

Rebuilding resilience of coastal populations and aquatic resources (RESCOPAR): habitats, biodiversity and sustainable use options.

Open water aquaculture - in this study we focus on shrimp culture in mangroves - often starts with insufficient knowledge of the trade-offs between natural resources and the culture based production. The resulting degradation and loss of resilience of aquatic natural resources affects livelihoods, coastal productivity and biodiversity. This research project starts from the recognition that people are part of dynamic ecosystems and are dependent on the environment for societal and economic development. Therefore, resource management should be embedded in a profound understanding of all ecological, social and institutional factors and feedbacks driving the processes of change. Developing multi-disciplinary approaches to assess and manage resilience are at the forefront of the challenge to address resource degradation in marine ecosystems. An important aim of the RESCOPAR project therefore is to further develop methodologies and approaches that can aid in the understanding of the processes that lead to the loss of social and ecological resilience, the provision of means of access to information and the facilitation of transparent and participatory decision making. This aim is reached through a range of research projects at two sites in Indonesia and Vietnam on coastal ecosystems and fisheries; shrimp-pond mangrove life support systems; livelihood resource use patterns and governance arrangements.



Shrimp culture contributes significantly to the rapid loss of South-East Asian mangroves: in the two study areas of the RESCOPAR program in Vietnam and Indonesia, respectively 20% and 70% was cleared over the past 30 years. Productivity of shrimp-ponds over time declines as a result of acidification, pollution and infectious diseases, forcing farmers to abandon their ponds within 5-15 years and to open new culture areas thereby leading to a spiral of mangrove loss. Shrimp cultures also affect marine productive functions: mangrove clearance results in a reduction of habitat complexity and the biodiversity and abundance of the associated fauna, with cascading effects to higher trophic levels, thereby affecting ultimately also the capture fisheries in near shore seas. These changes in coastal landscapes are induced by a multitude of livelihood decisions by farmers and fishers on resource exploitation driven both by their capabilities to access local resources, and by trade

and flows of information through local, national and global governance processes. Local arrangements to maintain coastal habitats and production systems are often ineffective: the slow degradation of resources means that warning signs often remain unrecognised. As a result, interventions are often too late, and spatial management is too fragmented. However, the ineffectiveness of management arrangements is also the result of governance processes controlling access to and participation in decision making from global to national and local socio-political scales.

The RESCOPAR research program focuses on understanding the ecological and social processes underlying the resilience of mangrove forested coastal ecosystems, and on the way decision making processes at different socio-political and spatial scales affect the use, management and conservation of living aquatic resources. A participatory and transparent decision making process will be facilitated by elucidating the position of stakeholders with regard to management tools and interventions.

Understanding will be gained through multidisciplinary research in PhD and MSc studies carried out at two selected sites in East Kalimantan in Indonesia and Ca Mau in Vietnam. Key challenges of the program are the identification of socially and ecologically sustainable fish based economic activities in the coastal zone, balancing the interests between poverty reduction (social resilience) with the sustainable use of natural resources for coastal fishery and mariculture (ecological resilience). Information and knowledge acquired will be presented at fora organised to gain interdisciplinary understanding of the basic research questions, and will result in various publications (PhD theses, peer-reviewed publications, book). Maintaining social and ecological resilience of coastal livelihoods and ecosystems may largely depend on particular pathways of development in different regions, a comparison between regions – Ca Mau, Vietnam and East Kalimantan, Indonesia - is required to derive some generic conclusions.

Providing access to information will be achieved through the development of spatially explicit management tools and information systems that support decision-making in coastal management. The aim of the program is to develop spatial scenarios, evaluated in a participatory way, that maintain a sustainable exploitation level of aquatic resource use for different stakeholders with multiple interests. Dissemination of results in local languages and aimed at local stakeholders will be a specific activity of the program.

Elucidating the position of stakeholders viz á viz management interventions will be part of the research process and requires interaction with local and provincial government authorities. Authorities and other stakeholders will be involved in the research process starting with the local program inception workshop and during the various fora in which research results will be presented.

