SPICE final conference
January 20 & 21, 2016

Proposal	
Affiliated to topic (Session 1- 8)	Understanding ecological and socioeconomic dynamics of mangrove ecosystems under pressure
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Understanding ecological and socioeconomic dynamics of mangrove ecosystems under pressure

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Abstract

In recent decades, it has become clear that mangrove forests and their connectivity to adjacent terrestrial and marine ecosystems provide important ecological functions and ecosystem services. By surviving harsh environmental conditions and climate and sea level changes for millions of years they demonstrated an adaptive capability, but they now face rates of environmental change that are unprecedented in their history. Effective conservation and management requires a local to regional scale assessment and understanding of mangrove responses to environmental change.

The Segara Anakan Lagoon (SAL) in south central Java, Indonesia, serves as an example of a river- and ocean-nourished mangrove ecosystem under heavy human pressure in a region which belongs to the most densely populated regions in the world. The natural resources and socioeconomic goods and services of the mangrove-fringed lagoon are affected by high riverine sediment inputs, overexploitation of natural resources and effluents from agriculture, industry and households.

The major overarching research goals in Segara Anakan and other mangrove ecosystems of Indonesia were (i) to understand how the interaction of natural processes and human activities affect ecosystem integrity, biodiversity and natural resource availability in mangroves and their associated watersheds during the Anthropocene and (ii) to assess and further develop governance options for these watersheds and the sustainable use of related natural resources. This presentation will provide an overview of major achievements from more than a decade of interdisciplinary research and capacity building activities on mangrove social-ecological systems in SPICE. We learnt that (i) hydrodynamics are a major control of element cycling and habitat distribution, (ii) eutrophication and organic pollution in SAL are moderate, (iii) biodiversity is declining, (iv) the carbon storage potential varies largely between environmental settings and (v) land tenure conflicts and other socioeconomic processes in the hinterland are major drivers of ecosystem health and resource potential of SAL.

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Incremental claiming and recognition of land tenure in the Segara Anakan Lagoon

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Abstract

The presentation focuses on the Segara Anakan Lagoon on the south coast of Java. Sedimentation in the lagoon has resulted in new, emergent land which has dramatically changed the physical environment and perceived values of the area. Despite decades of top down state led initiatives, local residents have incrementally shaped the sea and landscape of the lagoon and its surroundings, persistently claiming newly emergent land despite state efforts to the contrary. Whereas these efforts were evident as far back as the 1970s, they faced strong state resistance is pre-reform Indonesia. In the post-1998 period, de facto rights have been increasingly recognized, in a process that is transforming the tenure landscape of the lagoon from the bottom up, despite the persistence of pre-reform structures.

The presentation explores how different discourses of lagoon management and usage at both the national and local levels have developed and changed over time within the existing policy and legal context. It looks at how these framings have been deployed by a variety of actors in order to address different issues, and what this has meant for land tenure in the area. The presentation suggests the importance of unpacking tenure issues, spatially, temporally, and with respect to different actors and their interactions with each other. In doing this it draws a picture of complex interactions, with changes in land tenure in the lagoon driven not so much by state action as by local actors incrementally and persistently making their claims through physical transformation of the emergent landscape.

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Modelling morphodynamics of a tropical coastal lagoon, Segara Anakan, Indonesia

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Abstract

The present study aims to identify morphological changes and sediment fluxes in a tropical coastal lagoon, Segara Anakan, Indonesia. Its high sediment input related to high hinterland erosion because of land use change is considered a major problem by stakeholders. Previous studies based on unrealistic estimates of sediment input predicted the infilling of the lagoon in the 1990s. Today, it is a shallow dynamic lagoon that receives freshwater input from one major and a few minor rivers and it is connected to the Indian Ocean by two channel outlets. A three-dimensional morphodynamics model was set up in the Delft3D domain (Deltares, 2011) and was driven by river discharges and tides. The model was calibrated using field measurements collected during the SPICE research programme in the years 2005, 2006 and 2013. Scenarios were created in order to investigate the influence of the river discharge and tides on the water and sediment fluxes at the channel outlets and the sediment budget of the lagoon. The exchange mechanism is strongly controlled by river discharge at the western outlet, while tidal forcing is the major control at the eastern outlet. Additionally, we find that 12% of the total sediment input is deposited in the lagoon while the rest is exported to the Indian Ocean. The western part of the lagoon shows a high dynamic of depth changes due to its position which close to the sediment input. This results in a high rate of sedimentation in the central part of the western lagoon and a low rate of sedimentation in the eastern part of the lagoon. The general patterns of erosion and sedimentation of model results are in good agreement with the observed morphological features and hydro- and sediment dynamics. Creating scenarios of future developments in terms of morphodynamics and habitats will provide useful information for the management of the lagoon morphological features and hydro- and sediment dynamics.

