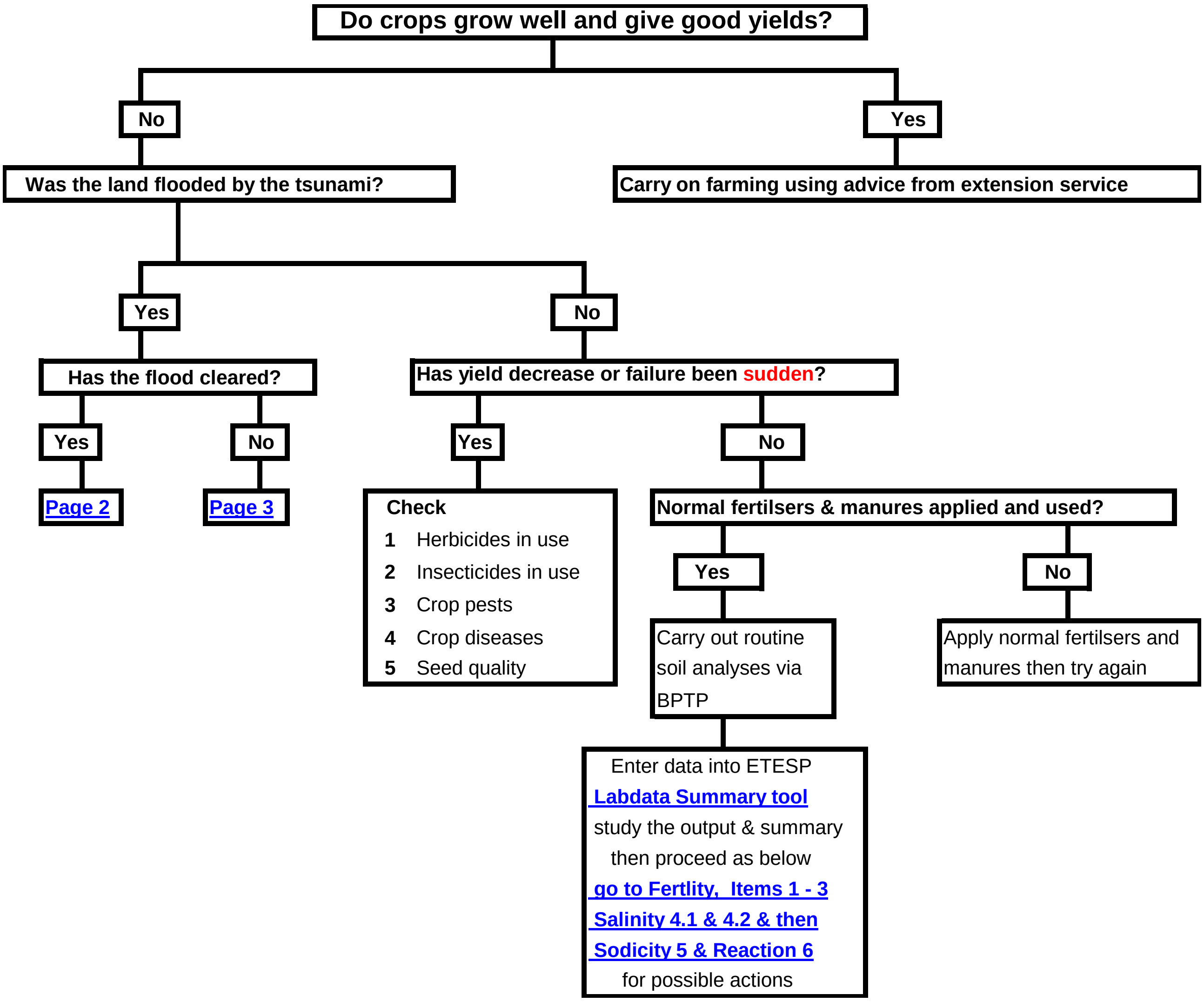
EARTHQUAKE AND TSUNAMI EMERGENCY SUPPORT PROJECT

ETESP

ETESP Land and Soil Problem Assessment Tool



May 2006

Contents

1. INTRODUCTION

Between October 2005 and May 2006 the ETESP Agriculture Soil Salinity and Improvement Specialist reviewed all relevant data which he could access, built up tools to address the problems pinpointed and described scenarios where many of these problems occurred. The various reports and tools are listed in Appendix A to this report.

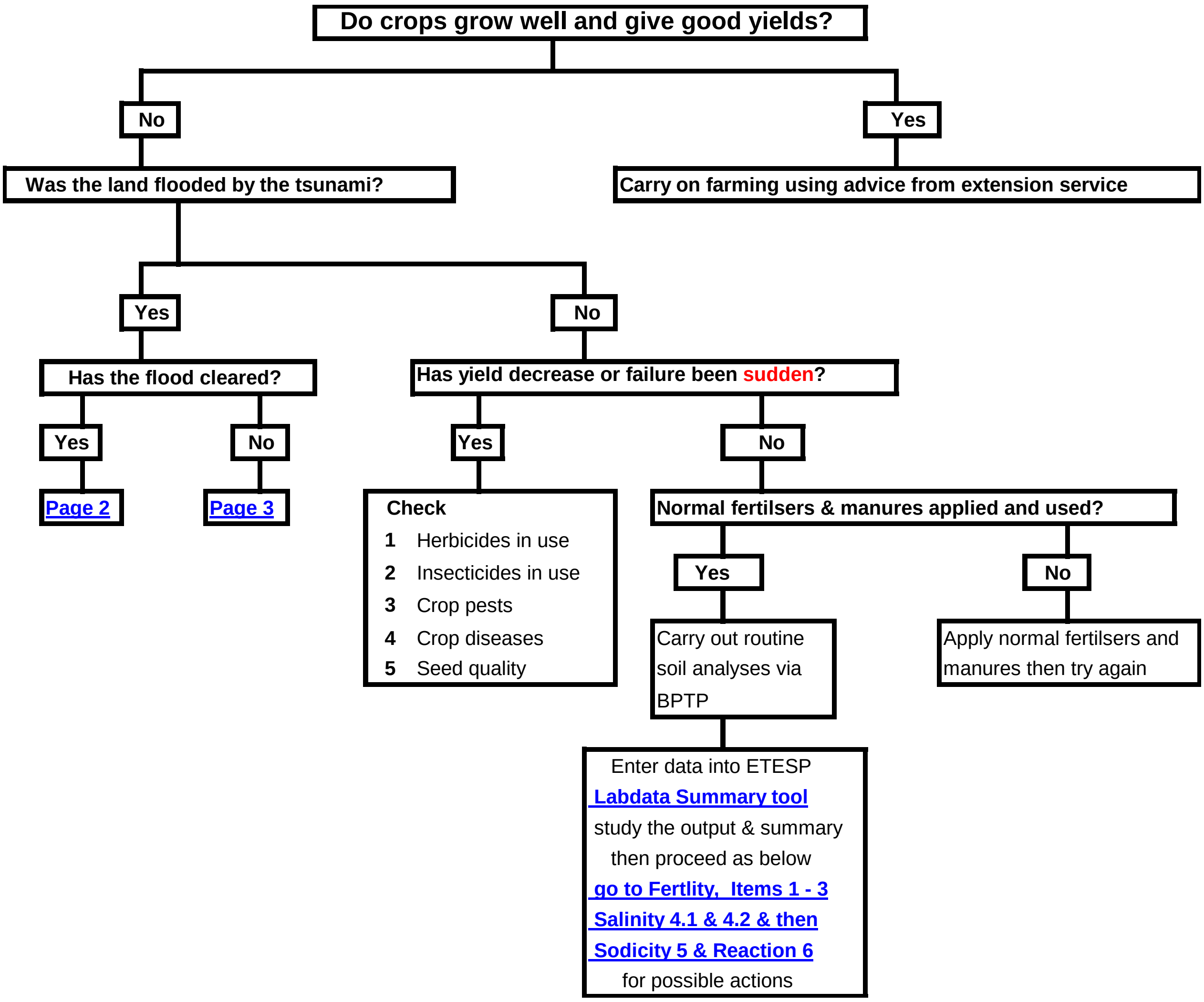
The tool described in this report has been compiled to allow the non-expert in soils, land-use, agriculture or computing to try and pinpoint just what problems he faces and also supply some, if not all, of the necessary interventions that might have to be taken to rectify the perceived problems. The main use of the tool is expected to be by trainers whilst capacity building within the agriculture sector, in particular within Dinas Pertanian.

The tool comprises a spreadsheet in MS Excel designed as a decision tree, where most of the responses to a relatively simple question is YES or NO. By following the tree explanations and possible actions are found. The design was also such that the tool could be printed out and this document is basically the Instruction Manual for the Tool. The page and section numbers shown in blue in the figures of this document are hyperlinks in the actual tool and the page numbers are tool page numbers and not page numbers of this document.

1.1. Start

The first question is obviously "Do crops grow well and give good yields"? A good yield means "is the yield acceptable" and is the farmer making a profit from his inputs?

Figure 1 Is there a problem?



As can be seen in Figure 1 above the tool has in-built "hyperlinks" which, when clicked, a jump is made to the page where the situation found is further explained. Hyperlinks are coloured "blue" and underlined.

As can be seen above where crops are apparently growing well there is no advice given, if advice were given it would be aimed at improving yields and that is not the purpose of ETESP. Advice on how to improve yields which are already acceptable should be sought from the Extension Staff of Dinas Pertanian.

The pages of the tool are presented in the order that they appear in the actual spreadsheet.

