Assessing temporal dynamics of groundwater and soil salinity and their impact on the green infrastructure after the 2004 Tsunami in Aceh, Indonesia

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

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Introduction

The seaquake and subsequent tsunami on December 26, 2004, caused severe damage to people, infrastructure and agriculture in Aceh, Indonesia. Especially West Aceh, the district closest to the epicentre of the seaquake was affected.

After the seaquake and flooding of the West Aceh coast, the agricultural Sector faced three major biophysical challenges:
1. Subsidence caused by tectonic movement
2. Salt water intrusion: Flooding; groundwater wedge shifted to the east
3. Mud deposit (marine sediments and eroded material from the hinterland)

Flooded area

Subsided area

Mud deposit

Study region in West Aceh

Tsunami effects on agriculture:

Short term effects
- Salt water intrusion: Soil and groundwater salinisation, plant damage
- Temporal increase of soil salinity with high impact on sensitive (tree) crops

Medium-to long-term effects
- Groundwater level change: Water logging due to subsidence, loss of paddy due to sediments
- Changes of groundwater quality near subsided areas, water stress or toxicity for plants
- Slow release of salts by mud deposits: Toxicity, nutrient imbalances or fertiliser effects

Objectives of the study

- To determine the impact of saltwater intrusion through the tsunami in time, on soil and groundwater quality
- To assess and understand consequences for different tree crops

Material & Methods

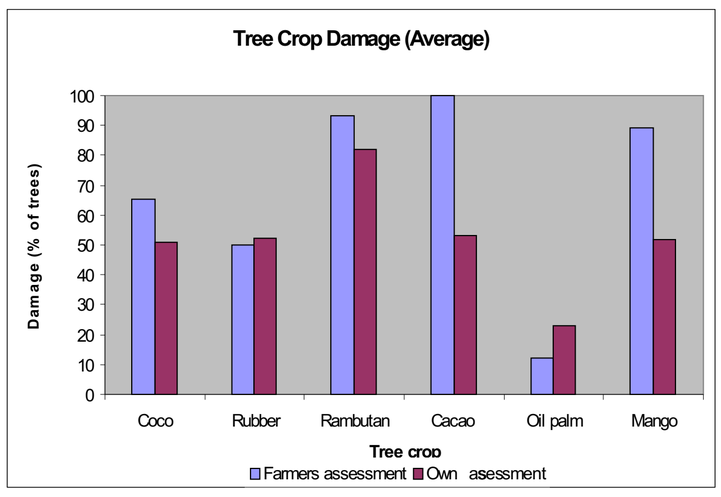
Soil and groundwater quality dynamics
- **Soil quality parameters**: eC, pH, Na+, Mg2+, Ca2+, Sodium Adsorption Ratio (SAR) & Exchangeable Sodium Percentage (ESP)
- **Groundwater quality parameters**: eC, pH, Mg2+, Ca2+, SO42-, Cl- were derived from data collected in 2005 (by Catholic Relief Service, Bundesanstalt für Geowissenschaften und Rohstoffe, Indonesian Soils Research Institute and University of Hohenheim/ReGrIn) and own datasets from 2007.

Assessment of damage to the economically most relevant tree crops: *Cocos nucifera* (coconut), *Hevea brasiliensis* (rubber), *Theobroma cacao* (cacao), *Nephelium lappaceum* (rambutan), *Elaeis guineensis* (oil palm) and *Mangifera indica* (mango).
Tree damage inventory parameters – mortality, yield depression, leaf shedding – were assessed along 10 transects perpendicular to the coastline and major water bodies through farmer interviews and image analysis (years 2005 and 2006) as well as field observations in 2007.

10 transects with their measurement points

Results and discussion

Groundwater quality:
Salinisation as expressed by electric conductivity generally decreased from 2005 to 2007, with exception to some points which were flooded again in 2007. EC declines with increasing distance to the sea or (see transect B and G) to water bodies connected to the sea. All groundwater samples were appropriate for irrigation and most even passed drinking water thresholds (1000µS/cm).
Soil parameters:
Na+ concentrations in soil correspond well to groundwater dynamics. For both parameters, high rainfall helped to leach salts out of the sandy soils.
Tree damage was assessed in 2007 in the field and based on owners memory in interviews referring to 2005. Both observations concurred well except for cacao, which had been removed and replanted in several cases.
Damage levels between species differed significantly between species for two reasons:
First, due to species-specific sensitivity to salt- or drought-stress as is known for rambutan or cacao. Second, because of traditional agroecological zonation: E.g. rubber trees are mostly planted in greater distance to the sea and suffered less than coconut close to the coastline.



Conclusions

Salinisation of groundwater and soils in the affected zones has clearly decreased since the tsunami and does not constrain cultivation of most agricultural crops. Only where subsidence of land has linked open water bodies to the sea, salinisation is still problematic. Tsunami mud depositions often had fertilising effects, but can also cause nutrient imbalances leading to reduced yields (e.g. for peanut; results not shown).
Different levels of tolerance to salt / drought stress were observed and reported between species. In combination with spatial distribution of salt levels, suitable locations and tree species for rebuilding the “green infrastructure” can be recommended. This is relevant since flooding frequently occurs in West Aceh, as happened lately in May 2005.

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