61dS/m was taken for the Reudup site from the EM38 survey as this is the average of:

- ECe for 0 – 90cm by the Rhoades equations, and
- ETESP estimate of the average salinity

The salinities from the EM38 survey and the recent data collected by ETESP in December are summarised in Table 4.6

Table 4.6 Comparison of Salinities from EM38 Survey and Dec o5

Location	Site	Overall EM38 dS/m	Rhoades 0–90cm EM38 dS/m	ETESP average EM38 dS/m	Rhoades 0–30cm EM38 dS/m	Rhoades 30–60cm EM38 dS/m	ETESP EMh EM38 dS/m	ETESP 0–25cm Dec 05 dS/m	ETESP 25+cm Dec 05 dS/m
Reudup	7-1	1.61	1.92	1.30	1.94	2.60	1.30	1.43	1.51
	7-2	2.08	2.15	2.00	1.86	3.06	1.90	ND	ND

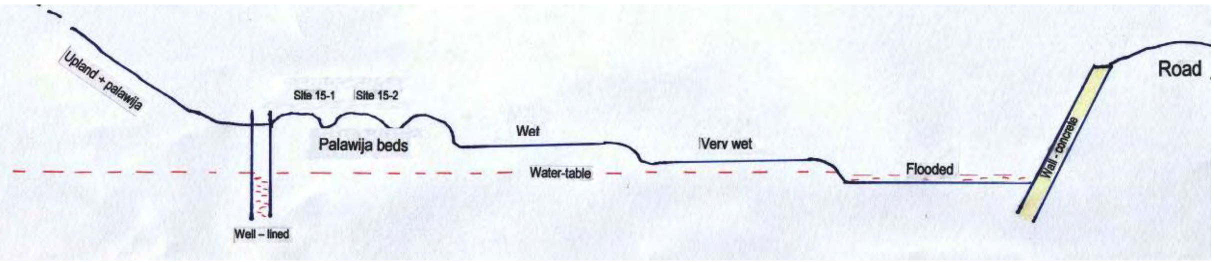
Note: ND – No data collected as site appeared so similar to 7-1

The salinity situation at Site 7-1 appears to have stayed the same since the time of the EM38 survey and December 2005. This is not surprising since this site does not receive irrigation water, the only additions are from rainfall and the drainage is poor. There is a drainage system but, as noted above and shown in Figure 4.4, the drainage does not escape from the site as the road protection wall / bank is acting as a dam. In fact, even though this site does have drainage it fits ETESP Scenario 1.

The existing minor salinity, whether it exists at the surface (0– 30cm) or in the subsoil (30-60+cm) will NOT go away or reduce if the drainage system cannot be improved. If the water presently held back by the road could be disgorged over the road into the mangrove area the situation would improve, the water table would fall and leaching would occur and the salinity reduced.

As an interim measure to allow the farmer re-establish his farm and livelihood, salt tolerant varieties of rice could be grown quite successfully on this site. Dry land cropping is just not possible, as an acceptable root zone of about 60cm needs to be established before palawija can be considered.

Figure 4.6 Cross Section of a Typical Scenario 1 Location



Typical Scenario 1 Problems

6. High water table which gets closer to the surface as the level of the land falls towards the natural stream lines
7. The land in the lower-slope positions is flooded since the water table is actually at the surface
8. Man-made structures, such as roads, urban and agricultural drainage ditches and irrigation channels, acting as dams and blocking the drainage
9. No or poor in-field or on-farm drainage and natural stream lines are no longer active resulting in any accumulated surface or drainage water cannot be removed form the site

Immediate actions

6. Improve the in-field & on-farm drainage, these can be farmer-installed with guidance and instruction
7. Clear, unblock and restore natural drainage lines and ensure they connect to the local river or drain
8. If palawija can be grown then deepen in-field furrows so they can act as drains to remove any saline leachate produced – the farmer can implement this
9. Apply any supplementary irrigation as overhead and not surface-flow, this will better enable soil leaching – use watering cans or appropriate, low-cost technology with piped or pumped supply
10. Use salt tolerant varieties and, for the immediate future, only grow palawija on raised beds with overhead irrigation techniques

A palawija cycle must be built into the cropping calendar to allow annual leaching and desalinisation

Possible reclamation problems and effects

5. Engineering difficulties bypassing man-made structures requiring minor to medium civil engineering inputs
6. Increasing salinity and flooding downstream as the saline leachate is removed from the sites and drained to local rivers
7. Development of soil acidity under palawija cropping, this is a known problem with some of the soils of the region and soil pH must be monitored. Soils with this possible problem should have large amounts of organic matter (FYM, compost) added to assist remove the aluminium from the soil and hence reduce the acidity. Liming materials may also be required. These soils will revert to neutral when flooded for padi in future.
8. Farmers might show some resistance to having to grow palawija rather than padi but, with selection of high value, marketable crops income generation could be considerably enhanced

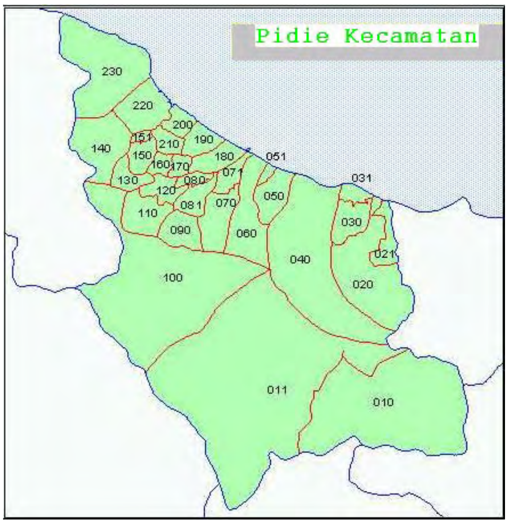
The services of an experienced soil / land drainage engineer should be used to design and oversee the installation of the suggested drains. In the worst effected areas no seed, fertilizer or other agricultural inputs should be supplied or applied until reclamation has been completed or at least underway.

CHAPTER 5 SIMPANG TIGA

5.1 Introduction

Kecamatan Panteraja, as previously noted, abuts and lies to the west side of Kecamatan Triang Gadeng on the north coast of Sumatra and labeled as 190 in Figure 5.1 below.

Figure 5.1 Kabupaten Pidie



Coordinates of the sites were taken in December 2005 and are shown in Table 5.1 then the GPS data were downloaded onto sheets 0421-34 and 0621-13 of the 1:50,000 scale topographic map. Extracts of that map are shown as Figure 5.2

Sites 1 and 2 were very close to each other and, in fact not that far from Site 3-1 but they are not shown on the same map as they actually land on different map sheets. Some salient facts about the sites are presented in Table 5.1, which was compiled form study of the original dataset – MS Word document plus the Excel spreadsheet and available maps

5.2 Salinity Survey

Three locations within the kecamatan was subjected to a salinity survey done with the EM38 salinity device. The locations were:

- Seukee: Site 1 with two transects, 1–1 with 9 samples points and 1–2 with 9 sample points
- Seukee: Site 2 with one transect, 2–1 with 8 sample points, and
- Tungoe: Site 3 with one transect, 3–1 with 8 sample points (Site name actually Cot Jaja)

Figure 5.2 Locations – Sites 1-1 and 2-1

Sheet 0421-34

Site 3-1

Sheet 0521-13

Table 5.1 Geographic Coordinates of the Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
1-1	5	21	32.0	95	58	13.1	13	Pidie, Simpang Tiga, Seukee
2-1	5	21	27.2	95	58	21.0	21	Pidie, Simpang Tiga, Seukee
3-1	5	20	27.7	96	00	17.1	17	Pidie, Simpang Tiga, Cot Jaja (Tungoe)

NB Altitudes from GPS unit and not to be taken as anything like accurate, must be found from topographical map
NB Where a second traverse was done at virtually the same location as another the records were merged

Table 5.2 Transect Information

Name	Site	Days flood	Sediment (cm)	No	EM38 Points	Sed. Treat	Landuse / Crop	Fertiliser	Notes
Simpang Tiga	Seukee	3	5	1 - 1	9	Mixed	Palawija Tomatoes	N, P, K & OM	Good crop but pale and patchy
Simpang Tiga	Seukee	3	5	1 - 2	9	Mixed	Palawija Cucumber	N, P, K & OM	Moderate crop but pale and patchy
Simpang Tiga	Seukee	3	3	2 – 1	8	Mixed	Palawija Cauliflower	N, P, K & OM	Good crop but pale coloured
Simpang Tiga	Tungoe	3	7	3 - 1	8	Mixed	Palawija Onion	N, P, K & OM	Good crop but pale coloured

5.3 Site Descriptions

The following site descriptions were compiled following the ETESP visits in December 2005. **Site 1-1** was on a virtually flat alluvial plain, close to the coast and adjacent to fishponds. There was a basic irrigation system which could command the fields if the irrigation channel was full to the top and it is possible that the tsunami sediment of 5cm was enough to put some sections of this site “out of command”. About 20% of the site was flooded with relatively saline water (1.54mS/cm) and there was a water table at 10cm depth with salinity of 0.33mS.cm. There was no effective drainage from this site. Pre-tsunami the site was favoured for padi but since the inundation there has been no successful cropping and the remnants of a dead palawija crop were visible on the filed. Site 1-2 was so close and similar no new data were collected.

Site 2-1 was very similar to 1-1 being virtually a flat alluvial plain, close to the coast and adjacent to fishponds. There was a basic irrigation system which could command the fields if the irrigation channel was full to the top. The irrigation water was slightly saline at 0.36mS/cm and there was a water table at 10cm, the farmer stated that during previous dry seasons the water table was at about 80cm depth. Currently there was no cropping and the remnants of a failed chili crop were in the field.