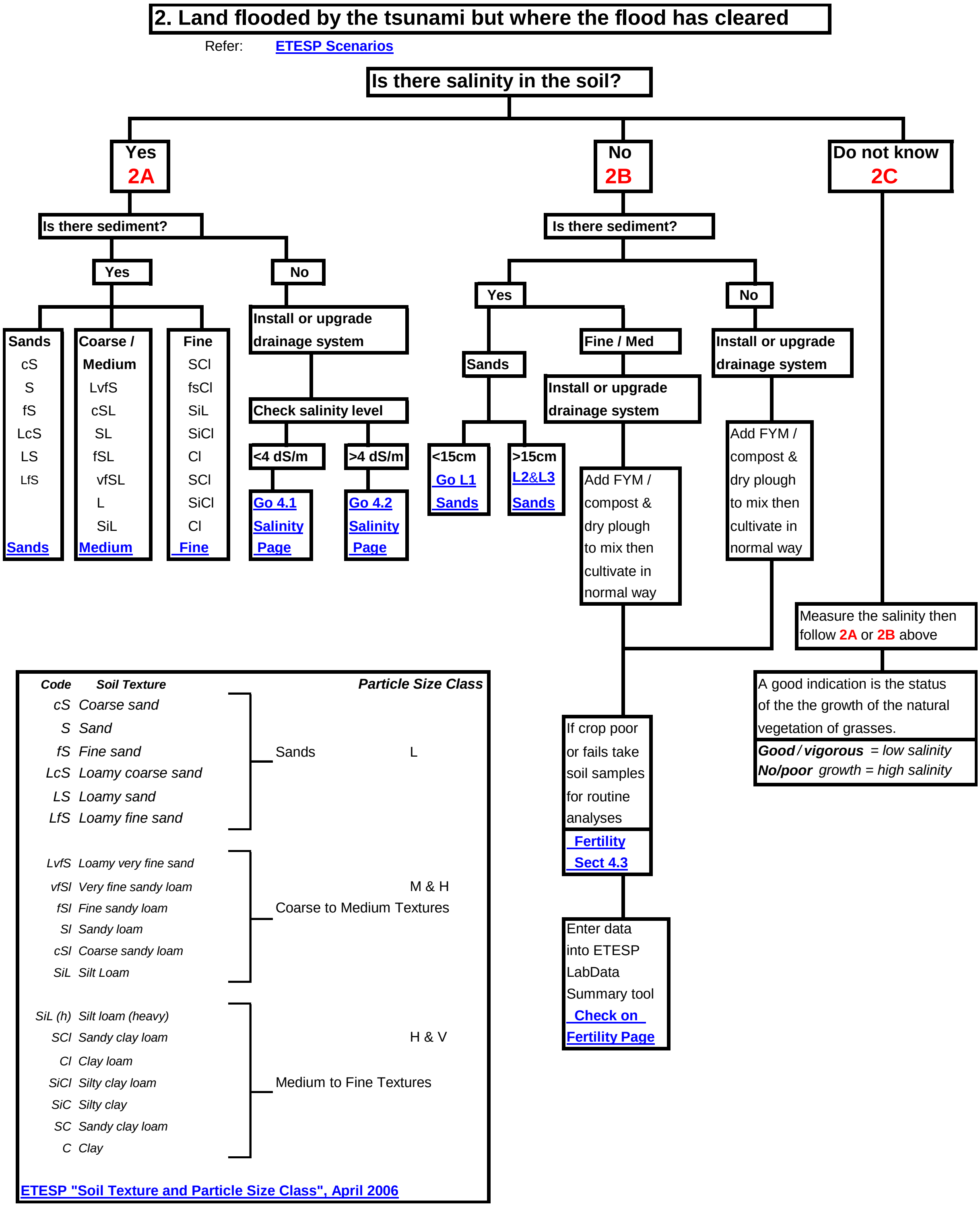
2. LAND FLOODED BY THE TSUNAMI BUT WHERE THE FLOOD HAS CLEARED

2.1 Introduction and Scenarios

This land, in theory, should have been some of the least damaged by the tsunami since the flood cleared quickly. Note that by damage we are talking about soil damage and NOT physical damage to infrastructure or the accumulation of vast amounts of debris.

The first "hyperlink" found on this page takes you to the various scenarios found and described by ETESP Agriculture. These scenarios try to give a pictorial display with photos and diagrams as to what has happened to the land due to the tsunami as well as list the necessary actions. The first question on this page is if the soil is saline or not with answers "Yes", "No" and "Do not know".

Figure 2 Where the Flood has Cleared



2.2 Where the Soil is Saline

In many areas there is some data existing as to whether the soil is saline or not and to what degree the soil is saline. Where salinity does exist follow the path marked as **2A** in the decision tree.

The next question to answer is, if there is sediment deposited by the tsunami or not.

If there is sediment it has to be established if that sediment is composed of sand, coarse textured, medium textured or fine textured materials (Refer to ETESP "Soil Texture and Particle Size Class"). When the texture of the sediment has been established the decision tree then shows which page to go to next.

Where there is no sediment the interventions start at this point and it has to be checked if there is a soil drainage system and, if there is, does that system work? If there is no drainage system then one has to be installed and if there is a poor system then it has to be upgraded with the field drains extending to a full 100 cm depth. Padi roots penetrate to 100 cm depth and the drains should go to that depth to ensure the soil can be properly desalinsed. Refer to:

- ETESP "Soil and land Reclamation Scenarios" and
- ETESP "Soil Conditions for Wetland Rice".

When the level of the salinity has been established the decision tree sends you to items on the "Salinity" page:

- When salinity is less than 4 dS/m the necessary actions are listed under Section 4.1, and
- When the salinity exceeds 4 dS/m the actions required are listed under Section 4.2.

2.3 Where the Soil is Non-saline

In many ways this is the picture when the soil has escaped very lightly and did not get salinised or where the salinity that did exist in the soil has been leached out. Areas where the soil did not get saline were in places which had reasonable slope and /or there was a good system of drainage or a river which gave the flood an easy passage back to the sea. An actual situation of where there was an actual river can be found at Lhoong in Aceh Besar and where the land was sloping with working drains was noted in Lambadeuk, Aceh Besar. Follow the path noted as 2B in the decision tree.
Refer:

- Site Visit report – Lhoong
- Red Cross Site – Lambadeuk

The next point to be established in path 2B is if there is sediment or not and if that sediment is sandy, (Refer to ETESP "Soil Texture and Particle Size Class) medium or fine in texture.

If the sediment is sandy then the tool takes you to the page for sands and the section that you have to then follow depends on whether the sand is less (Section L1) or more than 15 cm deep (Section L2 or L3).

If the sediment is of fine or medium texture, or if there is no sediment, then the interventions start here with:

- the addition of organic materials, farm yard manure (FYM) or composts
- dry ploughing to mix the sediment plus the organic material with the underlying original soil, and then
- cultivating in the normal manner as used before the tsunami

2.4 Where no Data Exist about Soil Salinity

Where no data exist (2C) then the soil has to be tested and this can be done in the field or by taking soil samples and sending them to the laboratory. Field testing is recommended as it is much quicker and can be done with:

1. Hand held salinity meter – this is a relatively cheap and easy to use instrument but does supply limited data
2. EM38 salinity probe or device – this is an expensive piece of equipment and a more complicated device, needs an expert operator who also needs the ability to interpret the results but it can supply a great deal of information. Refer ETESP Data Assessment and Reclamation reports:
    - Aceh Besar Kabupaten
    - Banda Aceh Kota
    - Bireuen Kabupaten, and
    - Pidie Kabupaten
3. Failing that, the status of the local vegetation can and does give a good indication of the salinity status of the soil or site with strong or vigorous, mixed vegetation indicating non or only slightly saline conditions whilst poor growth indicates saline conditions and a total lack of native grasses and vegetation indicates very saline conditions. (Refer ETESP Field Tour Report , Chapter 4, February 2006).

When the salinity status has been established then path 2A or 2B can be followed.

2.5 Final Checks

As and when the soil salinity has been deemed to have levels low enough to allow cropping the performance of the crop has to be me monitored and, if the crop fails, then soil samples have to be taken from the full depth of the soil down to 100 cm. The recommendation is that bulk samples are taken from:

- 0 – 25 cm
- 25 – 50 cm
- 50 – 75 cm and
- 75 – 100 cm and sent to the laboratory for analyses to determine if there is salinity at depth and / or fertility problems.

Information on this is supplied on the fertility page. Once the data are received from the laboratory the results for the various features measured should be entered into the ETESP "LabData Summary" tool which appends "ratings" as to whether any nutrient is low, moderately high or in excess etc and it also compiles basic summaries for the topsoil and subsoil covering:

- Overall inherent fertility of the sample
- The fertility potential, or ability to hold nutrients that get added as fertilisers
- The soil reaction or acidity
- The soil salinity
- The soil sodicity plus also calculates and is summarises
- Possible deficiencies of particular nutrients are noted, and
- Warnings about possible risks from other features arising from the chemistry of the soil are presented (However, it should be noted that some of the risk warnings are, to some extent, experimental and not to be totally accepted since they are dealing with very complicated factors).

