Application of tsunami modelling for escape and refuge planning in Aceh (Indonesia)

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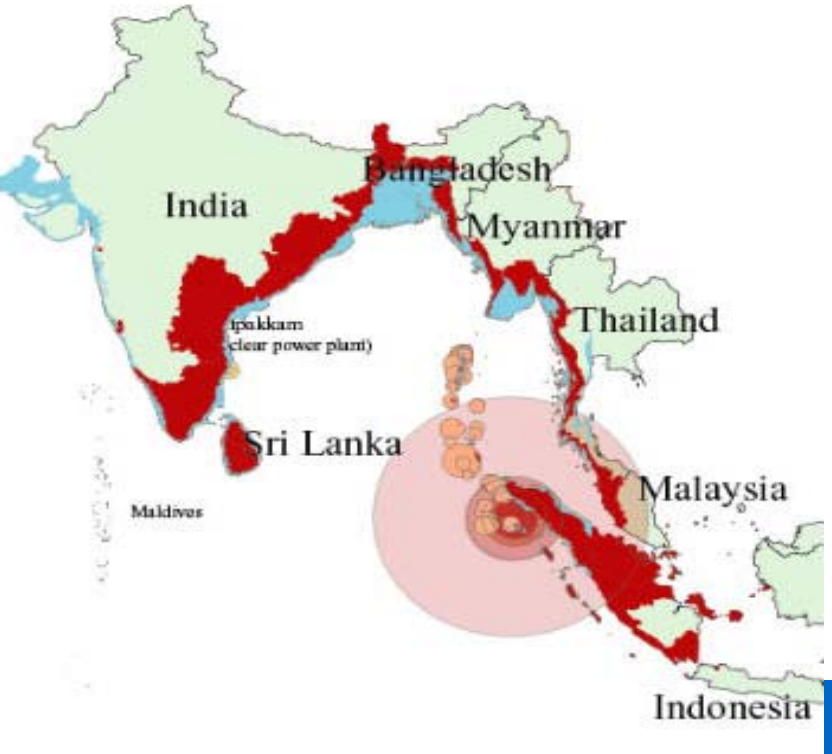
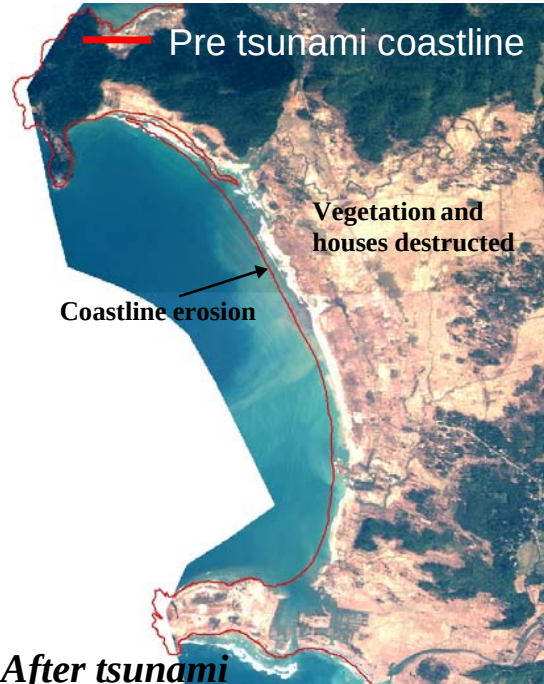
Tsunami 2004 event

- 9.2 MW extreme earthquake west of Sumatra, resulting in tsunami wave propagating in different directions
- Devastating effect on surrounding countries



Before tsunami



After tsunami

Indonesia

- More than 160,000 people deceased or missing
- More than 500,000 people loosing houses/ livelihoods etc.
- Province of Aceh was hit the hardest

Presentation outline

1. Introduction SDC Project
2. Tsunami inundation modelling
3. Flood hazard mapping
4. Escape and refuge planning
5. Follow-up and conclusions

SDC Project

- Sea Defence, Flood Protection, Refuge and Early Warning System Project (SDC Project)
- Dutch/ Indonesian consortium lead by DHV Group (other Dutch partners: Witteveen + Bos, Deltares)
- Primary development objectives:

-put in place an appropriate strategy for sea defence, flood protection, multifunctional refuge facilities and a regional early warning system
-provide design guidelines for such systems

Important consideration: resettlement in high risk coastal areas!