Figure 5.3 Across Site 3-1

Site 3-1 at Cot Jaja (Tungoe was not the correct name as noted during the EM38 survey) was at the edge of the village on a virtually flat alluvial plain and was adjacent to fish ponds very close to the coast. There was an irrigation system but no drainage system for the site. Standing water covered about 60% of the surface and this water was very saline at 15.6mS/cm. pre-tsunami this site was favoured for padi but currently, and since the inundation, cropping is not possible.

Figure 5.4 Fishponds Site 3-1

No additional soil analytical or laboratory data have yet been located for these sites.

5.4 Site Information from the EM38 Survey and ETESP

Table 5.2 Land preparation Post-tsunami

Site	Land Use Type	Crop or land preparation	Soil	Notes
1 – 1	Lowland rain fed Palawija	Fertiliser - Complete - (NPK 15:15: 15 %) • 20 kg/300 m^2 5 days after planting and 10 days rotations OM: Manure from cows and goats, rate of application not measured	Wet	Good crops obtained pre-tsunami
1 – 2	Lowland rain fed Palawija	Fertiliser - Complete - (NPK 15:15:15 %) • 20 kg/300 m^2 5 days after planting and 10 days rotations OM: Manure from cows and goats, rate of application not measured	Wet	Good crops obtained pre-tsunami

2 – 1	Lowland rain fed Palawija	Fertiliser - Complete - (NPK 15:15:15 %) Spreading 2 grams per plant weekly Compost: Spreading weekly	Wet	Good crops obtained pre-tsunami
3 - 1	Lowland rain fed Palawija	Fertiliser N: 1 kg/400 m^2 spread weekly P: 3 kg/400 m^2 spread on bed surface K: 1 kg/400 m^2 mixed with Urea, spread weekly OM: Manure at 200 kg/ 400 m^2	Wet	Good previous crops of hot pepper and onion

The sites were noted as rain fed palawija during the EM38 survey possibly because, at that time, that is what the farmers were trying to grow. Present advice was that padi was the favoured crop and usually with a palawija – padi rotation and good yields of Palawija crops were obtained pre-tsunami. When the EM38 survey was conducted the palawija crops in the ground seemed to be in medium to good condition – but they later failed or gave poor yields.

Table 5.3 Soil and Site Features December 2005

Site	PSC 0-25 cm	Soil Texture	Soil ECe 0 -25 cm	PSC 25 – 50 cm	Soil Texture	Soil ECe 25 – 50 cm	Soil Depth cm	WT Depth cm	WT EC dS/m
1-1	V	SiC	4.10	V / Hz	SiCl	3.76	10	10	1.54
1-2	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-1	V	SiC	2.57	V	SiC	2.65	10	10	1.36
3-1	M	fsL	11.60	ND	ND	9.80	0	0	15.65

No data from 1-2 as very close to 1-1 and in the same condition
Soil depth is noted as 0 (zero) when there is no depth of soil that could be considered an acceptable root zone for dry land crops or leached without improved in-field drainage

5.5 Problems

At the time of the EM38 survey field notes indicated that farming has resumed with crops rated as medium to good – previously crops were rated as good or very good. However, the sites have since virtually been abandoned to agriculture and the reasons are:

- very high water tables, and
- high soil salinities
- tidal effects from the ocean due to proximity to the coast and fish ponds

5.6 Soil Salinity

The raw data from a salinity survey carried out on the site was passed to ETESP for use in soil reclamation studies. The basic findings of what the data reveals are presented as simply as possible in this section without going into the theories or the processes of data-manipulation used. Table 5.4 below is a presentation showing a few facts that the data reveal, these facts are revealed by all EM38 datasets and are standard procedure. Table 5.5 contains the actual salinities determined from the EM38 data.

- Starting in the right hand column of Table 5.4 it states "Reading OK" – this has been determined from carrying out a check of some of the ratios of the various data items and is a standard procedure with the EM38. Data can be classified as "false" if an unacceptable ratio is found and would be caused by the presence of metallic objects in the soil – such as metal poles etc.
- Similarly, another check of another ratio of some of the data items reveals if the soil salinity sits in the topsoil (referred to "inverted" in the literature) or if it has been "leached " downwards to some extent. Sites 1–1and 3–1 would appear to have saline topsoil whilst 1–2 and 2–1 show there has been some leaching.
- The coloured coded column in Table 5.4 is the ETESP assessment of the degree of problem that the original depth of sediment presented – the key is shown as Figure 5.5. The coding is also used for salinity.

Figure 5.5 ETESP Problem Rating Key

ECe dS/m	PROBLEM RANKING	Sediment cm
0 - 1.9	None	0 - 0.9
2 - 3.9	Negligible	1 - 1.9
4 - 5.9	Very Slight	2 - 4.9
6 - 7.9	Slight	5 - 9.9
8 - 11.9	Moderate	10 - 14.9
12 - 15.9	Moderately Big	15 - 19.9
16 - 23 9	Big	20 - 29.9
>24	Very Big	>30

As can be seen in Table 5.4 the depths of sediment recorded at these sites was not high and considered as negligible problems

Table 5.4 Assessment of the EM38 Dataset for the Sites in Simpang Tiga

Kecamatan	Location	Site	mS/cm EMv	mS/cm EMh	mS/cm Average	Samples No	Sediment Cm	Flood Days	Status	Check
Simpang Tiga	Seukee	1 - 1	60	78	69	9	5	3	Saline topsoil	Reading OK
		1 - 2	64	50	57	9	5	3	Leached	Reading OK
Simpang Tiga	Seukee	2 - 1	31	19	25	8	3	3	Leached	Reading OK
Simpang Tiga	Tungoe	3 -1	18	21	19	8	7	3	Saline topsoil	Reading OK

The almost total lack of colour coding in Table 5.5 indicates that even when the "maximum" values of salinity at the time of the survey were considered there was, at worst, a "negligible" problem in this area – all codings are either green or no colour code is applied as the soils are non-saline.

Overall these soils are classified as Salinity Class SC1 at the time of the EM38 survey with only a few layers having ECe values in excess of 2dS/m. Generally, well managed soil and water applications under normal irrigation practice might have been possible in these areas and, on the assumption that there was a soil drainage system, the salinities could well reduce through natural leaching.

Table 5.5 Salinity Measurements for Sites in Simpang Tiga

			Rhoades			Rhoades	ETESP Lookup			Salinity Class		
Kecamatan	Location	Site	ECe 0 - 30cm dS/m	ECe 30 -60cm dS/m	ECe 60 -90cm dS/m	ECe 0 - 90cm dS/m	ECe EMv dS/m	ECe EMh dS/m	ECe EMav dS/m	Rhoades	ETESP	Lab
Averages												
Simpang Tiga	Seukee	1 - 1	3.20	0.25	2.23	1.89	1.4	1.8	1.6	SC1	SC1	ND
		1 - 2	0.80	1.70	0.90	1.13	1.5	1.1	1.3	SC1	SC1	ND
	Location mean		2.00	0.98	1.56	1.51	1.42	1.48	1.45	SC1	SC1	
Simpang Tiga	Seukee	2 - 1	-0.13	0.38	0.27	0.17	0.7	0.4	0.5	SC1	SC1	ND
	Location mean			0.38	0.27	0.17	0.7	0.4	0.5	SC1	SC1	
Simpang Tiga	Tungoe	3 -1	0.82	0.03	0.67	0.51	0.3	0.4	0.4	SC1	SC1	ND
	Location mean		0.8	0.0	0.7	0.5	0.3	0.4	0.4	SC1	SC1	
Maximums												
Simpang Tiga	Seukee	1 - 1	3.90	0.45	2.27	2.21	1.4	2.2	1.8	SC1	SC1	ND
		1 - 2	0.96	2.05	1.08	1.36	1.8	1.4	1.6	SC1	SC1	ND
	Location mean		2.43	1.25	1.67	1.79	1.64	1.80	1.71	SC1	SC1	
Simpang Tiga	Seukee	2 - 1	-0.26	0.35	0.28	0.12	0.8	0.4	0.6	SC1	SC1	ND
	Location mean			0.35	0.28	0.12	0.78	0.42	0.58	SC1	SC1	
Simpang Tiga	Tungoe	3 - 1	2.46	0.48	0.80	1.25	0.5	1.2	0.8	SC1	SC1	ND
	Location mean		2.46	0.48	0.80	1.25	0.48	1.19	0.76	SC1	SC1	
Minimums												
Simpang Tiga	Seukee	1 - 1	2.09	-0.08	2.20	1.40	1.3	1.3	1.3	SC1	SC1	ND
		1 - 2	0.53	1.30	0.70	0.84	1.2	0.9	1.0	SC1	SC1	ND
	Location mean		1.31	1.30	1.45	1.12	1.27	1.10	1.19	SC1	SC1	
Simpang Tiga	Seukee	2 - 1	-0.14	0.33	0.24	0.14	0.6	0.3	0.5	SC1	SC1	ND
	Location mean			0.3	0.2	0.1	1.1	0.3	0.5	SC1	SC1	
Simpang Tiga	Tungoe	3 - 1	0.18	0.37	0.20	0.25	0.3	0.2	0.2	SC1	SC1	ND
	Location mean		0.2	0.37	0.20	0.25	0.28	0.22	0.24	SC1	SC1	

Rhoades (1989) = Traditional estimate of salinity from EM38, **ETESP** = project estimate.
ND No data
Values in red "suspect" and excluded from manipulation

5.7 Sediment Depth

Table 5.4 notes that the sediment depths deposited on the soil at the Simpang Tiga sites were considered a "negligible" hazard or problem as the depth range was only 7cm at worst. Other sites with sediments of this depth and low salinities are already being cropped and there was no reason why this site cannot also be restored to full productivity assuming there was a drainage system and water available for leaching and irrigation.