Research activities in the four multidisciplinary themes are carried out by 9 sandwich PhD students and by probably 18 mostly local MSc students, supervised by nine Wageningen University Chairs of the research schools WIAS, PE&RC, CERES and WIMEK. Supervision in Vietnam and Indonesia will be done by a team of scholars from academic institutions (Can Tho University, Mulawarman University, Bogor Agricultural University and The Indonesian Institute of Sciences (LIPI)), a multilateral organisation (Network of Aquaculture Centres Asia (NACA)) and an NGO (WWF-Indonesia). The integrative aspects of the program will be ensured through an

International Advisory Board (IAB), a Wageningen Program Steering Committee (PSC) and through a series of scientific and stakeholder workshops. The interdisciplinary framework, working procedures and output are combined in a separate work package.

Research themes

Theme 1: Impacts of spatial arrangements and temporal changes of aquaculture and fisheries activities in coastal aquatic ecosystems

Coastal systems consist of coupled ecosystems as mangroves, sea grasses, coral reefs and near-shore seas. The spatial extent and configuration of a mangrove forest contribute to the sustenance of the fish/crustacean diversity and the productivity in mangrove enriched coasts. Consequently the nursery function of mangroves indirectly determines coastal fisheries catches. Habitat loss and fragmentation through pond construction will have impacts on coastal stocks, e.g. through loss of spawning and nursery functions, and through changes in the (spatial) allocation of coastal fisheries targeting them. A prediction is needed on how mangrove loss affects fish assemblages in essential estuarine habitats and what mangrove protection (Marine Protected Areas, maintaining coastal strips) can contribute to maintain coastal productivity.

PhD project 1: Trade-offs in coastal fisheries production, mangrove structure and extent and shrimp-culture: a spatial modeling approach

Site: Mekong Delta, Ca Mau province, Vietnam;

Participating institutes: Aquaculture and Fisheries Group and Geo-Information Science and Remote Sensing- Wageningen University
Can Tho University

Scale: coastal zone from habitat patch in mangrove forest to coastal fisheries

Reduction in mangrove habitat complexity is thought to reduce biodiversity and abundance of associated fauna, with cascading effects to higher trophic levels and ultimately fisheries. Size, location and connectivity are important attributes of mangrove habitats that function as nursery, feeding and shelter areas for fish and shrimp and with that enhance coastal production and recruitment to fisheries. Furthermore, to understand the relationship between mangroves and fisheries production reliable and accurate spatially referenced data from fisheries catches attributed to particular catchments are needed. We propose that the impact of mangrove conversion to shrimp-ponds, focused in particular on coastal fisheries, can be quantified by:

- Relating spatial extent and patterns of mangrove shape, structure and connectivity with their utilization as nurseries by selected commercially important fish and crustacean species;

- Assessing spatially referenced fisheries catch and fishing effort information, both historical and present.
- Activities entail the assessment of spatial change in the mangrove forests through the analysis of remote sensing images and historical maps of mangrove and adjacent near-shore seas; experimental fishing in mangrove and near-shore habitats; monitoring multigear and multispecies fisheries catch and effort data through logbooks filled in by participating local fishermen; assessment of historical changes through interviews with fishermen and pond farmers; spatial modeling.

The aim is to develop a spatial explicit model to evaluate the effect of different spatial scenarios of impacts of mangrove conversion on coastal productivity and diversity, by combining statistical fisheries information and information on habitat functions in the life-histories of fish species with spatial information techniques.

PhD project 2: Marine protected areas, shrimp farms and coastal fisheries: linkages through cascading effects

Site: Berau Delta, East Kalimantan, Indonesia;

Participating institutes: Research Ecology Group and Aquaculture and Fisheries - Wageningen University
 Mulawarman University, World Wildlife Fund for Nature - Indonesia

Scale: Mangrove forest and adjacent habitats (coral reefs) in the coastal zone from habitat patch in mangrove forest to coastal fisheries; Derawan Marine Protected Area

To understand and predict the changes from a productive to a non-productive state in shrimp-pond mangrove forest ecosystems it is important to study the negative and positive feedback processes that structure these systems so that indicators for state resilience can be found. At a larger scale the coastal mosaic of coupled coastal systems can be viewed as being built up from components, i.e. areas with a spatial extent, without flip-flopping coupled to components that show flip-flopping, while at a lower spatial scale these components are dealt with as being merely adjacent to each other. At the higher scale, the spatial arrangement of the components within the system thus becomes important: the spatial configuration and the extent of the different components of the ecosystem are essential attributes for reaching increased resilience. This has important consequences for the configuration of marine protected areas in relation to economic activities as mariculture and fisheries. A spatially explicit analysis is required before predictions can be made (Pittman et al 2004). Because productivity is one of the key parameters to describe ecosystem functioning, and because the south-east Asian mangrove and near-shore areas are widely used for fisheries, these areas are ideally suited to study the effects of resilience in a spatially explicit context. Productivity can be monitored through the effort of the local and regional fisheries. We predict that there is specific spatial setting and a maximum level of shrimp farming at which the productivity derived from coastal fisheries is stable, and system resilience can be maintained.

