

Abschlussbericht für das im Rahmen des Paktes für Forschung
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SUTAS (Sustainable Use of Tropical Aquatic systems)

Final Report

Title of project:

SUTAS
(Sustainable Use of Tropical Aquatic Systems)

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1. Executive summary:

SUTAS stands for “Sustainable Use of Tropical Aquatic Systems” and represents a high- level interdisciplinary Graduate Training School at the Leibniz Center for Tropical Marine Research (ZMT) in Bremen in the field of tropical coastal systems in their societal context. Here, rapid environmental change meets fundamental societal changes, like population growth or market integration, threatening ecosystem functions and services. For a functional understanding of these ecosystems, highly skilled experts are needed to develop realistic coping-strategies. This requires interdisciplinary research aimed at an understanding of the combined effects of natural and anthropogenic pressures on these systems.

SUTAS represents the logical extension of the interdisciplinary ZMT research and training concept into structured graduate education, and provides interdisciplinary as well as disciplinary training. It builds on the experience of the Master program ISATEC (International Studies in Aquatic Tropical Ecology) initiated by ZMT in 1999.

In SUTAS, a multidisciplinary nucleus group of six PhD students has worked in Zanzibar (Tanzania), a regional research focus area of ZMT. Here SUTAS has partnered with the IMS (Institute for Marine Science) and the State University of Zanzibar (SUZA). In Germany, SUTAS partners included the universities of Bremen and Oldenburg, the Jacobs University in Bremen, the Leibniz Institute for Epidemiology and Prevention Research (BIPS), Bremen, and the Senckenberg Research Institute and Natural Museum (SaM), Wilhelmshaven.

The interdisciplinary research spans from studies on the behavior of fishermen, over ecosystem - based fisheries assessment, and health and nutrition of local communities to the study of coral derived organic matter cycling and sea grass macroalgae interactions.

During the final workshop of SUTAS in Stone town, Zanzibar in September 2016 future avenues for the collaboration in marine sciences between Germany and Tanzania were defined in the following priority areas: (1) Assembling and mapping of data (using a GIS based multilayer data base) of research that has been conducted on coral reefs, sea grasses and fisheries to obtain a complete vision of the present state of knowledge; (2) Development of a fisheries monitoring programme, which allows for data optimization at lowest monitoring effort/costs; (3) Assessment of the artisanal fishery for large pelagic fish in conjunction with the assessment of offshore stocks harvested by the West Indian Thuna commission to get a clear picture of stock status; (4) Water quality as cross cutting research theme for all research groups. Eutrophication, heavy metal contamination, microbial contamination through sewage effluents, all impact on the quality of coastal waters, directly affecting the health of near shore ecosystems (sea grasses, coral reefs) but also inland (drinking) water is greatly impacted. Drinking water salinization is already occurring and water quality in terms of Coli and other bacteria seems to be critical in some areas. Integrated research needs to contribute to solve these problems of water supply; (5) Zanzibar, as an island Socio-ecosystem greatly driven by tourism development, is considered an ideal case study system to investigate and model system change over time as driven by local and global environmental and socio-economic drivers. Since coral reef biodiversity and endemism is high as is the landscape beauty and the importance of its cultural heritage status (Stone town), research on conservation is imperative and needs to be continued.

2. Aims of Project

SUTAS was aimed at providing ZMT doctoral students with a programme tailored to the needs of ZMT research and training. It provided a platform for doctoral students to work in multidisciplinary research teams on the island of Zanzibar (Tanzania), a focal region of ZMT research in order to tackle particular social-ecological problems of the region.

The training elements created for SUTAS students comprised 1) an annual summer school on relevant and annually changing topics; 2) a statistics round table offered on a regular basis (every second months), 3) an introductory course on the multidisciplinary research approach of ZMT, 4) a course on scientific communication and the publication process, 5) a course on the use of the ZMT laboratories and analytic instruments, 6) an introductory course on Ecosystem-based Resource management and 7) training for scientific diving and certification as tropical research diver). SUTAS was meant to create and test a doctoral study programme configuration, which would lead to a sustainable, long-term doctoral programme at ZMT

3. Development of work, including deviations from original plan/concept, scientific failures, problems with project organization and technical/logistical conduction

After successfully completing the recruitment process of the 6 doctoral students in the first three months of the year 2014, each student project was further planned individually between the student and his/her thesis supervisor. For each SUTAS student, a panel of three scientists was created who were accompanying the students throughout his/her study period. The frequency of panel meetings, the roles of the panel members, the number and structure of the reports to be written, all these details are written down in the *Doctoral Study Regulations of ZMT*.

