

Earthquake & Tsunami Emergency Support Project

ETESP

Bireuen Kabupaten

- [Samalanga](#)
- [Jeunieb](#)
- [Jeumpa](#)
- [Jangka](#)
- [Ganda Pura](#)



Data Assessment & Soil Reclamation
(December 2005)
(With map updates of April 2006)

CONTENTS

SUMMARY	6
S.1 Locations	6
Table S.1 Coordinates of Locations.....	6
Figure S.1 Locations.....	6
S.2 Site Features	6
Table S.2 Basic Features of the Sites.....	6
S.3 Soil Salinity and Reclamation	6
Table S.3 Salinity of the Soils	7
Table S.4 Number of Estimated Irrigations for Reclamation	7
Scenario 1 Sloping land with no irrigation or drainage.....	9
Cross Section of typical location	9
Surface Irrigation Perpetuating Salinity.....	9
Overhead Irrigation Giving Desalinisation.....	9
Scenario 2 Level, low lying close to the coast and still flooded with drainage.....	10
Typical site previously used for padi	10
Existing badly silted-up channel.....	10
Drainage entering main channel	10
Scenario 3 Rain fed area with no active drainage though drainage installed	11
Raised bund above the soil drain	11
Badly damaged and blocked drain.....	11
Scenario 4 Lower slopes of irrigation schemes, close to fish ponds	12
Cross section from village on high ground to fish ponds and the sea	12
Drainage Ditch / Collector Drain.....	12
Salinisation of low lying site from the sea and irrigation	12
Scenario 5 Flat to very gently sloping wetland-rice areas with irrigation.....	13
Cross section from village on high ground down-slope through padi area.....	13
New field and existing collector drains	13
Field Drain.....	13
Drainage Ditch / Collector Drain.....	13
CHAPTER 1 INTRODUCTION	15
1.1 Introduction	15
Figure 1.1 NAD Kabupaten.....	15
1.2 Kecamatan	15
Figure 1.2 Kabupaten Bireuen and Kecamatan	15
1.3 Background.....	15
1.4 Sites or Locations	16
Table 1.1 Kecamatan Reported for Bireuen	16
Table 1.2 Geographic Coordinates of Sites	16
Figure 1.3 Rainfall Distribution in Bireuen	16
1.5 Climate	17
1.5.1 Rainfall in Bireuen.....	17
1.5.2 Use of Rainfall Data	17
Table 1.3 Rainfall Distribution in Bireuen	17
Table 1.4 Recent Site Data	17
CHAPTER 2 SAMALANGA.....	18
2.1 Introduction	18
Figure 2.1 Kabupaten Bireuen	18
2.2 Salinity Survey	18
Figure 2.2 Site Location	18

Table 2.1 Geographic Coordinates of Sites	18
Table 2.2 Transect Information	18
2.3 Site Description	18
2.4 Site Information from the EM38 Survey and ETESP	19
Table 2.3 Land Preparation Post-tsunami	19
No significant information could be gleaned from the field notes made during the EM38 survey.	19
Table 2.4 Soil and Site features December 2005	19
2.5 Problems	19
2.6 Soil Salinity	19
Figure 2.3 ETESP Problem Rating Key	19
Table 2.5 Assessment of the EM38 Dataset for the Site	19
Table 2.6 Salinity Measurements for the Samalanga Site	20
2.7 Sediment Depth	20
2.8 Conclusions & Recommendations	20
Table 2.7 Comparison of Salinities from EM38 Survey and December 2005	20
CHAPTER 3 JEUNIEB	21
3.1 Introduction	21
Figure 3.1 Kabupaten Bireuen	21
3.2 Salinity Survey	21
Figure 3.2 Site Location	21
Table 3.1 Geographic Coordinates of the Site	21
Table 3.2 Transect Information	21
3.3 Site Description	21
Figure 3.3 Cross Section of Site	22
3.4 Site Information from the Em38 Survey and ETESP	22
Table 3.3 Land Preparation Post-tsunami	22
Table 3.4 Soil and Site` Features December 2005	22
3.5 Problems	22
3.6 Soil Salinity	22
Figure 3.4 ETESP Problem Rating Key	23
Table 3.5 Assessment of the EM38 Dataset for the Jeunieb Site	23
Table 3.6 Salinity Measurements for the Jeunieb Site	23
3.7 Sediment Depth	23
3.8 Conclusions & Recommendations	24
Table 3.7 Comparison of Salinities from EM38 Survey and December 2005	24
CHAPTER 4 JEUMPA	25
4.1 Introduction	25
Figure 4.1 Kabupaten Bireuen	25
Figure 4.2 Location	25
4.2 Salinity Survey	25
Table 4.1 Geographic Coordinates of Sites	25
Table 4.2 Transect Information	25
4.3 Site Descriptions	26
Figure 4.3 Cross Section of Typical Situation for Sites 8, 9 and 10	26
Figure 4.3 Down-slope Section of Typical Situation for Sites 8, 9 and 10	26
Figure 4.4 Village and Dry-land Area Site 9	26
Figure 4.5 Towards the Sea and beach Ridge	26
Figure 4.6 Dead Tomatoes	27
Figure 4.6 Dead Tomatoes with Dry-land behind	27
4.4 Site Information from the EM38 Survey and ETESP	27
Table 4.3 Land Preparation Post-tsunami	27
Table 4.4 Soil and Site` Features December 2005	27
4.5 Problems	28
4.6 Soil Salinity	28
Figure 4.7 ETESP Problem Rating Key	28
Table 4.5 Assessment of the EM38 Dataset for the Jeumpa Sites	28
Table 4.6 Salinity Measurements for the Jeumpa Sites	29
4.7 Sediment Depth	29

4.8 Conclusions & Recommendations	29
Table 4.7 Comparison of Salinities from EM38 Survey and December 2005	29
CHAPTER 5 JANGKA	31
5.1 Introduction	31
Figure 5.1 Kabupaten Bireuen	31
Figure 5.2 Location	31
Table 5.1 Geographic Coordinates of Sites	31
Table 5.2 Transect Information	31
5.3 Site Descriptions	31
Figure 5.3 Road Dam Site 12-1	32
Figure 5.4 Road + Site and Fishpond	32
5.4 Site Information from the EM38 Survey and ETESP	32
Table 5.3 Land Preparation Post-tsunami EM38 Survey Data	32
Table 5.4 Soil and Site Features December 2005	33
5.5 Problems	33
5.6 Soil Salinity	33
Figure 5.5 ETESP Problem Rating Key	33
Table 5.5 Assessment of the EM38 Dataset for the Sites in Jangka	33
Table 5.6 Salinity Measurements for Sites in Jangka	34
5.7 Sediment Depth	34
5.8 Conclusions & Recommendations	34
Table 5.7 Comparison of Salinities from EM38 Survey and December 2005	34
CHAPTER 6 GANDA PURA	35
6.1 Introduction	35
Figure 6.1 Kabupaten Bireuen	35
Figure 6.1 Location	35
6.2 Salinity Survey	35
Table 6.1 Geographic Coordinates of Sites	35
Table 6.2 Transect Information	35
6.3 Site Descriptions	35
Figure 6.3 Idealised Cross Section for Site 11	36
Figure 6.3 Down-slope Section for Site 11-2	36
6.4 Site Information from the EM38 Survey and ETESP	36
Table 6.4 Land Preparation Post-tsunami EM38 Survey data	36
Figure 6.5 Irrigation Supply at Top of 11-2	37
Figure 6.6 Down valley over Site 11-2	37
6.5 Problems	37
6.6 Soil Salinity	37
Figure 6.7 ETESP Problem Rating Key	37
Table 6.5 Assessment of the EM38 Dataset for the Ganda Pura Sites	37
Table 6.6 Salinity Measurements for Sites in Ganda Pura	38
6.8 Sediment Depth	38
6.9 Conclusions & Recommendations	38
Table 6.7 Comparison of Salinities from EM38 Survey and December 2005	39
CHAPTER 7 SOIL RECLAMATION and IMPROVEMENT	40
7.1 Introduction	40
Table 7.1 Features of the Sites	40
7.2 Water Requirements for Salinity Reduction	41
Table 7.2 Water required for reclamation	41
Maximum soil depths that can be reclaimed	41
Depths of leaching water required:	42
(a) The Medium Textured or “M” PSC Soil	42
(b) The Fine Textured or “H” PSC Group	42
7.3 Leaching Progress	42
Table 7.3 Depths of water passing through the soil layers – medium texture	42

Table 7.4 Depths of water passing through the soil layers – fine texture	43
7.4 Recommendations for Soil Reclamation and Improvement	43
Table 7.4 Number of Estimated Irrigations for Reclamation.....	43
APPENDIX A CLIMATE.....	44
A.1 Introduction.....	44
A.2 Monthly and Annual Rainfall	44
Table 1(a) Monthly Rainfall Data - 1999	44
Table 1(b) Monthly Rainfall Data Based on Long Term Data	45
Figure 1 Rainfall Distribution – monthly, average for project area	45
A.3 Rainfall Zones.....	46
Table 2 Rainfall Zones based on Long Term Precipitation	46
Figure 2 Long Term Precipitation by District (Kabupaten).....	46
Figure 3 Districts (Kabupaten) in the Study and Long Term Precipitation	47
A.4 Use of Rainfall Data	47
ANNEX A.1 Original Data Manipulation Spreadsheet	48
ANNEX A.2 Updated Data Manipulation Spreadsheet.....	48
ANNEX A.3 RAINFALL DISTRIBUTION DIAGRAMS.....	49
APPENDIX B DATA MANIPULATION	50
B.1 Introduction.....	50
B.2 Data Availability	50
B.3 Data Format	50
B.4 Data Manipulation	50
B.4.1 Correlation of EM38 with soil ECe.....	50
Table B.1 Approximate Correlation between EM 38probe and ECe.....	50
B.4.2 Rhoades Conversion / Calibration Equations.....	50
Table B.2 Comparison of ECe Determination	51
When EMh > EMv.....	51
When EMv>EMh	51
APPENDIX C Data	52
Figure C.1 Problem Rating or Ranking	52
Figure C.2 Overall Averages for Kabupaten Aceh Besar	52
Table C.3 Average Values of Manipulated Data	53
Table C.4 Maximum Values of Manipulated Data	54
Table C.5 Minimum Values of Manipulated Data.....	55
APPENDIX D REFERENCES.....	56

SUMMARY

S.1 Locations

Within Kabupaten Bireuen, salinity survey was carried out in five kecamatan. 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
8-1	5 12 43.8	96 39 09.2	24.0	Bireuen, Jeumpa, Kuala Jeumpa, Site 8-1
9-1	5 13 10.9	96 40 15.2	21.0	Bireuen, Jeumpa, Bate Tomoh, Site 9-1
10-1	5 13 31.2	96 40 41.7	18.0	Bireuen, Jeumpa, Cot Geureundong, Site 10-1
11-1	5 14 17.4	96 54 03.3	12.0	Bireuen, Ganda Pura, Lapang Timu, Site 11-1
11-2	5 14 20.7	96 54 03.7	10.0	Bireuen, Ganda Pura, Lapang Timu, Site 11-2
12-1	5 15 14.3	96 47 23.4	9.0	Bireuen, Jangka, Jangka Alue'u, Site 12-1
12-2	5 15 16.0	96 47 22.7	21.0	Bireuen, Jangka, Jangka Alue'u, Site 12-2
13-1	5 11 09.1	96 30 28.9	13.0	Bireuen, Jeunieb, Teupin Keupula, Site 13-1
14-1	5 12 06.5	96 22 27.0	27.0	Bireuen, Samalanga, Meulik, Site 14-1

Altitudes from GPS and NOT reliable

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

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 or 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. Site features are summarised in Table S.2 and findings plus conclusions are presented in Tables S.3 and S.4.

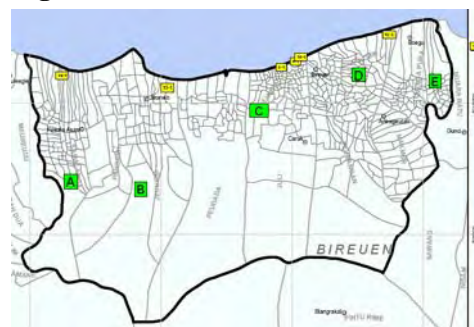
Table S.2 Basic Features of the Sites

Kecamatan	Desa	Site	Sediment	Land Preparation EM38	Present Landuse	Irrigation System	Drainage System
Samalanga	Meulik	14 – 1	15cm mixed	No data on inputs, land puddled	Palawija soon	Yes	Yes, poor
Jeunieb	Teupin Keupula	13 – 1	10cm mixed	No data or no inputs	Fallow	Closed	Yes, poor
Jeumpa	Bate Tomoh	9 – 1	10cm mixed	N, P & K	Land preparation	Yes	Yes
	Cot Geureundong	10 – 1	10cm mixed	N,P,K Combined & OM	Palawija, dead	Yes, poor	Yes, poor
	Kuala Jeumpa	8 – 1	7cm mixed	N, P & OM	Padi, harvest	ND	Yes
		8 – 2	7cm mixed	N, P & OM	ND	ND	Yes
Jangka	Jangka Alue'u	12 – 1	1cm mixed	N & P	Land preparation	Yes	Yes, poor
		12 – 2	2cm mixed	N & P	Padi harvest	Yes	Yes, poor
Ganda Pura	Lapang Timu	11 – 1	10cm mixed	N & P	None	No	No
		11 – 2	15cm mixed	N & P	None	Yes	Yes, good

S.3 Soil Salinity and Reclamation

The present situation in Bireuen is quite different to Aceh Besar and considerably better than in Pidie. Of the 10 sites studied in Bireuen, only 4 would now appear to be in need of the intervention of reclamation leaching. Six of the sites now have salinities that are now low enough to allow normal cropping to be done with the expectation of reasonable yields – in fact several of these sites have already achieved yields of about 60 – 70% of the pre-tsunami yield.

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 that were required to complete the assessments.

The salinities of the sites are presented in table S.3 where they are given sorted in the order of the present salinity as measured in December 2005. It is then possible to compare the present salinity (Column 6) with the average salinity measured via the EM38 survey (Column 3).