5.8 Conclusions & Recommendations

In summary, the data would appear to be reliable and there was not an obvious salinity problem on these sites at the time of the survey. The salinity problem was rated as "negligible" - colour coded green – for site the topsoil of site 1 with ECe values ranging from 1.2 – 2.2dS/m and only some, very minor reclamation leaching would have been envisaged if water-table conditions allowed and this should happen as part of normal cultivation under irrigated conditions. Other sites have indicated that salinity values can fall well below 1dS/m and in the long-term this should be possible at Site 1 with careful soil and water management. Overall soil salinity figures were calculated for these sites at the time of the EM38 survey from:

- ECe for 0 – 90cm by the Rhoades equations (dS/m), and
- ETESP estimate of the average salinity (dS/m)

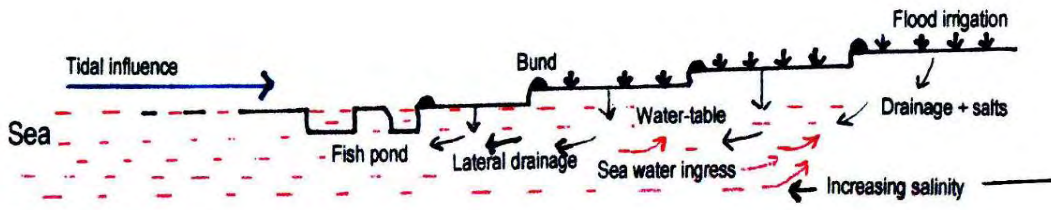
However, the situation at these sites has deteriorated badly since the original survey and salinity levels are now much higher. The EM38 and ETESP new data are compared below.

Table 5.6 Comparison of Salinities from the EM38 Survey and December 2005

Location	Site	Overall EM38 dS/m	Rhoades 0–90cm EM38 dS/m	ETESP average EM38 dS/m	Rhoades 0–30cm EM38 dS/m	Rhoades 30–60cm EM38 dS/m	ETESP EMh EM38 dS/m	ETESP 0–25cm Dec 05 dS/m	ETESP 25+cm Dec 05 dS/m
Seukee	1-1	1.75	1.89	1.60	3.20	0.25	1.80	4.10	3.76
Seukee	1-2	1.22	1.13	1.30	0.80	1.70	1.10	ND	ND
Seukee	2-1	0.34	0.17	0.50	ND	0.38	0.40	2.57	2.65
Cot Jaja	3-1	0.46	0.51	0.40	0.82	0.03	0.40	11.60	9.80

Reclamation leaching or, more likely, a change in land use is required at Site 1 in Seukee and Site 3 in Jaja whilst Site 2-1might be suitable for reclamation due to the much lower salinity. These sites probably all fit the ETESP Scenario 4 situation and the increasing salinities are probably coming mainly from tidal effects and sub-soil sea-water intrusion as depicted in Figure 5.6.

Figure 5.6 Salinisation of low lying site from the sea and irrigation



Salinisation is most likely coming from the tidal effects from the sea and sub-surface ingress. For the worst affected areas, there is probably no way to reclaim the land and land-use should be changed to construction of fish ponds.
Accumulation of salts in lower slope positions can be due to the sub-surface, lateral or sideways drainage of the soils further upslope, but the connection at these sites was not too obvious. This lateral drainage is a natural phenomenon and is to be expected in most low-lying sites, in particular where there has been inadequate provision of soil drainage to intercept and remove the lateral flow. However, the existing salinity, whether it is high or low, whether it exists at the surface (0–30cm) or in the subsoil (60+cm) layers, will NOT go away or reduce if:

- the sites do not have an operational drainage system to remove the saline water and leachate from the site once reclamation is started
- new saline water enters the site, whether this is from tidal effects, sea-water ingress through the subsoil or carried in the drainage from sites higher up the valley

If the sites cannot be drained and the addition of new saline water cannot be prevented then a change in Landuse has to be seriously considered.

CHAPTER 6 SOIL RECLAMATION and IMPROVEMENT

6.1 Introduction

No matter how the salts got into the soil they can be removed (at a cost) provided the reasons for the salt accumulation are understood and the appropriate remedial measures undertaken. The reasons for the salt accumulation have been addressed to some extent in Chapter 2. The process of salt removal is termed reclamation.

The general principles for the reclamation of salty soils comprise:

- the removal of salts by leaching plus the removal of the saline leachate from the site
- the replacement of exchangeable sodium by exchangeable calcium and
- the prevention of further accumulation of salt or sodium.

Reclamation is only feasible if leaching water is able to move downwards through the soil profile, carrying the salts below the main root zone and eventually being removed from the site as drainage and disposed of in an environmentally acceptable manner. This leaching water can be required in large quantities and, in association with the continuing percolation of water from irrigated crops, results in the deeper layers becoming waterlogged and a rise in the water-table towards the surface. In most situations natural drainage is insufficient to cope with the water flow and some sort of artificial drainage becomes necessary at some stage in the reclamation cycle.

Reclamation (in the first instance) involves the desalinisation of a defined depth of soil (root-zone) to a particular salt content. There will be an initial phase of saline water percolating below the root-zone that eventually merges with the subsurface water table, resulting in increased salinity and movement of the water-table towards the surface. Subsequent normal irrigation continues to remove salts from the soil and the quantities of salt carried will decrease over time.

Planning for the reclamation of saline areas requires an estimate of the size of the salinity problem (how saline is the soil? – measured in dS/m) and a reliable estimate of the quantity of water necessary to reduce soil salinity to a level where crops can be economically produced.

6.2 Water Requirements for Salinity Reduction

For the sites in question some assumptions have to be made. Assumptions are presented in "italics" in Table 6.1 along with known features. Since many of these sites are presently flooded or have water tables at about 10cm depth it is just not possible to carry out reclamation now. However, farmers and other local people spoken to claim that in the dry season the water table is usually at about 75-80cm depth. Accordingly, reclamation has been "planned" for the driest month and, according to the available records, that would be June and the water table assumed to be at 75cm (750mm). The recommendation for reclamation leaching is that raised beds for palawija are installed since the furrows between the beds can act as the first level of soil drain. A soil depth of 600mm (60cm) should be the target depth to recover – as this is an acceptable rooting depth for most palawija crops.

Table 6.1 Features of the Sites

Kecamatan	Location	Site	Existing Salinity (dS/m)	Soil depth to be recovered (mm)	Depth of water table (mm)	Drainage System Status	Irrigation System in use	Soil PSC
Meureudu	Meuraksa	6 – 1	1.04	600	*750*	Yes	Yes	H
Triang Gadeng	Raya	4 – 1	0.24	600	*750*	No	Yes	M
Triang Gadeng	Cot Leue Rheng	5 - 1	7.26	600	*750*	Yes	Yes	H
Triang Gadeng	Cot Leue Rheng	5 - 2	4.29	600	*750*	Yes	Yes	H
Panteraja	Reudup	7 – 1	1.47	600	*750*	Yes	No	H
Panteraja	Reudup	7 – 2	2.08	600	*750*	Yes	No	H
Simpang Tiga	Seukee	1 – 1	3.93	600	*750*	No	Yes	H
Simpang Tiga	Seukee	1 – 2	1.22	600	*750*	No	Yes	H
Simpang Tiga	Seukee	2 – 1	2.61	600	*750*	Yes	Yes	H
Simpang Tiga	Tungoe (Cot Jaja)	3 - 1	10.70	600	*750*	No	Yes	M

However, it must be recognized that as of now, with the sites flooded or with very high water-tables reclamation leaching cannot be done or even attempted.
The available and assumed data were then inserted into the tool for determining the depths and volumes of water required for reclamation – the outputs are seen in Table 6.2.

Table 6.2 Water required for reclamation

Kabupaten	Site / Sample Number	Reclamation Start Month	Soil PSC, Texture or Type	Depth want to reclaim (mm)	INITIAL Salinity ECo dS/m	INITIAL Salinity class	TARGET / DESIRED EC dS/m	TARGET / DESIRED Salinity class	H20 table depth (mm)	Max soil depth reclaimable (mm)	Reclamation Required	Leaching H_20 Needed: Dlw (mm) DEPTH LEACHING WATER	Leaching H_20 Needed: Dlw m3/ha CUBIC METRES WATER / Ha	Pptn bonus during gifts
		Add	Add	Add	Add	Auto	Add	Auto	Add	Auto				
Meurudu - Meuraksa	6 - 1	Jun	H	600	1.0	SC1	0.25	SC1	750	500	Yes	208	2080	22
Triang Gadeng - Raya	4 - 1	Jun	H	600	0.2	SC1	0.1	SC1	750	500	Yes	120	1200	13
Triang Gadeng - Cot Leue Rheng	5 - 1	Jun	H	600	7.3	SC2	0.5	SC1	750	500	Yes	726	7260	76
Triang Gadeng - Cot Leue Rheng	5 - 2	Jun	H	600	2.2	SC1	0.5	SC1	750	500	Yes	220	2200	23
Panteraja - Reudup	7 - 1	Jun	H	600	1.5	SC1	0.1	SC1	750	500	Yes	735	7350	77
Panteraja - Reudup	7 - 2	Jun	H	600	1.7	SC1	0.1	SC1	750	500	Yes	850	8500	89
Simpang Tiga - Seukee	1 - 1	Jun	H	600	3.9	SC1	0.5	SC1	750	500	Yes	393	3930	41
Simpang Tiga - Seukee	1 - 2	Jun	H	600	3.9	SC1	0.5	SC1	750	500	Yes	393	3930	41
Simpang Tiga - Seukee	2 - 1	Jun	H	600	2.6	SC1	0.5	SC1	750	500	Yes	261	2610	27
Simpang Tiga - Tungoe (Cot Jaja)	3 - 1	Jun	M	600	10.7	SC3	0.5	SC1	750	500	Yes	1070	10700	112

Source: Leaching water requirement.XLS

The various outputs from Table 6.2 are given below with explanations.

6.2.1 Maximum soil depths that can be reclaimed

For palawija the aim is to reclaim 600mm (60cm) depth as this is a reasonable rooting depth for most of the crops that would be grown but this is reduced to than 500mm if the water table at the time of reclamation was 750mm (75cm). However, if the water table at reclamation time was less then 750mm the depth of soil that could be reclaimed would be reduced even further. The reduction is due to an allowance made for capillary rise from the water table.