During the first year of SUTAS, the director of the program met with the students and supervisors on a regular bi-weekly basis to discuss the individual projects with all students, to identify needs for change in plans and to coordinate logistics with the project partners in Zanzibar.

In the following lines, a brief description of all realized Doctoral studies will be provided following a common report structure:

Dieuwke Hoeijmakers, Project: WP1.1. Seagrass-macroalgae competition/Eutrophication of Sea grass meadows of West-Zanzibar

Aims: To assess the current stage and species composition of sea grass meadows of Zanzibar along a gradient of eutrophication

Objectives/research questions: How is sea grass meadow productivity, e.g. photosynthetic yield, abundance, plant morphology, biomass and total C:N tissue contents, responding to different levels of nutrient loads?

Summary of work conducted and main findings:

In this study, we assess the current state of sea grass meadows of Zanzibar, Tanzania and focus on the densely populated, but less studied western side of the archipelago's main island. Zanzibar's west coast has an estimated 600,000 inhabitants with no access to wastewater treatment facilities. An estimated 2.2×10^6 L⁻¹ day⁻¹ of untreated sewer is emanated, with yet unstudied effects on the surrounding sea grass meadows. Due to high population density of this area, the

coastal waters are documented to be impacted by cultural eutrophication. Sea grass meadows were selected with increasing distances from the coast in order to obtain a gradient in anthropogenic nutrient input receding from the Unguja's capital, i.e. Zanzibar city. Along this gradient several monospecific and heterospecific sea grass meadows were sampled in 2013 along 50m transects. Water column and sediment pore water nutrients (NH_4^+ , NO_x , PO_4^{-3}), Chl *a*, POM and photometric measurements were determined together with measurements of photosynthetic yield, cover, abundance, biomass and C:N contents of the sea grass plants. In contrast to our expectations, results showed low ambient nutrient concentrations throughout the sampled area, with NO_x and PO_4^{-3} levels $<2\mu\text{M}$, and NH_4^+ concentrations not exceeding $5\mu\text{M}$ and $30\mu\text{M}$ in water column and sediment pore water respectively. However, preliminary results on sea grass community composition, biomass and plant morphological variations along the gradient provide strong evidence that the sea grass meadows on Unguja's western coast are impacted and possibly declining in this region. From these five sites, two main sites were selected to carry out annual surveys from 2013-2015 and field experiments. These sites were defined as 'low' (Snake) and 'high' (Harbor) level of anthropogenic nutrient input from Zanzibar city. Both sites have similar environmental parameters and are characterized by extensive sea grass meadows dominated by *Cymodocea serrulata*. Standard water quality parameters, including water column and sediment pore-water nutrients were determined. Meadow productivity, e.g. photosynthetic yield, abundance, plant morphology, biomass and total C:N tissue contents were measured. In addition, to simulate projected nutrient loading increase, *in situ* fertilization experiments were set-up and surveyed for 42 days. Sea grass responses to nutrients at the sites were measured. Water column nutrient concentrations were overall higher at the Harbor site. However, throughout the sampled area ambient nutrient concentrations were low. With NO_x and PO_4^{-3} levels $<2\mu\text{M}$, and NH_4^+ concentrations did not exceed $5\mu\text{M}$ and $35\mu\text{M}$ in water column and sediment pore-water respectively. Belowground tissue accounted for the difference in biomass among the sites, with Snake yielding more than twice the biomass in comparison to Harbor plants. Corresponding with the low nitrogen concentrations observed, lowest N tissue contents were found in Snake's plants. Moreover, $\delta^{15}\text{N}$ of 2.8‰ found in the rhizomes suggests N_2 -fixing organisms are supporting this meadow. Additional nitrogen loading at the Harbor meadow negatively affected the sea grass plants at this site. This could be an early indicator that the Harbor meadow is at a critical threshold point towards cascading decline. Sea grass at Snake showed signs of nutrient limitation with a positive response to nutrient enrichment. Samples of the sea grass species, *Cymodocea serrulata*, were also taken to develop a Transcriptome RNA library for further molecular work, including RNA expression in response to nutrients. However, development of the library and gene expression work could not be completed due to time limitations. **Sea grass Nutrient uptake** (Complementary MSc thesis research of Daniel Arturo Saavedra Hortúa). To complement field surveys, experiments, and molecular work, nutrient uptake rates of *Cymodocea serrulata* were determined in laboratory experiments the ZMT. Results obtained indicate that *C. serrulata* present short term physiological responses to eutrophication, which could be positive because the nitrogen is incorporated to the plant system and stored or used for its growing. However, long term exposure to increased nitrogen concentration - especially ammonium, which has been evaluated in other sea grass species- has shown negative impacts on the physiology of sea grasses. Additionally, the evaluation of sea grass communities indicates stress of sea grasses due to competition with microalgae and potential irreversible changes in the sea grass ecosystem under an enriched nutrient environment. **Carbon storage in the sea grass meadows of West coast of Zanzibar** (Complementary post-doctoral research of Post-doc E. Fay Belshe). Carbon storage within sea grass meadows of the West coast of Zanzibar was measured among 19 different sites. Study results