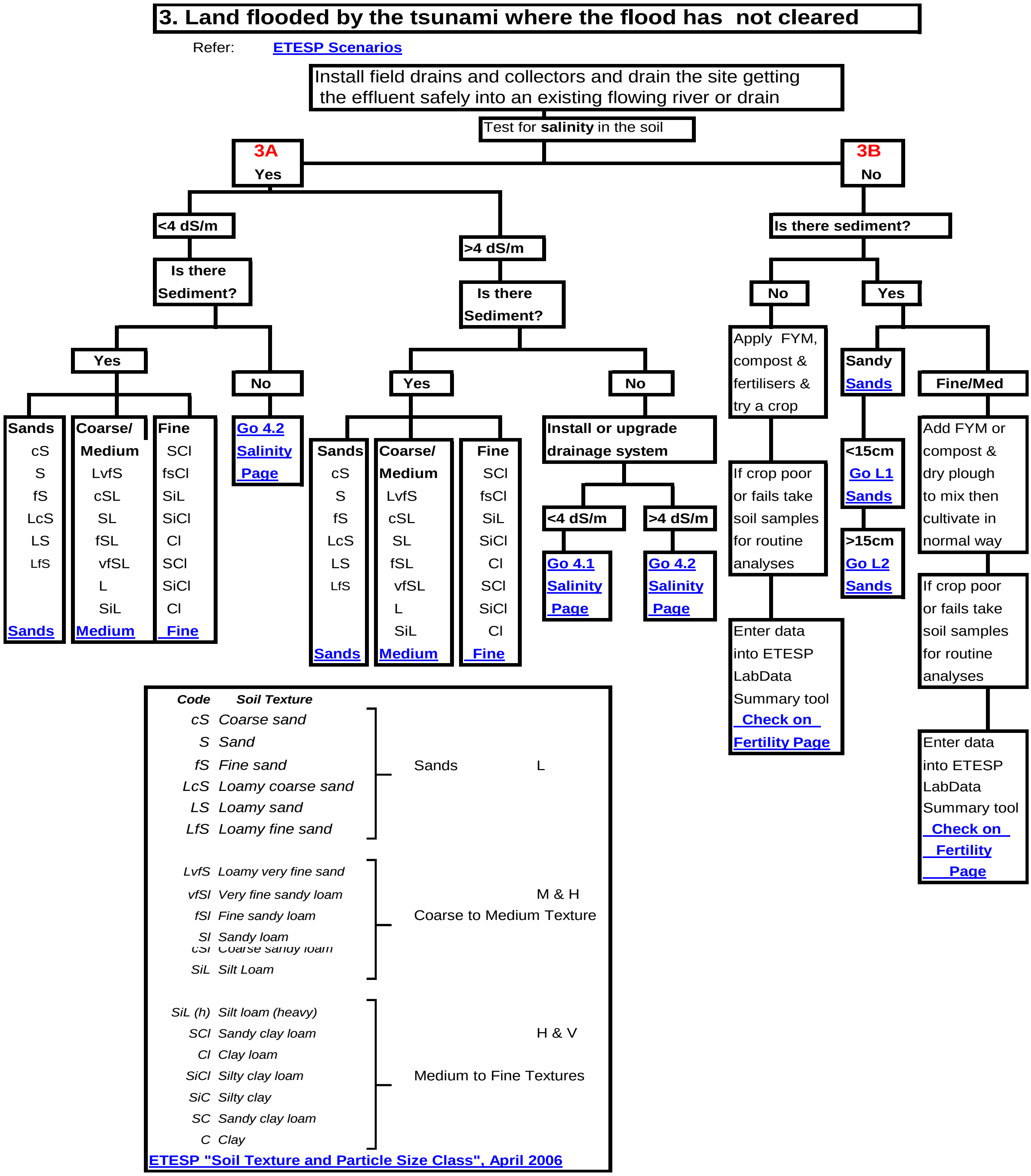
3. LAND FLOODED BY THE TSUNAMI WHERE THE FLOOD HAS NOT CLEARED

3.1 Introduction and Scenarios

This land is some of the most seriously damaged by the tsunami since the saline flood-water has remained on the land and soil salinisation has, in some cases got worse in the year or so since the disaster. Note that by damage we are talking about soil damage and NOT physical damage to infrastructure or the accumulation of vast amounts of debris.

The first "hyperlink" found on this page takes you to the various scenarios found and described by ETESP Agriculture. These scenarios try to give a pictorial display with photos and diagrams as to what has happened to the land due to the tsunami as well as list the necessary actions. The main relevant "Scenarios" are Numbers 2, 3, 4 and 6 with 9 having a strong influence.

Figure 3 Where the Land is still Flooded



The necessary interventions begin at the top of this page of the decision tree where the instruction is "Install field drains and collectors and drain the site getting the effluent safely (environmentally) into an existing flowing river or drain". Unless saline, flooded land has drains installed the land will never be desalinsed as the salt will become trapped in the soil and move up and down the profile depending on the season and the state of wetness or dryness of the soil.. The processes involved are explained to some extent in Scenario 1. Drain depth is explained in ETESP "Soil Conditions for Wetland Rice".

Once drains have been installed, are operational and the floodwaters removed from the site the salinity level of the soil has to be established and a "Yes" or "No" answer leads to branches **3A** and **3B** of the decision tree respectively.

3.2 Soil is Saline

As on Page 2 of the tool the next step is to determine if the salinity is >4 or < 4 dS/m and the processes are virtually identical from here onwards as on Page 2, so no further explanation is offered.

3.3 Soil is Non-saline

As on Page 2 it has to be determined if the non-saline soil has sediment or not and, if it has, then the texture has to be determined and the process is identical to that on page 2 from this point forward.

3.4 Final Checks

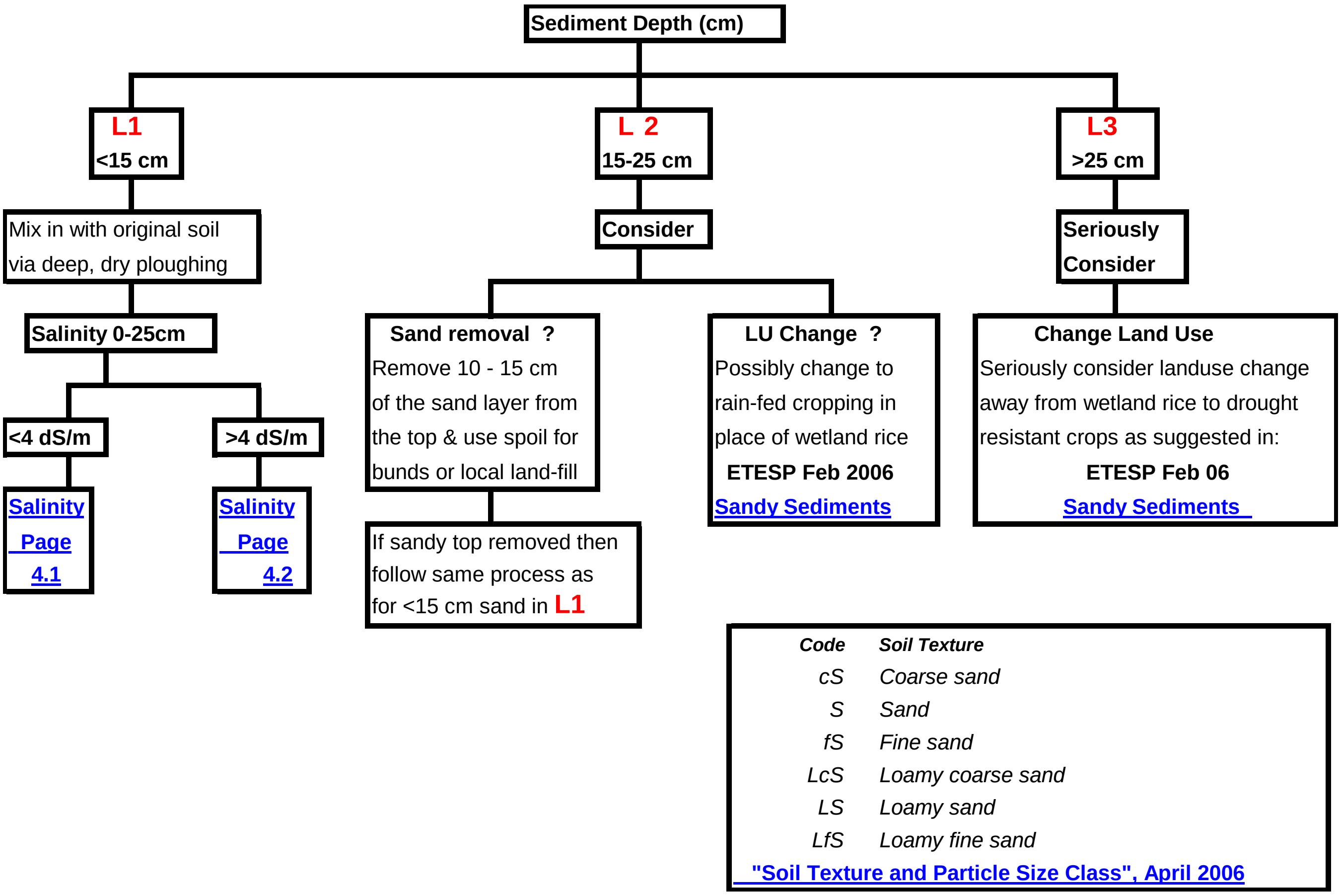
As and when the soil salinity has been deemed to have levels low enough to allow cropping the performance of the crop has to be me monitored and, if the crop fails, then soil samples have to be taken from the full depth of the soil down to 100 cm. The recommendation is exactly the same as presented in Section 2.4, that is bulk samples are taken from the four 25 cm layers down to 100 cm depth.

4. SANDY SEDIMENTS

4.1 Sands and Textures

All the standard sand textures, apart from loamy very fine sand (LvfS), are included in this group and texture is explained in ETESP Soil Texture and Particle Size Class. These materials all fall into the sandy or coarse particle size class (PSC) of the USDA system and carry the symbol L.. This PSC has in excess of 70% sand and 15% or less clay. The sandy sediments are treated on their own since sands have specific features which render them generally unsuitable for agriculture and particularly unsuitable for wetland rice cultivation. The additional problemsof the depth of sandy deposits laid down by the tsunami are also considered since the depth of sand varies quite a bit and there can be several ways to deal with the various depths. Some additional data and information on sands and the tsunami can be found in ETESP Report "Sandy Sediments".

Figure 4 Sandy Sediments



4.2 Sand Problems

The main problems with using sands for agriculture are connected with the two main features of sands – they have very little ability to retain moisture, that is they have low AWHC, and they also are inherently very infertile. When it comes to irrigated agriculture sandy textures can be used but certainly not with surface flow though they can be eminently suited to overhead or spray type irrigation. However, there is not much in the way of high tech irrigation systems in use in Aceh.

If cropping is to be considered on these sands the crops to consider first and foremost would be those that the local farmers would have grown on sandy or coarse textured areas before the tsunami. The following crops are presented with the known criteria that will be of importance. The main things to be considered are:

- Does the crop have tolerance to periods of drought? These soils have low AWHC!
- Does the crop have high or low nutrient demand? These soils are inherently infertile!

Table 4.1 Crops for Sandy Soils

Crop	Preferred Soil	Tolerance to drought	Salinity (dS/m) Tolerance	Nutrient Demand	Suitable	Data Source
Ground nut	Medium to coarse	Medium	3.2 – 6.5	Medium	Yes	Bookers
Soybean	Medium to coarse	Medium to low	5.0 – 10.0	Medium to low	Yes	Bookers
Coconut	Medium to coarse	Low	2.5 – 10.0	Low	Yes	Bookers
Oil Palm	Medium to coarse	Low	1.0 – 2.5	Medium to high	No	Bookers
Water Melon	Medium to coarse	Not determined	2.5 – 10.0	Low to medium	Possibly	Bookers

4.3 What to do with the Sands

As can be seen in Figure 4 the decision tree offers three suggestions for the sandy sediments and the decisions are dependent on the depth of the sandy sediment.

4.3.1 Sediment Depth of 15 cm and less

If the sediment depth is 15 cm or less (L1 option) it is suggested that the sediment should be dry-ploughed into the underling originals soil after the addition of organic material to boost fertility and fertility potential. A good plough, such as a moldboard, should be able to mix sand of this depth well into the original soil as it should be possible to till the soil to about 25 cm.