Table S.3 Salinity of the Soils

Desa	Site	Overall 1 soils salinity EM38 dS/m	Rhoades estimate 0 – 90cm EM38 dS/m	ETESP Average salinity EM38 dS/m	ETESP field salinity Dec 05 EM38	Conclusions, Recommendations and Scenario
Kuala Jeumpa	8 – 2	2.15	2.51	1.80	ND	Assume as 8-1 & well recovered, no leaching interventions required Scenario 5, upper slope
Bate Tomoh	9 – 1	1.39	1.38	1.40	0.25	Soil recovered, no leaching intervention required Scenario 5, upper slope
Lapang Timu	11 – 2	4.45	5.00	3.90	0.35	Soil well recovered, no leaching interventions required Scenario 5, upper slope
Kuala Jeumpa	8 – 1	2.10	2.40	1.80	0.45	Soil well recovered, no leaching interventions required Scenario 5, mid to upper slope
Lapang Timu	11 – 1	1.83	1.86	1.80	0.51	Soil well recovered, no leaching interventions required Scenario 5 with “road dam” as found in Scenario 1
Meulik	14 – 1	1.25	1.50	1.00	0.67	Soil well recovered, no leaching interventions required Scenario 5, mid to upper slope but with marketing problems
Jangka Alue’u	12 – 1	2.06	2.31	1.80	1.55	Soil recovering or stable but drainage and leaching required Has irrigation but basically Scenario 1
Jangka Alue’u	12 – 2	1.88	2.08	1.70	1.56	Soil recovering or stable but drainage and leaching required Has irrigation but basically Scenario 1 to Scenario 4
Teupin Keupula	13 – 1	1.52	1.24	1.80	2.57	Salinity actually increased, drainage and leaching required Scenario 1 to Scenario 3 since irrigation not open
Cot Geureundong	10 – 1	1.46	1.62	1.30	2.69	Salinity actually increased, drainage and leaching required Scenario 4 type situation

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

The data are then further compared in Table S.4 where it is determined if the intervention of leaching reclamation is required and, if leaching is required, just how much water has to pass down through the profile and how much has to be added as irrigation gifts.

Table S.4 Number of Estimated Irrigations for Reclamation

Kecamatan	Location	Site	Existing Salinity Dec 05 (dS/m)	Reclaim Leach Needed	Soil depth to recover (mm)	Depth of water table (mm)	Soil PSC	Leaching water required mm	Number of 100 mm Irrigation gifts
Jeumpa	Bate Tomoh	9 1	0.25	No	NA	NA	H	0	NA
Ganda Pura	Lapang Timu	11-2	0.35	No	NA	NA	H	0	NA
Jeumpa	Kuala Jeumpa	8-1	0.45	No	NA	NA	H	0	NA
Jeumpa	Kuala Jeumpa	8-2	0.45	No	NA	NA	H	0	NA
Ganda Pura	Lapang Timu	11-1	0.51	No	NA	NA	H	0	NA
Samalanga	Meulik	14-1	0.67	No	NA	NA	H	0	NA
Jangka	Jangka Alue’u	12-1	1.55	Yes	600	750	H	86	4
Jangka	Jangka Alue’u	12-2	1.56	Yes	600	750	H	87	4
Jeunieb	Teupin Keupula	13-1	2.57	Yes	600	750	M	143	6 – 7
Jeumpa	Cot Geureundong	10-1	2.69	Yes	600	750	H	149	5 - 6

NA not Applicable as reclamation leaching not required

As can be seen only the lower 4 sites in this table would need to be leached to get the salinity down to acceptable levels. 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 through 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 100 mm in depth for each irrigation
- There has to be soil drainage that collects and removes the saline leachate from the bottom (subsoil) 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 desalinated very quickly and the deeper soil will be desalinated 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.

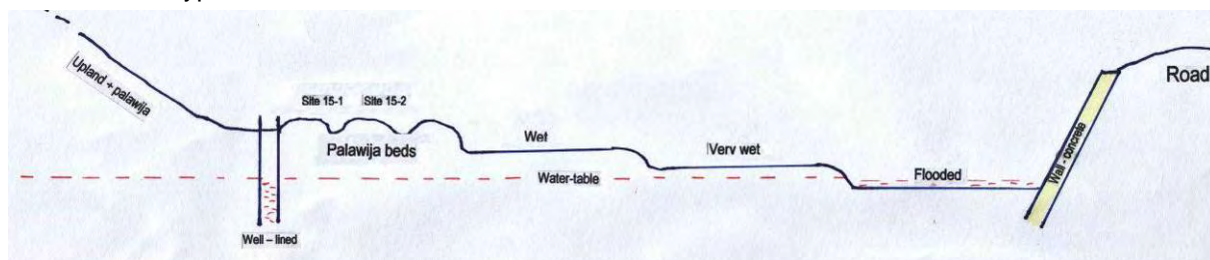
Reclamation leaching can and does use a lot of water as the data in Table S.4 shows. Economic analysis would be required before proceeding with civil works and leaching at any site that could not be reclaimed by the farmer himself.

Scenario 1 Sloping land with no irrigation or drainage

The soil is considered slightly to moderately damaged with salinity levels of 2-4 dS/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 50-75 cm with salinity of 0.25-0.50 dS/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.

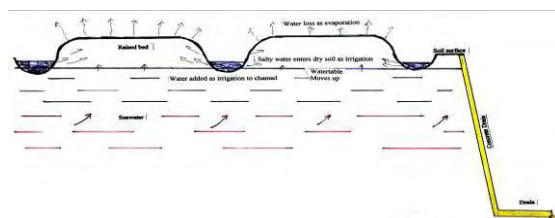
Cross Section of typical location



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

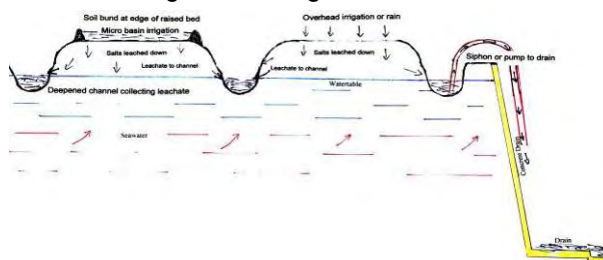
Surface Irrigation Perpetuating Salinity



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



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.

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

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 ingress.

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.

A follow up visit to the original site with this scenario showed water being rapidly drained from the site since drains had been cleared and / installed as necessary.

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

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 4-6 dS/m (SC2) and water table at 30-50cm with salinity level of 0.3-0.6 dS/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



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.

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 1700 mm/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 utilised 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.

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.

Badly damaged and blocked drain

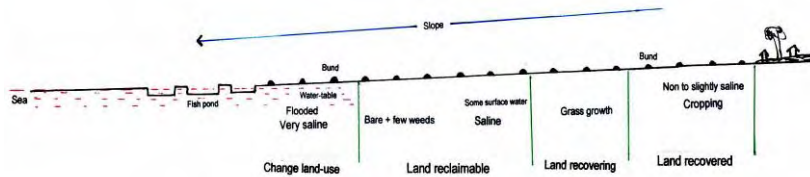


Refurbishment will be mainly a civil engineering task and relatively expensive to implement but very necessary if not essential – not only for agriculture but also for social reasons.

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.

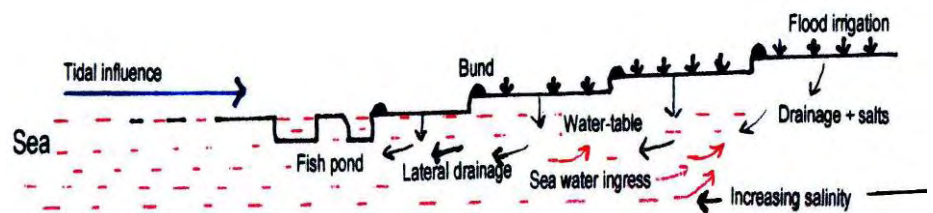
However, there is often a larger drainage channel running directly down-slope at the opposite side of the field from the inlet for the irrigation water, hence there is some drainage of the land.

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.

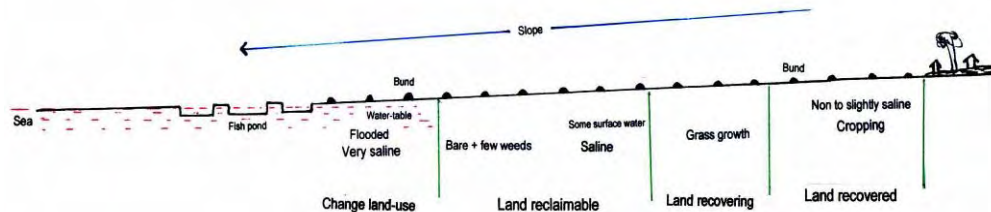
Conclusions and Recommendations

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 with 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 in 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.

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.

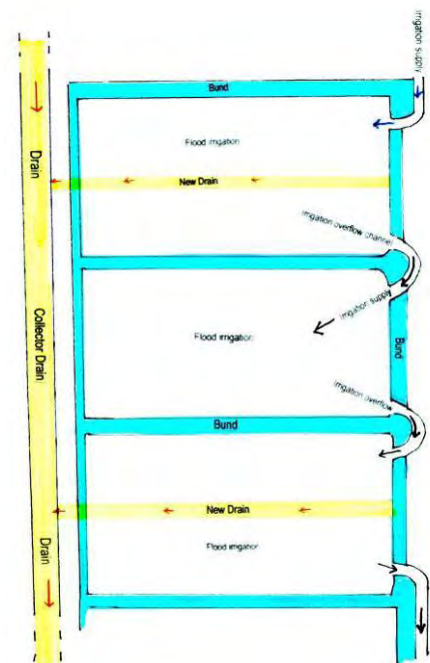
Possible reclamation problems and effects

Field Drain



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.

New field and existing collector drains



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.

Earthquake & Tsunami Emergency Support Project

ETESP

Bireuen Kabupaten

- [Samalanga](#)
- [Jeunieb](#)
- [Jeumpa](#)
- [Jangka](#)
- [Ganda Pura](#)



CHAPTER 1 INTRODUCTION

1.1 Introduction

The Tsunami of 26 December 2004 inundated the Bireuen 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.

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 allow agriculture to resume as quickly as possible.

All the Kabupaten within the immediate study area are shown in Figure 1.1 and Bireuen is labeled 10 in the middle of the north coast of Sumatra and abutting Pidie Kabupaten. Several sites from a few Kecamatan, with available soils and salinity data, within Bireuen are reported here.

Figure 1.1 NAD Kabupaten



1.2 Kecamatan

In Figure 1.2 the relevant Kecamatan have been coded:

A Kec No. 10 – Samalanga

B Kec No. 30 – Jeunieb

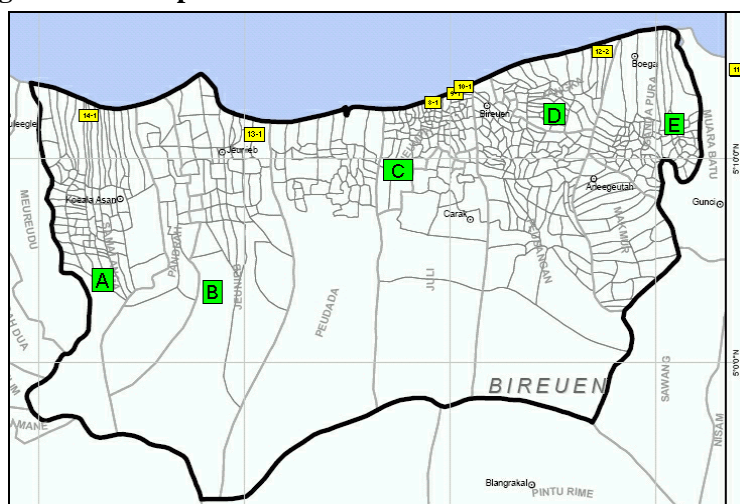
C Kec No 60– Jeumpa

D Kec No 70 – Jangka

E Kec No 100 – Ganda Pura

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.

Figure 1.2 Kabupaten Bireuen and Kecamatan



It should be noted that some error in the map boundaries or geo-registration exists since site 11 appears to fall outwith the kabupaten. No attempt is made here to explain this anomaly.

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 – these data has been consulted and used. Limited climatic data were reported in the Interim Report (ETESP 2005) 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, 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 five Kecamatan at 7 locations with 10 transects being completed in total. Most of these sites were visited in early December 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 Bireuen

No	Kecamatan	Features	Location / Desa	Transect	Days flood	Sediment (cm)	Landuse EM38
10	Samalanga	Narrow kecamatan stretching from coast to 29km inland	Meulik	14 – 1	7	15	Sawah
30	Jeunieb	Narrow kecamatan stretching from promontory on coast to 38km inland	Teupin Keupula	13 – 1	7	10	Palawija
60	Jeumpa	Small kecamatan mainly on the coast and stretching 9km inland	Bate Tomoh	9 – 1	5	10	Sawah
			Cot Geureundong	10 – 1	5	10	Palawija
			Kuala Jeumpa	8 – 1 8 – 2	5	7 7	Sawah
70	Jangka	Moderately small kecamatan on coast in east of kabupaten stretching 7km inland	Jangka Alue'u	12 – 1 12 – 2	3	1	Sawah
100	Ganda Pura	Moderately sized kecamatan on the eastern boundary of kabupaten with short coastline and stretching 14km inland from the coast	Lapang Timu	11 – 1 11 – 2	5	120 15	Sawah

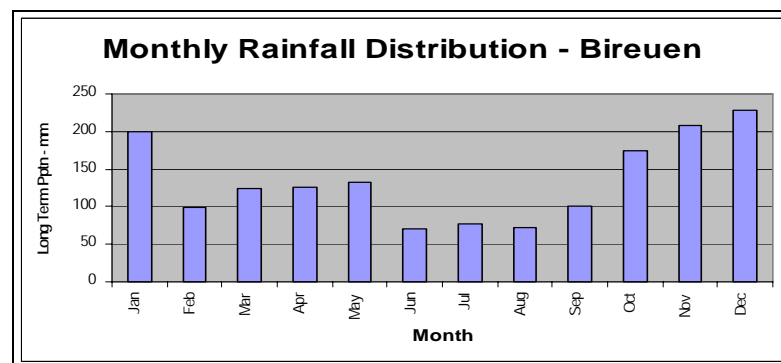
The Kecamatan are presented by kecamatan number and not in alphabetical, size or perceived order of importance.