suggest that the geophysical conditions (energetic flow regime, relatively coarse carbonate parent material) led to a low-deposition, sediment-limited environment, which was not conducive to OC stabilization and outweighed any variation in the quantity or quality of plant inputs, ultimately leading to low OC storage within all sea grass communities. This highlights the complexity of OC cycling in sea grass ecosystems and cautions against the use of plant traits as a proxy for OC storage across all sea grass ecosystems. **Sea Urchin Grazing on Sea grass** (complementary MSc thesis research of Agustín Moreira-Saporiti). In this study we describe an overgrazing event by the sea urchin *Tripnesutes gratilla* in *Thalassodendrum ciliatum* meadows around Prison Island, Zanzibar, Tanzania, that occurred between 2014 and 2015. According to the gut content, feeding rates and electivity parameters, *T. gratilla* had a feeding preference for *T. ciliatum* and, in a lesser extent, for *Syringodium isoetifolium*. *T. ciliatum* meadows show some recovery, suggesting that even though these events are destructive for the sea grass meadows shoots, their belowground biomass can support the recovery through their energy reserves; demonstrating the resilience of sea grass meadows to withstand severe changes in their environment. **Seaweed farming and sea grass meadows** (complementary MSc research of Agustín Moreira-Saporiti). The goal of this study was to test the effects of seaweed farming on sea grass and microalgae, and to check whether the opportunistic species *H. stipulacea* can out-compete the climax species *T. hemprichii* under these conditions. Results suggest that Seaweed farming could be harmful for sea grass and microalgae communities in the long run, as it reduces macro algae cover and impedes further growth of sea grass. On the other hand, trampling exerts an intermediate disturbance, promoting the production of new shoots in the climax species *T. hemprichii*, but not in the ephemeral *H. stipulacea*. *T. hemprichii* is, therefore, resistant to both shading and trampling, increasing production of shoots when shading is not present but trampling is. *H. stipulacea* is not highly affected by shading, showing that trampling is the main effect on its shoot density. Macro algae is highly sensitive to the shading, but not to the trampling. **Phenolic compounds** (complementary MSc research of Katrin Gese). Sea grass produces phenolic compounds as a deterrent substance to avoid grazing from herbivores. It has been shown that the concentration of phenolic compounds in sea grass leaves can be altered by the environmental conditions and nutrient availability. A study was conducted in two (low and high nutrient) sites in the coast of Stone Town (Unguja Island, Tanzania). The results show no clear relation between nutrient availability and phenolic compounds concentrations in seagrass leaves. Also, the concentration of phenolic compounds is similar within one sea grass shoot, showing no significant differences between new and old leaves.