The next step would then be to flood the soil and "puddle" in the normal way for wetland rice cultivation. If the puddling is done well the result should be that the sand fraction settles out first leaving the finer material, from the original soil, to settle on top of the sand. If this happens then the resultant surface layer may not be that different from the original soil and flood irrigation could be possible.

The intervention would then continue with determination of the salinity of the 0-25 cm layer with the necessary steps or actions described in Sections 4.1 and 4.2 of the Salinity page.

4.3.2 Sediment Depth of 15 – 25 cm

Two possible courses of action (L2 option) are suggested for sandy sediments of this depth:

1. Physically remove most of the sand to bring the original soil much nearer the surface. Various methods have been talked about to achieve this including;

- Manually digging the sand up and carrying it off site or to the edge of the field, where it could be used to build up bunds or inter-padi-field areas for dryland crops
- Using heavy machinery to push the sand off the surface (bull-dozer or grader), or
- Mechanical shovels to pick and load the sand into trucks

Sand removal, as suggested above, would be a major task, whether it is done by "people-power" (manual labour) or via contractors using heavy machinery. This would involve huge expenditures of time and / or funds depending on use of manual labour or contractors and machinery. The reasons for undertaking sand removal would need to be fully justified and could be influenced by:

- Social reasons – the area to be cleared may always have been an important area for livelihoods and the requirement may still exist and the people may not want, or be able, to consider changing their way of life and farming
- Padi production – the area may have previously been a very productive area for paid with highly suitable soils and it is felt that the land just has to be recovered

As suggested the "spoil" (material moved) could be used for several purposes, but a use has to be found locally as it would be a large, unnecessary expense to truck the spoil long distances for disposal. Some possible uses could be:

- Building up "protection" banks or bunds to protect the recovered land from further flooding. The flooding risk would normally be from the sea as virtually all the sites with sand are close to the ocean. Refer ETESP "Sandy Sediments – the damage the tsunami caused", March 2006.
- When the sand is moved manually one of the easiest disposal routines would be to build up raised beds between the padi fields being cleared and use the raised areas for such things as Kelapa or suitable dryland crops. The advantage in this method would be the very short distance the sand would have to be transported
- Increasing the height of, filling-in undulations or depressions within or forming new raised areas to be used for dryland farming or Kelapa
- Increasing the height of, filling-in undulations or depressions within or forming new raised areas to be used for house construction or new village developments

2. Change land use away from irrigated to dryland cropping or tree growth. ETESP Report "Sandy Sediments" March 2006. This option should be considered as an alternative, or even in preference, to "moving" sand whenever possible since the expenditures are much lower and, with the cultivation of the correct crops, returns could be better than from resuming padi production.

4.3.3 Sediment Depth >25 cm

The option (L3) should be seriously considered when the sand depth is greater than 25 cm; often the depths are as much as or greater than one metre and removal of the sand would be a huge civil engineering task and horrendously expensive. In addition to the sand-related problems detailed under **L1** and **L2** the mere depth of the sand will almost certainly mean that the land is no longer under command of the previous irrigation system, in fact the whole system of canals and channels could be buried to some depth.

Option **L3** is that the land use is changed and, with these depths of sand, irrigation will be out of the question – unless high-tech or very labour intensive overhead systems are employed. High-tech systems would be "spray" systems whilst labour intensive systems would involve the use of watering cans. The latter would be very labour intensive since so much water would have to be applied since the deep sands would rapidly absorb, but not hold, large volumes of water due to their infiltration rates and low AWHC. Refer ETESP Sandy Sediments for crop suggestions.

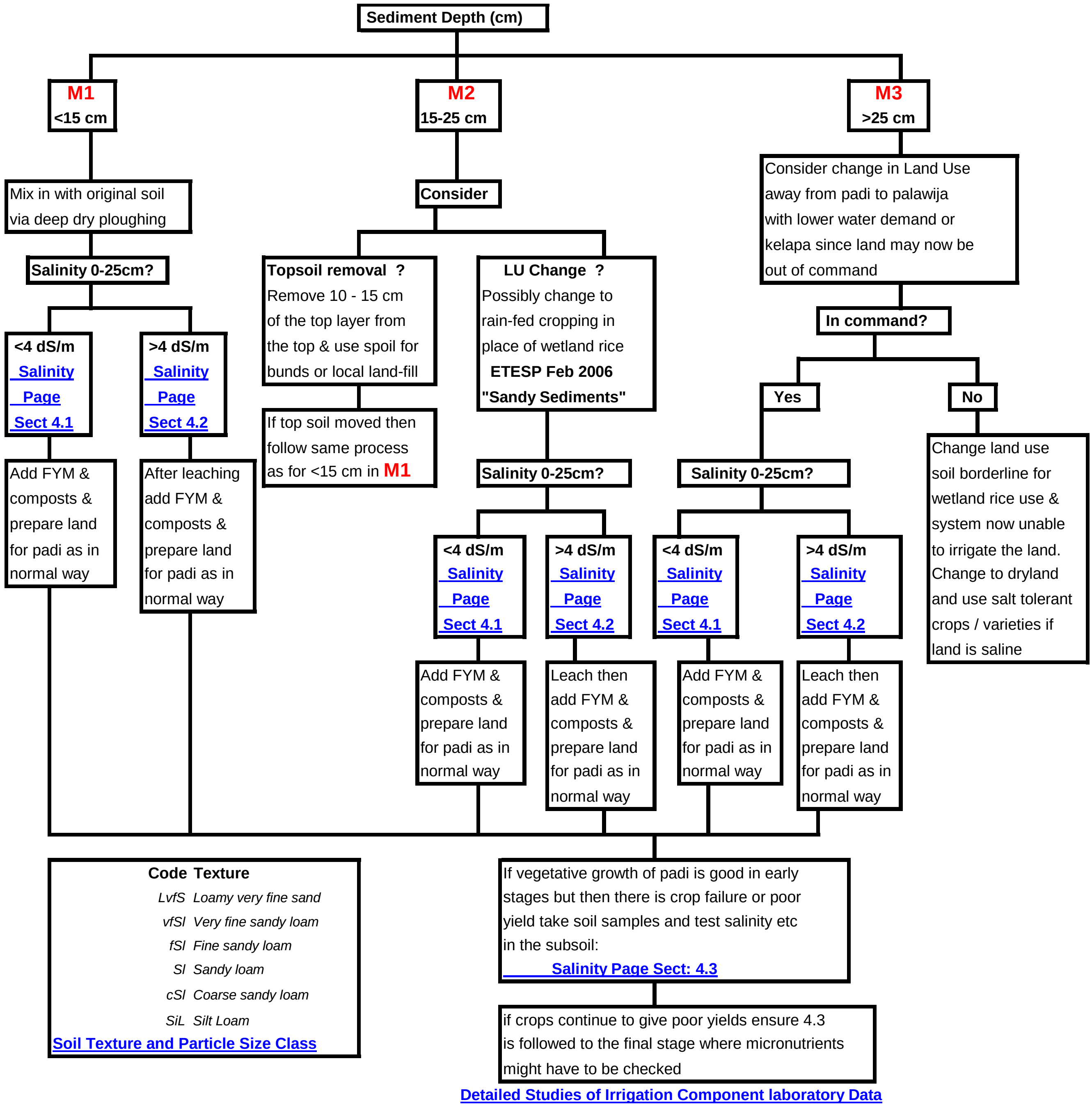
5 COARSE to MEDIUM TEXTURED SEDIMENTS

5.1 Introduction

Coarse to medium textured sediments covers the textural range from loamy very fine sand to silt loam. The textures included in this group can be seen in Figure 5 and further information on textures can be seen in ETESP Soil Texture & Particle Size Class, April 2006. In the USDA system these materials fall into the coarse-loamy particle size class (PSC) with the symbol M. This PSC comprises materials composed of between 15 – 70% sand and 15 – 18% clay with the balance being silt . This group comprises soils that have many properties that are similar including available water holding capacity (AWHC), fertility potential (CEC) and inherent fertility.

With similar properties the uses of the various soils will be similar as will the associated problems. As far as the effects from such textured sediments is concerned the main feature that has to be considered is the depth of the sediment – and that is the starting point on this page of the tool. With these textures the depth of sediment is important mainly from the standpoint of "is the land still within command of the original irrigation system?" The salinity of the soil is then considered.

Figure 5 Coarse to Medium Textured Sediments



5.2 Sediment Depth <15 cm

Where the sediment depth is 15 cm or less the first thing to do is mix the sediment in with the original soil by ploughing – option M1, this is best done when the soil is NOT flooded and it is better not to add organic manures and composts but wait till the salinity of the land has been determined.

If the salinity is 4 dS/m or less then the land can be prepared for padi in the normal way with puddling plus addition of organic manures and mineral fertilisers. It has been established that at such salinities most varieties of rice can grow and the leaching effects of normal irrigated cultivation will leach out the remaining low level of salt.

If the salinity is greater than 4 dS/m the procedures as set out on the salinity page, Section 4.2 and eventually 4.3 must be followed.

5.3 Sediment Depth 15 – 25 cm

Where the sediments fall into this depth class there are more options to consider – M2. If the land must be used for wetland rice cultivation then removal of the top 10 – 15 cm of sediment could be considered since with the medium type textures infiltration rate makes the topsoil less than perfect for padi cultivation. If padi does not need to be grown then a change to other crops is recommended as a less demanding and less expensive option – in fact careful selection of crop could lead to better farm income than can be obtained from padi.

If the topsoil is removed then the process to follow after removal is exactly as detailed in path M1 in the decision tree and as set out in 5.2 above. The uses of the spoil would also be exactly the same as when sands are removed.

If land use change is planned then the salinity of the soil has to be checked and decisions made as to whether:

- The salinity is low enough to allow immediate growth of salt tolerant crop and varieties, or
- If soil reclamation leaching has to be undertaken, or
- Is the soil now out of command and too high to be irrigated, and hence leached, from the original supply?

If padi does not need to be grown then a change to other crops is recommended as a less demanding and less expensive option – in fact careful selection of crop could lead to better farm income than can be obtained from padi.