6.2.2 Depths of leaching water required

The depths of leaching water that must pass down through the various soils at these sites are, in fact, all quite different since the range in soil salinity is quite wide, as can be seen in Table 6.1. Some of the soils (Raya) are virtually non-saline (Salinity Class SC1) whilst others – at Cot Jaja and Cot Leue Rheng for example – are moderately to highly saline and fall into Salinity Classes SC2 and SC3. The depths of water that have to pass down through the 60cm (600mm) depth range from just over 120mm to over 1,000mm.

It must be remembered that these are the depths of water that have to pass through the soil; the depths of water that have to be applied to the soil as irrigation ‘gifts” are much greater than this and can be seen in Table 6.3.

6.2.3 Water Requirement groups

The various sites have been placed into water requirement groups, that is groups based on how much water would be required to recover the soil to 60cm (600mm) depth, bearing in mind that only 500mm can be recovered if the water table is at the predicted 750mm depth.

The difference between the “leaching” water requirement and the “irrigation” water requirement is the bonus of the calculated rainfall that should occur during the reclamation period. However, if there is low or no rainfall then all or most of the water will have to be applied as irrigation.

(a) Low water requirement group

Location	Site	Leaching Water Requirement (mm)	Depth of water to apply (mm)	Notes
Triang Gadeng - Raya	4–1	120	550	Appears to have natural drainage so could be reclaimable
Meureudu - Meuraksa	6-1	208	650	Reclamation in hand and farmer already cultivating so probably worth recovering and possible as there is irrigation supply plus drainage
Triang Gadeng –Cot Leue Rheng	5-2	220	650	The subsoil of this site seems to be leached and the surface flooding stops some 200m up-slope from the site. There is irrigation supply and drainage so possibly reclaimable.

(b) Medium depth of water requirement group

Location	Site	Leaching Water Requirement (mm)	Depth of water to apply (mm)	Notes
Simpang Tiga - Seukee	2-1	261	750	There is irrigation supply and drainage so possibly reclaimable BUT it is close to the sea and adjacent to fishponds so it is possible re-salinisation could occur
Simpang Tiga - Seukee	1-1	393	1050	No active drainage though there is irrigation supply and proximity to fishponds and the sea suggests that re-salinisation could easily occur. Change in Landuse should be considered.
Simpang Tiga - Seukee	1-2	393	1050	As above

(d) High water requirement group

Location	Site	Leaching Water Requirement (mm)	Depth of water to apply (mm	Notes
Triang Gadeng –Cot Leue Rheng	5–1	726	1850	Low lying site with high salinity very close to fishponds and the sea make reclamation doubtful. If reclaimed re-salinisation would probably occur. Change in land use should be considered.
Panteraja- Reudup	7-1	735	1850	Not too saline but blocked off from drainage discharge by the road. Higher water depth required as planned target salinity set at lower level than other sites. Farmer claims no irrigation but there is drainage, possible that the drainage channel is actually irrigation supply.
Panteraja- Reudup	7-2	850	1850	Basically as above
Simpang Tiga –Tungoe (Cot Jaja)	3-1	1070	2500	This sited starts with initial salinity of 10dS/m the highest recorded salinity during the EM38 survey. Careful thought needs to be given before trying to reclaim this site as it will take a lot of water and many leaching "gifts". There is no drainage, the site is low lying close to the sea and adjacent to fishponds and a change is land use would seem appropriate

However, it must be remembered that we are talking about the volume of water that must pass down through the soil – NOT THE AMOUNT that has to be APPLIED to the surface. The number of irrigations is determined in Section 6.3 below.

6.3 Leaching Progress

The other tool that has been used at this time is the spreadsheet "Leaching Progress.XLS". The normal situation would be the application of several irrigation gifts of 100mm (10cm) to achieve the target amount determined above to pass down through the depth of soil being reclaimed. Intermittent irrigation has to be used for reclamation as it has proved to be the most efficient (Refer Mobilisation Report, October 2005). What this means is that the irrigation gifts are applied about 7 days apart – this is to allow the soil surface and upper layer of soil to dry to some extent which draws the salts to the surface of any soil peds (units) or cracks that develop. At the next irrigation, these salts get dissolved and leached downwards.

- The target was 60cm reclaimed but only 50cm possible due to water table depth
- Total requirement is for between 120 - 1070mm leaching water to pass below 50cm depth at the various sites
- There has been no rainfall and all water has to be applied by irrigation

Table 6.3 Depths of water passing through the soil layers

Medium Textured Soil (PSC M)

Medium	**Accumulative**	**Volumes**	Accumulative Water Passing through layer			
Irrigation No	**Water applied (mm)**	**Water entering soil (mm)**	**Layer 1** (0 – 25 cm)	**Layer 2** (25 – 50cm)	**Layer 3** (50 – 75cm)	**Layer 4 (75 – 100cm)**
1	100	70	10	0	0	0
2	200	140	50	0	0	0
3	300	210	90	30	0	0
4	400	280	130	70	10	0
5	500	350	170	110	50	0
6	600	420	210	150	90	30
7	700	490	250	190	130	60
8	800	560	290	230	170	90
9	900	630	330	270	210	120
10	1000	700	370	310	250	150
11	1100	770	410	350	290	180
12	1200	840	450	390	330	210
13	1300	910	490	430	370	240
14	1400	980	530	470	410	270
15	1500	1050	570	510	450	300
16	1600	1120	610	550	490	330
17	1700	1190	650	590	530	360
18	1800	1260	690	630	570	390
19	1900	1330	730	670	610	420
20	2000	1400	770	710	650	450
21	2100	1470	810	750	690	480
22	2200	1540	850	790	730	510
23	2300	1610	890	830	770	540
24	2400	1680	930	870	810	570
25	2500	1750	970	910	850	600
26	2600	1820	1010	950	890	630

Source: *Pidie Irrigation Leaching Progress.XLS*

For the low water requirement group the minimum water that must pass through is 120mm (Site 4–1) and the highest amount is 220mm (Site 5–2).

As can be seen from the above table, to reclaim the 0–50cm depths the number of irrigations required would be 5 to 6 for a medium textured soil with the lowest demand and between 4 and 5 for a heavy textured soil. To achieve the same degree of leaching when the requirement is as at Site 5–2 (220mm) this would be achieved after 8 irrigations of the medium textured soil and after 6 or 7 irrigations of the heavier textured one. This number of leaching irrigation gifts is not excessive and could be considered worthwhile.

The medium depth requirement group requires between 260mm (Site 2–1) and 390mm (Site 1–1) and this amount of water would pass through the 50cm depth more or less after 7-8 and 10-11 irrigations respectively of the heavy textured soils at the sites. This number of irrigations might be considered worthwhile but the economics of using this amount of irrigation water and the time involved would need to be considered.

Table 6.4 Depths of water passing through the soil layers

Heavy Textured Soil (PSC H)

Heavy Irrigation No	Accumulative Water applied (mm)	Volumes Water entering soil (mm)	Accumulative Water Passing through layer			
			Layer 1 (0 – 25 cm)	**Layer 2** (25 – 50cm)	**Layer 3** (50 – 75cm)	**Layer 4 (75 – 100cm)**
1	100	70	20	0	0	0
2	200	140	65	15	0	0
3	300	210	110	60	10	0
4	400	280	155	105	55	5
5	500	350	200	150	100	50
6	600	420	245	195	145	95
7	700	490	290	240	190	140
8	800	560	335	285	235	185
9	900	630	380	330	280	230
10	1000	700	425	375	325	275
11	1100	770	470	420	370	320
12	1200	840	515	465	415	365
13	1300	910	560	510	460	410
14	1400	980	605	555	505	455
15	1500	1050	650	600	550	500
16	1600	1120	695	645	595	545
17	1700	1190	740	690	640	590
18	1800	1260	785	735	685	635
19	1900	1330	830	780	730	680
20	2000	1400	875	825	775	725
21	2100	1470	920	870	820	770
22	2200	1540	965	915	865	815
23	2300	1610	1010	960	910	860
24	2400	1680	1055	1005	955	905
25	2500	1750	1100	1050	1000	950

Source: *Pidie Irrigation Leaching Progress.XLS*

The most salinised sites (5–1 and 7 within the H textural group) which falls in the high water requirement group would require 18 irrigations. The medium textured soil (Site 3) would require about 25 irrigations to achieve reclamation. The amount of irrigation water involved here would probably NOT be justified and other uses of the land should be considered.

However, if the leachate merely goes into and adds to the water table reclamation is NOT possible; the leachate must leave the site and be discharged into a collector drain and eventually into the sea.

6.4 Recommendations for Soil Reclamation and Improvement

The volumes of water involved in the possible reclamation leaching of the sites in Pidie are summarised in Table 6.5. From the previous comments made and the economics of applying the various amounts of water, decisions can be reached as to whether any specific site should be reclaimed. The decisions that have to be made are:

- Should the site be reclaimed for agricultural use
- Should a change in land use, possibly to fish ponds or the likes, be considered
- Should the land just be abandoned and allowed to revert to some form of natural wetland with grasses etc

This subject is expanded more in the summary presented at the start of this report and some of the critical data to use are shown in table 6.5.