The activities entail a baseline study to quantify shrimp pond spatial configuration; a participatory questionnaire to indicate target fish species under multigear fisheries in

respect to habitat preferences, seasonal effects and exploitation level; a monitoring study to quantify fisheries outcome and shrimp production with the assistance of fishermen and shrimp producers; experimental fishing of target fish species; modelling of fish community structure under influence of human exploitation from fisheries and shrimp ponds. The aim is an ecosystem model that can be used for scenario testing in particular related to the configuration of the Marine Protected Area in the Berau Delta mangrove-coral-reef system.

Theme 2: Spatial interactions and resilience of shrimp pond – mangrove forest ecosystems.

Like many other types of animal production sectors, diseases and environmental problems are major limiting factors for sustainability in shrimp farming. Thus understanding the transmission modes for these diseases, how spatial planning could influence disease occurrence over a longer period, and how farm management influence the fate of wastes in the production system and their interaction with the shrimp health, are all important factors to improve sustainability in shrimp culture.

PhD project 3: Spatial spread and virulence development of White Spot Syndrome Virus in cultured shrimp

Site: Mekong Delta, Ca Mau province, Vietnam;

Participating institutes: Laboratory of Virology and Quantitative Veterinary Epidemiology - Wageningen University
Can Tho University

Scale: Interaction between virus and host (transmission) between ponds within a location, between locations and between successive batches of shrimps in the same pond of the same location.

WSSV is a rampant disease in cultured shrimp both in estuarine, tidal ponds and in other more inland farms around the world. It is also a threat to non-shrimp crustaceans, also in pristine environments. Virus replication, disease development and epidemics are highly dependent on shrimp culturing practices, trade and social infrastructure. This project will study the nature of a virus epidemic using molecular markers and try to explain the observed development of WSSV towards virulence. Virus isolates will be obtained from different locations (regions, ponds), from the same locations at different times, and from experimental passages in shrimp. These different isolates will be characterised both genotypically as well as phenotypically. For the latter, isolates will be compared in standard experiments (to be developed together with PhD 4) both for virulence as well as transmission characteristics. Virulence markers will be identified and studied. The typing will be used to reconstruct the evolutionary history of WSSV epidemic and in collaboration with PhD 4, study the transmission paths and quantify transmission between ponds and between production cycles.

PhD project 5: Disease transmission of White Spot Syndrome Virus in shrimp

Site: Mekong Delta, Ca Mau province, Vietnam;

Participating institutes: Laboratory of Virology, Aquaculture and Fisheries Group and Quantitative Veterinary Epidemiology - Wageningen University
Can Tho University

Scale: Interaction between virus and host at a limited time scale (the production cycle of one pond) and a limited spatial scale (the pond and its neighbours).

The potential for transmission and the susceptibility of shrimp to White Spot Syndrome Virus disease will be studied experimentally and by observations of natural outbreaks in ponds. The experiments and observations will lead to quantification of the parameters necessary to model “within pond” transmission. Additional data from the PhD project 3 will allow modelling of “between pond and between production cycle” transmission. Moreover, the two PhD studies, 3 and 4 will provide insight in when infection with WSSV will lead to disease (clinical signs). This information will be correlated with coastal pond and mangrove estuary management parameters. With this information we can quantitatively model disease development dependent on management both spatially and over time.