If the land has to be used for padi the process is basically the same as in path M1 with determination of the salinity then proceeding with padi planting if less than 4 dS/m and leaching if greater than 4 dS/m. However, it must be realised that water use will be less efficient than pre-tsunami since the (new) lighter surface soil textures have greater intake (infiltration) rates and poorer AWHC than the original heavier soil and these factors mean that there may not be sufficient water to obtain equivalent production as in pre-tsunami days.

One factor that has not been included in path M2 is the possibility that the land may actually now be too high to be irrigated from the original supply and this could be a reason for deciding to remove the top few centimeters of sediment. This might be the deciding factor as to which path is followed.

5.4 Sediment Depth > 25 cm

When the sediment depth is >25 cm there is every chance that the land will now be "out-of-command" and cannot be leached or irrigated from the original irrigation supply. The first decision that should be made should be based on the facts that:

- The land is / is not within command, and
- Such soil is not really suitable for flood irrigation as used in padi cultivation

Because of this, the first message in path M3 is to consider land use change, but it is accepted that there can be reasons beyond the technical suitability of the land for padi and the land may have to be used. If padi does not need to be grown then a change to other crops is recommended as a less demanding and less expensive option – in fact careful selection of crop could lead to better farm income than can be obtained from padi and more efficient use of the water supplies.

The general assumption in the decision tree is that padi will be grown and the steps to take to achieve this are given with the next step being to determine the salinity level as in the other paths already described. It is possible that when such areas are prepared for rice cultivation the intake (infiltration) rates will slowly revert to pre-tsunami rates after the land is 'puddled" a few times. This can happen and is a simple result of soil physics in that the heavier sand fractions in the soil settle out before the finer, lighter silt and clay fractions and hence layers of silt or clay can, and will, be formed at the surface.

6. MEDIUM to FINE TEXTURED SEDIMENTS

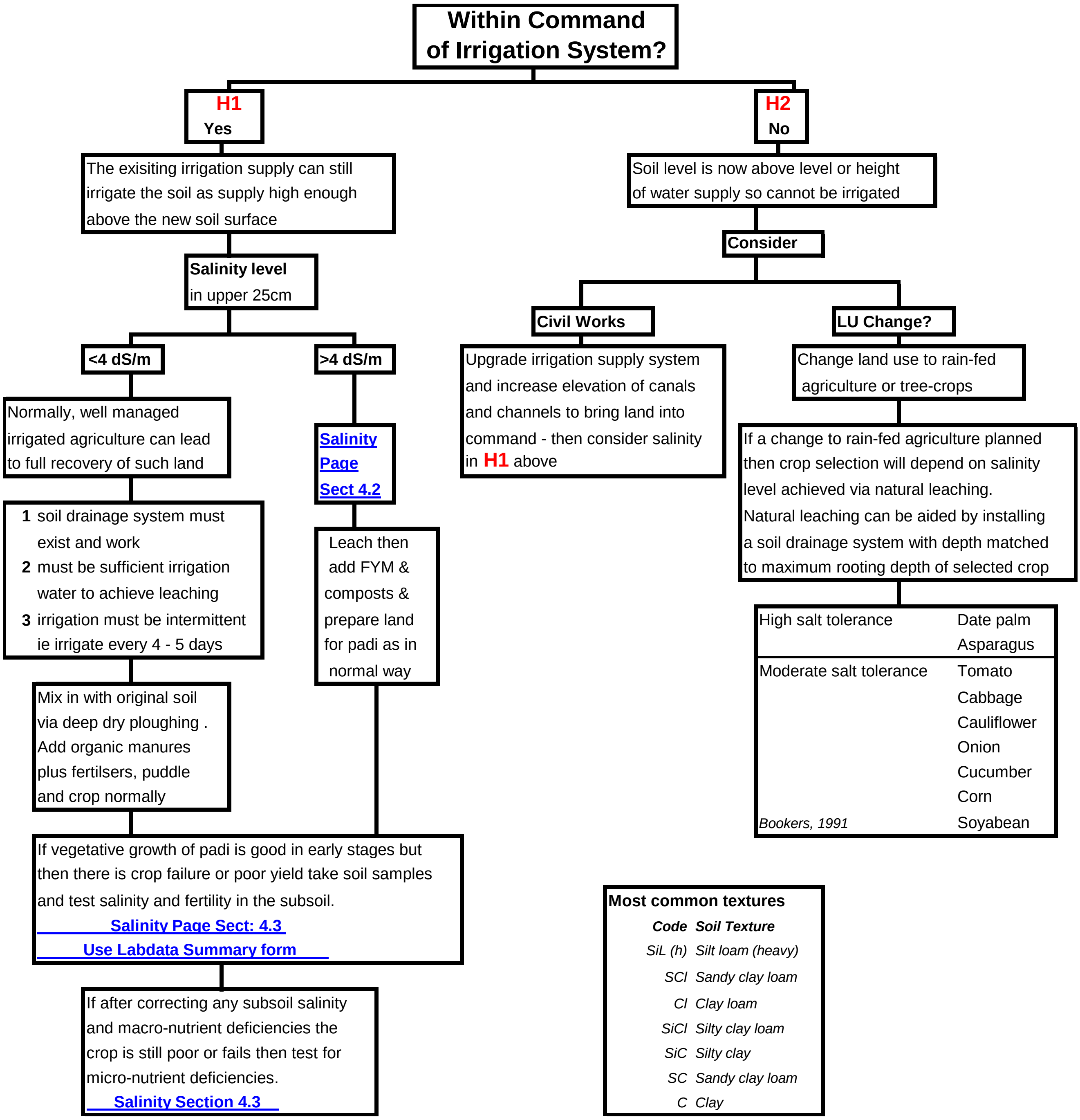
6.1 Introduction

By fine textured sediments we are speaking about material with texture between sandy clay loam or silt loam to the various clays that are defined in soil science. The textures and variations can be seen in ETESP "Soil texture & Particle Size Class", May 2006. In the USDA system these soils fall in the fine-loamy (symbol H - with in excess of 18% clay) to fine (V with in excess of 35% clay) and very fine (VV - with in excess of 60% clay) particle size classes.

Generally these soils have greater fertility potential (CEC) and higher moisture holding abilities (AWHC) than the coarse and medium textured soils. Also, the higher the clay and silt content then the lower the intake or infiltration rate of moisture and more suited they are to padi.

Hence, deposit of such sediments is not always a bad thing and many farmers report that their farms have improved due to such deposits. (ETESP "Field tour Report", February 2005). ETESP has concluded that such material originated by redistribution of surface soil by the tsunami flood and generally did not originate from marine deposits.

Figure 6 Medium to Fine textured Sediments



6.2 Effects from Medium to Fine Sediment Deposits

As stated above some farmers have reported that the tsunami deposits have improved their farms. This is quite understandable if the process was as hypothesized by ETESP Agriculture (Soil Conditions for Wetland Rice and Sandy Sediments, March 2006), in that, once the tsunami dumped its main load of sand (from the ocean) close to the coast the wave then proceeded to redistribute the surface soils over which it flowed. In this way fine-textured surface soil would and could have been deposited in areas that previously had degraded or coarse-textured soils.

Hence, if a farm was covered in fine sediments it could have ended up with improved water holding capacity (AWHC), improved fertility potential (CEC) and infiltration rates more suitable for wetland rice cultivation. However, one big draw-back is that if the sediments were deep enough the land could have been raised to a level where it was out-of-command by the existing irrigation system.

All such deposits would or could have been saline to some extent due to being carried by the tsunami wave which was saline and originated in the ocean. However, the level of the salinity of the deposit would have depended on just how long the material was in contact with the flood and hence salinised by the tsunami flood. The fine particles of silt and clay could have sealed the soil surface to some extent as they settled on the surface and if the flood then did not remain too long the salinisation risk would have been lowered.

The process followed in this part of the decision tree is that the risk of the land being out-of-command is considered first and then the salinity level of the soil is considered.

6.3 Land still within Command

This land is the easier to deal with and the process suggested in H1 should be followed. Depending on the salinity in the upper 25 cm, the land can be used immediately for padi if salinity is <4 dS/m, following normal padi puddling and preparation with addition of organic manures and fertilisers. But if the salinity exceeds 4 dS/m some leaching will be required.

6.4 Land no longer within Command

Where the land is no longer within command of the irrigation is a more difficult situation and the recommendations are to be found in H2. A decision has to be made as to whether the costs of refurbishing and upgrading the irrigation system to get the land back under command are going to be worthwhile and make economic sense. Moving vast quantities of heavy soil would be a major task and would involve the use of heavy equipment.

It could make much more economic sense to change the Landuse away from flood irrigated rice to rain-fed agriculture.

Whichever path is followed the salinity of the soil would then need to be checked and, if the land was brought back under command, any salinity could be leached out as per the processes detailed in H1 etc. If the land use was changed then any salinity would have to be allowed for in crop or species selection whilst, at the same time, ensuring there is a drainage system installed so that, in time, natural leaching arising from rainfall could clean the salts out and they could be removed from the site.

Table 6.1 Some Possible Salt Tolerant Crops

Crop type	High Salt Tolerance	Medium Salt Tolerance	Slight Salt Tolerance
Fruit	Date Palm		
Vegetable	Asparagus[	Tomato Cabbage Cauliflower Lettuce Carrot Onion Cucumber	
Field crops		Corn Sunflower Soyabean	Rice

Source: Bookers Tropical Soil Manual, 1991

The above crops are listed entirely on the basis of their tolerance to salinity; climatic suitability of the crops has not been considered and agronomic help would be required to finalise and decide which crops to grow.

7. FERTILITY and DEFICIENCY RISKS

7.1 Introduction

In several sections of the decision tree the user is advised to check on the fertility page after inserting the results from laboratory analyses into the ETESP tool Labdata Summary. The information in the following tables should be studied, used and based on the output from the tool.

7.2 LabData Summary Tool

Instructions on how to use this tool are given on the first sheet of the tool and all that the operator has to do is type-in the laboratory data into the relevant cells on the "data" sheet of the tool – however, before starting to insert data the tool has to be renamed as it is write protected. Renaming allows the tool to be used and saved with the additions. The renaming routine is to open the tool then immediately use the "Save As" routine in the menu of Excel and give the spreadsheet an appropriate name.

7.3 What the Tool Does

The tool adds a "rating" against every item of data that is inserted stating if the item (nutrient or soil feature) exists in quantities that are considered as "toxic', "high" to "low" or "deficient".