Focus of presentation

➢ SDC's objectives require more insight in flood risk:

⇒ Set up of tsunami inundation models and creation of flood hazard maps

➢ Various uses of flood hazard maps in SDC project:

- Spatial planning purposes (focus on saving lives; escape and refuge planning)
- Warning system (database of hazard maps)
- Detailed damage and risk assessment
- Assessment effectiveness and cost benefit analysis tsunami protection measures
- Increased understanding propagation tsunami wave and resulting coastal flooding

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presentation

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- Warning system (database of hazard maps)
- Detailed damage & casualties + risk assessment
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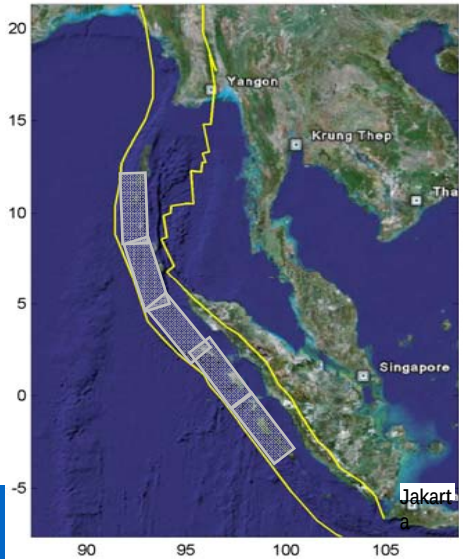
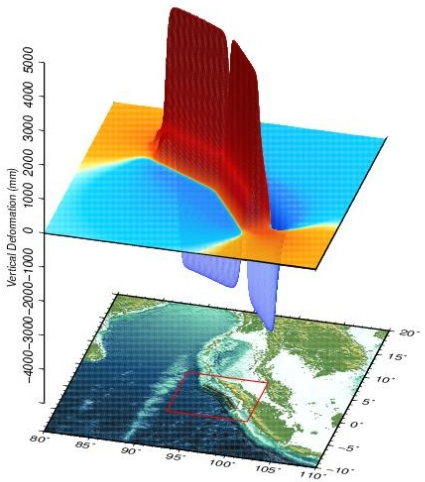
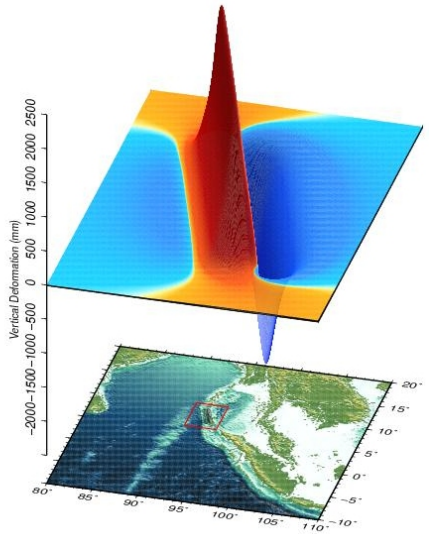
Tsunami inundation modelling

- Initial tsunami wave field (a. fault modelling for different earthquake scenarios or b. data for actual event)

- Hydrodynamic tsunami model then computes:
  - -propagation through ocean
  - -resulting flooding when reaching coastal areas







SDC inundation models

➢Existing tsunami inundation models (Delft3D software, set up by project partner Deltares) showed:

