Tropentag 2007
University of Kassel-Witzenhausen and University of Göttingen, October 9-11, 2007

Conference on International Agricultural Research for Development

Assessing short and long term time dimensions of the tsunami impact on the green infrastructure in Aceh, Indonesia: A challenge to data collection and methodological approaches.

Marohn, Carsten[1], Andreas Distel[1], Juan Laso[1], Dian Yusvita[1], Gerd Dercon[1], Sonya Dewi[2], Betha Lusiana[2], Laxman Joshi[2], Fahmuddin Agus[3], Uwe Meyer[4], Meine v. Noordwijk[2] and Georg Cadisch[1]

[1]University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Garbenstr.13, 70593 Stuttgart, Germany
[2]World Agroforestry Centre, Jl. CIFOR, Situ Gede, Sindang Barang, Bogor, Indonesia
[3]Indonesian Soils Research Institute, Jl. Juanda 98, Bogor, Indonesia
[4]Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, 30655 Hannover, Germany

The presentation will give a synopsis of interactions between the 2004 tsunami and land use systems in Aceh over different time scales. The respective studies were conducted within the framework of the EU-funded research and development project ReGrIn (Rebuilding Green Infrastructure with Trees People Want, EuropeAid Asia Pro-Eco IIb). ReGrIn is led by the World Agroforestry Centre, in cooperation with the Indonesian Soils Research Institute, the Indonesian Research Institute for Estate Crops and the University of Hohenheim.

The earthquake and tsunami of December 26, 2004, had far-reaching effects on all sectors in the ReGrIn study area of Aceh Barat, Indonesia, the district closest to the epicentre. While direct effects on human population shortly after the event received adequate attention by relief organisations, tsunami impacts on land use systems and the role of these systems in mitigation of flood damages are not yet well-understood. With a focus on trees in the landscape, this research aims at linking up short- to long-term impacts of the tsunami on tree crop damage and land use change. In this context, uprooting of trees, salinisation of groundwater and soils, permanent water-logging as a consequence of subsidence, but also fertilisation of soils through marine deposits are of relevance (Wahyunto et al. 2006). With respect to disaster mitigation through trees, especially the potential of mangroves to dissipate wave energy has been highlighted after the 2004 disaster (Smith 2006; Tanaka et al. 2007) and since led to intense planting of 'greenbelts' and 'bioshields' on numerous beaches in Aceh. On the other hand, even some of the sources advocating tree belts admit, that sound scientific evidence for a mitigating

effect has not been found yet (Danielsen et al. 2005) and it has been argued that these plantations might create a deceptive feeling of safety among villagers. A combination of biophysical and socio-economic parameters covering appropriate time horizons has been selected to investigate underlying patterns.

Geopolitical settings in the province of Nanggroe Aceh Darussalam were changed drastically through the tsunami. As a consequence of the disaster, a peace treaty between the Indonesian government and the Acehnese GAM ended over 20 years of civil war. Indonesian authorities, foreign aid organisations and settlers entered. Capital inflow and increased purchasing power created new markets. The construction and services sectors' expansion bound labour force at the cost of agriculture. The recent opening after decades of social unrest and isolation, massive external influence and interests as well as cultural peculiarity make Aceh a unique case to observe changes on different time-scales. The challenge of selection, combination and triangulation of data in an extremely dynamic environment will be highlighted in the presentation. A selection of biophysical and socioeconomic parameters influencing farmers' decisions on land use change over different time scales is shown in fig. 1.