In addition, the average values for the topsoil and the subsoil are calculated and all that the operator has to do is decide which horizons are topsoil and which are subsoil and enter the horizon number into the appropriate box – this is explained on the sheet. If bulk sampling has been done to collect the soils samples then the 0 – 25 cm layer is the topsoil abd the subsoil comprises the 25 – 50 plus the 50 – 75 and 75 – 100 cm layers.

Summaries of the basic features of the topsoil and subsoil are then automatically generated and, by using these summaries in conjunction with the following tables, guidelines as to what is required are given. In the "Fertility" section there are presentations on:

- Inherent Fertility
- Fertility Potential, and
- Possible Deficiencies

A similar process is undertaken on the Salinity , Sodicity and Soil Reaction pages below. Finally there are a few "experimental" items in the summary of perceived risks from the various chemical features of the soil. These "warnings" or assessments are experimental and should be used with some caution, but they might prove to be useful.

7.4 Fertility

7.4.1 Inherent Fertility

This is the fertility status of the soil as it exists in the field at the time the samples were taken and is based on the results of the laboratory data.

Table 7.1 Inherent fertility

No	Item	Description	Actions	
1	Inherent Fertility	This is the basic, natural fertility of the soil and is assessed using the BS (Base Saturation). If this is low to moderate then study the data in LabData summary and see which nutrients have very low, low or moderate ratings. Also check deficiency warnings below (No3).		**Actions**
			1.1	Apply appropriate fertilisers and / or manures to overcome the shortages or deficiencies:
			a	Superphosphate for low P and Ca
			b	XYZ for Nitrogen (N)
			c	ABC for Potassium (K)
			d	*&% for balanced N, P and K
			e	Compost / FYM for overall poor fertility
			f	Liming material if dryland use planned and soil is acidic - use dolomitic limestone if Mg also low

7.4.2 Fertility Potential

This is a measure of how well the soil might be expected to perform as and when fertilisers are added and is based on the ability of the soil to retain the nutrients whilst making them available for plant use and growth.

Table 7.2 Fertility Potential

No	Item	Description	Actions	
2	Fertility Potential	This is the ability of the soil to hold any added nutrients and make them available for plant growth and is assessed by CEC (Cation Exchange Capacity). If this is low, it usually is for sandy soils, then the CEC can be boosted and careful application of fertilisers can help.		
		Generally, the more clay there is in the soil then better is CEC, and organic matter has high CEC	2.1	Apply copious amounts of organic material as FYM (Farm Yard Manure) and / or composts as these have high CEC as well as containing nutrients. Plough the organic materials into the soil as soon as applied and do not leave it exposed on the surface as this leads to losses due to mineralisation of, for example, nitrogen
			2.2	If mineral fertilisers are to be applied use slowly soluble forms and apply sparingly in several small doses to reduce losses by leaching out of the soil - especially coarse textured soils. Mineral fertilisers should not be applied until the organic materials have been applied and ploughed in.

7.4.3 Possible Deficiencies

This basically checks the status of calcium, magnesium and, to some extent, potassium in the soil and the possibility of deficiencies of these nutrients. The warnings are generated by studying the ratio of the various nutrients against each other.

Table 7.3 Possible Deficiencies

No	Item	Description	Actions	
3	Possible deficiencies	These are "flagged" by the LabData tool via checking the ratios of some of the nutrients. The deficiency is often caused by an imbalance between the different nutrients, in particular Ca:Mg and Mg:K		
		The usual deficiencies that will be noticed are of the major nutrients calcium (Ca), magnesium (Mg) and potassium (K) though in some situations a deficiency of phosphorus (P) can be flagged - but normally this would only happen in very calcareous soils. It may be getting flagged with the Aceh data due to the very low levels of Mg	3.1	Cross-check and deficiency warnings with the "level" and "rating" developed in the data area of the LabData form - it should be possible to see which of the nutrients is causing the warning - this would be due to a "very low" or possibly a "very high" level" of one or more nutrients
			3.2	Apply appropriate amendments (fertilisers) and liming materials to overcome the possible deficiencies
			3.3	If reaction is very acidic or worse - pH of 5.5 or less - Ca (calcium) will probably be in short supply so apply liming material, use Dolomitic limestone if Mg (magnesium) flagged as deficient in acidic soils

7.4.4 Possible Fertilisers

The study of the soil laboratory data for over 200 samples taken from irrigation schemes effected by the tsunami (ETESP Detailed Study of Irrigation Component Laboratory Data, April 2006) indicated that there was an overall infertility problem with all of the soil samples analysed. In some cases there was also strong suggestion of a deficiency of magnesium.

The following table has been compiled from a literature search basically because this subject is not a specialty of the soil desalinisation specialist and, it is suggested, that local expertise on the use of fertilisers in the Aceh area should be considered before any action is taken to change or modify existing fertiliser application packages.

One of the main considerations used to compile this table has been the acidifying affects or otherwise of the various fertilisers for which information and data could be found.

Table 7.4 Possible Fertilisers

No	Item	Name or Type		Considerations
4	Fertilisers			
	P & Ca	Triple Superphosphate (TSP) for **P**, K, **Ca**, Mg & S	**4.1**	Superphosphates generally used for rectifying low levels of soil phosphorus (P) but also supplies appreciable amounts of calcium(Ca) whilst SSP and TSP also supply some magnesium (Mg). However, TSP and SSP can acidify the soil to some dgree and most of the soils are already acid. Organic fertilser use should possibly be considered rather than mineral sources to supply these nutrients
	N	Calcium Cyanamide or Calcium Nitrate for **N**, **Ca**, Mg & S	**4.2**	These two fertilsers suggested since they help reduce the soil pH and hence help reduce soil acidity. Urea is generally used for nitrogen supply but urea acidifies the soil even further. Calcium cyanamide also as some herbicidal qualities and can help control some weeds. Nitrates are generally held to be responsible for much environmental pollution via outwash so use should be carefully considered and monitored
	Mg	Sulfomag (Potassium magnesium sulphate) for P, **K** Ca, **Mg** & **S**	**4.3**	This fertiliser supplies appreciable amounts of potassium (K), magnesium (Mg) and sulphur (S) so could be used to help overcome the indicated magnesium deficiency. It also supplies some phosphorus (P) and calcium (Ca) but it also has a slight acidifying effect
	N & K	Potassium nitrate for **N**, **K,** Ca, Mg, S and Cl	**4.4**	Nitrate of potash supplies appreciable amounts of notrogen (N) and potassium (K) and low levels of calcium (Ca), magnesium (Mg) and sulphur (S) but also supplies chloride (Cl) which may not be required. It also only acidifies to a negligible extent
	N, P & K	Compost / FYM for overall poor fertility	**4.5**	Various composts and manure all supply appreciable amounts of nitrogen (N), phosphorus (P) and potassium (K) and should probably used in preference to mineral fertilisers if they are readily available. In addition these organic materials also boost the fertility potential of the soil by increasing CEC
	P & Ca	Other organics like bone meals for N, **P**, **Ca**, Mg and S	**4.6**	Bone meals, which could be a bye-product of an abbatoir, supply high levels of phosphorus (P) and calcium (Ca) whilst also supplying reasonable level of nitrogen (N) and some magnesium (Mg) and sulphur (S). Raw bone meal also supplies chloride, which may not be required, so steamed bone meal could be the better alternative
	Liming Ca & Mg	Liming material if dryland use planned and soil is acidic - use dolomitic limestone to supply **Ca** and **Mg**	**4.7**	Generally liming is not required in land used as padi since the main purpose of liming is to reduce soil acidity - and soil reaction reverts to neutral when the soil is flooded. However if the land is to be used for palawija / dryland cropping there could well be a need for acidity reducion and increased supply of calcium (Ca) to replace aluminium (and hydrogen) on the soil exschange complex. Where there is a known or suspected dolomitic limestone should be employed as this also supplies magnesium (Mg)

NB *This topic is not a speciality of the desalinisation specialist and further advice should be sought*

Source; Bookers Tropical Soil Manual

8. SALINITY

8.1 Introduction

Salinisation of the soils which were flooded by the tsunami was the initial big fear following the catastrophe. A great deal of work, some of it not very helpful or scientifically accurate, was done and some inaccurate conclusions were drawn in the early days following the tsunami. ETESP Agriculture was able to refute the general statement made by someone that "*there is no SALINITY problem in Aceh". (*ETESP Soil and Land Reclamation Executive Summary, December 2005) and show that there was a low level salinity problem compounded by the lack or non-operation of drainage systems.

Accordingly, ETESP has continued to use and check salinity data and still recommends that this checking continues until such time all the salt is removed from the soil and sites damaged by the tsunami. Three separate sections are presented below based on existing salinity levels in the topsoil, plus another section with suggestions and recommendations if crops do not improve after following the suggestions in the first two routines.

8.2 Salinity Levels and Routines

Table 8.1 Soil Salinity Levels and Class

Description	Salinity class	Range in ECe (dS/m)
Non saline	SC1	0.1 – 3.9
Slightly saline	SC2	4.0 – 7.9
Moderately saline	SC3	8.0 – 15.9
Highly saline	SC4	16.0 – 31.9
Extremely saline	SC5	32.0 – 63.9
Ultra saline	SC6	64.0 – 127.9

NB Some versions of the classification system include "strongly saline" between "moderately" and "highly" and the lowest class can also be split to show "non-saline" (0 -1.9) and "very slightly saline" (2 – 3.9).

The above classification is the "International" standard and has been used in these studies.

8.2.1 Topsoil with < 4 dS/m Salinity

Basically where the salinity of the top 25 cm is 4 dS/m or less padi can be transplanted as the young seedlings are relatively tolerant to salinity during the vegetative stage of growth. Since irrigation is applied from the time the transplanting is done there should be some element of soil leaching and the salts should be getting removed from the upper layers and down through the profile.

However, to ensure this is really happening the water management has to be good with sufficient irrigation water applied to give a leaching fraction and soil drains should exist or be installed and working.