Table 6.5 Number of Estimated Irrigations for Reclamation

Kecamatan	Location	Site	Existing Salinity (dS/m) Dec 05	Soil depth to be recovered (mm)	Depth of water table (mm)	Soil Text Class	Depth leaching water required (mm)	No of "Gifts"	Depth of water to be applied (mm)
Meureudu	Meuraksa	6 – 1	1.0	600	750	H	208	6 – 7	650
Triang Gadeng	Raya	4 – 1	0.2	600	750	H	120	5 – 6	550
Triang Gadeng	Cot Leue Rheng	5 - 1	7.3	600	750	H	726	18 – 19	1850
Triang Gadeng	Cot Leue Rheng	5 - 2	2.2	600	750	H	220	6 – 7	650
Panteraja	Reudup	7 – 1	1.5	600	750	H	735	18	1800
Panteraja	Reudup	7 – 2	1.7	600	750	H	850	20 – 21	2050
Simpang Tiga	Seukee	1 – 1	3.9	600	750	H	393	10 – 11	1050
Simpang Tiga	Seukee	1 – 2	3.9	600	750	H	393	10 – 11	1050
Simpang Tiga	Seukee	2 – 1	2.6	600	750	H	261	7 – 8	750
Simpang Tiga	Tungoe	3 - 1	10.7	600	750	M	1070	25	2500

"Gifts" refer to irrigation gifts of 100mm each.

APPENDIX A CLIMATE

A.1 Introduction

For the ETESP, Agriculture Component Inception Report the only rainfall data available were those quoted in Table 4.1, which contained monthly data for the year 1999 plus long term totals. The data sets were not all complete for all months or for all Kabupaten and a few "gaps" existed.

Accordingly, to try and establish a more complete data set, until such time as full meteorological data sets can hopefully be obtained, the data were manipulated to give monthly rainfall data based on the long term "total" rainfall for each Kabupaten. The hope being that by using the long term data the information just might be more reliable – but this cannot be guaranteed.

Also, in the Inception Report it was stated that rainfall was greater on the west coast than on the east – this statement, though basically accurate, did not supply much useful information. Accordingly the available data was again manipulated to try and establish "rainfall" zones which might prove useful in planning rehabilitation processes.

A.2 Monthly and Annual Rainfall

The original 1999 data plus the "manipulated" data sets are shown as Table 1.

Table 1(a) Monthly Rainfall Data - 1999

Kabupaten Code	8	16	7	15	12	1	9	10	11	5
Kabupaten Name / **Month**	Aceh Besar	Aceh Jaya	Aceh Barat	Nagan Raya	Aceh Barat Daya	Simeulue	Pidie	Bireuen	Aceh Utara	Aceh Timur
	mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
Jan	72	242	242	384	216	40	195	195	330	246
Feb	139	180	94	159	313	75	327	97	91	387
March	114	240	299	299	254	55	126	122	85	497
April	78	140	215	286	138	65	163	123	38	170
May	74	87	307	221	280	121	85	130	-	166
June	34	61	33	33	155	70	57	69	7	129
July	51	155	147	147	206	107	30	76	-	211
Aug	92	314	314	291	185	186	123	70	-	270
Sept	107	202	202	202	488	110	333	99	-	287
Oct	41	416	416	416	210	141	140	171	-	285
Nov	83	273	273	273	98	135	98	204	-	-
Dec	173	268	268	279	231	139	129	224	-	396
Total 1999	1057	2578	2809	2990	2774	1244	1807	1541	1318	3044
Long Term Total	1668	2649	3149	3360	3303	1127	1889	1613	ND	2222

Source: *ETESP Inception report October 2005*

From Land Rehabilitation and Environment Sub-Section

Recent local advice is that the figure for Simeulue should be about 3,000 and not the above quoted 1127 or 1244mm.

Table 1(b) Monthly Rainfall Data Based on Long Term Data

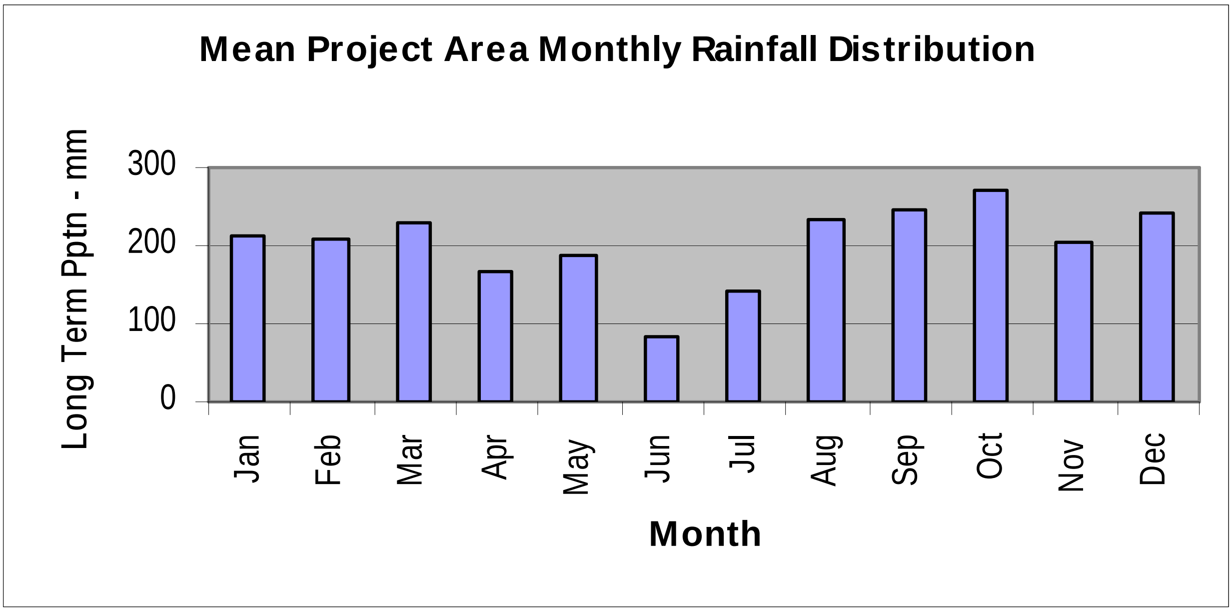
Code	8		16		7		15		12		1		9		10		11		5		Overall	
Name / Month	Aceh Besar	Monthly as % of annual	Aceh Jaya	Monthly as % of annual	Aceh Barat	Monthly as % of annual	Nagan Raya	Monthly as % of annual	Aceh Barat Daya	Monthly as % of annual	Simeulue	Monthly as % of annual	Pidie	Monthly as % of annual	Bireuen	Monthly as % of annual	Aceh Utara	Monthly as % of annual	Aceh Timur	Monthly as % of annual	Monthly as % of annual	Overall monthly average long
	mm	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*%*	*mm*
Jan	114	7	249	9	271	9	432	13	257	8	96	3	204	11	199	12	123	9	180	8	10	212
Feb	219	13	185	7	105	3	179	5	373	11	181	6	342	18	99	6	126	9	282	13	9	209
Mar	180	11	247	9	335	11	336	10	302	9	133	4	132	7	125	8	129	9	363	16	9	228
Apr	123	7	144	5	241	8	321	10	164	5	157	5	170	9	126	8	96	7	124	6	7	167
May	117	7	89	3	344	11	248	7	333	10	292	10	89	5	133	8	101	7	121	5	7	187
Jun	54	3	63	2	37	1	37	1	185	6	169	6	60	3	70	4	55	4	94	4	3	82
Jul	80	5	159	6	165	5	165	5	245	7	258	9	31	2	78	5	76	6	154	7	6	141
Aug	145	9	323	12	352	11	327	10	220	7	449	15	129	7	71	4	127	9	197	9	9	234
Sep	169	10	208	8	226	7	227	7	581	18	265	9	348	18	101	6	140	10	209	9	10	248
Oct	65	4	427	16	466	15	467	14	250	8	340	11	146	8	175	11	145	11	208	9	11	269
Nov	131	8	281	11	306	10	307	9	117	4	326	11	103	5	208	13	107	8	146	7	8	203
Dec	273	16	275	10	300	10	314	9	275	8	335	11	135	7	229	14	141	10	143	6	11	242
Total - LT	1668		2649		3149		3360		3303		3000		1889		1613		1365		2222		Avrg	2422
Check	1668		2649		3149		3360		3303		3000		1889		1613		1365		2222		Avrg	2422

Source: Developed by manipulating data of 1999 rainfall to get % of 1999 per month then applying percentages to Long Term Total Rainfall

Total for Bireuen changed from 1100+ to 3000mm on local advice

The full spreadsheet showing the percentages per month etc is shown as Appendix 1 and rainfall distributions graphs (block diagrams) are shown in Appendix B. The overall rainfall distribution for the project area, for which data are held, is shown in Figure 1.

Figure 1 Rainfall Distribution – monthly, average for project area



A.3 Rainfall Zones

For planning soil reclamation and, later, agricultural inputs, it is very helpful – perhaps necessary – to have as much climatic data, including isohyets mapping information as possible. No such information was immediately available hence the existing rainfall data has been manipulated with the following outputs.