Relevance for management Sea grass meadows are of vital importance to the Zanzibarian people. Since they provide ecosystem services, including shoreline protection of the Stone town, feeding and nursery habitat for several commercial important fish/crustacean species and their water-filtering capacity (i.e. facilitate water clarity for other photosynthesizing organisms like coral reefs). Reducing nutrient loads on the west-coast marine ecosystems could prevent further sea grass decline. Additional stressors, like sea urchin overgrazing events can cause serious sea grass decline and even cascade into sea grass habitat loss.

Future research questions include: What drives the community composition of sea grass meadows along the Zanzibar west coast? Do different communities provide different ecosystem services? Do different sea grass community compositions have higher resilience against multiple stressors? What will be the effect of additional nutrient loading on the different sea grass species? What causes sea urchin outbreaks in this region? Is there an effect of overfishing on predatory species? Or is there another factor effecting sea urchin recruitment successes?

Stephanie Helber, WP1.2 - Project: Coral derived organics matter cycling/ Chemical ecology of sponges

Aim: to investigate the chemical ecology of sponges on coral reefs off Zanzibar's West Coast. The overall goal was to define the role of sponges and their competitive ability towards corals by examining the chemical defense mechanisms of sponge extracts in the laboratory as well as in the field under natural conditions.

Research questions:

1. How are benthic coral reef communities in Zanzibar structured? What are the dominant benthic reef organisms? How abundant and diverse are epi-reefal sponges on Zanzibar's reefs?
2. Is the increasing prevalence of sponges on the reef related to sponge chemical defenses against various threats such as predators, microorganisms and competitors?
3. Do sponges contain allelochemicals, which negatively affect the health of coral competitors?
4. Is the reef around Bawe resilient enough to withstand further disturbances? Are there indications for possible phase-shifts?

Summary of work conducted and main findings:

Sponges are among the dominant benthic organisms on coral reefs, representing important spatial competitors for reef-building corals. Coral reefs have experienced drastic declines in coral cover and corresponding increases in the abundance of other spatial competitors, such as macro algae, corallimorpharians and sponges, due to a combination of global and local stressors. The ability of sponges to chemically defend themselves against predators, microbes and other competitors may partially explain their high abundance on reefs worldwide. Nonetheless, studies investigating sponge abundance and chemical ecology are rare, particularly in the Western Indian Ocean, which is considered a hotspot of coral and sponge biodiversity.

Thus, this thesis is the first study that provides insights into the chemical ecology of sponges from the Western Indian Ocean. We assessed the benthic community composition of the reef at Bawe, an island on Zanzibar's West Coast. This reef was dominated by reef-building corals, but sponges also represented a diverse and abundant component of the reef fauna. Moreover, laboratory experiments were conducted to investigate if predation was a key factor in structuring the sponge community. Findings revealed that the reef was dominated by palatable rather than chemically defended sponge species, demonstrating a lack of predatory control on the sponge community likely due to overfishing. In the absence of predation, palatable sponges could potentially undergo uncontrolled growth in the future and thus subject reef-building corals to greater competitive pressure.

We further investigated the antimicrobial and cytotoxic activities of secondary metabolites extracted from the most abundant sponges at the reef around Bawe. The experiments revealed that the most abundant sponges were remarkably well defended against co-occurring marine bacteria and in particular against potential pathogens. Moreover, the majority of the sponge extracts also displayed cytotoxic activities. Metabolites with either antimicrobial or cytotoxic properties can provide sponges with a competitive advantage over corals. Antimicrobial compounds could alter the coral microbiota while cytotoxic compounds are able to impair the cell division of corals. Consequently, the potential allelopathic properties of sponge crude extracts from the three most abundant and bioactive sponges were further examined

in field experiments under natural conditions. These experiments showed that the extracts of all three sponges possessed allelopathic compounds that adversely affected the photosynthetic efficiency of the corals symbiotic zooxanthellae. The presence of allelopathic compounds, and their significantly negative effect on coral photo efficiency, suggests that allelopathy by sponges does play a role in spatial competition with corals. As a result, sponges might be able to exert negative effects on the coral's fecundity, their reproduction or even their associated micro biome making corals more vulnerable towards further natural or anthropogenic disturbances and pathogenesis.