PhD project 5: Mechanistic analysis and (possible) optimisation of management measures on pond level and adjacent mangrove forest

Site: East Kalimantan, Indonesia;

Participating institutes: Aquaculture and Fisheries Group and Aquatic Ecology and Water Quality Group - Wageningen University
Mulawarman University, Bogor Agricultural University

Scale: Shrimp ponds and patches (undisturbed and restored) of mangrove forest

This project provides insight on how pond development influences environmental quality and health of shrimps by studying the relation between environmental quality and shrimp health in coastal ponds and mangrove estuaries. The activities of this study are a mix of field work and experimental work. As read out parameter of environmental quality, the availability of dissolved oxygen in the sediment and in the flocculent layer on top of the sediment in ponds and mangrove forests is chosen, taking both horizontal and vertical variability into account. In marine benthic environments, dissolved oxygen is considered one of the key parameters determining biodiversity and productivity. Equal importance will be given to field observations and laboratory scale mesocosm studies. Field samples will be taken of the benthic communities and related to abiotic factors, including O₂, TAN and NO₂ levels. The samples will be taken in such a way that the biomass present per surface unit area can be calculated. The species diversity in benthic samples will be determined to compare biodiversity between sample sites. Mesocosm studies concentrate on the relationship between environmental conditions and shrimp health. The mesocosm studies will be executed in close collaboration with the PhD study on disease transmission of white spot syndrome virus in farm raised shrimps (PhD 2.2)

Theme 3. Trade-offs and feedbacks in resource use patterns, institutions and livelihoods

Vietnam and Indonesia have different political, social-cultural, and environmental histories. State and non-state institutional arrangements result in different dynamics of global-local interactions concerning aquatic resource use, regulation, and decision making. Discriminating factors in the comparison between the two studies are:

- 1) population mobility;
- 2) the strength of customary regulations vis-à-vis national and transnational social, economic and environmental forces;
- 3) the flows of information and processes of knowledge construction between stakeholders at various scales; and
- 4) The material, technical, and environmental conditions of aquaculture development.

This subprogram aims to compare systematically the ways in local decision-makers in fish-based livelihoods operate within these contexts in order to identify the crucial factors that cause these livelihoods to evolve in specific (unsustainable) directions. These factors can be at the basis for recommendations concerning the domains where to initiate activities to improve governance arrangements of mariculture resources at decentralised, national, and international/regional scales.

PhD project 6: Decision-making and change in coastal fish-based livelihoods in the Ca Mau area, Vietnam

Site:	Mekong Delta, Ca Mau province, Vietnam;
Participating institutes:	Law and Governance Group, Rural Development Sociology – Wageningen University Can Tho University
Scale:	Localities of shrimp farmers and estuarine and coastal fishers and traders

The objective of this project is to analyze decision-making of individuals in fish-based livelihoods in the Mekong Delta in Vietnam in order to identify the most relevant technical, ecological, economic and political factors influencing livelihood decisions and the expansion of shrimp production at the level of households and commercial fish-producers both in mariculture and in fisheries. This will be done in a context of rapid expanding production of shrimp in ponds and rapidly decreasing areas of mangrove forests. Particular attention will be given to the institutional and legal arrangements rendering access to the necessary resources for the sustenance of livelihoods and markets as the entry points for improved policy-making concerning the growing of fish and shrimp and the sustainable management of mangrove ecosystems. The identified factors influencing livelihood decisions will provide the linking pins with the technical and governance PhD projects and relevant clues for developing policies for the sustainable management of artisanal fisheries and mangrove forests. The main methods are life-history interviews and the investigation of livelihoods by monitoring flow of inputs, labour investments, outputs and income. With the help of focussed interviews information will be gathered on the rationales

and driving factors behind decisions and the consequences of sudden shocks (risks) in taking decisions.

PhD project 7: Decision-making and livelihoods in East Kalimantan, Indonesia

Site: East Kalimantan, Indonesia;
Participating institutes: Rural Development Sociology and Aquaculture and Fisheries Group - Wageningen University
Mulawarman University, The Indonesian Institute of Sciences, Research Center for Economics.
Scale: Localities of shrimp farmers and fishers and traders
To be developed.

Theme 4: Governance arrangements facilitating change in aquatic natural resource use

Governance is a political process that deals with how power is distributed between stakeholders, allowing different groups to participate, control and use resources in a way transparent to all others involved. Customary and state governance processes over natural resources are increasingly interdependent, linked by locally and globally scaled forces that create and regulate flows of information, commodities and finance. State and non-state institutional arrangements, with their associated political, social-cultural and environmental histories, resulting from these global-local dynamics influence decision-making over aquatic resource use, regulation and management. Vietnam and Indonesia contrast two different sets of dynamics or development pathways to market liberalisation and control over the natural resources. The PhD studies in each country compare development pathways by focusing on coastal resources in the context of: agency and mobility of resource dependent populations; the material, technical, and environmental conditions of mariculture and fisheries development; the influence of national and trans-national forces over customary institutions; formal and informal access to information and trade; and the construction of knowledge between stakeholders at various scales. The sub-programme will provide a scientific basis for recommendations concerning improved governance arrangements of living aquatic resources both across coastal environments and socio-political national and international scales.