- A table showing rainfall zones
- A diagram showing rainfall in the various Kabupaten, and
- A simple map showing the location of these zones

Table 2 Rainfall Zones based on Long Term Precipitation

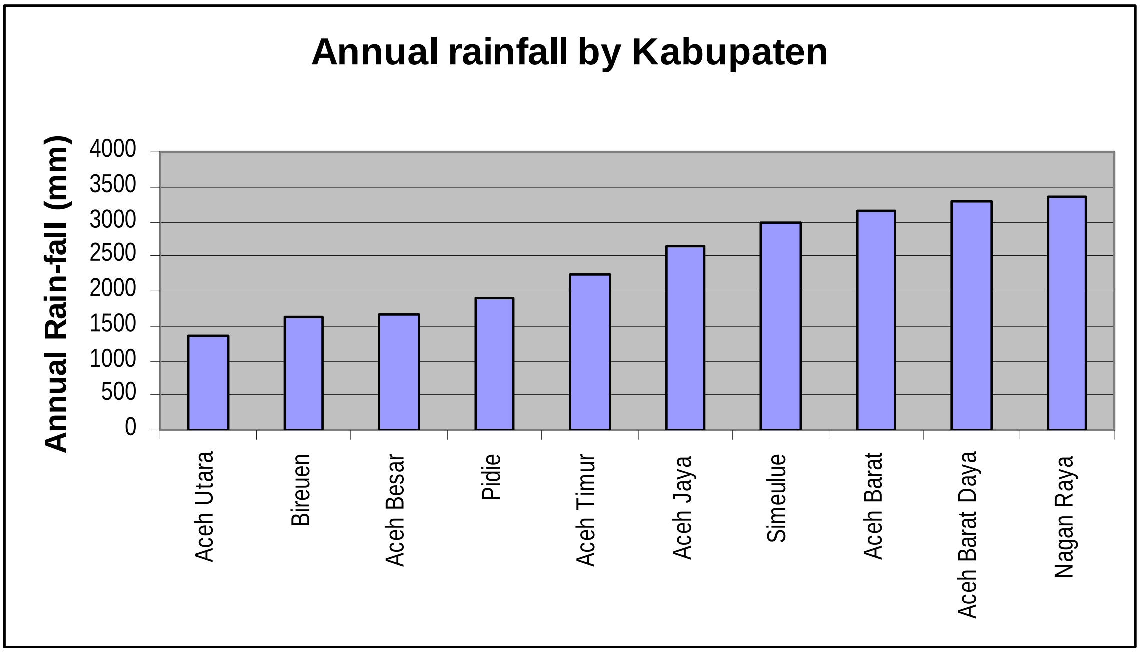
District No	Name	Location	Annual long term Pptn (mm)	Pptn in 1999	1999 as % of average
11	Aceh Utara	N	1365	1318	97
		Average	**1365**	**1318**	**97**
10	Bireuen	N	1613	1541	96
8	Aceh Besar	N	1668	1057	63
9	Pidie	N	1889	1807	96
		Average	**1723**	**1468**	**85**
5	Aceh Timur	E	2222	3044	137
16	Aceh Jaya	W	2649	2578	97
		Average	**2436**	**2811**	**117**
1	Simeulue	W	3000	ND	ND
7	Aceh Barat	W	3149	2809	89
12	Aceh Barat Daya	W	3303	2774	84
15	Nagan Raya	W	3360	2990	89
		Average	**3203**	**2858**	**87**

It can be seen in Table 2 that groupings based on latitude and or geographical position do show variations with:

- The lowest rainfall, less than 1500mm, in Aceh Utara which is at the eastern end of the N coast
- Average of around 1700mm found along the N coast
- Average of around 2400mm in the band with Aceh Jaya in the W and Aceh Timur in the E and at about the same latitude
- The lower west coast, including the island of Simeulue, having the highest – overall average of over 3200mm

With slightly more data and knowledge of actual rainfall stations it would be possible to draw crude isohyets; this has not been attempted by ETESP.

Figure 2 Long Term Precipitation by District (Kabupaten)



It appears that rainfall decreases as one comes north and the pattern appear to be governed by latitude (how far north) and not location on the north or west coast. What has, in most previous reports, been referred to as the east coast is, in fact, largely a north coast! Only Aceh Timur should really be considered as lying on the east coast.

Figure 3 Districts (Kabupaten) in the Study and Long Term Precipitation

The original data as manipulated and used for the ETESP inception report has been found to be incorrect for Simeulue; long term annual rainfall was given as just over 1,000mm per annum when it should be about 3,000mm – this information being supplied by local Dinas staff from the area.

However, the lower figure should not be totally cast aside as it is possible that the data came from a rainfall station that is in a rain shadow – but for planning purposes the higher, 3000mm, figure should be used.

A.4 Use of Rainfall Data

The monthly rainfall data have already been built into one of the main "reclamation" tools which is an MS Excel spreadsheet (Leaching Water Requirements.XLS) for calculating the depth (mm) and volume (cubic metres per hectare) required to leach soils of various textural class with salinised horizons of various depths.

ANNEX A.1 Original Data Manipulation Spreadsheet

Kabupaten Monthly Precipitation from Long Term Annual Rainfall

Code	8		16		7		15		12		1		9		10		11		5		Overall	
Name / Month	Aceh Besar	Monthly as % of annual	Aceh Jaya	Monthly as % of annual	Aceh Barat	Monthly as % of annual	Nagan Raya	Monthly as % of annual	Aceh Barat Daya	Monthly as % of annual	Simeulue	Monthly as % of annual	Pidie	Monthly as % of annual	Bireuen	Monthly as % of annual	Aceh Utara	Monthly as % of annual	Aceh Timur	Monthly as % of annual	Monthly as % of annual	Overall monthly average lor
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	%	mm
Jan	114	7	249	9	271	9	432	13	257	8	36	3	204	11	199	12	123	9	180	8	10	206
Feb	219	13	185	7	105	3	179	5	373	11	68	6	342	18	99	6	126	9	282	13	9	198
Mar	180	11	247	9	335	11	336	10	302	9	50	4	132	7	125	8	129	9	363	16	9	220
Apr	123	7	144	5	241	8	321	10	164	5	59	5	170	9	126	8	96	7	124	6	7	157
May	117	7	89	3	344	11	248	7	333	10	110	10	89	5	133	8	101	7	121	5	7	169
Jun	54	3	63	2	37	1	37	1	185	6	63	6	60	3	70	4	55	4	94	4	3	72
Jul	80	5	159	6	165	5	165	5	245	7	97	9	31	2	78	5	76	6	154	7	6	125
Aug	145	9	323	12	352	11	327	10	220	7	169	15	129	7	71	4	127	9	197	9	9	206
Sep	169	10	208	8	226	7	227	7	581	18	100	9	348	18	101	6	140	10	209	9	10	231
Oct	65	4	427	16	466	15	467	14	250	8	128	11	146	8	175	11	145	11	208	9	11	248
Nov	131	8	281	11	306	10	307	9	117	4	122	11	103	5	208	13	107	8	146	7	8	183
Dec	273	16	275	10	300	10	314	9	275	8	126	11	135	7	229	14	141	10	143	6	11	221
Total - LT	1668		2649		3149		3360		3303		1127		1889		1613		1365		2222		Avrg	2235
Check	1668		2649		3149		3360		3303		1127		1889		1613		1365		2222		Avrg	2235

LT = Long Term data source

This sheet shows Simeulue as having an annual rainfall of about 1130mm

The above is extracted from the MS Excel spreadsheet Kabupaten Precipitation.XLS and can be supplied on request.

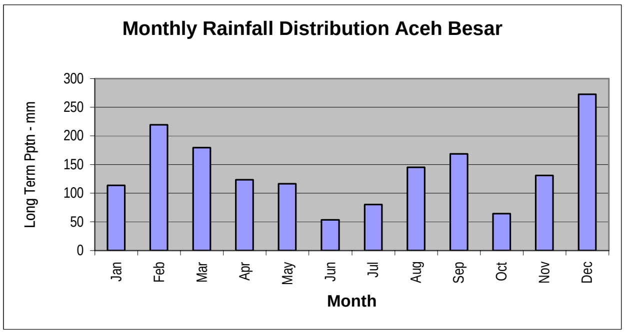
ANNEX A.2 Updated Data Manipulation Spreadsheet

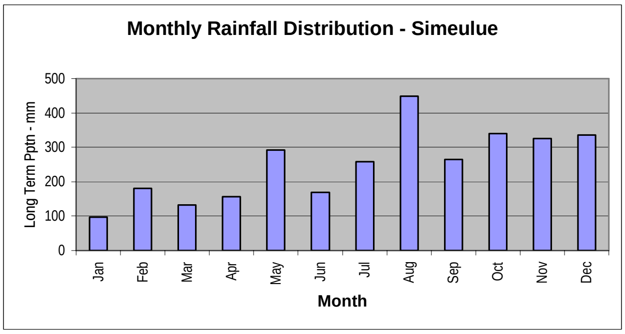
Code	8		16		7		15		12		1		9		10		11		5		Overall	
Name / Month	Aceh Besar	Monthly as % of annual	Aceh Jaya	Monthly as % of annual	Aceh Barat	Monthly as % of annual	Nagan Raya	Monthly as % of annual	Aceh Barat Daya	Monthly as % of annual	Simeulue	Monthly as % of annual	Pidie	Monthly as % of annual	Bireuen	Monthly as % of annual	Aceh Utara	Monthly as % of annual	Aceh Timur	Monthly as % of annual	Monthly as % of annual	Overall monthly average long
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	%	mm
Jan	114	7	249	9	271	9	432	13	257	8	96	3	204	11	199	12	123	9	180	8	10	212
Feb	219	13	185	7	105	3	179	5	373	11	181	6	342	18	99	6	126	9	282	13	9	209
Mar	180	11	247	9	335	11	336	10	302	9	133	4	132	7	125	8	129	9	363	16	9	228
Apr	123	7	144	5	241	8	321	10	164	5	157	5	170	9	126	8	96	7	124	6	7	167
May	117	7	89	3	344	11	248	7	333	10	292	10	89	5	133	8	101	7	121	5	7	187
Jun	54	3	63	2	37	1	37	1	185	6	169	6	60	3	70	4	55	4	94	4	3	82
Jul	80	5	159	6	165	5	165	5	245	7	258	9	31	2	78	5	76	6	154	7	6	141
Aug	145	9	323	12	352	11	327	10	220	7	449	15	129	7	71	4	127	9	197	9	9	234
Sep	169	10	208	8	226	7	227	7	581	18	265	9	348	18	101	6	140	10	209	9	10	248
Oct	65	4	427	16	466	15	467	14	250	8	340	11	146	8	175	11	145	11	208	9	11	269
Nov	131	8	281	11	306	10	307	9	117	4	326	11	103	5	208	13	107	8	146	7	8	203
Dec	273	16	275	10	300	10	314	9	275	8	335	11	135	7	229	14	141	10	143	6	11	242
Total - LT	1668		2649		3149		3360		3303		3000		1889		1613		1365		2222		Avrg	2422
Check	1668		2649		3149		3360		3303		3000		1889		1613		1365		2222		Avrg	2422