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Effects of environmental change on mangrove biodiversity, community dynamics and ecosystem functions

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Abstract

Essential functions of mangrove forests may depend on particular tree or macrobenthic species. For instance, crabs and gastropods enhance carbon storage and nutrient cycling through feeding and burrowing. Forest degradation can cause changes in community structure and a decline in species numbers which can lead to a loss in functional diversity. We investigated the response of macrobenthic communities to vegetation changes in the Segara Anakan Lagoon, a mangrove-fringed estuarine system in Java between 2005 and 2015. The study combined a taxonomic diversity analysis with a biological traits analysis. Behavioural, life history and morphological characteristics were used to define functional trait groups.

We recorded a high species richness but a low biomass of benthic invertebrates compared to other Indo-West Pacific mangrove forests. A comparison of mixed mangrove sites and deforested areas which are overgrown by understorey plants showed that they have the same number of species but differ in taxonomic composition and functional structure of their communities. Some functional groups are only represented by one or two species. The crab communities were dominated by burrowing, opportunistic species with a short life span whereas long-lived and large species were rare. Due to their small sizes crabs have very shallow burrows. This is likely to affect nutrient cycling and the oxygenation of the sediment.

Abundances of facultative litter feeders increased significantly between 2005 and 2015, indicating their low vulnerability to vegetation changes. By contrast, abundances of species with other feeding modes decreased considerably. Overall, 51 crab species were recorded in 2005 of which 13 rare species were not found in 2015. The shift in taxonomic and functional community structure is a response to a significant decline in tree density, a further spread of understorey plants and a decreasing habitat complexity. It is likely that other rare species will disappear if mangrove degradation continues.

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Soil organic carbon stocks in estuarine and marine mangrove ecosystems are driven by nutrient co-limitations of P and N

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Mangrove play an important role in carbon sequestration, but soil organic carbon (SOC) stock differ between marine and estuarine mangroves, suggesting differing processes and drivers of SOC accumulation in soil. Here, we compared undegraded and degraded marine and estuarine mangroves in a regional approach for their C sequestration potential in soil and evaluated possible drivers imposed by nutrient limitations along the land-to-sea gradients. SOC stocks in natural marine (271 – 572 Mg ha^{-1} m^{-1}) mangroves were much higher than under estuarine mangroves (100 – 315 Mg ha^{-1} m^{-1}) with a further decrease caused by degradation to 80 – 132 Mg ha^{-1} m^{-1}. Soils differed in C/N-ratio (marine: 29 – 64; estuarine: 9 – 28), $\delta^{15}N$ (marine: -0.6 – 0.7 ‰; estuarine: 2.5 – 7.2 ‰), and plant-available P (marine: 2.3 – 6.3 mg kg^{-1}; estuarine: 0.16 – 1.8 mg kg^{-1}). We found N and P supply of sea-oriented mangroves primarily met by dominating symbiotic N_2 fixation from air and P import from sea, while mangroves on the landward gradient increasingly covered their demand in N and P via SOM recycling. Pioneer plants favored by degradation further increased nutrient recycling from soil resulting in smaller C-stocks in the topsoil. These processes explained the differences in SOC stocks along the land-to-sea gradient in each mangrove type as well as the SOC-stock differences observed between estuarine and marine mangrove ecosystems. This first large-scale evaluation of drivers of SOC stocks under mangroves thus suggest a continuum in mangrove functioning across scales and ecotypes and additionally provide viable proxies for C-stock estimations in PES or REDD schemes.

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Impact of increased siltation on energy flow structure and ecosystem services of the Segara Anakan lagoon ecosystem, Indonesia: a twenty year´s perspective

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Abstract

The Segara Anakan lagoon (SAL) ecosystem has experienced large changes over the past decades, with mangrove areas that have been converted to rice fields, aquaculture ponds and urban settlements. Mud flats and lagoon areas also greatly decreased in size due to high sedimentation.The objective of this study was to develop a SAL ecosystem mass balanced reference model for the year 1990 and to evaluate the changes in the ecosystem over the period of the following two decades (1990–2010). Comparative analysis of trophic status and energy flow structure was carried out between these periods and the impact of environmental and man-made changes on the SAL ecosystem functioning was assessed. The distribution of the total system biomass and catch at different TLs changed with decreasing proportions in habitat area. Total biomass and total flows through the SAL ecosystem in 2010 were with 25.5 % and 41.4% significantly smaller than for the 1990s model. Lower net primary production in the 2010s compared to the 1990s model (by 28%) is due to reduced biomass of mangrove as well as the reduced water area.

The importance of direct and also indirect trophic interactions among functional groups was assessed using comparative network analysis. Organisms at medium trophic levels such as grapsidae, ocipodidae and portunidae were identified to have relatively high impact onfish groups.Total catches of crabs, fish, shrimp and bivalve decreased by 60.2% from the 1990s to the 2010s. At the same time mangrove cutting increased in 2010s.As revealed by the study results, the Segara Anakan Ecosystem has,within the 20 years time period analysed, lost large parts of the services formerly provided, and if the current trend continues, this last remaining lagoon system of os the island of Java shall be lost forever.