Table 1.2 Geographic Coordinates of Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
8-1	5	12	43.8	96	39	9.2	224	Bireuen, Jeumpa, Kuala Jeumpa
9-1	5	13	10.9	96	40	15.2	21	Bireuen, Jeumpa, Bate Tomoh
10-1	5	13	31.2	96	40	41.7	18	Bireuen, Jeumpa, Cot Geureundong
11-1	5	14	17.4	96	54	3.3	12	Bireuen, Ganda Pura, Lapang Timu
11-2	5	14	20.7	96	54	3.7	10	Bireuen, Ganda Pura, Lapang Timu
12-1	5	1	14.3	96	47	23.4	9	Bireuen, Jangka, Jangka Alue'u
12-2	5	15	16.0	96	47	22.7	21	Bireuen, Jangka, Jangka Alue'u
13-1	5	11	9.1	96	30	28.9	13	Bireun, Jeunieb, Teupin Keupula
14-1	5	12	6.5	96	22	27.0	27	Bireuen, Samalanga, Meulik

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

Figure 1.3 Rainfall Distribution in Bireuen



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 is shown diagrammatically below in Figure 1.3 and as Table 1.3

1.5.1 Rainfall in Bireuen

The annual rainfall, or precipitation, for the area is taken as just over 1600 mm.

The monthly distribution, as seen in Figure 1.3, appears to suggest there are two main peaks – December with over 220mm and between March - May with about 125 – 135mm/month.

1.5.2 Use of Rainfall Data

The monthly rainfall data have already been built into one of the main “reclamation” tools.

This tool 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.

Table 1.3 Rainfall Distribution in Bireuen

Kabupaten Bireuen No 10	Rainfall	Distribution
<i>Month</i>	<i>mm</i>	<i>%</i>
Jan	199	12
Feb	99	6
Mar	125	8
Apr	126	8
May	133	8
Jun	70	4
Jul	78	5
Aug	71	4
Sep	101	6
Oct	175	11
Nov	208	13
Dec	229	14
Total - LT	1613	

LT = Long-term precipitation / rainfall

Table 1.4 Recent Site Data

Name	Location / Desa	Transect	Water table depth (cm)	Soil PSC	Drainage System	Irrigation System	Land-use
Samalanga	Meulik	14 – 1	50	M/H	Yes, but weeds over-growing	Yes	Prepared for palawija, now getting +/- normal cropping but returns too low for intensive palawija growth!
Jeunieb	Teupin Keupula	13 – 1	0	M/H	Yes, but badly overgrown	Yes, but presently not used. Good to fair supply	None
Jeumpa	Bate Tomoh	9 – 1	0	H	None visible	Yes	Padi, second crop with 60% yield
	Cot Geureundong	10 – 1	0	H	Yes, but main drain blocked	Yes, but poor supply as at edge of scheme	Palawija, poor tomato growth with no fruiting
	Kuala Jeumpa	8 – 1	0	H	None visible	Yes	Padi, second crop OK
		8 – 2	0	ND	ND	ND	ND
Jangka	Jangka Alue'u	12 – 1	0	H	Yes, but road dam effect and removes surface water onl	Yes	Land preparation in hand. Post tsunami yield 50% now about 80%
		12 – 2	0	H	Yes, towards fish ponds but no real outlet	Yes	Stubble only as crop harvested, about 70% yield
Ganda Pura	Lapang Timu	11 – 1	0	ND	No	None, rain fed only	No crop but usually 1 – 2 crops padi depending on rain
		11 – 2	0	M/H	Yes, but quite far away down slope	Yes, good supply	No crop in field, usually 2-3 crops padi / year

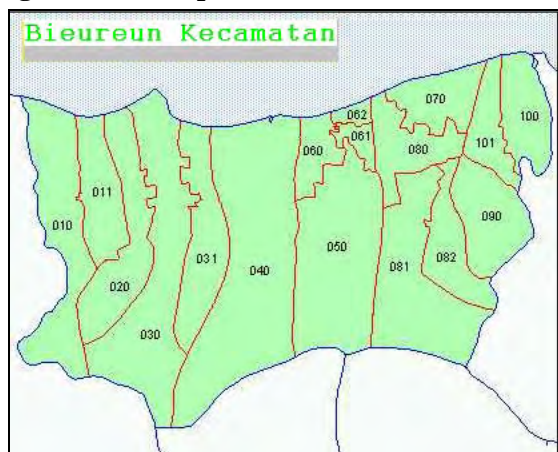
PSC Particle Size Class leaching progress: M = medium, H = heavy (clays)

CHAPTER 2 SAMALANGA

2.1 Introduction

Kecamatan Samalanga is, as previously noted, located on the western boundary of the kabupaten with a short exposure to the ocean and labeled as 010 in Figure 2.1 below. Only one location within the kecamatan was subjected to a salinity survey and this was in Meulik where one transect was done with the EM38 salinity device.

Figure 2.1 Kabupaten Bireuen



Coordinates of the site were taken in December by ETESP and are shown below in Table 2.1 and the site is shown on an extract of the 1:50,000 topographic map in Figure 2.2. The mauve line on the map is a GPS trace of a road followed in a later field trip.

2.2 Salinity Survey

One transect was done in Meulik and the location is shown as below. Some salient facts about the site are presented in Table 2.2, which has been compiled from study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

Figure 2.2 Site Location



Table 2.1 Geographic Coordinates of Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
14-1	5	12	6.5	96	22	27.0	27	Bireuen, Samalanga, Meulik

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	Landuse / Crop	Fertiliser	Notes EM38 Survey
Samalanga	Meulik	7	15	14-1	14	Mixed	Sawah	N	Second crop post tsunami

2.3 Site Description

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

Site 14-1 lies on a flat alluvial plain at the edge of the village which is edged with trees and looks reasonably prosperous. Crops seen around the village were dry land, palawija, but at quite low intensity as the farmer reports it is not economic to grow at high intensity as the returns from marketing are too low. Normally two crops per annum of padi grown with one crop of palawija – but as stated above only low intensity. There was an irrigation supply (water salinity of 0.10mS/cm) and a basic (surface) water drainage system but this was badly overgrown with weeds. The farmer claims there is usually about a metre of dry soil acting as a root zone for palawija but at present the water table is sitting at 50cm depth. About 5% of the surface was covered with standing water (EC of 0.12mS/cm).

No additional soil analytical or laboratory data have yet been located for this site.

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
14-1	Sawah	No data available	Wet	10cm irrigation on new planting of padi

No significant information could be gleaned from the field notes made during the EM38 survey.

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	Soil Texture	Soil ECe 25 – 50 cm	Soil Depth cm	WT Depth cm	WT EC dS/m
14-1	M	Loam	0.57	ND	ND	0.76	50	50	ND

The area around the site was not heavily cultivated but there was one plot with healthy looking beans close by. Information from the farmer was that the land could be heavily cultivated but cropping intensity was low because the returns from growing palawija were too low to be economic.

2.5 Problems

There were no immediate land or soil problems to be seen in December 2005 and it would appear that this land has more or less recovered and should be suitable for normal agriculture.

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 are 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. Site 14-1 shows as leached, meaning that the topsoil has lower salinity than the subsoil
- 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 2.3. The coding is also used for salinity.

Figure 2.3 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 the Site

No	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check
10	Samalanga	Meulik	14 - 1	46	45	46	14	15	7	Leached	Reading OK

The salinity data in Table 2.6 reveals that, based on the average values, the salinity problem is negligible for this site (colour code green) and the various determinations of salinity all fall into Salinity Class SC1 (International System) and estimates range from 1 - 2dS/m. This is the value that would be normally be aimed for when reclaiming a badly salinised site. In other words this site has no actual salinity problem and this would be supported by the field notes

during the survey that cropping was proceeding normally. This was further confirmed by the site visit in December 2005.

If the maximum values are studied it can be seen that all determinations still fall into Salinity Class SC1 with values ranging from 1.1–2.4dS/m. The minimum values, as would be expected, fall into the SC1 and the group considered as having no salinity problem at all – that is they are “non-saline” and do not have any colour code attached.

Table 2.6 Salinity Measurements for the Samalanga Site

				Rhoades		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
Kecamatan	Location	Site									
Averages											
Samalanga	Meulik	14 - 1	1.52	2.03	0.95	1.50	1.0	1.0	1.0	SC1	SC1
Location Mean			1.5	2.0	0.9	1.5	1.0	1.0	1.0	SC1	SC1
Maximums											
Samalanga	Meulik	14 - 1	1.74	2.38	1.12	1.75	1.3	1.2	1.2	SC1	SC1
Location Mean			1.74	2.38	1.12	1.75	1.30	1.24	1.24	SC1	SC1
Minimums											
Samalanga	Meulik	14 - 1	1.26	1.74	0.82	1.27	0.9	0.9	0.9	SC1	SC1
Location Mean			1.26	1.74	0.82	1.27	0.94	0.89	0.94	SC1	SC1

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

2.7 Sediment Depth

Table 2.5 notes that the sediment depth deposited on the soil at the Samalanga site is considered to be “moderately big” problem. However, as the local cultivation of this site has apparently been successful through “mixing” the sediment with the native soil and there is no salinity problem it appears that there is no longer a problem from the sediment; perhaps there never was a problem from the sediment. Similar sites with this depth of sediment (15cm) should be treated the same way and the sediment mixed in via good ploughing with the application of fertilisers and organic manures.

2.8 Conclusions & Recommendations

In summary, the data would appear to be reliable and there was not much of a salinity problem on this site at the time of the EM38 survey, or at present. However, the existing salinity, though not expected to cause any real problem, will NOT go away or reduce if, as suspected, this area is similar to the Kuta Alam site in Banda Aceh and has nil or very poor soil drainage. At the time of the survey an overall salinity figure of 1.25dS/m has calculated as the average of:

- ECe for 0-90cm by the Rhodes equation, and
- ETESP estimate of “average” salinity

Table 2.7 Comparison of Salinities from 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
Samalanga	14–1	1.25	1.50	1.00	1.52	2.03	1.00	0.57	0.76

The salinity at this site has fallen to virtually normal, acceptable level since the time of the EM38 survey. It appears as though leaching is still happening since the salinity, as measured in December, is lower in the surface layer than the layer below – values of 0.57 and 0.76dS/m respectively.

No immediate action is required at this site but, the status of the drainage system should be fully inspected and upgraded if it does not seem to be as efficient as it could be. Even under normal irrigated farming there can be a build up of salinity and the best way to control this is a working drainage system and careful water management.

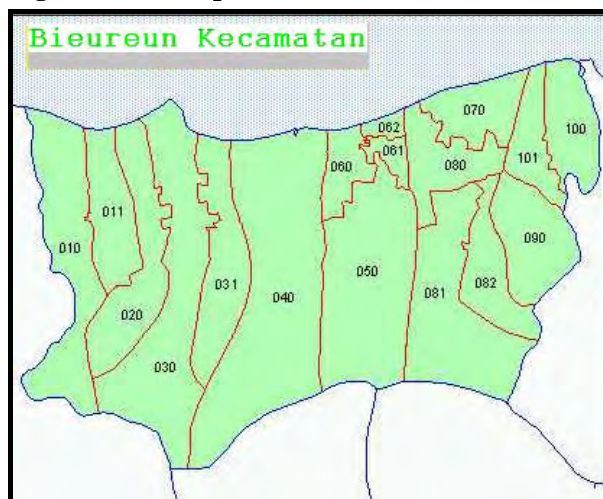
Otherwise no other intervention is required apart from updated agronomic advice and perhaps improved varieties.

CHAPTER 3 JEUNIEB

3.1 Introduction

Kecamatan Jeunieb, as previously noted, lies in the western half of Kabupaten Bireuen, has small exposure to the ocean as a promontory that juts out a few kilometres into the sea and labeled as 030 in Figure 3.1. One location within the kecamatan was subject of a salinity survey done with the EM38 salinity device.

Figure 3.1 Kabupaten Bireuen



Coordinates of the site were taken in December 2005 by ETESP and are shown in Table 3.1 below.

The GPS software Ozi Explorer was used to download the location onto the 1:50,000 topographic map sheet 0521-21 and an extract of that map as presented as Figure 3.2.

3.2 Salinity Survey

One transect was done in Desa Teupin Keupula, Site 13-1 with one transect of 26 sample points.

Figure 3.2 Site Location



Some salient facts about the sites are presented in Table 3.1, which has been compiled from study of the original dataset – MS Word document plus the Excel spreadsheet and the available maps.

Table 3.1 Geographic Coordinates of the Site

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
13-1	5	11	9.1	96	30	28.9	13	Bireuen, Jeunieb, Teupin Keupula

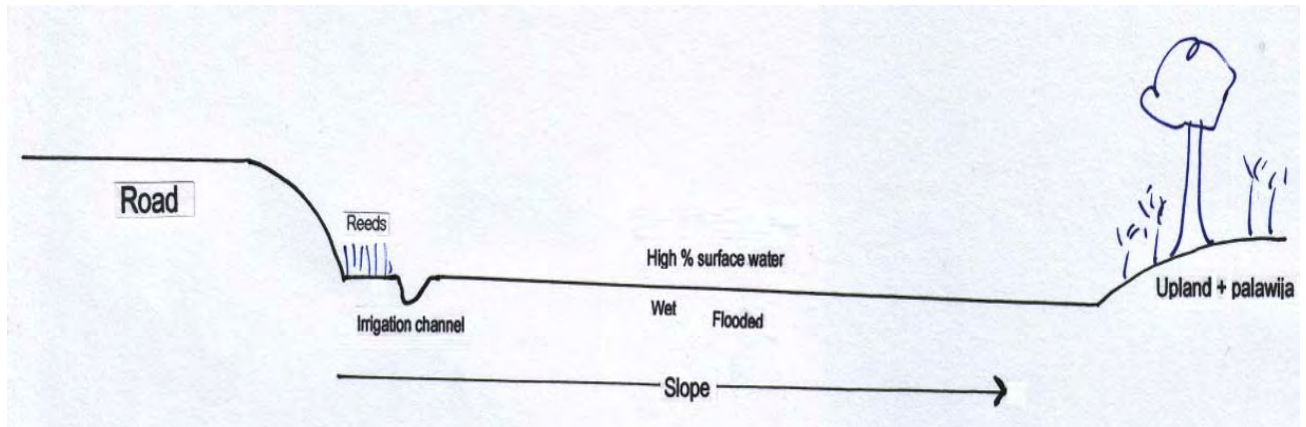
NB Altitudes from GPS unit and not to be taken as anything like accurate, must be found from topographical map
NB Where a second traverse was done at virtually the same location as another the records were merged

Table 3.2 Transect Information

Name	Site	Days flood	Sediment (cm)	No	EM38 Points	Sediment	Landuse / Crop	Fertiliser	Notes
Jeunieb	Teupin Keupula	7	10	13-1	26	Mixed	Palawija Corn on rice land	/	Corn failed

3.3 Site Description

This site description was compiled by ETESP after the site visit in December 2005. **Site 13-1** lies on a virtually flat alluvial plain located between a road, which is raised well above the level of the site, and an area with some trees and other dry land crops or species, this area is also raised above the level of the site. The whole site is flooded with water with EC of 0.62mS/m and, with this low salinity level, is assumed to be recent rain water or irrigation water. There was an irrigation system but farmer information was that this system was presently closed and not in use. The farmer also reported that there was a drainage system but this was not actually seen as the site was very overgrown with weeds and, if there was a drainage system, then that system was virtually non-functional due to the weeds.