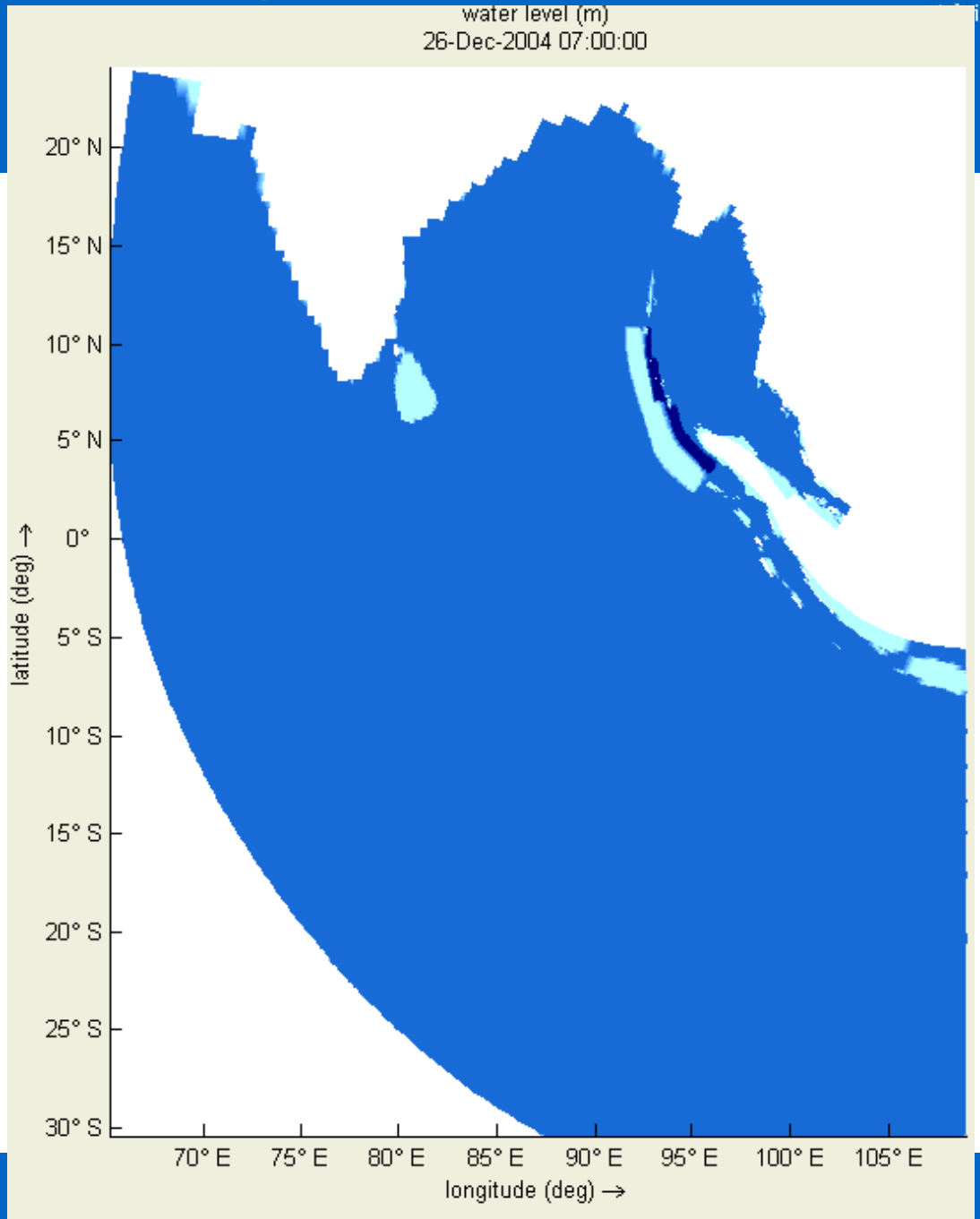
- good simulation of overall tsunami inundation patterns
- improvement required for detailed patterns

➢Existing models were refined (grid resolution, more detailed bathymetry and topography data)

➢Resulting in new set of SDC inundation models:

-1 overall propagation model, 1000 m resolution
-5 regional flooding models, 200 m resolution
-1 detailed flooding model case study area Banda Aceh, 50 m resolution