Collectively, the present study demonstrated that sponges on reefs in Zanzibar are serious spatial competitors against reef-building corals. The increased sewage input in combination with other local stressors, such as destructive fishing practices or damage to the reef through tourism activities, will most likely result in more frequently occurring sponge-coral interactions. Thus, management strategies for Zanzibarian reefs should focus on minimizing anthropogenic stressors, like the establishment of a sewage water treatment facility to minimize stress on the benthic community, in order to reduce the risks to coral reef health. Fisheries regulations should also be enforced as an important component of coral reef management plans in order to restore healthy herbivorous as well as spongivorous fish populations on the reefs, which limit the proliferation of competing macro algae and sponges.

Challenges/Problems

Ms Stephanie Helber had to change her main supervisor (Prof. Dr. C. Wild), when he left ZMT to work at the University of Bremen. The SUTAS Programme director, Prof. M Wolff took over his role as principal supervisor. Secondary supervisors (Prof. Schulp, Uni Oldenburg and Prof. Richter, AWI, Bremen) helped during the supervision process. Due to the change in supervisor the thematic orientation of the doctoral study changed to the chemical ecology of sponges.

Natalie Herran, Project: WP1.3. Effect of Aquaculture on Carbonate builders/ Calcium carbonate production and the response of calcifying organisms to natural and anthropogenic threats on the shallow platform of Zanzibar, Tanzania

Aims and scope

The present study examines from a holistic perspective the ecological value, status, production, breakdown and composition of coral reefs in the Western Archipelago of Zanzibar. We used census-based field exploration to quantify the carbonate builders abundance and distribution to determine the relative contribution of different carbonate producers to the total net budget. We followed certain theoretical premises sensu Chave et al.(1977): 1) The measure of gross carbonate production (GCP) states for the collective carbonate producers in a reef scale.

2) The net calcium carbonate production, estimated the total CaCO₃ produced and potentially permanently retained within the reef system (i.e. the net balance of bio construction and bio erosion processes).

In addition, we assessed the dispersal of particulate sediment on adjacent reefs to Stone Town, in the western coast of the Zanzibar platform to estimate the extent of local human impacts (pollution). We also investigated the linkage between ecological processes and geomorphic formations, as physical factors re-work and transport carbonate material produced in the reefs, which ultimately can be utilized by other marine organisms. Therefore, we also considered reef connectivity, because the ecosystem services coral reef provides (e.g. carbonate sediments) work as a foundation for other marine habitats, i.e. Sea grass beds. Five general aspects were addressed:

- Reef community composition and overall coral reefs status.
- CaCO₃ production and bio erosion
- Response, plasticity, and adaptation of the coral's inhabitants to turbid conditions
- Anthropogenic influences on reef geomorphology
- Carbon storage