Figure 3.3 Cross Section of Site

Pre-tsunami the site carried padi and palawija in seasonal rotation with, reportedly, good yields. Presently there is no cropping, the area is covered in grasses and weeds on which buffalo were grazing.

No additional soil analytical or laboratory data have yet been located for this site.

3.4 Site Information from the Em38 Survey and ETESP

Table 3.3 Land Preparation Post-tsunami

Site	Land Use Type	Crop or land preparation	Soil	Notes
13-1	Palawija / Sawah	No data available apart from sediment mixed in and cropping was palawija but corn failed, then planted to rice	Wet	10 cm irrigation on new planting of padi

The only significant conditions noted for this site was that the post-tsunami crop of corn failed and the site was then planted with rice.

Table 3.4 Soil and Site Features December 2005

Site	PSC 0-25 cm	Soil Texture fsL / fsCl	Soil ECe 0 -25 cm	PSC 25 – 50 cm	Soil Texture Cl	Soil ECe 25 – 50 cm	Soil Depth cm	WT Depth cm	WT EC dS/m
13-1	H	fsL / fsCl	3.16	H/V	Cl	1.97	0	0	0.61

Water table depth and soil depth noted as zero since site flooded and no “dry” soil available for root zone

3.5 Problems

The immediately obvious problems at this site are the flooding, poor drainage and salinity, which is not high but enough to prevent normal cropping without having salt tolerant varieties.

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. The data analysis shows:

- 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.

- Site 13-1 is noted as leached, 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 3.4. The coding is also used for salinity.

The salinity data in Table 3.6 reveals that, based on the average values, there is virtually no salinity problem at all at the Teupin Keupula site and all values are 2dS/m or less. As can be seen only one of the ETESP determined values has warranted a colour coding and that is green – “negligible” problem whilst the rest are considered as non-saline.

Figure 3.4 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 Jeunieb Site

Kec No	Kecamatan	Location	Site	EMv	EMh	Average	Samples	Sediment	Flood	Status	Check
							No	Cm	Days		
30	Jeunieb	Teupin Keupula	13 - 1	86	63	75	26	10	7	Leached	Reading OK

When the maximum values are considered it is found that the site would still classify as not particularly saline with values between 1.13dS/m (topsoil) and 2.69dS/m (upper-subsoil) by the Rhoades determination whilst the ETESP values are slightly less. All these values classify as Salinity Class SC1 and under normal circumstances the site would not be considered for reclamation leaching.

As would be expected the minimum values are considerably less by all the various determinations with values ranging from 0.24 to 1.4dS/m, are considered non-saline (no colour coding) and would fall into Salinity Class SC1.

Table 3.6 Salinity Measurements for the Jeunieb Site

			Rhoades			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
Kecamatan	Location	Site									
Averages											
Jeunieb	Teupin Keupula	13 - 1	0.68	1.96	1.09	1.24	2.0	1.5	1.8	SC1	SC1
Location Mean			0.7	1.96	1.1	1.2	2.0	1.5	1.8	SC1	SC1
Maximums											
Jeunieb	Teupin Keupula	13 - 1	1.13	2.69	1.45	1.76	2.63	1.96	2.3	SC1	SC1
Location Mean			1.13	2.69	1.45	1.76	2.63	1.96	2.0	SC1	SC1
Minimums											
Jeunieb	Teupin Keupula	13 - 1	0.24	1.19	0.70	0.71	1.4	1.0	1.2	SC1	SC1
Location Mean			0.24	1.19	0.70	0.71	1.4	1.0	1.2	SC1	SC1

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

3.7 Sediment Depth

Table 3.5 notes that the sediment depth (10cm) deposited on the soil at all this site is considered a “moderate” problem and is colour coded mauve. This is supported by the fact that the first crop of corn failed and this could well have been due to the sediment initially having a higher salinity than that recorded during the survey. Leaching of the site during the failed cultivation of the corn could well have supplied all the leaching that this site required to get the salinity down to the levels noted – and allow cropping to now continue. Similar sites with this depth of sediment (8 – 12 cm) should be treated the same way and the sediment mixed in via good ploughing with the application of fertilisers and organic manures.

3.8 Conclusions & Recommendations

In summary, the data would appear to be reliable and there was no large salinity problem on this site. The sediment depth deposited does not seem to have presented any long-lasting problem. However, the existing salinity, though not expected to cause any big problem, will NOT go away or reduce if soil drainage is not improved. In fact the salinity could worsen.

Reclamation leaching is required at Teupin Keupula, Site 13-1 and the existing slight salinity, which exists in layer two (30–60cm depth) will NOT go away or reduce if this site does not have an operational drainage system to remove the saline water and leachate from the site once normal irrigated agriculture is fully re-established.

An overall salinity figure was calculated for this site and is the average of :

- 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 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
Teupin Keupula	13–1	1.52	1.24	1.80	0.68	1.96	1.50	3.16	1.97

According to the data collected in December 2005 the surface salinity at this site has doubled whilst the upper sub-soil (25/30-60cm) has remained virtually unchanged. This situation was predicted in the section above and the overriding item is almost certainly the status of the drainage system.

Although this area is claimed to have both drainage and irrigation the situation could be fitted to either ETESP Scenarios 1 or 2 and the solution is to improve the drainage of the soils, starting with in-field drains. Once drains are installed and operational soil reclamation leaching could be commenced, or might even to start to happen naturally via rainfall plus normal irrigated agriculture.

CHAPTER 4 JEUMPA

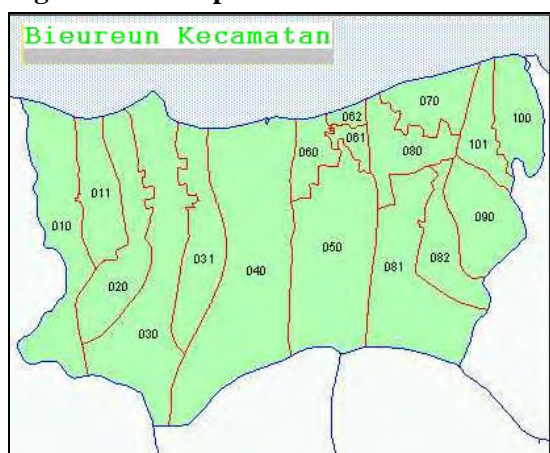
4.1 Introduction

Kecamatan Jeumpa is, as previously noted, lies on the north coast of Sumatra in the middle of Kabupaten Bireuen, is relatively small, only extends inland for about 9 kilometres and labeled as 060 in Figure 4.1. Three locations within the kecamatan were subjected to a salinity survey done with the EM38 salinity device.

The locations were:

- Batee Tomoh- Site 9 with one transect, 9–1 and 11 samples point
- Cot Geureundong-Site 10 with one transect 10–1 and 5 sample points, and
- Kuala Jeumpa-Site 8 with two transects 8–1 with 21 samples points and 8–2 with 11 sample points

Figure 4.1 Kabupaten Bireuen



Coordinates of the sites were taken in December 2005 by ETESP and are shown below in Table 4.1. The GPS software Ozi Explorer was used to download the location onto sheet 0521-21 of the 1:50,000 scale topographic map and an extract of that map is presented as Figure 4.2.

Figure 4.2 Location



4.2 Salinity Survey

Three sites with 4 transects were done within Jeumpa and the locations are shown above and, as can be seen, the sites were very close to the coast. Some salient facts about the sites are presented in Table 4.2, which has been compiled from study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

Table 4.1 Geographic Coordinates of Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
8-1	5	12	43.8	96	39	9.2	224	Bireuen, Jeumpa, Kuala Jeumpa
9-1	5	13	10.9	96	40	15.2	21	Bireuen, Jeumpa, Bate Tomoh
10-1	5	13	31.2	96	40	41.7	18	Bireuen, Jeumpa, Cot Geureundong

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

Table 4.2 Transect Information

Site	Days flood	Sed (cm)	Site	EM38 Points	Sediment	Landuse / Crop	Fertiliser	Notes
Kuala Jeumpa	5	7	8–1	21	Mixed	Sawah	N, P & OM	Second crop post tsunami – previous crop good
	5	7	8–2	11	Mixed	Sawah	N, P & OM	Second crop post tsunami – previous crop good
Batee Tomoh	5	10	9–1	11	Mixed	Sawah	N, P & K	Second crop post tsunami
Cot Geureundong	5	10	10–1	5	Mixed	Palawija	N, Complete & OM	Second crop post tsunami – previous crop poor
						Tomato		

4.3 Site Descriptions

These site descriptions were compiled by ETESP after the site visit in December 2005.

Sites 8-1 and 8-2 lie within a formal, planned irrigation scheme and are on an level to very gently sloping alluvial plain lying between sections of upland, villages and dry land crops being found on the uplands. There is a good irrigation supply and the water had an EC of 0.03ms/m – making it Class 1 irrigation water. The surface of the sites was flooded, presumably following irrigation, and no visible drainage system could be seen – but it has to be assumed that there were soil drains installed at the time the scheme was set up. A second crop of padi had just been harvested and this was the second, post-tsunami crop with an estimated yield of 70% of expected – the first crop gave a yield of about 30%. This suggests that considerable leaching of the site has occurred since the first crop was grown. Site8-2 was not visited but as it lay very close to 8-1 it has to be assumed as very similar, and was claimed to be so by the farmer.

Figure 4.3 Cross Section of Typical Situation for Sites 8, 9 and 10



Site 9-1 also lies in an almost flat alluvial plain located between islands of upland and has an irrigation supply with water with EC of 0.05ms/cm. It was not established if this site had a drainage system or not but, as it was very close to the coast and there was a sandy, beach ridge it is possible that the site was draining naturally due to sub-soil sand layers. The farmer advised that he followed a padi / palawija pattern and his second crop since the tsunami was almost acceptable but was patchy and gave about 60% of predicted yield.

Figure 4.3 Down-slope Section of Typical Situation for Sites 8, 9 and 10

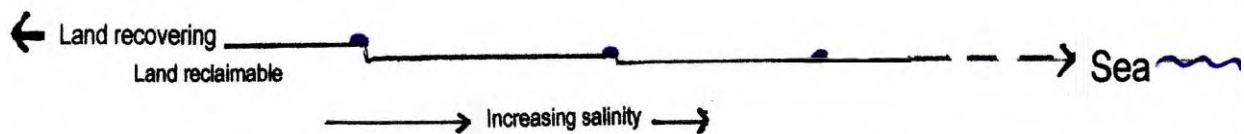


Figure 4.4 Village and Dry-land Area Site 9



Figure 4.5 Towards the Sea and beach Ridge



Site 10-1 also lies on an almost flat alluvial plain between dry-land high-spots and the site is very close to the coast and sea. There was an irrigation system but, being near the edge of the scheme, the farmer claimed that the supply was less than good and had very small delivery channels. There was also a drainage system but this was also poor and the main drain was clogged up with weeds etc. and the husbandry considered rather poor. The site was about 80% flooded and the standing water had an EC of 1.86ms/cm. The current crop was very poor in that tomatoes did grow but failed at the fruiting stage.

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

Figure 4.6 Dead Tomatoes**Figure 4.6 Dead Tomatoes with Dry-land behind**

4.4 Site Information from the EM38 Survey and ETESP

Table 4.3 Land Preparation Post-tsunami

Site	Land Use	Crop or land preparation	Soil	Notes
8 – 1	Sawah	Good previous rice performance but yield reduction of 70% post tsunami N: 60 kg/1200 m ² , before planting and 21 days after planting P: 20 kg/1200 m ² , before planting OM: 1 ton/ha, Applied before planting	Wet	Field flooded (irrigated) to 15 cm depth Patchy pale crop
8 – 2	Sawah	Good previous rice performance but yield reduction of 70% post tsunami N: 60 kg/1200 m ² , before planting and 21 days after planting P: 20 kg/1200 m ² , before planting OM: 1 ton/ha, Applied before planting	Wet	Field flooded (irrigated) to 15 cm depth Patchy, pale, poor crop
9 – 1	Sawah	Good crops pre-tsunami N: 50 kg/1300 m ² , before planting and 21 days after planting P: 20 kg/1300 m ² , before planting K: 8 kg/1300 m ²	Wet	Second crop post tsunami, first crop showed 70% yield reduction. Field flooded 15 cm irrigation Crop pale coloured, patchy and variable crop condition throughout site
10 - 1	Palawija	Previous post-tsunami tomato crops NOT good N: Before planting 30g urea/plant Combo: 50 grams/plant, applied before planting OM: 0.5 kg/plant	Wet	Crop not in good condition, pale, yellowish and patchy

The land is categorized as Sawah or lowland rain fed but the survey notes indicate that both rice and Palawija have been / are grown

Table 4.4 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
8-1	H	SiCl	0.37	ND	ND	0.52	0	0	0.04
8-2	ND	ND	ND	ND	ND	ND	ND	ND	ND
9-1	H	SiCl	0.25	H/V	SiCl / SiC	0.00	0	0	0.05
10-1	H	SiCl	2.44	H/V	SiC	2.93	0	0	1.86

Water table depth and soil depth noted as zero since site flooded and no "dry" soil available for root zone

4.5 Problems

There were no significant problems at Sites 8 and 9 but Site 10 had no drainage, poor water supply, flooding, high salinity and, consequently, no active successful cropping.