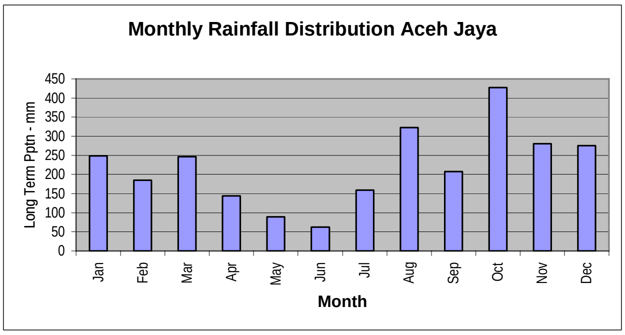
Original figure suspect and replaced with 3,000mm on local advice

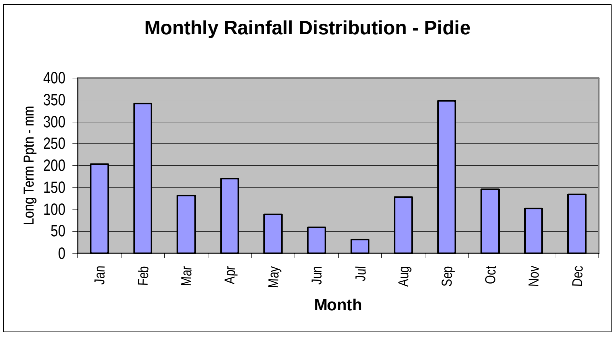
LT = Long Term data source

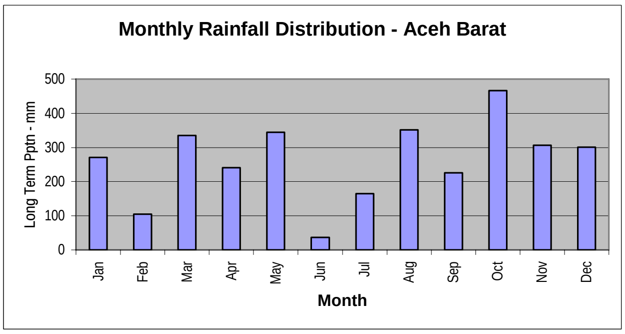
ANNEX A.3 RAINFALL DISTRIBUTION DIAGRAMS

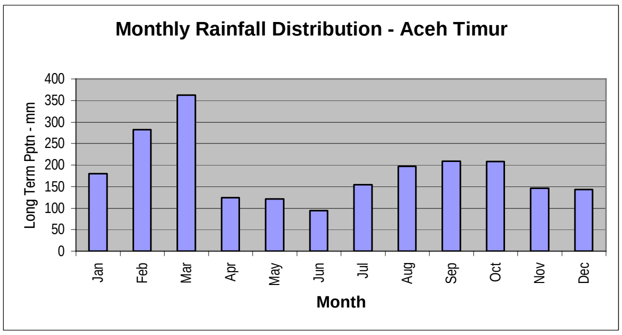


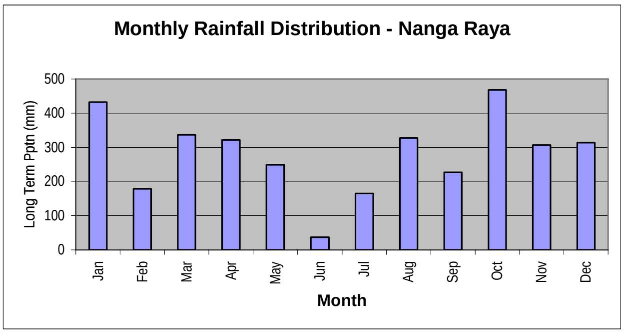


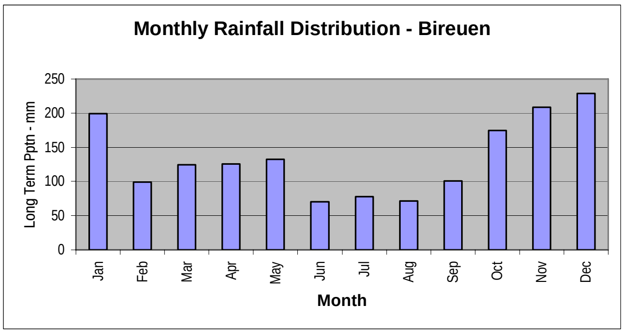


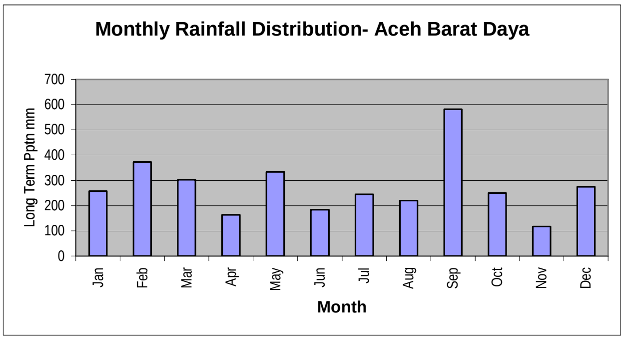


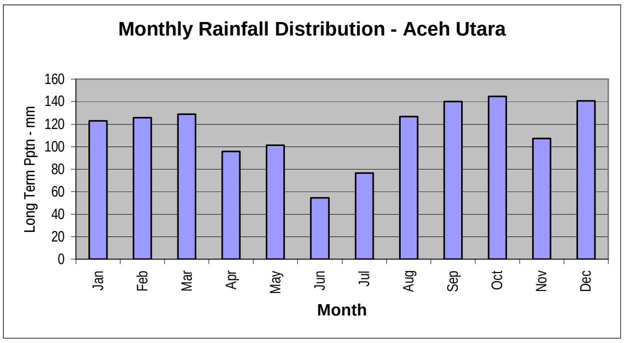












APPENDIX B DATA MANIPULATION

B.1 Introduction

There is no presentation of the theory and practices of soil reclamation given in this document. If such material is required the reader is referred to ETESP, Agricultural Component, Desalinisation and Improvement, Mobilisation Report of October 2005.

B.2 Data Availability

Data was not abundantly or obviously available but BPTP were extremely generous is rapidly supply ETESP with the dataset that they did hold. Similarly, Dr A. Rachman offered to pass on data recently collected in new surveys on the west coast as soon as the data has been compiled and collated. Both these actions have been / are greatly appreciated by ETESP.

B.3 Data Format

The BPTP data was contained in two digital files – one on MS Word and the actual EM38 measurements in MS Excel, making data transfer, manipulation and study straightforward.

The soil reclamation and improvement specialist built the data supplied into a larger, more sophisticated Excel spreadsheet titled "*EM38.XLS*" and finally extracted averages etc into a final spreadsheet ECe from "EM387.XLS"

Traditional laboratory data were supplied by BPTP as hardcopy and these data were transferred to the Excel spreadsheet "*lab data.XLS*".

B.4 Data Manipulation

All data manipulation has been done in the above spreadsheets and each spreadsheet has an "Introduction" page indicating what it does, how it works or what data inputs are required.

When data are entered into the indicated section the manipulation, for example ratings and ratios, are processed automatically.

B.4.1 Correlation of EM38 with soil ECe

Raw data for salinity surveys were made available to ETESP by BPTP and the consultant had to try and calculate a correlation between the EP38 values from the survey (EMv and EMh in mS/cm) and soil salinity or ECe in dS/m.

Rachman (personal communication) advised that a rough and ready correlation that could be tried or utilized and this is as shown below:

Table B.1 Approximate Correlation between EM 38probe and ECe

EM38 Readings in mS/cm	Salinity Class	Approximate ECe (dS/m) Values
0 - 100	SC1	2
100 - 150	SC1	2 – 4
150 - 200	SC2	4 – 6
>200	SC2 – SC3	>6

Accordingly, a spreadsheet was compiled to automatically allocate an approximate ECe value to each separate EMh, EMv and EM average reading as supplied by BPTP in their data set.

In addition, the original conversions proposed by Rhoades (1989) were applied in the same spreadsheet.

B.4.2 Rhoades Conversion / Calibration Equations

The proceedings of the EM38 workshop held in India in February 2000 were supplied by the National Soil Resources Institute (NSRI), Silsoe College, UK in answer to a request for help with this problem. The equations are rather complicated and which equation to use depends on whether EMh (Horizontal) or EMv (Vertical) is larger for each specific measurement. The spreadsheet has all the necessary checks built into it to automatically guide the user to apply the correct equation and the details are not gone into here. The introductory page to the spreadsheet (ECe from EM38.XLS) offers sufficient explanation for a relatively computer literate operator to arrive at acceptable decisions and obtain the required ECe data.

On testing the two methods it was found that most readings were relatively close irrespective of which method was applied – some minor adjustments were made to the "look-up" tables used in the spreadsheet and, based on the EMh and EMv reading, ECe values falling in the same salinity class are arrived at by either method. It was then felt that the correlation or calibration was sufficiently accurate to allow further data manipulation to proceed and that the data could be used in the "reclamation" tools referred to in Appendix. These manipulation procedures were further supported when a traditional laboratory measurement of ECe of one of the EM38 sites was compared and the results were close enough to be acceptable.

Table B.2 Comparison of ECe Determination

Banda Aceh - Averages				Rhoades				Lookup			New Data	
				ECe	ECe	ECe	ECe	ECe	ECe	ECe	ECe pre	ECe post
	mS/cm	mS/cm	mS/cm	0 - 30cm	30 -60cm	60 -90cm	0 - 90cm	EMv	EMh	EMav	Tsunami	Tsunami
Location	EMv	EMh	Avg	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m
Kantor BPTP	95	113	104	4.49	0.20	3.57	2.75	2.3	2.7	2.5	0.79	3.8

Table A.2.2 compares the various determinations of ECe for the site at the BPTP office in Banda Aceh and it can be seen that all the determinations fall between 2.3 – 4.49 dS/m and these readings are all in Salinity Class 1. In fact the average of the "determined" vales is 3.1 dS/m whilst the laboratory determined value is 3.8 dS/m.