Overall propagation model



Regional models and case study area Banda Aceh

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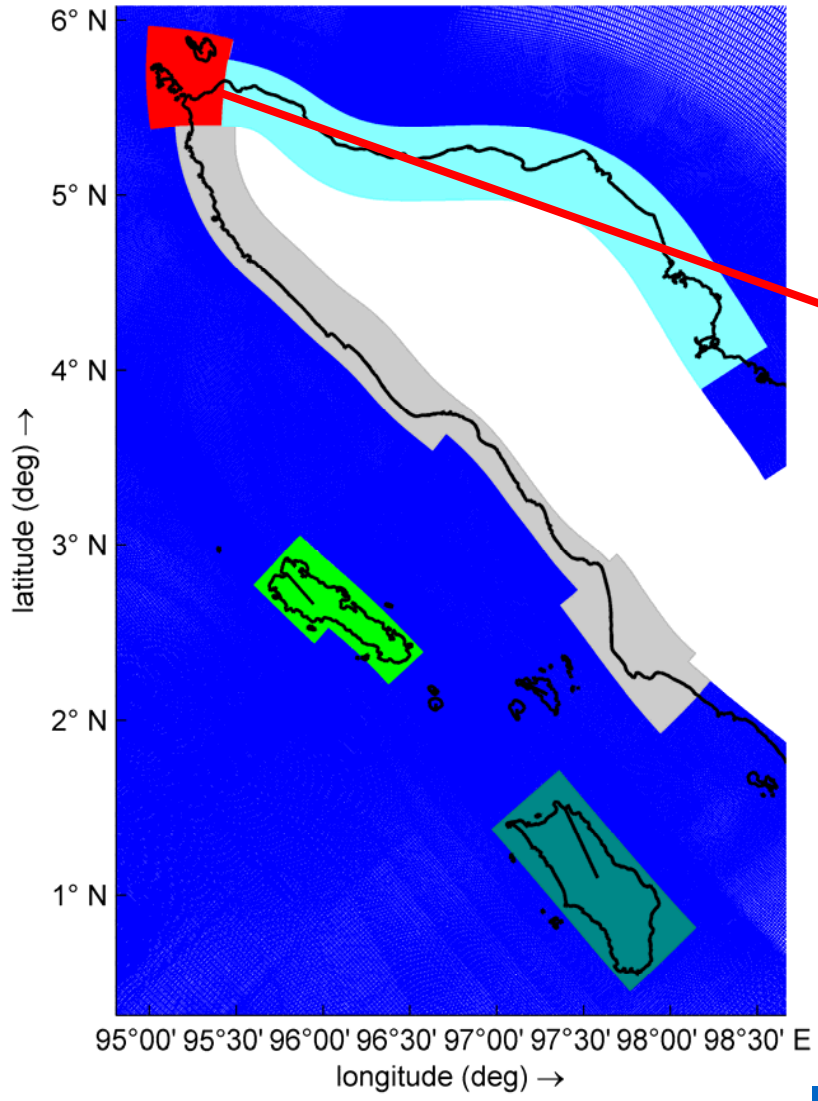