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 4.5 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 4.6 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 4.5 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. Only Site 10–1 indicates a saline topsoil whilst the rest are leached to some extent and the salinity lies further down the soil profile
- The coloured coded column in Table 4.5 is the ETESP assessment of the degree of problem that the original depth of sediment presented. Sites 9 and 10 have deeper sediments and hence a potentially greater problem than site 8 – the key is shown as Figure 4.7. The coding is also used for salinity.

Figure 4.7 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 4.5 Assessment of the EM38 Dataset for the Jeumpa Sites

No	Kecamatan	Location	Site	EMv	EMh	Average	Samples	Sediment	Flood	Status	Check
							No	Cm	Days		
60	Jeumpa	Batee Tomoh	9 - 1	65	54	59	11	10	5	Leached	Reading OK
60	Jeumpa	Cot Geureundong	10 - 1	49	67	58	5	10	5	Saline topsoil	Reading OK
60	Jeumpa	Kuala Jeumpa	8 - 1	77	74	76	21	7	5	Leached	Reading OK
			8 - 2	75	75	75	11	7	5	Leached	Reading OK

The salinity data in Table 4.4 reveals that, based on the average values, the salinity problem was non-existent to negligible for the surface (0–30 cm) layer of the Batee Tomoh site (no colour coding, with SC1) with an ECe value of about 1.1 dS/m. In the other sites that were labeled “leached” (Table 4.5), that is Sites 8-1 and 8–2, the surface soil has a “negligible” problem and colour coded green with values between 2.4 and 2.6 dS/m. The site that was noted as not being leached, Site 10-1, has a very clear reduction in salinity dropping from 2.78 dS/m in the surface layer to 0.25 dS/m in the second layer – this concentration of salt in the surface layer is colour coded green and is only regarded as a “negligible” problem.

The maximum values for these sites still present no great problem as they also fall into SC1 whilst the minimum values are still in SC1 and many are in the non-saline group and do not have any colour coding.

Basically, the sites at Jeumpa did not have a large salinity problem at the time of the survey, in fact only a very minor problem and all ECe values are classified as falling Salinity Class SC1 and only minimal soil reclamation leaching might be required. However, this statement has been proved wrong for Site 10 following the December 05 visit.

Table 4.6 Salinity Measurements for the Jeumpa Sites

Averages			Rhoades			Rhoades	ETESP Lookup			Salinity Class	
			ECe 0 - 30cm	ECe 30 -60cm	ECe 60 -90cm	ECe 0 - 90cm	ECe EMv	ECe EMh	ECe EMav	Rhoades	ETESP
Kecamatan	Location	Site	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m		
Jeumpa	Batee Tomoh	9 - 1	1.13	2.00	1.01	1.38	1.5	1.2	1.4	SC1	SC1
Jeumpa	Cot Geureundong	10 - 1	2.78	0.25	1.82	1.62	1.1	1.6	1.3	SC1	SC1
Jeumpa	Kuala Jeumpa	8 - 1	2.39	3.28	1.54	2.40	1.8	1.8	1.8	SC1	SC1
		8 - 2	2.57	3.40	1.57	2.51	1.8	1.8	1.8	SC1	SC1
Maximums											
Jeumpa	Kuala Jeumpa	8 - 1	3.58	-0.03	3.45	2.33	2.2	2.3	2.2	SC1	SC1
		8 - 2	3.04	-0.11	3.20	2.04	2.0	2.0	2.0	SC1	SC1
Jeumpa	Batee Tomoh	9 - 1	1.80	2.73	1.33	1.95	1.8	1.6	1.7	SC1	SC1
Jeumpa	Cot Geureundong	10 - 1	3.36	0.33	2.14	1.94	1.3	1.9	1.6	SC1	SC1
Minimums											
Jeumpa	Kuala Jeumpa	8 - 1	1.21	2.06	1.03	1.43	1.5	1.2	1.4	SC1	SC1
	Kuala Jeumpa	8 - 2	1.92	2.71	1.29	1.97	1.6	1.5	1.5	SC1	SC1
Jeumpa	Batee Tomoh	9 - 1	0.47	1.31	0.72	0.83	1.3	0.9	1.1	SC1	SC1
Jeumpa	Cot Geureundong	10 - 1	2.51	0.24	1.63	1.46	1.0	1.4	1.2	SC1	SC1
Location Mean			2.51	0.24	1.63	1.46	0.99	1.40	1.22	SC1	SC1

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

Values in red suspect and excluded from manipulations

4.7 Sediment Depth

Table 4.5 notes that the sediment depths deposited on the soil at the Reudup sites are considered a “slight to moderate” hazard or problem as the depth was only between 6-12cm. 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.

4.8 Conclusions & Recommendations

In summary, the data would appear to be reliable, there was not a very large salinity problem on these sites at the time of the survey, and what salinity there was present in the two upper layers 0–30 and 30–60 cm depth

The salinity problem was rated as “negligible” - colour coded green and some, minor reclamation leaching could be envisaged if water-table conditions and drainage allowed.

However, the existing minor salinity, whether it existed at the surface (0–30 cm) or in the subsoil (60+ cm) could NOT go away or reduce if there was nil or very poor soil drainage. This has proved to be the case at Site 10 where the lack of a drainage system has actually led to the situation getting worse between the time of the survey and December 2005. At sites 8 and 9, which did have drainage and irrigation supplies the land was able to leach and salinity did lower.

An overall salinity figures based on the EM38 data have been calculated by taking the average of the:

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

Table 4.7 Comparison of Salinities from EM38 Survey and December 2005

Location	Site	Overall EM38 dS/m	Rhoades 0–90 cm EM38 dS/m	ETESP average EM38 dS/m	Rhoades 0–30 cm EM38 dS/m	Rhoades 30–60 cm EM38 dS/m	ETESP EMh EM38 dS/m	ETESP 0–25 cm Dec 05 dS/m	ETESP 25+ cm Dec 05 dS/m
Kuala Jeumpa	8 – 1	2.10	2.40	1.80	2.39	3.28	1.80	0.37	0.52
	8 - 2	2.15	2.51	1.80	2.57	3.40	1.80	ND	ND
Batee	9 – 1	1.39	1.38	1.40	1.13	2.00	1.20	0.25	0.00
Cot Geureundong	10 – 1	1.46	1.62	1.30	2.78	0.25	1.60	2.44	2.93

Site 8-2 not visited so no new data (ND)

The situations at Sites 8 and 9 have improved to the stage that the land can be considered virtually fully reclaimed or recovered from the salinity that did exist at the time of the EM38 survey. This change is almost totally due to the fact that these sites had drainage and irrigation systems. The irrigation system delivered clean, non-saline water in large enough quantities to the site to enable soil leaching, whilst the drainage system removed the saline leachate produced as the salts were leached out of the soil.

No interventions, possibly apart from extension advice on husbandry and use of newer techniques and seed etc, need to be made at the sites and the land should remain productive as long as good land and water management is adhered to.

However, the situation at Site 10 has not improved and, in fact worsened, with the surface layer not being very different from previously but the subsoil salinity has increased from <1dS/m to almost 3dS/m. This situation has come about because the site does not have, or does not have a good, irrigation supply and – more importantly – does not have a drainage system.

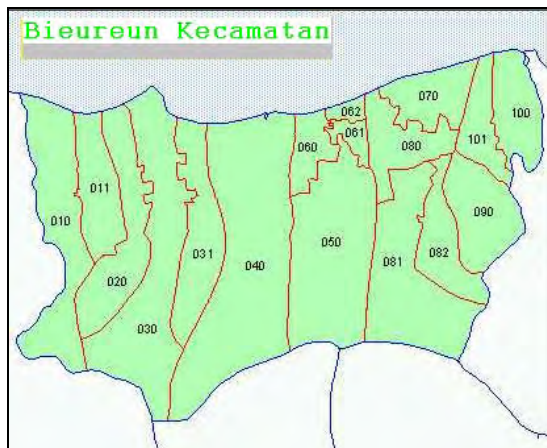
This site can be reclaimed and the first, and most important intervention, must be the installation of a soil drainage system. The situation more or less fits the ETESP mid to lower slope Scenario 4 and the suggestions offered in that scenario should be followed.

CHAPTER 5 JANGKA

5.1 Introduction

Kecamatan Panteraja, as previously noted, abuts and lies to the east of Jeumpa on the eastern side of Kabupaten Bireuen on the north coast of Sumatra and labeled 070 in Figure 5.1.

Figure 5.1 Kabupaten Bireuen



Only one location within the kecamatan was subjected to a salinity survey with the EM 38 device. The location was in Desa Jangka Alue'u, Site 12 with two transects:

- 12 – 1 with 8 sample points, and
- 12 – 2 with 11 sample points

Coordinates were taken in December 2005 by ETESP and are given in Table 5.1

Figure 5.2 Location



The actual location cannot be shown on the 1:50,000 map as the relevant sheet is not available. However, the sites lie about 200m north of the name Jangka Alue on the extract of the map above.

5.2 Salinity Survey

As noted 2 transects were done but, again as noted, they cannot be shown on the map. Salient facts about the site are given in table 5.2 which has been compiled from study of the original dataset

Table 5.1 Geographic Coordinates of Sites

Site	Deg	Min	Sec	Deg	Min	Sec	Altitude	Notes
	N	N	N	E	E	E	masl	
12-1	5	15	14.3	96	47	23.4	9	Bireuen, Jangka, Jangka Alue'u
12-2	5	15	16.0	96	47	22.7	21	Bireuen, Jangka, Jangka Alue'u

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

Table 5.2 Transect Information

Name	Site	Flood	Sediment (cm)	No	EM38 Points	Sediment	Landuse / Crop	Fertiliser	Notes
Jangka Janka Alue'u		3 day	1	12–1	8	Mixed	Sawah	N, & P	Second crop post tsunami – previous crop poor
		3 day	2	12–2	11	Mixed	ND	ND	ND

5.3 Site Descriptions

Theses site descriptions were compiled by ETESP after the site visit in December 2005

Site 12-1 lies in the typical situation of most of the Bireuen sites in that it is on an almost flat alluvial plain with some upland nearby with local settlement and housing on these dry land areas. This site has the additional feature of a road running along one edge creating what ETESP is now calling a 'road dam' – meaning that the road is actually blocking natural soil drainage to some extent. There is a channel running parallel to the road at the edge of the site and it is not totally clear if this channel is irrigation supply or drainage – the farmer referred to it as drainage. If this is a drain then it removes surface water only and there is no proper outlet to allow the water to discharge downstream.

Figure 5.3 Road Dam Site 12-1**Figure 5.4 Road + Site and Fishpond**

The site was totally flooded but the water rainwater as the EC was 0.01 mS/cm whilst the irrigation supply had EC of 0.18 mS/cm.. The land was presently being prepared for cropping and, in the past a padi / palawija rotation was used. The first post-tsunami yield was poor at about 50% but the recent crop gave about 80% of predicted yield so the land seems well on the way to recovery.

Site 12-2 was very close to 12-1 and is rather similar in that it is bounded on two sides by roads but the road is not, in this instance protected by a concrete wall. The third side of the triangular site is bordered by a wall at the edge of a village / upland area with dry land crops and trees. Over the road on the down slope side of the site there are fish ponds but it would appear that, in this instance the “road dam” is actually protecting the site and preventing tidal and or sea water ingress into the site. This site with the road, fish pond and upland dry land area can be seen in Figure 5.4. The site has the same irrigation water supply / drainage system as Ste 12-1 and the drainage is towards the fishponds but there does not appear to be an obvious outlet to the ponds.

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 5.3 Land Preparation Post-tsunami EM38 Survey Data

Site	Land Use	Crop or land preparation	Soil	Notes
12 – 1	Sawah	Good crops obtained pre-tsunami - N: Urea, 200 kg/ha, - 35 % before planting - 35 % 21 days after planting 30 % before flowering P: Phosphate 200 kg/ha, applied before planting	Wet	Previous post-tsunami crop had 70% yield depression Present crop green and healthy looking Site flooded (irrigated) to 10 – 15cm
12 – 2	Sawah	Good crops obtained pre-tsunami - N: Urea, 200 kg/ha, - 35 % before planting - 35 % 21 days after planting 30 % before flowering P: Phosphate 200 kg/ha, applied before planting	Wet	Site flooded (irrigated) to 10 – 15cm

The land is categorized as Sawah and is being used for rice cropping.

Table 5.4 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
12-1	H	SCI	2.00	H	CI	1.09	0	0	0.01
12-2	H	SCI	1.56	ND	ND	ND	0	0	0.18

Water table depth and soil depth noted as zero since site flooded and no “dry” soil available for root zone

5.5 Problems

The significant conditions noted for these sites at the time of the EM38 survey were:

- good yields of Palawija crops were obtained pre-tsunami
- crop immediately after tsunami suffered 70% yield reduction
- present crops are medium to good

In December 2005 the fact that the sites did not appear to have any obvious drainage outlet was considered to be a problem and it was not actually clear if there was any real soil drainage. In the case of Site 12-2 the “road dam” may in fact be advantageous as it prevents ingress of salt water from the nearby fishponds.

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 5.5 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 5.6 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 5.5 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 12–1 and 12–2 would appear to have been leached
- The coloured coded column in Table 5.5 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	PROBLEM	Sediment
dS/m	RANKING	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 5.5 Assessment of the EM38 Dataset for the Sites in Jangka

Kec No	Kecamatan	Location	Site	EMv	EMh	Average	Samples	Sediment	Flood	Status	Check
							No	Cm	Days		
70	Jangka	Jangka Alue'u	12 - 1	78	73	75	8	1	3	Leached	Reading OK
			12 - 2	74	68	70	11	2	3	Leached	Reading OK
		Location Average		76	71	73	19	2	3	Leached	Reading OK

The colour coding in Table 5.5 indicates that even when the “maximum” values of salinity are considered there was, at worst, a “negligible” problem in this area at the time of the EM38 survey – all codes are either green or no colour code is applied as the soils are non-saline.

Overall these soils are classified as Salinity Class SC1 with only a few layers having ECe values in excess of 2dS/m. With well managed water applications under normal irrigation practice it should be possible to reduce the low level of salinity to even lower values, on the assumption that there is a soil drainage system.