PhD project 8: Global and local governance over coastal zone management in the Mekong Delta: the resilience of coastal communities to ecological change.

Site: Mekong Delta, Ca Mau province, Vietnam;
Participating institutes: Environmental Policy Group, Law and Governance Group – Wageningen University
Can Tho University

Scale: Research activities will be divided between analytical scales: global (trade, policy information dissemination); national (shrimp and fisheries management, extension and trade); local (policy, management, trade)

Population growth and increased transport infrastructure in the Mekong Delta of Vietnam has led to rapid change of land use and resource exploitation in diverse coastal habitats. The ecological vulnerability of coastal environments is directly linked to the social resilience of coastal communities who are dependent on aquatic resources. These communities do not operate in isolation, but instead make decisions based on a combination of government policy, customary institutions and market trade. As the Vietnamese government further promotes an export oriented economy the decisions taken by resource users and planners alike is increasingly dependent on their access to global flows of information, commodities and finances. Customary institutions control decision making at the local level through a range of context specific, socially and culturally embedded norms, rules and regulations. In order to facilitate equitable and sustainable management of coastal resources, managers and resource users alike require a more informed understanding of how increasingly globalised dynamics - such as trade, information and finance - influence local level decision-making over resource use. Using a multi-scale, multi-actor approach the research will incorporate both quantitative and qualitative methods to examine the trade-offs between existing governance arrangements at global, national and local levels that influence relevant state and customary institutions governing the use and management of coastal areas. At the local level resource use history, conceptual mapping, and participant observation will be used to identify and critically analyze the role of customary resource use, trade and management regimes. At national and global levels, policy networks will be analyzed through in-depth interviews and analyses of legal and institutional frameworks of relevant state and non-state organizations responsible for trade, policy, management and information dissemination. To integrate multiple scales into a coherent analysis both conceptual and spatial mapping techniques will be used to track the flows of policy, information commodities between global, national and local levels.

PhD project 9: Coastal governance between decentralisation and transnational forces in Eastern Kalimantan, Indonesia

Site: East Kalimantan, Indonesia;

Participating institutes: Rural Development Sociology, Environmental Policy Group – Wageningen University
Mulawarman University, The Indonesian Institute of Sciences, Research Center for Economics.

Scale: Research activities will be divided between analytical scales: global (trade, policy information dissemination); national (shrimp and fisheries management, extension and trade); local (policy, management, trade)

East Kalimantan is rich in aquatic resources. The region serves as a socio-economic frontier attracting entrepreneurs from Kalimantan and elsewhere. Indonesian models for resource management are usually top-down, land-oriented, and sector bound. Coastal governance differs in that it concerns highly dynamic aquatic resource uses

and management decisions across administrative scales and sectors. It needs to accommodate the livelihood needs of a highly mobile population, short-term changes in livelihoods involving aquatic resource management, and trans-national to decentral scales of decision-making. Insight is needed in the actual implementation of laws and regulations, the resource-related practices of a variety of local 'stakeholders' who have unequal access to the resources, and the institutional contexts, historical processes and social values within which these are embedded.

This is a bottom-up case study of everyday practices and strategies of actors at multiple social spatial and temporal scales. A three-tiered approach is used of field research, including interviews, cognitive mapping, and observations. This is supported by an historical analysis of secondary sources and oral history accounts to show historical transformations since 1950s at district, provincial, national and transnational levels using formal statistics, maps. Both qualitative and quantitative data will be gathered to supplement each other, as well as to complement official statistical data. A policy study of central/decentralized laws and regulations will provide insight in possible overlap and contradictions between legal texts, between laws and regulations issued by different sectors and levels, and between the laws and their implementation. The RESCOPAR PhD in Kalimantan closely co-operates with at least 2 MSc researchers of the EU-funded MANGROVE project who will carry out livelihood studies and the PhD researcher working on governance in Vietnam.

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