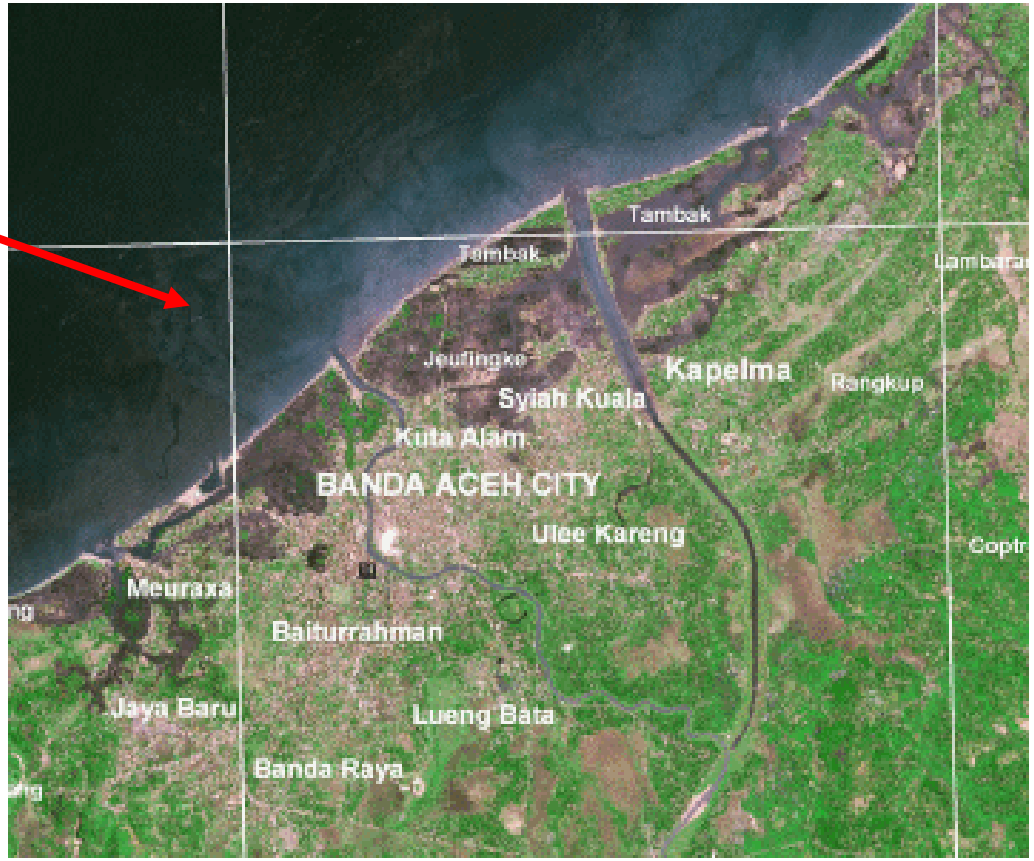
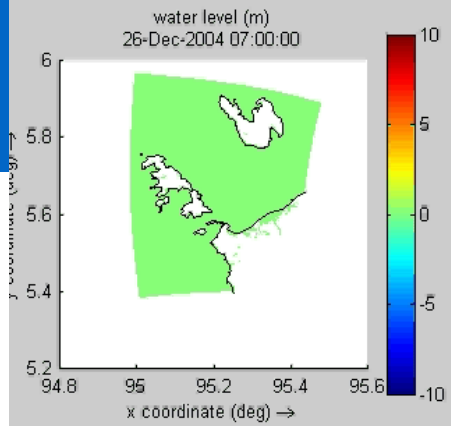
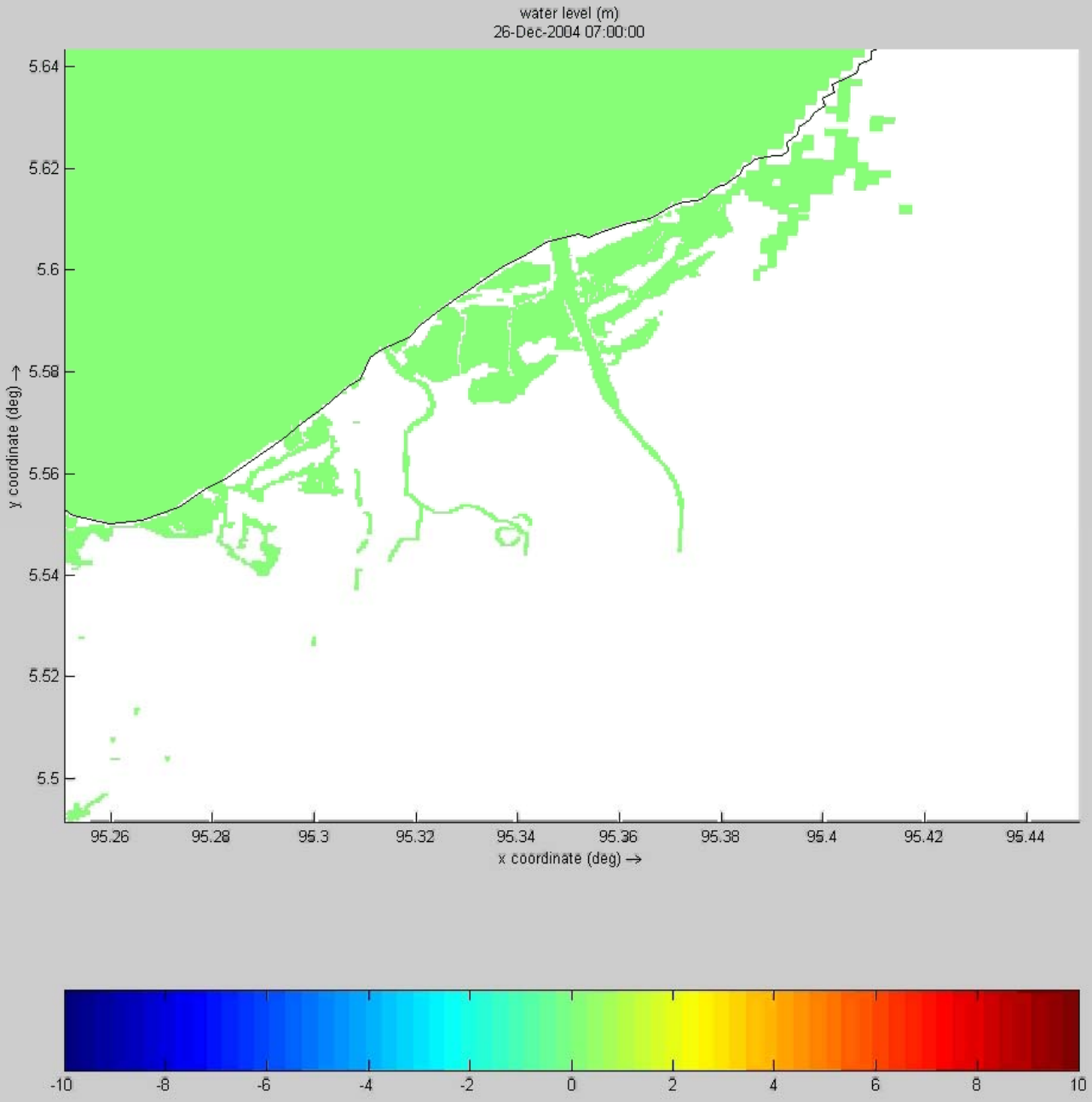