Table 5.6 Salinity Measurements for Sites in Jangka

				Rhoades		Rhoades	ETESP Lookup			Salinity Class	
			ECe 0 - 30cm	ECe 30 -60cm	ECe 60 -90cm	ECe 0 - 90cm	ECe EMv	ECe EMh	ECe EMav	Rhoades	ETESP
Kecamatan	Location	Site	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m		
Averages											
Jangka	Jangka Alue'u	12 - 1	2.26	3.17	1.50	2.31	1.8	1.7	1.8	SC1	SC1
Location Mean		12 - 2	2.00	2.88	1.38	2.08	1.7	1.6	1.7	SC1	SC1
			2.1	3.0	1.4	2.2	1.8	1.7	1.7	SC1	SC1
Maximums											
Jangka	Jangka Alue'u	12 - 1	2.64	3.57	1.67	2.63	2.0	1.9	1.9	SC1	SC1
Location Mean		12 - 2	2.44	3.30	1.54	2.42	1.8	1.8	1.8	SC1	SC1
			2.5	3.4	1.6	2.5	1.9	1.8	1.8	SC1	SC1
Minimums											
Jangka	Jangka Alue'u	12 - 1	1.90	2.82	1.36	2.03	1.8	1.6	1.7	SC1	SC1
Location Mean		12 - 2	1.59	2.51	1.23	1.78	1.7	1.5	1.6	SC1	SC1
			1.74	2.67	1.30	1.90	1.75	1.54	1.63	SC1	SC1

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

5.7 Sediment Depth

Table 5.5 notes that the sediment depths deposited on the soil at the Simpang Tiga sites are considered a “negligible” hazard or problem as the depth range was only 2cm at worst. 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 full productivity assuming there is 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 EM38 survey.

The salinity problem is rated as “negligible” - colour coded green, with ECe values ranging from 1.7–3dS/m and only some, very minor reclamation leaching could be envisaged if water-table conditions allow 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 12-1 and 12-2 with careful soil and water management.

However, the existing minor salinity, whether it exists at the surface (0–30cm) or in the subsoil (60+cm) will NOT go away or reduce if, there is nil or very poor soil drainage. Indications are that these sites have drainage but it is not obvious just how good that drainage is or if it will cope in the long-term. An overall soil salinity figures was calculated from the EM38 data for these sites from:

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

Table 5.7 Comparison of Salinities from 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
Jangka Alue'u	12-1	2.06	2.31	1.80	2.26	3.17	1.70	2.00	1.09
Jangka Alue'u	12-2	1.88	2.08	1.70	2.00	2.88	1.60	1.56	ND

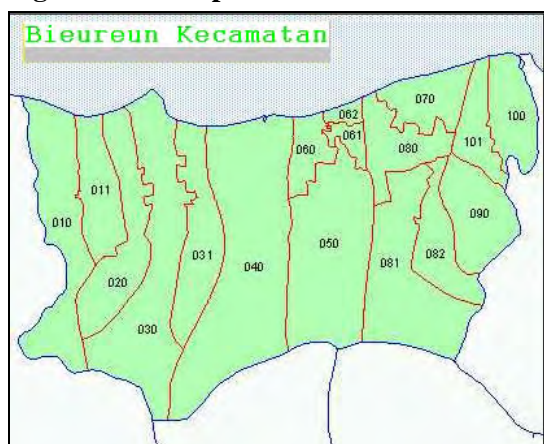
The situation at Site 12-1 has improved with the salinity of the sub-soil layer (25+cm) fallen to at least half of what it was at the time of the Em38 survey, it is being assumed that the situation at 12-2 is similar. However, as the salinity could fall lower still and allow yields to return to full pre-tsunami level and there is no obvious soil drainage from these sites it is strongly recommended that the drainage is improved. This intervention will lower salinity further and also help to prevent future build up of salinity through normal irrigated farming.

CHAPTER 6 GANDA PURA

6.1 Introduction

Kecamatan Ganda Pura is, as previously noted, relatively small, lies on the eastern boundary of the Kabupaten on the north coast of Sumatra, stretches about 14km inland from the coast and is labeled as 100 in Figure 6.1.

Figure 6.1 Kabupaten Bireuen



One location was subjected to a salinity survey by EM38 – details of the site are:

Lapang Timu - Site 11 with two transects,

- 11 – 1 with 17 samples points and
- 11 – 2 with 16 sample points

Coordinates were taken in December by ETESP and these are shown in Table 6.1

Figure 6.1 Location



The sites lie just north of the main road and the mauve line on the extract of the 1:50,000 topographic map above is a GPS trace of the road.

6.2 Salinity Survey

Two transects were done in this kecamatan but the exact locations cannot be shown as no geo-referencing data were included in the dataset passed to ETESP by BPTP.

Some salient facts about the sites are presented in Table 6.2, which has been compiled from study of the original dataset – MS Word document plus the Excel spreadsheet – and the maps available.

Table 6.1 Geographic Coordinates of Sites

Site	Deg N	Min N	Sec N	Deg E	Min E	Sec E	Altitude masl	Notes
11-1	5	14	17.4	96	54	3.3	12	Bireuen, Ganda Pura, Lapang Timu
11-2	5	14	20.7	96	54	3.7	10	Bireuen, Ganda Pura, Lapang Timu

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

Table 6.2 Transect Information

Name	Site	Days flood	Sediment (cm)	No	EM38 Points	Sediment	Landuse / Crop	Fertiliser	Notes
Ganda Pura	Lapang Timu	5	10	11 – 1	17	Mixed	Sawah	N & P	Crop harvested but 70% yield loss
		5	15	11 - 2	16	Mixed			

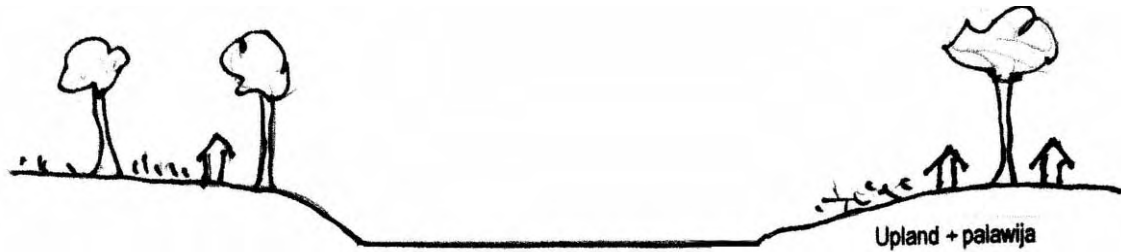
6.3 Site Descriptions

These site descriptions were compiled by ETESP after the site visit in December 2005.

Site 11-1 lies in the typical situation of most of the Bireuen sites in that it is on an almost flat alluvial plain with some upland nearby with local settlement and housing on these dry land areas. This site has the additional feature of a road running along one edge and the irrigation supply for Site 11-2 runs along, parallel at the other side of this road. At the time of the visit this irrigation channel was full to overflowing, with rainwater, and the overflow was passing over the road and draining into Site 11-1. This rather negates, or confuses, the farmers statement that there is no irrigation to

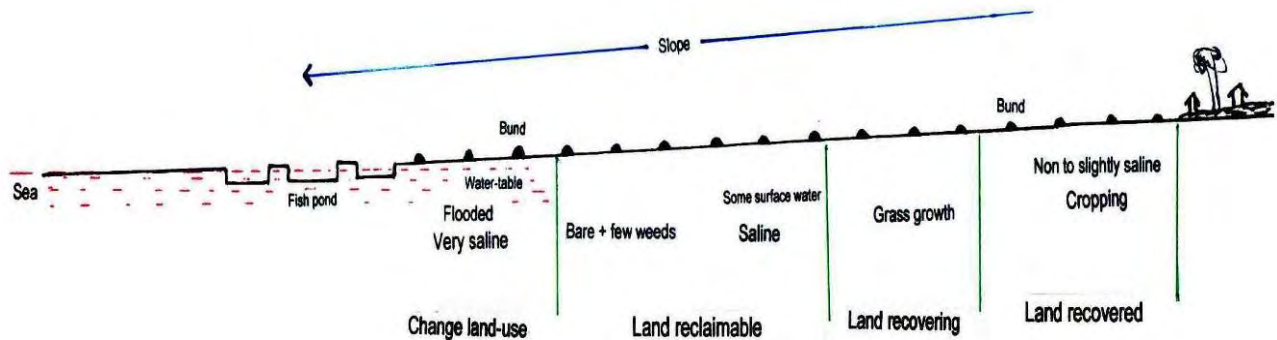
this site. There was, however, no drainage visible for this site. The site was 100% flooded with rain water (EC 0.67mS/m) and there was no crop in the ground. Normal farming pre-tsunami gave 1 – 2 crops of rain fed padi.

Figure 6.3 Idealised Cross Section for Site 11



Site 11-2 lies right at the top of the slope in an almost flat alluvial plain, located between islands of upland, and has the irrigation supply for this block of land as the upper boundary. The irrigation supply had water with EC of 0.01ms/cm. There was a drainage system but the first drains were, reportedly, quite far away down slope from the actual site. The farmer advised that pre-tsunami he could grow 2 – 3 crops of padi per year. There was no crop currently in the ground but the farmer stated that since the grass, growing on the site, was very even and very green he felt that it was now safe to plant his crops. Site 11-2 lies on the right hand side just below the dry land in Figure 4.3 in the area labeled ‘land recovered’ and as seen in Figure 6.6.

Figure 6.3 Down-slope Section for Site 11-2



No additional soil analytical or laboratory data have yet been located for this site.

6.4 Site Information from the EM38 Survey and ETESP

Table 6.4 Land Preparation Post-tsunami EM38 Survey data

Site	Land Use Type	Crop or land preparation	Soil	Notes
11 – 1	Sawah	Poor crop post-tsunami N: Urea, 200 kg/ha - 35 % before planting - 35 % 21 days after planting 30 % before flowering P: Phosphate 50 kg/ha, applied before planting	Very dry	Good crops pre-tsunami Crop just harvested so land not irrigated (wet). Yield reduction of about 70%
11 - 2	Sawah	Poor crop post-tsunami N: Urea, 200 kg/ha - 35 % before planting - 35 % 21 days after planting 30 % before flowering P: Phosphate 50 kg/ha, applied before planting	Very dry	Good crops pre-tsunami Site has many weeds in places

Figure 6.5 Irrigation Supply at Top of 11-2**Figure 6.6 Down valley over Site 11-2**

6.5 Problems

Massive reduction in yield post tsunami but now, almost one year on, the farmer estimates that the land has recovered – based on grass cover and condition. December 2005 salinity measurements by ETESP would appear to confirm the farmer's conclusion.

6.6 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 6.5 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 6.6 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 6.5 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 11-1 and 11-2 both show there has been some leaching.
- The coloured coded column in Table 6.5 is the ETESP assessment of the degree of problem that the original depth of sediment presented – the key is shown as Figure 6.7. The coding is also used for salinity

Figure 6.7 ETESP Problem Rating Key

ECe	PROBLEM	Sediment
dS/m	RANKING	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 6.5 Assessment of the EM38 Dataset for the Ganda Pura Sites

Kec No	Kecamatan	Location	Site	EMv	EMh	Average	Samples	Sediment	Flood		
							No	Cm	Days	Status	Check
100	Gandapura	Lapang Timu	11 - 1	81	69	75	17	10	5	Leached	Reading OK
			11 - 2	161	155	158	16	15	5	Leached	Reading OK
			Location mean	121	112	116	33	13	5	Leached	Reading OK

As indicated in Table 6.5 these two sites have been leached to some extent as it can be seen in Table 6.6 that the salinity figures are higher in the 30 – 60cm layer than in the top layer (0 – 30cm) – location mean being 3.3dS/m in the surface layer and 4.7dS/m in the upper sub-surface layer.

Site 11 – 1 is hardly colour coded at all indicating that this site has been classified as Salinity Class SC 1 – non-saline apart from layer two (30 – 60cm) which has a negligible salinity problem and colour coded green. This site was more or less reclaimed at the time of the EM38 survey.

Site 11 – 2 still had only a minor salinity problem with the topsoil being coded yellow (very slight problem) and the upper sub-soil blue (slight problem) with salinity values of 4.97 and 6.82 respectively. At the time of the EM38 survey this site would have benefited from reclamation leaching to reduce the EC values to 2dS/m or less.

Table 6.6 Salinity Measurements for Sites in Ganda Pura

			Rhoades			Rhoades	ETESP Lookup			Salinity Class	
Averages			ECe 0 - 30cm	ECe 30 - 60cm	ECe 60 - 90cm	ECe 0 - 90cm	ECe EMv	ECe EMh	ECe EMav	Rhoades	ETESP
Kecamatan	Location	Site	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m	dS/m		
Averages											
Gandapura	Lapang Timu	11 - 1	1.60	2.66	1.33	1.86	1.9	1.6	1.8	SC1	SC1
		11 - 2	4.97	6.82	3.20	5.00	4.0	3.9	3.9	SC2	SC1
	Location Mean		3.3	4.7	2.3	3.4	3.0	2.7	2.9	SC1	SC1
Maximums											
Gandapura	Lapang Timu	11 - 1	2.15	3.34	1.63	2.38	2.3	2.0	2.1	SC1	SC1
		11 - 2	8.71	11.89	5.57	8.72	7.7	7.4	7.6	SC3	SC2
	Location Mean		5.43	7.62	3.60	5.55	5.00	4.70	4.83	SC2	SC2
Minimums											
Gandapura	Lapang Timu	11 - 1	1.15	2.02	1.02	1.39	1.5	1.2	1.4	SC1	SC1
		11 - 2	1.47	2.53	1.27	1.76	1.9	1.6	1.7	SC1	SC1
	Location Mean		1.31	2.27	1.15	1.58	1.72	1.41	1.57	SC1	SC1

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

When the maximum values are considered it can be seen that Site 11–1 was almost all considered to have a “negligible” problem and is mainly colour coded green. Site 11–2 was considered to have a slight to moderate problem with salinities ranging from 5.57 to 11.89dS/m and coded from yellow (60 – 90cm Layer) through blue (ETESP determinations) to mauve in the top tow layers and overall from 0 – 90cm by the Rhoades formula.