Table 8.1 Salinity < 4 dS/m

No	Item	Description	Actions	
4	Salinity	This is measured by the ECe (Electrical Conductivity) of the soil extract and is measured in dS/m. Direct reading instruments now allow levels to be estimated in the field. Since the main soils being studied are used for wetland rice (padi) the main zone to check is the planting zone , that is the 0 - 25 cm depth layer.	**4.1**	**If 0 - 25cm salinity <4 dS/m** then normal, well managed irrigated agriculture will overcome the residual slight salinity in the soil and padi can be planted but:
			4.1.1	soil drainage must be installed and working
			4.1.2	there must be sufficient water applied as irrigation to give leaching
			4.1.3	irrigation must be intermittent - that is, allow the soil surface to dry slightly between irrigations but water will be applied every 4 - 5 days

8.2.2 Topsoil with >4 dS/m Salinity

Where the salinity in the topsoil (0 – 25 cm depth) exceeds 4 dS/m rice seedlings should not be transplanted as the soil is too saline for successful growth and the seedlings will wither and die. A programme to leach the top 25 cm of soil must be undertaken to clean up this depth of soil then rice can be transplanted.

A reclamation leaching programme must be designed and executed to achieve levels of salinity in, in the first instance, the top 25 cm that will allow rice to be transplanted. The initial soil salinity level must be known, as must a few other basic facts about the location and site, and the data must be inserted into the ETESP tool “Leaching Water Requirements”. This is an Excel spreadsheet and instructions for use are shown on the first sheet of the tool. There is different sheet for each kabupaten so that some estimate of the water received from annual precipitation can be calculated – this water received from rainfall is looked upon as a bonus and is not included in the water requirement estimates. In other words, if the leaching is done using only the water calculated by the tool the job will be done to the depth selected and to the salinity level planned, but if there is rainfall then the salinity level achieved will be lower and a greater depth of soil will be leached.

The full process of reclamation leaching is detailed in the ETESP Soil Desalinisation and Improvement Specialists “Mobilisation Report” of December 2005. The recommended procedure to follow is shown in Table 8.2 (Section 4 of the tool) below.

Table 8.2 Salinity > 4 dS/m

No	Item	Description	Actions	
4	Salinity	This is measured by the ECe (Electrical Conductivity) of the soil extract and is measured in dS/m. Direct reading instruments now allow levels to be estimated in the field. Since the main soils being studied are used for wetland rice (padi) the main zone to check is the planting zone , that is the 0 - 25 cm depth layer.	**4.2**	**If 0 - 25 has salinity >4 dS/m** padi should not be planted until reclamation leaching has been done and soil drains are installed and working. Soil drains should be excavated to the recommended depth (100cm) as in ETESP, March 2006 **Soil Conditions for Wetland Rice**
			4.2.1	Use ETESP "Leaching Water Requirement" tool to calculate the leaching water requirement (Dlw). You will need the following data from the site:
			(i)	Which Kabupaten are you in?
			(ii)	Depth of soil you want to reclaim, for example 0 - 250 or 250 - 500mm etc? (taken in mm - that is cm x 100)
			(iii)	Initial or existing salinity of the soil in dS/m
			(iv)	What is the target salinity level you want to achieve, for example 0, 2 or perhaps 4 dS/m?
			(v)	What is the depth of any water table that exists at the site (taken in mm - that is cm x 100)
				This tool tells you how much water has to pass down through the soil to get it to the required salinity by leaching out the salts. The depth of water (Dlw - depth leaching water) is given in mm and also in cubic metres per hectare. The water has to be applied as several irrigation "gifts" in an intermittent manner - usually 100mm every 4 - 5 days.
				The amount of water that has to be applied as irrigations is far greater than the Dlw - this is because the soil absorbs and holds a lot of the water that is applied. The Dlw may be 100mm but up to 300mm may need to be applied until the required 100mm passes out through the drainage.
			4.2.2	The progress of leaching and depth of water that has to be applied can be seen in the ETESP "Irrigation Leaching Progress" tool. For example, if 100mm irrigation is applied to the surface the following amounts will pass down through the 0 - 25cm (250mm) layer on the first irrigation and enter the 25 - 50cm (500mm) layer:
			(i)	light textured soil 40mm, that is 60% of the water applied is lost or stored by the soil
			(ii)	medium textured soil 10mm, that is 90% of the water applied is lost or stored by the soil
			(iii)	heavy or fine textured soil 20mm, that is 80% of the water applied is lost or stored by the soil
				For 100mm to pass through the 250mm layer would require the application of:
			(a)	for the light textured soil - 200mm
			(b)	for the medium textured soil - 320mm
			(c)	for the fine or heavy textured soil - 290mm
				ETESP "Mobilisation Report - Salinity and Soils" March 2006

8.2.3 Where Crops still Fail after Apparent Land Recovery

If there is good vegetative growth of the young rice but then no or very little grain is formed further investigations have to carried out. The first thing to do is take bulk samples from the fixed depths of:

- 0 – 25 cm
- 25 – 50 cm
- 50 – 75 cm and from
- 75 – 100 cm

Bulk sampling means taking auger samples from those depths and thoroughly mixing the soil samples to try and achieve a uniform, representative sample for the whole depth range. The samples must then go to the analytical soil laboratory where, at this stage, only routine analyses are carried out – these analyses are detailed in the following table.

On receipt of the soil chemical data from the laboratory the data must now be entered into the ETESP tool "Labdata Summary" which has already been described in Section 7.2 in Chapter 7.

Table 8.3 Continued Crop Failure

No	Item	Description	Actions	
4	Salinity	If, however, early growth of rice is good (vegetative stage) but the crop then fails or produces very low or no yield in the later stages of growth check the subsoil salinity. As rice grows the roots go deeper and exploit down to 100 cm depth. If there is salinity trapped at depth the crop will fail.	**4.3**	Have the soil sampled for standard laboratory analyses by taking bulk samples from 0 - 25, 25 - 50, 50 -75 and 75 - 100 depths. The samples can most easily be collected using a soil auger.
			4.3.1	Carry out only routine analyses at this stage: These include *(i)* Soil Reaction with pH (water) plus *(ii)* Exchangeable H (hydrogen) and Al (aluminium) *in me/100g soil* *(iii)* Soil salinity as EC – *in dS/m* *(iv)* Exchangeable-Ca (calcium) *in me/100g soil* *(v)* Exchangeable-Mg (magnesium) *in me/100g soil* *(vi)* Exchangeable-K (potassium) *in me/100g soil* *(vii)* Exchangeable-Na (sodium) *in me/100g soil* *(viii)* Total-N% *(ix)* Organic carbon% *(x)* Available-P in ppm, and *(xi)* CEC – Cation Exchange Capacity *in me/100g soil*
			4.3.2	If salinity >4 dS/m exists in any of the deeper layers then set up a leaching programme after ensuring the soil drains are excavated to 100cm depth. Follow the system detailed in Section 4.2 to calculate leaching water requirement (Dlw) using the ETESP tools described in that section
			4.3.3	Try cropping again after leaching is complete but make use of the soil analytical data and ensure any nutrient deficiencies are also rectified
			4.3.4	If yields are still poor or if the crop still fails to produce grain then undertake a programme of foliar sampling and have the micro-nutrient status checked. ETESP April 2006 **"Detailed Studies of Irrigation Component laboratory Data"**

After checking the output from the Labdata tool (Chapter 7) it will then be possible to see if there are any nutrient deficiencies at depth that could be effecting the crop and also if there is any salinity within the rooting depth of the crop. Obviously, any deficiencies must now be corrected and reclamation leaching done to remove any deep lying salinity.

If after all the above actions have been taken the crop is still failing then a programme of investigation is required to check if there are any deficiencies in micro-nutrients. Micro-nutrient study and interpretation of soil based data is not easy and it is recommended that the levels of micro-nutrients be established via foliar analysis – that is by analyzing the leaves of crops suffering the 'poor growth" symptoms. Skilled agronomic and or soil science skills might be required if such a programme has to be undertaken as it is an extremely specialised field. Refer ETESP "Detailed Studies of Irrigation Component Laboratory Data", March 2006.

9. SODICITY

9.1 Introduction

Soil "sodicity" develops when there is sufficient sodium within the soil to displace the normal nutrients (calcium, magnesium and potassium) from the soil exchange complex. There is always some sodium in the soil but levels are normally low. The sodicity is measured by the Exchangeable Sodium Percentage (ESP) which is calculated as on the right:

$$\frac{\text{Exchangeable-Na in me/100g soil}}{\text{Cation Exchange Capacity in me/100g soil}} \times 100$$

The ETESP tool "LabDatasummary" calculates the ESP automatically and the summary section shows the sodic classification of the soil. This classification can be seen in the table below. It should be noted that soil is now referred to as being "sodic" in place of the older term "alkali" since alkali can be confused with alkaline; alkaline being a standard term used in soil reaction.

9.2 Effect of Sodicity

The fact there is more sodium on the soil exchange complex than normal means that there are fewer of the other nutrients such as calcium, magnesium and potassium held and so the soil can be less fertile. Also, once sodicity levels get a bit higher the soil can suffer what is called dispersion. Dispersion is where the individual mineral fractions of the soil are no longer held together, by the divalent nature of calcium for example, but the individual fractions become separated from each other or are dispersed. When this happens the individual fractions are so small that when they settle they can completely block all drainage within the soil and create a major problem. This is rather too far into soil chemistry for most people and further explanations can be found in soil science textbooks.

Table 9.1 Sodicity

No	Item	Description	Actions
5	Sodicity	This feature refers to the soils as being "sodic rather than the older term "alkali" - sodicity comes from the name of the main salt causing the problem "sodium". When the soil becomes sodic dispersion can occur and this can lead to very poor drainage - this is in addition to any fertility problems caused by the sodium replacing the calcium and magnesium nutrients on the soil exchange complex. Soils are classified as follows: * Non-saline non-sodic: EC <4 and ESP <15 * Saline: EC >4 and ESP <15 * Saline Sodic: EC >4 and ESP >15 * Non-saline Sodic: EC <4 and ESP >15	
		The critical level being ESP of 15% or greater. Only a few of ETESP soils investigated to date have been "sodic" and the problem is not through to be large or widespread. The worst case scenario is NON SALINE SODIC and reclamation leaching of these soils must not be started without a source of "calcium" or "magnesium" first being incorporated into the soil.	**5.1** If "sodicity" occurs and has to be dealt with this is done by reclamation leaching. For saline versions of the sodic soils normal irrigation water is OK and no special additions or ammendments need be used.
			5.2 If non-saline sodicity occurs gypsum ($CaSO_4$) should be mixed in with the soil as a source of calcium to replace the sodium before leaching is started
			Mobilisation Report - Salinity and Soils

9.3 Reclamation of Sodic Soils

Whilst the irrigation water is saline or does contain some soluble cations such as calcium etc normal reclamation of saline-sodic soils will happen under normal reclamation leaching. However, there can be problems with the non-saline sodic soils in that the soil water no longer contains any salts (making it saline) and, if totally pure water is used for leaching, the situation can be made worse as virtually all the more soluble sources of calcium etc will be leached out leaving only sodium in the soil and on the exchange complex. If this happens and ESP increases dramatically the soil can disperse and with the poor drainage that develops leaching will not happen.