Detailed flood model case study area Banda Aceh





Validation model results

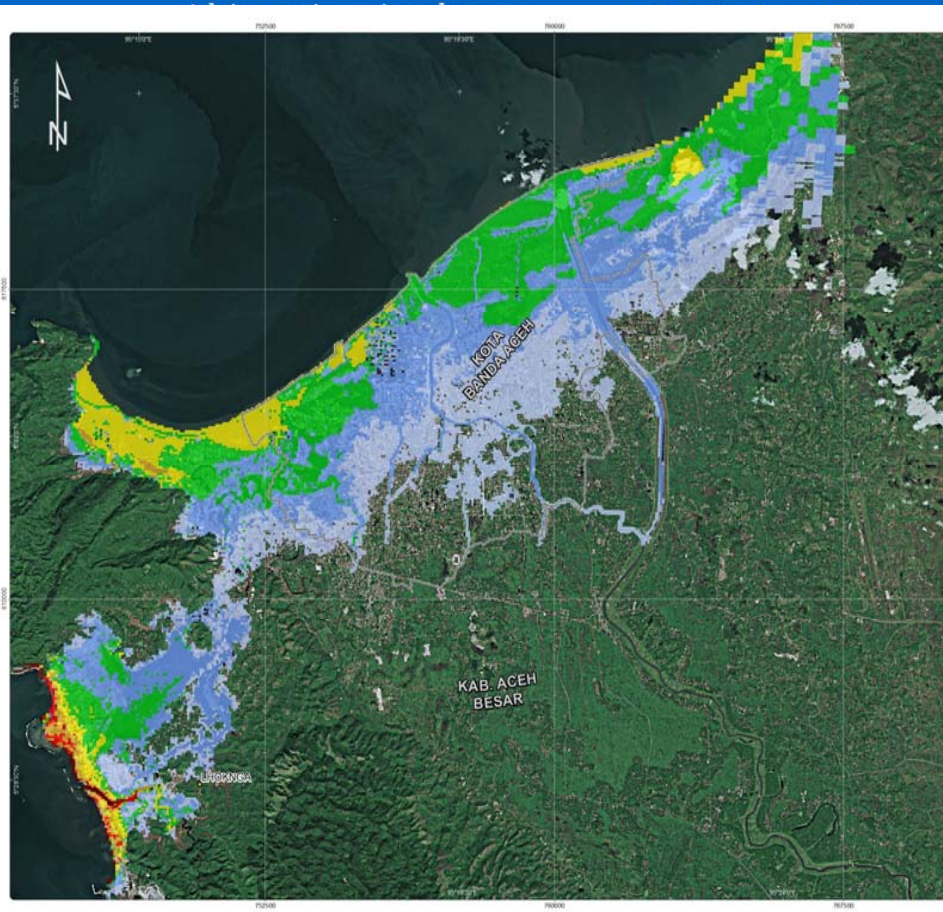
Validation only possible for December 2004 event:

- Wave heights at sea, these were validated and found to be accurately simulated for existing models by Deltares (Vatvani, 2005)

- Inundation patterns and depths were analysed based on satellite pictures (presence vegetation), eyewitness reports and measured values by survey teams. Computated inundation with refined models turned out to agree very well with actual inundation, patterns as well as depth.

Validation of inundation patterns Banda Aceh

Satellite imagery
(December 30th 2004)



Computed inundation

Conclusion: new set of models provide a tool that is reliable and suitable for SDC's project objectives

Probability of occurence

- Data over sufficiently long period is not available
- Based on other studies and analyses, an estimate was set up of probability of occurence for earthquake scenarios