As would be expected the minimum values show the site to be non-saline to having only a negligible problem with only the 30 – 60cm layer being colour coded, the rest is non-saline with values below 2dS/m.

6.8 Sediment Depth

Table 6.5 notes that the sediment depths deposited on the soil at the Site 11–1 was 10cm and considered a moderate problem whilst at 11–2 the sediment was 15cm deep, was considered a “moderately big” hazard or problem and this was manifested by the higher salinity at this site.

Other sites with sediments of this depth and low to moderate salinities are already being cropped and there is no reason why this site cannot also be restored to full productivity assuming there is a drainage system and water available for leaching and irrigation.

6.9 Conclusions & Recommendations

In summary, the data would appear to be reliable and there was a bit of a salinity problem at Site 11–2, though Site 11–2 was virtually in a reclaimed state..

The salinity problem at Site 11–2 was rated slight to moderate and this site would have benefited from reclamation leaching to reduce the ECe values to less than 1 – 2dS/m.

However, the existing minor salinity, whether it existed at the surface (0 – 30cm) or in the subsoil (60+cm) can NOT be reduced by leaching if there is nil or very poor soil drainage. 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)

Table 6.7 Comparison of Salinities from 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
Lapang Timu	11-1	1.83	1.86	1.80	1.60	2.66	1.60	0.46	0.56
Lapang Timu	11-2	4.45	5.00	3.90	4.97	6.82	3.90	0.62	0.07

The salinity situation at Lapang Timu seems to have improved dramatically and, it has to be said, that this virtually proves the ETESP hypothesis that if there is soil drainage, plus a supply of water for irrigation or leaching, the soils will be cleaned up and the salinity reduced.

At these sites there was no specific interventions to enhance the leaching that happened as a result of the continuing application of irrigation water plus rainfall, was the leaching of the salts out of these profiles. The saline leachate was then removed in the drainage system which, on a rapid field visit, did not seem to be that good..

Also, the theory that the depth of sediment was a big problem would appear to have been wrong and the depths of sediment appear to have been an unfounded worry or “red herring”. If the sediments are thoroughly mixed in with the native soil and subjected to leaching the salts are removed and the salinity problem can be over come. However, what now has to be established is “just how fertile” is the soil following the addition of the sediment plus all the leaching that has happened.

However, if the sediment had been coarse textured – that is sand – there would have been a problem since the sand would certainly have caused problems due to:

- Low inherent fertility
- Low fertility potential, and
- Low water holding capacity

However, shallow to moderate depths of sand can and should be incorporated, as recommended for other sediments, via tillage. If the land is then puddled the sand will start to settle at the bottom of the plough layer and could, in fact be beneficial for drainage – but fertility would need to be continually monitored and a slight change in irrigation frequency or gift size would need to be considered.

The above scenario at Site 11-2 is what has been recognized as ETESP Scenario 5.

CHAPTER 7 SOIL RECLAMATION and IMPROVEMENT

7.1 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 sodium on the soil exchange complex by 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), the depth of soil to be reclaimed and a reliable estimate of the quantity of water necessary to reduce soil salinity to a level where crops can be economically produced.

For Bireuen there has been a fair amount of natural leaching of the soils due to the fact that many of the sites fall within properly designed irrigation schemes where there has been a supply of irrigation water, in addition to rainfall, and an active drainage system. Accordingly, several of the sites do not need any reclamation intervention and, for the Bireuen sites, a decision has been made based on the average, existing salinity as measured by ETESP in December 2005. The existing salinity values have been sorted in “increasing” order in table 7.1 and when the average salinity of the upper 50cm is less than 1dS/m it is classed as NOT needing reclamation leaching.

On this basis the soils at sites 9-1, 11-2, 8-1, 8-2, 11-1 and 14-1 need no leaching intervention and with good water management these soils will continue to desalinise.

Table 7.1 Features of the Sites

Kecamatan	Location	Site	Existing Salinity Dec05 (dS/m)	Reclaim Leach Needed	Soil depth to recover (mm)	Depth of water table (mm)	Drainage System	Irrigation System in use	Soil PSC
Jeumpa	Batee Tomoh	9-1	0.25	No	NA	NA	Yes	Yes	H
Ganda Pura	Lapang Timu	11-2	0.35	No	NA	NA	Yes	Yes, good	H
Jeumpa	Kuala Jeumpa	8-1	0.45	No	NA	NA	ND	Yes	H
Jeumpa	Kuala Jeumpa	8-2	0.45	No	NA	NA	ND	Yes	H
Ganda Pura	Lapang Timu	11-1	0.51	No	NA	NA	No	No	H
Samalanga	Meulik	14-1	0.67	No	NA	NA	Yes, poor	Yes	H
Jangka	Jangka Alue'u	12-1	1.55	Yes	600	750	Yes, poor	Yes	H
Jangka	Jangka Alue'u	12-2	1.56	Yes	600	750	Yes, poor	Yes	H
Jeunieb	Teupin Keupula	13-1	2.57	Yes	600	750	Yes, poor	Closed	M
Jeumpa	Cot Geureundong	10-1	2.69	Yes	600	750	Yes, poor	Yes, poor	H

NA Not Applicable as leaching not required

However, the sites in Jangka (12-1 and 12-2), Jeunieb (13-1) and one site in Jeumpa (10-1) do need to be improved and reclaimed via a leaching intervention.

7.2 Water Requirements for Salinity Reduction

As stated above, several of the sites in this kabupaten do not need any leaching intervention. The sites that do require leaching 10-1 in Jeumpa, 12-1 and 12-2 in Jangka and 13-1 in Jeunieb are all presently flooded and they have either poor drainage systems or no obvious drainage system at all; resulting in very high water tables. There is no way these sites can be leached at present

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, 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 be installed since the furrows between the beds can act as the first level of soil drain (Refer ETESP Scenario 1). A soil depth of 600mm (60cm) should be the target depth to recover – as this is an acceptable rooting depth for most palawija crops.

The textures of the soils at the various sites were noted by ETESP in December and the textures are all relatively fine with most field recordings showing silty clay or sandy clay loam to clay, though one site (13-1) appeared to be a loam rather than a clay loam. The textural group of the soils is noted in Table 7.1 and the PSC allocated is what has been used in the ETESP tools to calculate the depth of leaching water required.

The available data were then inserted into the tool (Leaching Water Requirement.XLS) for determining the depths and volumes of water required for reclamation – the outputs are seen in Table 7.2.

Table 7.2 Water required for reclamation

Kabupaten	Add	Add	Add	Add	Add	Auto	Add	Auto	Add	Auto	Auto	Leaching	Water	Auto
	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	H2O table depth (mm)	Max soil depth reclaimable (mm)	Reclamation Required	Dlw (mm) DEPTH LEACHING WATER	Dlw m ³ /ha CUBIC METRES WATER / Ha	Weekly Pptn Bonus (mm)
Jeumpa, Cot Geureundong	10 - 1	Jun	H	600	2.69	SC1	0.9	SC1	750	500	Yes	149	1494	10
Jeunieb, Teupin Keupula	13 - 1	Jun	M	600	2.57	SC1	0.9	SC1	750	500	Yes	143	1428	10
Jangka, Jangka Alue'u	12 - 2	Jun	H	600	1.56	SC1	0.9	SC1	750	500	Yes	87	867	10
Jangka, Jangka Alue'u	12 - 1	Jun	H	600	1.55	SC1	0.9	SC1	750	500	Yes	86	861	10
Samalanga, Meulik	14 - 1	Jun	H	300	0.67	SC1	0.9	SC1	200	50	No			10
Ganda Pura, Lapang Timu	11 - 1	Jun	H	300	0.51	SC1	0.9	SC1	200	50	No			10
Jeumpa, Kuala Jeumpa	8 - 1	Jun	H	300	0.45	SC1	0.9	SC1	200	50	No			10
Jeumpa, Kuala Jeumpa	8 - 2	Jun	H	300	0.45	SC1	0.9	SC1	200	50	No			10
Ganda Pura, Lapang Timu	11 - 2	Jun	H	300	0.35	SC1	0.9	SC1	200	50	No			10
Jeumpa, Batee Tomoh	9 - 1	Jun	H	300	0.25	SC1	0.9	SC1	200	50	No			10

Source: Leaching water requirement.XLS

The various outputs from Table 7.2 are given below with explanations.

Maximum soil depths that can be reclaimed:

Only the sites that require leaching are discussed here. For the palawija crop that would be grown during the leaching, or soon after the process starts, the aim would be to reclaim 600mm (60cm) depth, as this is a reasonable rooting depth for most of the crops that would be grown. However, not the full 600mm can be reclaimed and this has been reduced to 500mm (50cm) at all sites that require reclamation due to the presence of a water table (750mm or 75cm). Capillary rise from the water table will continually move any salts in the water back into the planned root zone.

Depths of leaching water required:

The depths of leaching water that must pass down through the various soils that do need leaching are, in fact, all quite low and the depths range from about 85mm to 150mm, as can be seen in Table 7.1.

The sites have been split into 2 groups on the basis of the texture of the soil since different textured soils require different volumes of water to bring them to field capacity before leaching starts. These groups are:

- Medium textured soils – “M” PSC, this soil is found at Site 13-1, and
- Fine textured soils – “H”, these soils are found at Sites 10-1, 12-1 and 12-2

(a) The Medium Textured or “M” PSC Soil

Location	Site	Leaching Water Requirement (mm)	Depth of water to apply (mm)	Notes
Jeunieb, Teupin Keupula	13-1	143	650	6 – 7 irrigation gifts of 100mm each

(b) The Fine Textured or “H” PSC Group

Location	Site	Leaching Water Requirement (mm)	Depth of water to apply (mm)	Notes
Jeumpa, Cot Geureundong	10-1	149	550	5 – 6 irrigation gifts of 100mm each
Jangka, Jangka Alue’u	12-1	86	400	4 gifts of 100mm each
Jangka, Jangka Alue’u	12-2	87	400	4 gifts of 100mm each

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 7.3 below.

7.3 Leaching Progress

The other tool that has been used at this time is the spreadsheet “Leaching Progress.XLS”. The reclamation requirement is that application of several irrigation gifts of 100mm are made to achieve the target amount 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 5-7 days apart – this is to allow the soil surface 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 are dissolved and leached out.

Table 7.3 Depths of water passing through the soil layers – medium texture

Medium (PSC M)			Accumulative Water Passing thro layer			
Irrigation No	Water applied (mm)	Water entering soil (mm)	Layer 1 (0 - 25)	Layer 2 (25 - 50)	Layer 3 (50 - 75)	Layer 4 (75 - 100)
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	70

The medium textured soil requires that 143mm pass down through the depth being reclaimed, target was 600mm. Study of Table 7.3 shows that after 6 irrigations 150mm should have passed down through the 50cm (500mm) depth. After the 7th irrigation about 190mm will have passed through the 50cm depth and well over the required 143mm will have passed below 60cm since 130mm will have already passed below 75cm depth.

That is, to reclaim this soil to a depth of 600mm (60cm) means that 6 to 7 irrigation gifts of 100mm each will achieve to be applied, and applied in an intermittent manner. In total about 700mm of water will have to be applied to this site.

For the fine, or heavy, textured soils the requirement is that 86 – 143mm of leaching water have to pass through the full depth being reclaimed. Study of Table 7.4 shows that after 4 irrigations over 100mm has passed below 50cm hence Sites 12-1 and 12-2 will be reclaimed with 4 irrigations.

Table 7.4 Depths of water passing through the soil layers – fine texture

Heavy	Textured Soil	(PSC H)	Accumulative Water Passing thro layer			
Irrigation No	Water applied (mm)	Water entering soil (mm)	Layer 1 (0 - 25)	Layer 2 (25 - 50)	Layer 3 (50 - 75)	Layer 4 (75 - 100)
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

Site 10-1 requires 150mm to pass down through the profile and this will have happened after 5 to 6 irrigations. In total between 500 and 600mm of water will have to be applied to achieve this.

7.4 Recommendations for Soil Reclamation and Improvement

Very little more can be said about these sites apart from re-stating that before any reclamation leaching is attempted soil drainage must be installed and in working order. If the saline leachate that is produced cannot be removed from the site then reclamation will not happen. The basics for reclamation are:

- Establishing the actual soil depth available for the crops in question to exploit – governed by the crop type, water table depth, depth of soil drain and season of the year
- Establishing the depths of the various water tables at the sites
- Checking the soil texture and particle size class of the soils at the sites
- Establishing the status or presence of any soil drainage and its efficiency
- Establishing there is an irrigation system to ensure there is an adequate supply of suitable leaching water
- The soil surface should be thoroughly tilled / ploughed to ensure as even a tilth as possible and that any sediment is well mixed in
- The leaching should be done in the dry season when water tables are at maximum depth
- Leaching would be better done on raised beds to allow the furrows between the beds to act as the first level of drain. If flood irrigation has to be used the system should be as small basins to ensure as even a spread of water as possible
- Irrigation gifts would be better applied via overhead irrigations using watering cans or other appropriate technology delivery system; these gifts would be applied in an intermittent manner

Table 7.4 Number of Estimated Irrigations for Reclamation

Kecamatan	Location	Site	Existing Salinity Dec05 (dS/m)	Reclaim Leach Needed	Soil depth to recover (mm)	Depth of water table (mm)	Soil PSC	Leaching water required mm	Number of 100mm Irrigation gifts
Jeumpa	Batee Tomoh	9-1	0.25	No	NA	NA	H	0	NA
Ganda Pura	Lapang Timu	11-2	0.35	No	NA	NA	H	0	NA
Jeumpa	Kuala Jeumpa	8-1	0.45	No	NA	NA	H	0	NA
Jeumpa	Kuala Jeumpa	8-2	0.45	No	NA	NA	H	0	NA
Ganda Pura	Lapang Timu	11-1	0.51	No	NA	NA	H	0	NA
Samalanga	Meulik	14-1	0.67	No	NA	NA	H	0	NA
Jangka	Jangka Alue'u	12-1	1.55	Yes	600	750	H	86	4
Jangka	Jangka Alue'u	12-2	1.56	Yes	600	750	H	87	4
Jeunieb	Teupin Keupula	13-1	2.57	Yes	600	750	M	143	6 – 7
Jeumpa	Cot Geureundong	10-1	2.69	Yes	600	750	H	149	5 - 6