The procedure with non-saline soils is that a source of calcium, in the form of gypsum, should be mixed into the soil before leaching to ensure there is a supply of calcium to replace the sodium.

10. SOIL REACTION

10.1 Introduction

Soil reaction is the level of acidity or alkalinity in the soil and is measured by pH. The classes of soil reaction used in these studies are presented in Table 10.1. A fuller discussion on the subject is given in ETESP Soil Acidity & Aluminium Saturation Percentage.

Most plants prefer soil reaction to be neutral or near neutral (slightly acid / slightly alkaline) though there are plants which can grow in more acid conditions. In most situations soil reaction is not a problem for wetland rice cultivation since, when a soil is flooded, the reaction reverts to neutral or near neutral. Only in special cases are amendments required to overcome unsuitable soil reaction.

Table 10.1 Soil Reaction Classes

Acidity / Reaction pH (water)	>7.6	7.5 - 6.6	6.5 – 5.6	5.5 – 4.6	< 4.5
Soil Reaction Class	**alkaline**	**neutral**	**slightly acid**	**very acid**	**extremely acid**

10.2 Soil Reaction Problems Noted in ETESP Studies

Several soils have been noted with acidic reaction and most of them have been soils which have other properties which render them basically unsuitable for agriculture. Most of the very acidic soils have been peat and generally it is not recommended to use peat soils for agricultural purposes. ETESP Detailed Study of Irrigation Component Laboratory Data, April 2006.

Some normal mineral soils on upland sites and which are used for dry-land agriculture do develop acidity and this is a well known phenomenon in tropical soils under high rainfall and is closely tied up with exchangeable aluminium. However, since most of the soils under study are flooded, or will be flooded, for rice cultivation the acidity problem is of little importance since, as stated above, such soils revert to near neutral when flooded.

10.3 Steps to take when Unsuitable Soil Reaction Found

The procedures to follow as and when unsuitable soil reaction is located or noted in the data are set out in Table 10.1 which covers section 6 of the assessment tool.

Table 10.2 Soil Reaction

No	Item	Description	Actions
6	Reaction	Soil reaction is the measure of the acidity or alkalinity of the soil and is measured as pH. Most plants grow best on soils that are neutral or near neutral (pH range 6 - 8) though several crops do grow well on acid soils. Soil acidity is closely associated with exchangeable aluminium in upland or dryland soils and with sulphates in soils reclaimed from organic rich sediments or deposits which are commonly associated with swampy coastal areas or mangroves.	**6.1** When a non-organic (mineral) soil is flooded, as for rice production, soil reaction reverts to near neutral (+/- pH 7) - refer ETESP Soil; Acidity and Aluminium. Hence, generally there is no need to add any ammendments to control the pH of normal non-organic soils apart from flooding them then puddling **6.2** When an acid organic soil dries out acid-sulphate conditions can develop and there is no real amendment that can economically reclaim such soils - if there is a smell of rotten eggs (H_2S) as an organic soils dries there is a problem. **6.3** When an upland / dryland soil becomes acid it is normally due to Exchangeable-Al and the necessary amendment or procedures are: *(i)* apply calcium rich materials such as lime or gypsum so that the calcium can replace the aluminium *(ii)* apply large amounts of composts or FYM *(iii)* grow acid tolerant crops or varieties - such as pineapple

APPENDIX A ETESP REPORTS, TOOLS and REFERENCES

A.1 ETESP Soil Desalinisation and Improvement Reports

A.1.1 Technical Data Reports

ETESP Agricultural Component, Desalinisation & Soil Improvement, Mobilisation Report, OCTOBER 2005 (Updated February 2006)

ETESP, Banda Aceh Kota, Kuta Alam, Data Assessment and Soil Reclamation, NOVEMBER 2005

ETESP, Aceh Besar Kabupaten, *Lhoknga, Darussalam and Baitissalam*, Data Assessment and Soil Reclamation, DECEMBER 2005

ETESP, Pidie Kabupaten, *Meureudu, Triang Gadeng, Panteraja and Simpang Tiga*, Data Assessment and Soil Reclamation, DECEMBER 2005 *[maps update of April 2006*]

ETESP, Bireuen Kabupaten, *Samalanga, Jeunieb, Jeumpa, Jangka and Ganda Pura*, Data Assessment and Soil Reclamation, DECEMBER 2005 *[maps update of April 2006*]

ETESP, Executive Summary, Soil and Land Reclamation, DECEMBER 2005

ETESP, Soil and Land Reclamation Scenarios, DECEMBER 2005 (Updated March 2006)

ETESP, Interpretation of Laboratory Data for ETESP Irrigation Component, FEBRUARY 2006 (Updated March 2006)

ETESP, Detailed Study of Laboratory Data, APRIL 2006

A.1.2 Background Technical Papers

ETESP, Background Paper, Annual & Monthly Rainfall, OCTOBER 2005

ETESP, Background Paper, Soil Acidity and Aluminium, DECEMBER 2005

ETESP, Digital Maps, FEBRUARY 2006 (Updated March 2006)

ETESP, Sandy Sediments, FEBRUARY 2006 (Updated March 2006)

ETESP, Soil Conditions for Wetland Rice, MARCH 2006

ETESP, Soil Texture and particle Size Class, April 2006

A.1.3 Site Visit and Tour Reports

ETESP, Site Visit Report – BRR Area at Lhoong: Kemukiman Cot Jeumpa, DECEMBER 2005

ETESP, Site Visit report, BLANG KREUNG SITE, DECEMBER 2005

ETESP, Tour Report, Field Tour Report NAD Areas, Feb 20th – Feb 24th 2006, FEBRUARY 2006

ETESP, Site Visit Report, Visit to Oxfam Sites Calang, MARCH 2006

ETESP, Site Visit Report, Visit to Red Cross Site, Aceh Besar, MARCH 2006

ETESP, Site Visit Report, Lhamno Irrigation Sites, Aceh Jaya, MARCH 2006

A.2 ETESP Soil Desalinisation and Improvement Tools

File name and date	Purpose
ETESP ECe from EM38 data.XLS OCTOBER 2005	Calculate soil salinity (ECe) values from raw data collected by EM38 salinity device when no calibration information provided
ETESP Leaching Water Requirements.XLS NOVEMBER 2005	Calculate the depths and volumes of water that have to be applied and pass through a selected depth of soil to achieve desalinisation. Information required includes: • Textural class of soil • Initial salinity of the soil (dS/m) • Target salinity wished to be achieved (dS/m)
ETESP Irrigation Leaching Progress.XLS NOVEMBER 2005	Determine how many irrigation gifts have to be applied to achieve de-salinisation of various depths of variously textured soil. Information required includes: • Soil textural group, or • AWHC (Available Water Holding Capacity) • Estimate of water application efficiency, or use default values • Size of irrigation gift as mm of water
ETESP Survey Density.XLS DECEMBER 2005	1. Correlate the scale at which to map surveys of various types from reconnaissance to very detailed level 2. Determine observation density (Sites / hectare) 3. Calculate the total number of sites for surveys at various reliability levels Requirements: • Survey area extent in hectares (ha) Also presents various map and mapping information
ETESP Labdata summary.XLS Version 4 FEBRUARY 2006	Enter standard laboratory data and obtain ratings as to the level of all the various nutrients and chemical properties. Also calculate weighted mean vales for topsoil and subsoil plus obtain automatic simple summary of: • Inherent fertility • Fertility potential • Possible nutrient deficiencies • Salinity status, and • Reaction Also experimental estimate of possible perceived risks
ETESP Site Monitoring tool.XLS MARCH 2006	Enter field data for specific sites or villages making note of : 1. Locational information • Kabupaten • Kecamatan • Desa • Farmer or Land-owner, and • Geographic coordinates 2. Soil, land and crop features • surface soil textural group • soil salinity • soil acidity • irrigation water quality (salinity) • status of drains, plus • estimate (%) of the actual pre-tsunami crop yield to monitor land reclamation progress and get information on further interventions possibly required

ETESP Soil Conditions Database MARCH 2006	Enter field collected on the site form, or data collated and analysed from the data on the site form into a format that will be the first stages of a dbms / GIS compilation: • surface soil textural group • soil salinity • soil acidity • irrigation water quality (salinity) • status of drains, plus • estimate (%) of the actual pre-tsunami crop yield The data are stored against the official Dinas selected villages that qualify for ETESP inputs. This collation will allow monitoring land reclamation progress within kecamatan and kabupaten and get information on further interventions possibly required
ETESP Auger Description Form MARCH 2006	Simple pro-forma for recording data collected during soil investigations to establish depths and distribution of sandy sediments
ETESP HRD Database, Training Needs MARCH 2006	Draft database design for recording the training needs of Dinas Pertanian staff in the various districts. Compiled in MS Access.
ETESP Survey Database MARCH 2006	Draft database design in MS Excel for recording data collected during any soil survey inspections or observations. Data being collected using the"Auger Description Form". If use was to be made of this database it could / should be recompiled in MS Access as this offers a more secure data storage medium.
ETESP Labdata Collation.XLS APRIL 2006	Enter standard laboratory data and obtain ratings as to the level of all the various nutrients and chemical properties pH ECe Exch H and Al Exch-cations Total-N Organic-C CEC TEB BS ASP ESP Ca:Mg ratios Mg:K ratios
ETESP Land & Soil Problem Assessment.xls	A spreadsheet designed as a DECISION TREE to allow the identification and categorisation of various soil and land problems associated with the tsunami. Remedial actions are then suggested as well as the appropriate tools to further check the situation and devise recovery routines.

A.3 References

Bookers, 1991. Bookers Tropical Soil Manual – A handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Longman Scientific and Technical, UK, 1991. ISBN 0-582-00557-4