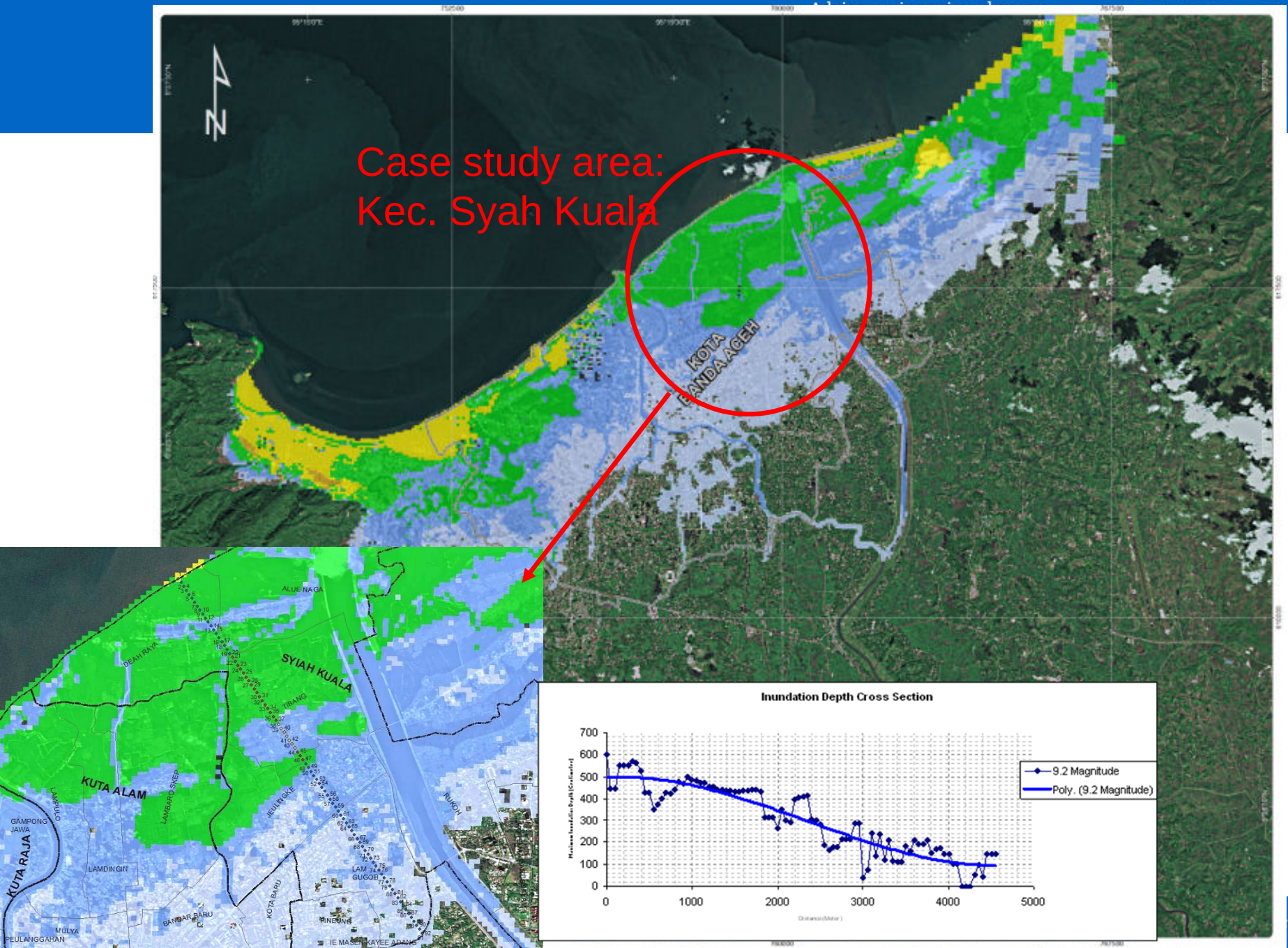
Magnitude (Mw)	Anywhere along fault line	At one specific spot
7.5	50 years	100 years
8	75 years	150 years
8.5	100 years	200 years
9	250 years	500 years
9.5	500 years	1000 years

Probability of event similar December 2004 to occur anywhere along Sunda fault line is in the range of 1/300 to 1/500 years

Flood hazard maps

- Over 300 computations executed up to now for creation of database flood hazard maps (for different earthquake scenarios; varying location, strength, focal depth, dip angle)
- Initial design condition for escape and refuge planning: December 2004 event flood hazard map

Flood hazard map Banda Aceh (December 2004 event)