NA not Applicable as reclamation leaching not required

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

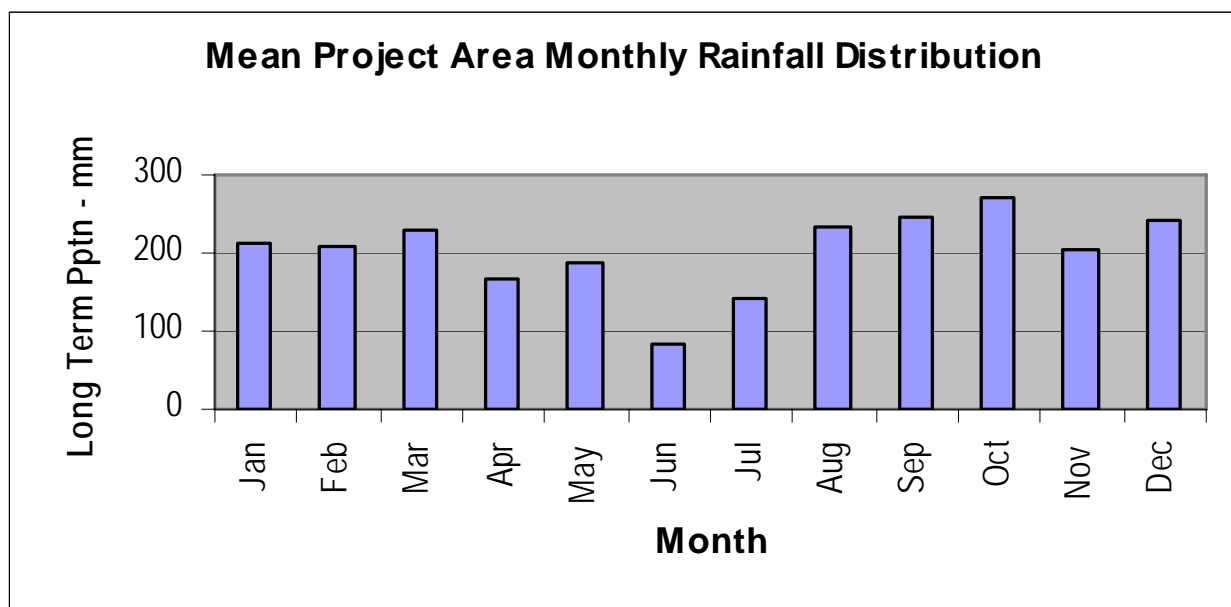
Recent local advice is that the figure for Simeulue should be about 3,000 and not the above quoted 1127 or 1244mm.

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

Code Name	8	16	7	15	12	1	9	10	11	5	Overall
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)

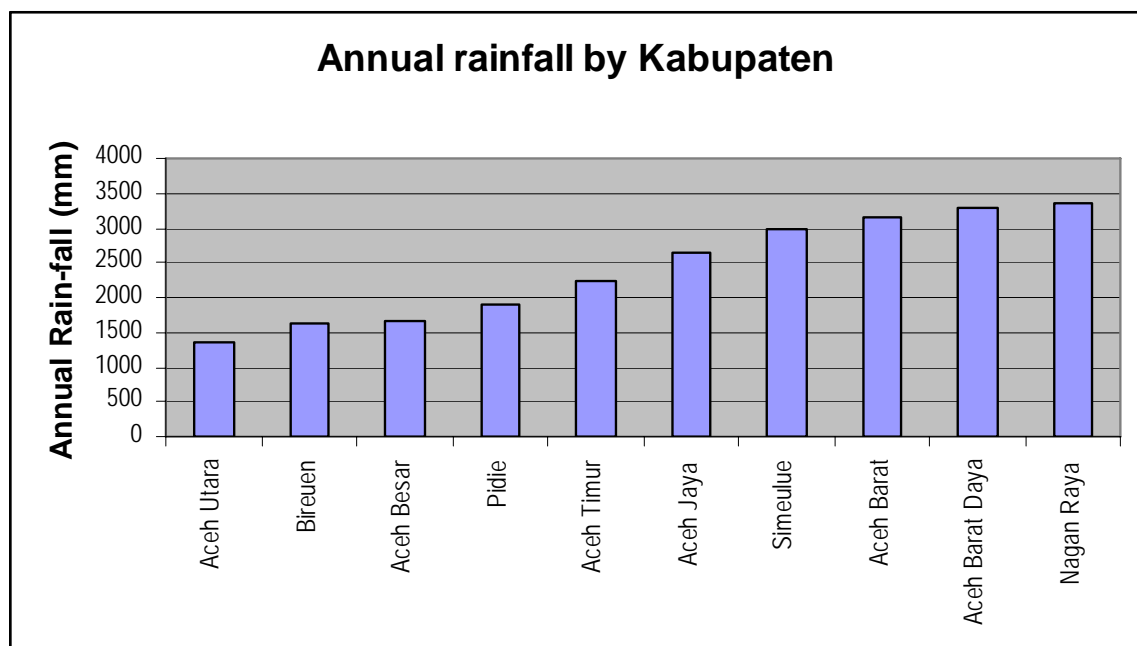


Figure 3 Districts (Kabupaten) in the Study and Long Term Precipitation



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.

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	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 for
Month	mm	%	mm	%	mm	%	mm	%	mm	%	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																																

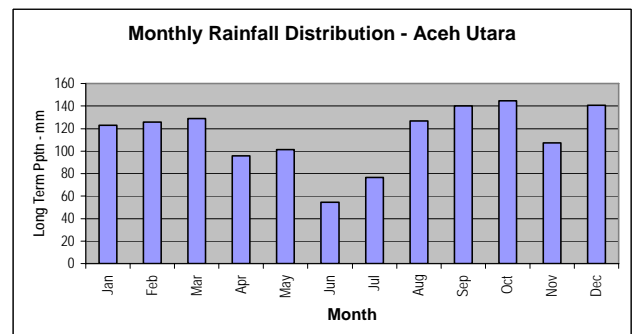
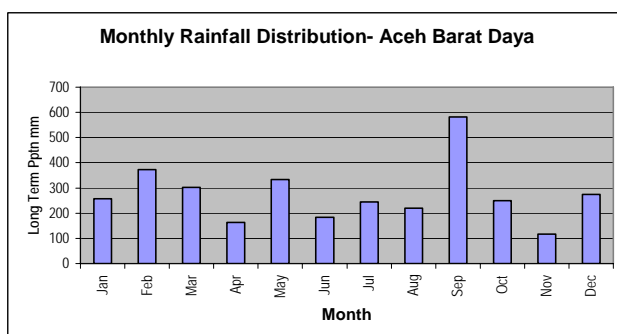
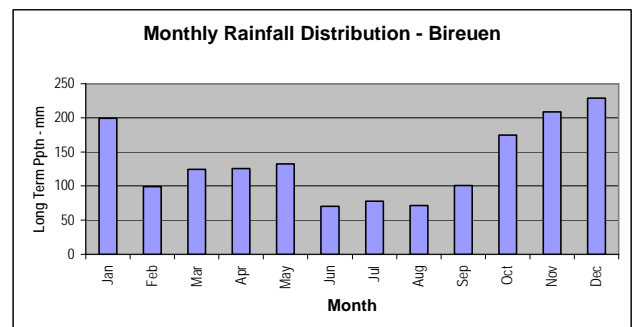
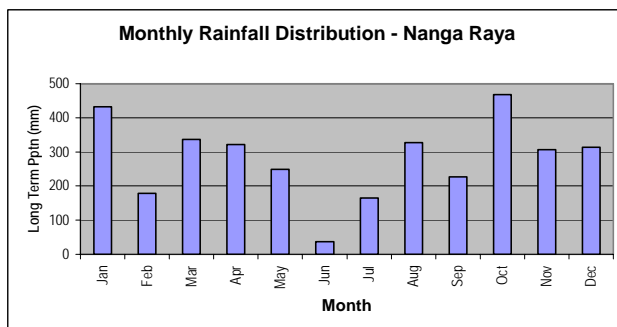
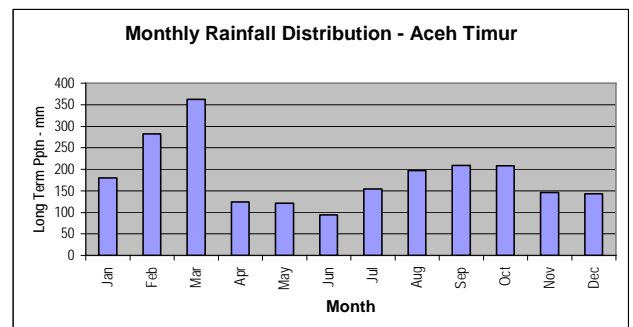
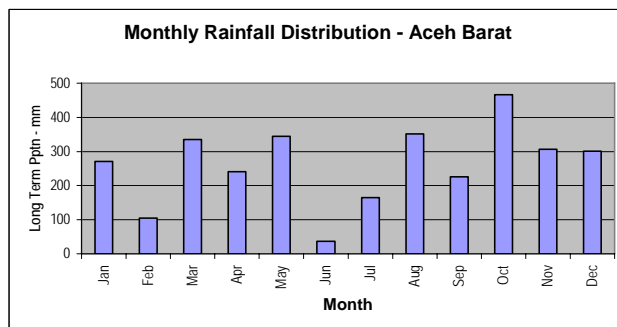
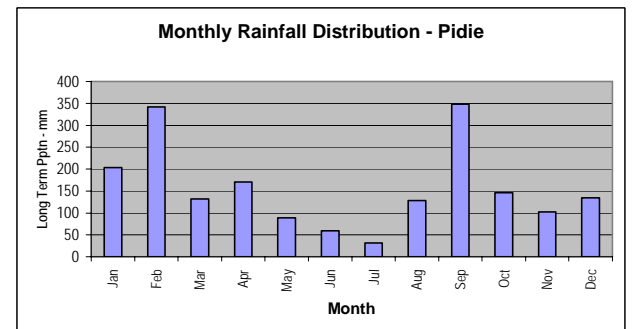
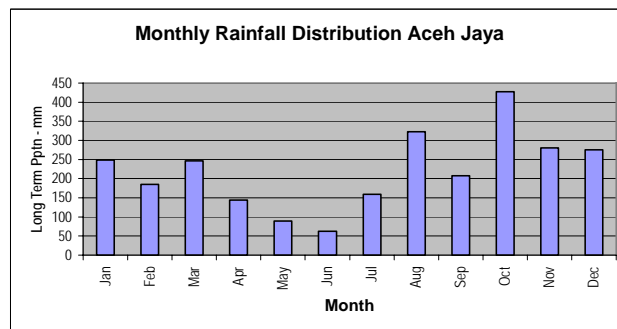
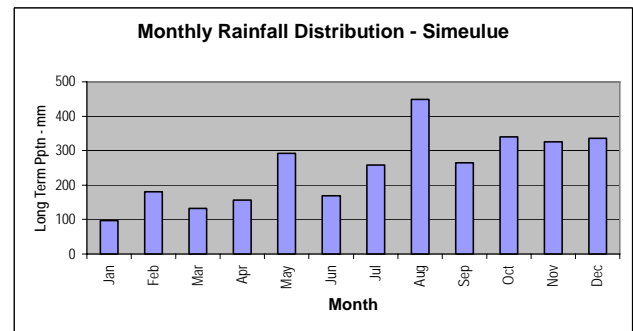
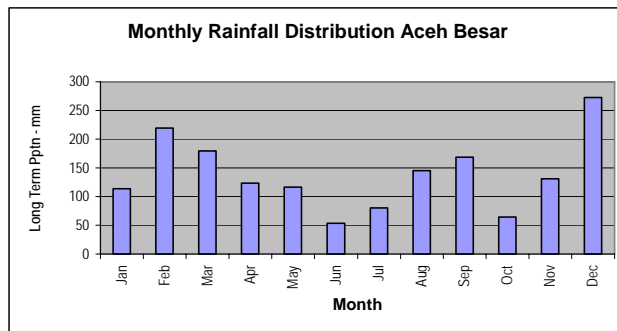
This sheet shows Simeulue as having an annual rainfall of about 1130mm

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 Name	8		16		7		15		12		1		9		10		11		5		Overall																							
	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	
Month	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	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
Location	mS/cm EMv	mS/cm EMh	mS/cm Avg	0 - 30cm dS/m	30 -60cm dS/m	60 -90cm dS/m	0 - 90cm dS/m	EMv dS/m	EMh dS/m	EMav dS/m	Tsunami dS/m	Tsunami 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 C.3)
- 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	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

Figure C.2 Overall Averages for Kabupaten Aceh Besar

							Rhoades	ETESP Lookup				Salinity Class	
							ECe	ECe	ECe	ECe			
							0 - 90cm	EMv	EMh	EMav	Rhoades	ETESP	
Kecamatan		Samples	Sediment	Flood	Status	Check	dS/m	dS/m	dS/m	dS/m			
		No	Cm	Days									
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												Rhoades ECe 0 - 90cm dS/m	ETESP Lookup				Salinity Class	
Aceh Besar Averages													ECe EMv dS/m	ECe EMh dS/m	ECe EMav dS/m	Rhoades	ETESP	
Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check							
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	
Location average			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	
				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	
Location average			16 - 2	60	93	76	10	3		Saline topsoil	Reading OK	2.3	1.4	2.2	1.8	SC1	SC1	
				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

												Rhoades	ETESP Lookup				Salinity Class	
												ECe 0 - 90cm	ECe EMv	ECe EMh	ECe EMav	Rhoades	ETESP	
Aceh Besar Maximum Values							Samples	Sediment	Flood									
Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	No	Cm	Days	Status	Check	dS/m	dS/m	dS/m	dS/m			
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	
Location average			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	
				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

Table C.5 Minimum Values of Manipulated Data

											Rhoades	ETESP Lookup				Salinity Class	
											ECe 0 - 90cm	ECe EMv	ECe EMh	ECe EMav	Rhoades	ETESP	
Kabupaten	Kecamatan	Location	Site	EMv	EMh	Average	Samples No	Sediment Cm	Flood Days	Status	Check	dS/m	dS/m	dS/m	dS/m		
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
Location average			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
			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
Location average			16 - 2	44	77	71	9	3	3	Saline topsoil	Reading OK	1.9	1.0	1.8	1.7	SC1	SC1
			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 D REFERENCES

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