The actual Rhoades equations calculate what is called ECa which is the bulk EC of the layer in question. In each case the layers used are 30cm thick. The equations are used are as follows:

When EMh > EMv

Depth range (cm)	Equation
0 – 30	ECa = 1.690(EMh) – 0.591 EMv
30 – 60	ECa = 0.554EMh – 0.595EMv
60 – 90	ECa = -0.126EMh + 1.283EMv – 0.097

When EMv>EMh

Depth range (cm)	Equation
0 – 30	ECa = 3.023EMh – 1.982EMv
30 – 60	ECa = 2.585EMh – 1.213EMv -0.204
60 – 90	ECa = 0.958EMh – 0.323EMv – 0.142

APPENDIX C Data

The outputs from the manipulated data are presented in separate sections for each of the three Kecamatan as:

- Overall averages (Table C.2)
- Average data values (Table C3)
- Maximum data values, and (Table C.4)
- Minimum data values (Table C.5)

These values are also coded to highlight the size of the problem that exists, or existed, when the surveys were conducted. In fact the salinity data may well not present the situation now as some natural leaching from the rainfall will have occurred.

The size of the problem also presented by the sediments is also coded.

The coding used in all of the data forms is as shown below as Figure C.1

Figure C.1 Problem Rating or Ranking

ECe	PROBLEM	Sediment
dS/m	RANKING	cm
0 - 1.9	None	0 - 0.9
2 - 3.9	Neglibible	1 - 1.9
4 - 5.9	Very Slight	2 - 4.9
6 - 7.9	Slight	5 - 9.9
8 - 11.9	Moderate	10 - 14.9
12 - 15.9	Moderately Big	15 - 19.9
16 - 23 9	Big	20 - 29.9
>24	Very Big	>30

Figure C.2 Overall Averages for Kabupaten Aceh Besar

						Rhoades	ETESP Lookup			Salinity Class	
						ECe	ECe	ECe	ECe		
	Samples	Sediment	Flood			0 - 90cm	EMv	EMh	EMav	Rhoades	ETESP
Kecamatan	No	Cm	Days	Status	Check	dS/m	dS/m	dS/m	dS/m		
Lkonga	37	10	5	Leached	Reading OK	2.3	1.9	1.9	1.9	SC1	SC1
Darussalam	20	3	3	Saline topsoil	Reading OK	2.3	1.4	2.3	1.8	SC1	SC1
Baitissalam	35	27	30	Saline topsoil	Reading OK	3.3	2.6	2.9	2.8	SC1	SC1
Kabupaten Means	**92**	**13**	**13**			**2.6**	**2.0**	**2.4**	**2.2**	**SC1**	**SC1**

Table C.3 Average Values of Manipulated Data

Aceh Besar Kabupaten

Aceh Besar Averages

Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check	Rhoades ECe 0 - 90cm dS/m	ETESP Lookup ECe EMv dS/m	ECe EMh dS/m	ECe EMav dS/m	Salinity Class Rhoades	ETESP
Aceh Besar	Lhoknga	Nusa	15 - 1	77	75	76	11	10	5	Leached	Reading OK	2.5	1.8	1.8	1.8	SC1	SC1
			15 - 2	84	78	81	19	10	5	Leached	Reading OK	2.4	2.0	1.9	1.9	SC1	SC1
			15 - 3	78	86	82	7	10	5	Saline topsoil	Reading OK	2.1	1.9	2.0	1.9	SC1	SC1
		Location average		80	80	80	37	10	5	Leached	Reading OK	2.3	1.9	1.9	1.9	SC1	SC1
Aceh Besar	Darussalam	Miruk Taman	16 - 1	62	97	80	10	3	3	Saline topsoil	Reading OK	2.4	1.4	2.3	1.9	SC1	SC1
			16 - 2	60	93	76	10	3		Saline topsoil	Reading OK	2.3	1.4	2.2	1.8	SC1	SC1
		Location average		61	95	78	20	3	3	Saline topsoil	Reading OK	2.3	1.4	2.3	1.8	SC1	SC1
Aceh Besar	Baitissalam	Suleue	17 - 1	83	87	85	16	20	30	Saline topsoil	Reading OK	2.1	2.0	2.1	2.0	SC1	SC1
		Location average		83	87	85	16	20	30	Saline topsoil	Reading OK	2.1	2.0	2.1	2.0	SC1	SC1
Aceh Besar	Baitissalam	Blang Kreung	18 - 1	154	149	151	12	30	30	Leached	Reading OK	4.8	3.8	3.7	3.8	SC2	SC1
		Location average		154	149	151	12	30	30	Leached	Reading OK	4.8	3.8	3.7	3.8	SC2	SC1
Aceh Besar	Baitissalam	Lampeudaya	19 - 1	86	122	104	7	30	30	Saline topsoil	Reading OK	3.0	2.0	3.0	2.5	SC1	SC1
		Location average		86	122	104	7	30	30	Saline topsoil	Reading OK	3.0	2.0	3.0	2.5	SC1	SC1

Table C.4 Maximum Values of Manipulated Data

Aceh Besar Maximum Values

Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check	Rhoades ECe 0 - 90cm dS/m	ETESP Lookup ECe EMv dS/m	ETESP Lookup ECe EMh dS/m	ETESP Lookup ECe EMav dS/m	Salinity Class Rhoades	Salinity Class ETESP
Aceh Besar	Lhoknga	Nusa	15 - 1	102	90	96	11	10	5	Leached	Reading OK	2.6	2.5	2.2	2.3	SC1	SC1
			15 - 2	101	90	92	19	10	5	Leached	Reading OK	2.6	2.4	2.2	2.2	SC1	SC1
			15 - 3	91	114	97	7	10	5	Leached	Reading OK	2.8	2.2	2.8	2.3	SC1	SC1
		Location average		98	98	95	12	10	5	Leached	Reading OK	2.7	2.4	2.4	2.3	SC1	SC1
Aceh Besar	Darussalam	Miruk Taman	16 - 1	73	116	88	10	3	3	Saline topsoil	Reading OK	2.8	1.7	2.8	2.1	SC1	SC1
			16 - 2	72	108	85	9	3	3	Saline topsoil	Reading OK	2.6	1.7	2.6	2.0	SC1	SC1
		Location average		73	112	86	10	3	3	Saline Topsoil	Reading OK	2.7	1.7	2.7	2.1	SC1	SC1
Aceh Besar	Baitissalam	Suleue	17 - 1	96	119	103	16	20	30	Saline topsoil	Reading OK	2.9	2.3	2.9	2.5	SC1	SC1
		Location average		96	119	103	16	20	30	Saline topsoil	Reading OK	2.9	2.3	2.9	2.5	SC1	SC1
Aceh Besar	Baitissalam	Blang Kreung	18 - 1	175	182	170	12	30	30	Leached	Reading OK	6.8	4.4	4.6	4.3	SC2	SC2
		Location average		175	182	170	12	30	30	Leached	Reading OK	6.8	4.4	4.6	4.3	SC2	SC2
Aceh Besar	Baitissalam	Lampeudaya	19 - 1	110	137	117	7	30	30	Saline topsoil	Reading OK	4.8	2.7	3.4	2.8	SC2	SC1
		Location average		110	137	117	7	30	30	Saline topsoil	Reading OK	4.8	2.7	3.4	2.8	SC2	SC1

Table C.5 Minimum Values of Manipulated Data

Aceh Besar Minimum Values

Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check	Rhoades ECe 0 - 90cm dS/m	ETESP Lookup ECe EMv dS/m	ETESP Lookup ECe EMh dS/m	ETESP Lookup ECe EMav dS/m	Salinity Class Rhoades	Salinity Class ETESP
Aceh Besar	Lhoknga	Nusa	15 - 1	54	58	56	11	10	5	Saline topsoil	Reading OK	1.4	1.2	1.3	1.3	SC1	SC1
			15 - 2	66	57	62	19	10	5	Leached	Reading OK	1.6	1.6	1.3	1.4	SC1	SC1
			15 - 3	66	60	63	7	10	5	Leached	Reading OK	1.8	1.6	1.4	1.5	SC1	SC1
		Location average		62	58	60	37	10	5	Leached	Reading OK	1.6	1.4	1.4	1.4	SC1	SC1
Aceh Besar	Darussalam	Miruk Taman	16 - 1	46	74	60	10	3	3	Saline topsoil	Reading OK	1.8	1.0	1.8	1.4	SC1	SC1
			16 - 2	44	77	71	9	3	3	Saline topsoil	Reading OK	1.9	1.0	1.8	1.7	SC1	SC1
		Location average		45	76	66	19	3	3	Saline topsoil	Reading OK	1.8	1.0	1.8	1.5	SC1	SC1
Aceh Besar	Baitissalam	Suleue	17 - 1	66	72	71	16	20	30	Saline topsoil	Reading OK	1.8	1.6	1.7	1.7	SC1	SC1
		Location average		66	72	71	16	20	30	Saline topsoil	Reading OK	1.8	1.6	1.7	1.7	SC1	SC1
Aceh Besar	Baitissalam	Blang Kreung	18 - 1	125	128	136	12	30	30	Leached	Reading OK	3.1	3.1	3.2	3.4	SC1	SC1
		Location average		125	128	136	16	30	30	Leached	Reading OK	3.1	3.1	3.2	3.4	SC1	SC1
Aceh Besar	Baitissalam	Lampeudaya	19 - 1	56	108	92	7	30	30	Saline topsoil	Reading OK	2.6	1.3	2.6	2.2	SC1	SC1
		Location average		56	108	92	16	30	30	Saline topsoil	Reading OK	2.6	1.3	2.6	2.2	SC1	SC1

APPENDIX E REFERENCES

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