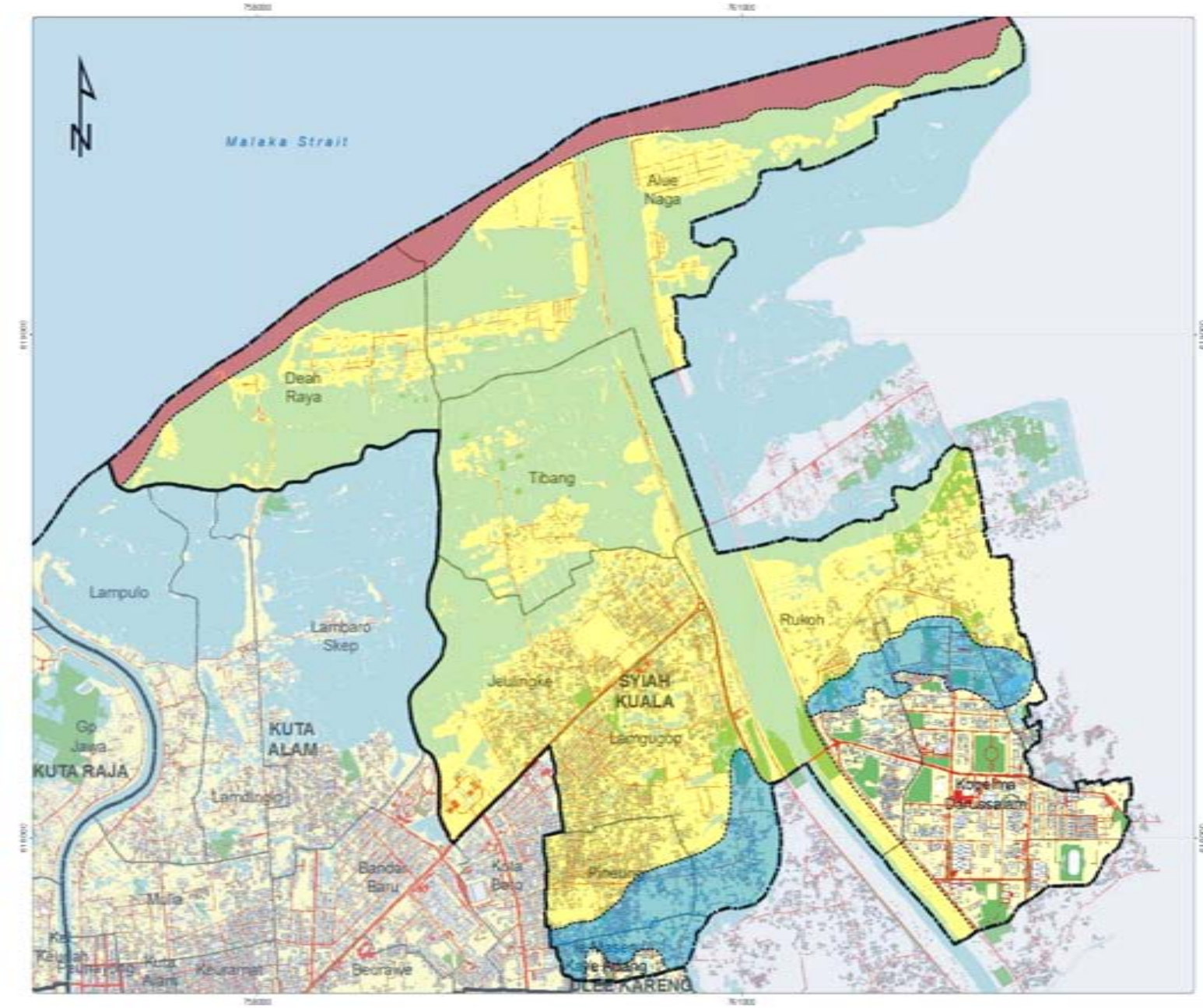


Zoning plan

Based on the flood hazard map and inundation depths, impact areas are defined for planning purposes:

- Direct impact zone; survival rate minimum, only specifically designed buildings will remain standing
- Evacuation zone; evacuation required, only solid engineered structures will remain standing
- Wet feet zone; debris remains a threat to human lives, most normal structures will remain standing
- Safe zone; no impact

Zoning plan case study area Banda Aceh



Gateway to solutions

Escape and refuge plans

Based on the zoning plan and spatial data (population figures, road maps, inventory of buildings), more detailed escape and refuge plans are set up:

- Escape capacity plan
- Refuge facility plan
- Escape route plan
- Warning plan

Note: People are resettling in high risk areas in Banda Aceh, where fatality rates are expected to be 60-70%. Escape and refuge plans very important and therefore have been set up for all high risk areas.

Escape and refuge plans case study area Banda Aceh

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Follow-up Sumatra

- Collaboration has been set up with universities Sumatra; training and support in further development of model.

First target: expanding tsunami model for entire high risk area Sumatra west coast (completion in 2009).

Possible follow up: set up of escape and refuge plans for these areas.

General conclusions

- The SDC tsunami inundation models has proven to be a reliable tool and suitable for detailed risk assessment and spatial planning purposes.
- A general stepwise methodology translating flood hazard maps to detailed escape and refuge plans has been set up and can be used in other areas.

Similar regional tsunami inundation models and the presented stepwise methodology can be applied in other countries surrounding the Indian Ocean.

Thank you for your attention
Questions?