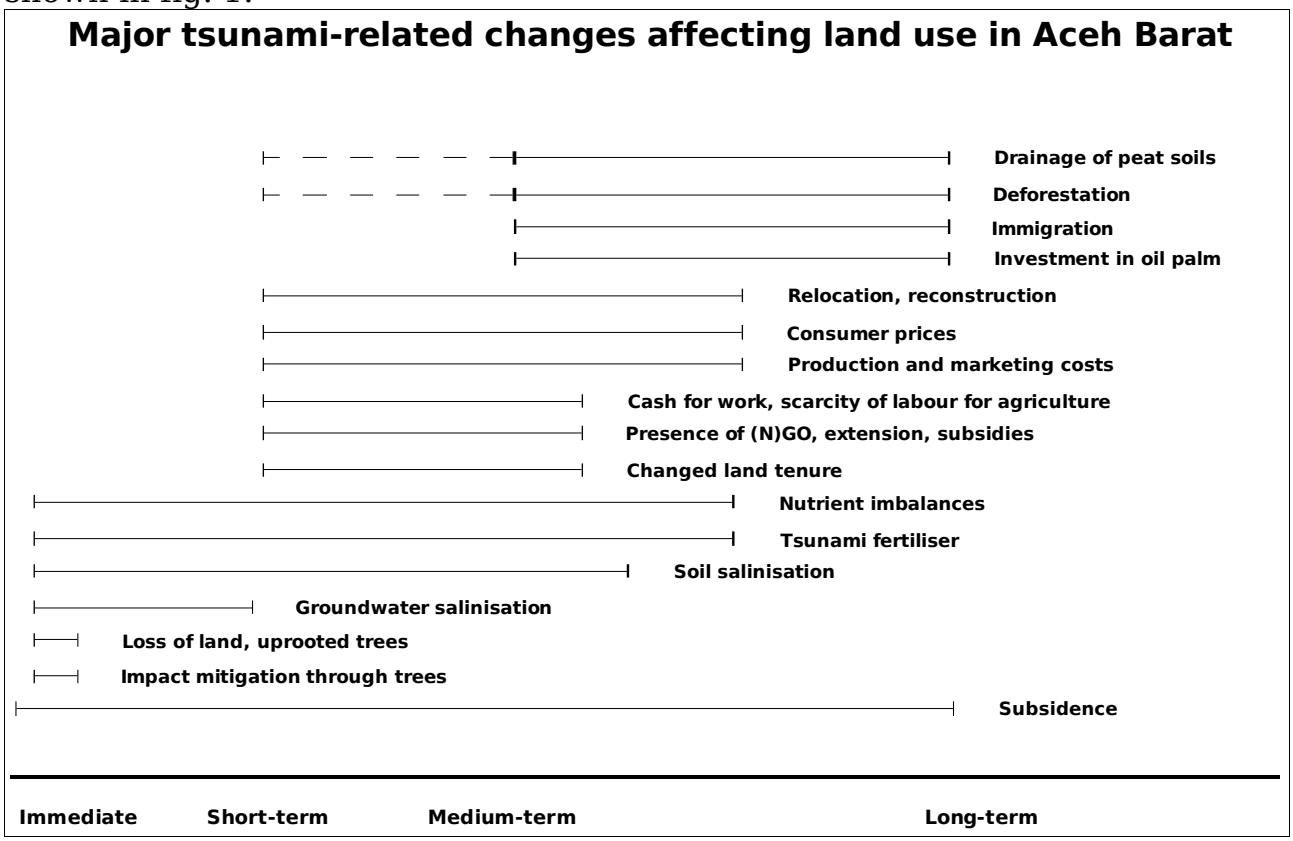

Fig. 1: Tsunami-induced land use changes and their respective time scales

Methods: Under the aspect of losses of lives as well as physical damage to infrastructure and trees *immediately* after the event, the role of existing tree belts in coastal protection is assessed combining remote sensing, GIS-based land use classification as well as official statistics and own interview data at village level. In areas with uniform coastal geomorphology and bathymetry (s. Borrero et al. 2006), pre-tsunami land uses (with their associated roughness),

topography and distance to the sea are used as predictors for run-up height which again is correlated to damage caused to structures and losses of human lives (for details see Laso et al. 2007).
To determine *short- to mid-term* effects of subsidence, salinisation and mud deposits with their related fertilisation effect on crops and trees, repeated groundwater measurements were conducted and soil samples collected. Salinity data collected earlier after the tsunami (Catholic Relief Services, unpublished; Siemon et al. 2005) served as reference values to determine tendencies. Data were consolidated through farmer interviews and related to field inventories of tree damage.
Farmers' perception of the mentioned biophysical factors and the largely changed socio-economic settings influence land use decision-making on household level *in a longer perspective*. Major factors determining decision-making are development of markets and prices, the role of extension through development organisations and farmers' adoption and learning style. Present changes are monitored and an understanding for farmers' motives is developed on the basis of individual and focus group interviews. These data will later serve as inputs for a modelling approach to prospect a baseline as well as alternative land use scenarios over a time horizon of 30 years.

Preliminary results: Groundwater salinisation decreased after relatively short time (6 months) due to a propitious rainfall regime (Distel et al. 2007); similar tendencies have been found for Sri Lanka (Villholth et al. 2005). Soil salinisation also decreased, although to a lesser extent than groundwater (Distel et al. 2007; Subiksa et al. 2007). Low salt-levels were indicated by absence of stress symptoms in salt-sensitive beans observed on plots covered by tsunami sediments. Yields of various crops were reported to have increased due to fertilising tsunami mud (Wahyunto et al. 2006), contrary to what had generally been expected (e.g. Verrelst & Schaepman 2007).
A protective effect of tree belts on humans and buildings will be assessed through multiple and non-linear regression techniques currently being applied on the field data collected earlier this year. Findings will be compared to such of modeling by Shuto (1987), Harada & Kawata (2004) and of Hiraishi & Harada (2003), who simulated tsunamis in a water channel and found evidence for significant energy dissipation behind and increased run-up height in front of miniature tree imitations (Laso et al. 2007).
Interview data from individual and group interviews evaluated up to date show a decisive influence of capital investment and extension on land use decisions made by farmers (Yusvita et al. 2007).

Outlook: In an ongoing masteral thesis, changed economics of tree crop production and marketing as a consequence of the tsunami are being investigated.
Further, changing carbon pools in drained peat soils will be quantified on plot level in a chronosequence, since conversion of forests increased sharply after 2004. Land use-related changes in carbon stocks on a landscape level will also be assessed using a modelling approach based on the spatially explicit FALLOW model developed by ICRAF.
An understanding of major land use dynamics as obtained from the work presented above will allow to integrate our findings into an adapted version of the model.

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