Summary of work conducted and main findings

Biologically produced calcium carbonate (CaCO₃) structures are the foundation of coral reefs ecosystems and associated landforms. Produced by the growth and decay of hermatypic scleractinian corals and reef dwelling organisms (e.g. calcifying macro algae, bryozoans, crustose coralline algae, mollusks, etc.), constructive and destructive processes typically occur on an individual scale. Over time collectively they control the reef framework accretion (on a long-term, reef-spatial scale) and the development of sedimentary deposits (e.g. coral cays and sandbanks). Also, the supply of reef-derived sediments supports other associated shallow water marine ecosystems (e.g. sea grass beds), and the reef framework roughness supports large amounts of biomass on coral reefs, which are among the most diverse ecosystems in the world. However, adverse effects of natural (e.g. marine snow, storms and earthquakes, water temperature rise, coral bleaching, and Crown-of-Thorns) and anthropogenic (e.g. sewage, nutrient loading, overfishing, tourists, mangrove cutting, construction and sedimentation) impacts on benthic community composition affecting coral reef functionality and CaCO₃ production, among others, over a variety of spatial and temporal scales. The objective of this work was to investigate the biophysical interactions that affect calcifying organisms (hard corals, crustose coralline algae, and calcifying macro algae) and modify fringing reefs. With an emphasis on overall ecosystem health and the relevance of conservation areas, this study focuses on unprotected fringing reefs and a marine protected area, located in the Archipelago of Zanzibar, Tanzania. We assessed the status of the coral ecosystem and its function to produce CaCO₃ and maintain complex reef structures, using a range of multidisciplinary approaches, from ecological census-based methods, biogeochemistry and hydrodynamic measurements to morphological and sedimentological surveys. Traditional ecological census surveys provided a good estimation of the structural complexity, which ranged from (1.18±0.13 to 1.51±0.24 m/m) and community structure of the ecosystem, which pointed hard coral as major CaCO₃ producers (8.47±4.37 to 16.90±9.70KgCaCO₃ m⁻² yr⁻¹) and the dominant benthic taxa (>50% coverage). However, sedimentological approaches provide a broad understanding of time-averaged, coral-derived sediment sources shaping the landscape. With the use of biogeochemical approaches, we measured the concentration of suspended particular matter (18.2 to 36.4 mgL⁻¹) and characterized the composition of its organic fraction (particular organic matter). The organic fraction shows that untreated sewage reaches coral reefs adjacent to Stone Town (δ¹⁵N, 10.28±0.9‰ on surface waters). Also, turbidity and associated shading effects control bathymetrically coral reef formations to 16±2 meters. Moreover, since no baseline studies were available in the literature, we compared our findings with estimates from a local marine protected area, Chumbe Island Coral Park, to better understand potential negative effects of natural and anthropogenic impacts on the natural ecosystem. Despite that Zanzibarian reefs show on average a healthy reef condition, CaCO₃ produced on Chumbe Island Coral Park shows doubled production in comparison to CaCO₃ produced on more degraded reefs. So far Chumbe Island Coral Park shows the highest CaCO₃ budget globally, although scored similar values to other marine protected areas in the Caribbean, which highlighted the importance of conservation areas to keep corals functionality.

Aims and research questions

The scope of the project was to assess the fishery of Chwaka Bay by applying single-species methods and by placing the fishery into an ecosystem-based context using the *EwE* ecosystem model. Furthermore, using Chwaka Bay as a reference site the study aimed at approaching the answer to the question of the sustainability of Zanzibar's near shore fisheries. The specific research questions of the study were:

- I. Where is the evidence for an overexploitation of Zanzibar's near shore fisheries and to what extent are they overexploited?
- II. What is the state of selected key target species of the Chwaka Bay fishery?
- III. What is the overall state of the Chwaka Bay ecosystem and its fishery? How are the different gears in use impacting the trophic structure and energy flows of the system? What is the impact of the different gears on the local fishing community?
- IV. What are the impacts of a reduction or reallocation of dragnet fishing effort on the biomasses of the different functional groups and on the profits of the fishing communities? How can the dragnet fishing effort be reduced without compromising the livelihood of the fishing community?

Summary of work conducted and main findings

Small-scale fisheries are essential livelihood and protein providers for coastal communities in developing countries. On the semi-autonomous island state Zanzibar (Tanzania) and, in particular, in Chwaka Bay, located on the east coast of the island, the dependency on small-scale fisheries is very high. Perceived decreases in individual catches and the use of destructive gears and small mesh sizes have led to concerns for an unsustainable use of the bay's fisheries resources. Particularly, the increasing use of the destructive dragnets has led to resource concerns and to strong conflicts between fishermen. However, the lack of knowledge on the state and dynamic of the fishery strongly impedes the potential for the development of proper management plans.

The aim of the present dissertation was, therefore, to assess the status of Chwaka Bay's ecosystem and its fishery, as well as to evaluate potential use scenarios for a sustainable fisheries management. Furthermore, using Chwaka Bay as a reference site, the dissertation aimed at approaching the answer to the question of the sustainability of Zanzibar's near shore fisheries. The approach used in this dissertation is twofold: 1) length-based stock assessments were conducted for six of the main target species; and 2) a trophic flow model of the bay was constructed using *Ecopath with Ecosim/Ecospace*. The data used in both approaches were collected through an extensive field survey conducted over an annual cycle in 2014.

A review of the literature about the state of Zanzibar's fisheries revealed that no fisheries assessments have been conducted after 2000. Analyses of the annual reported landings between 1990 and 2014 suggest that, except for clupeids, none of the target groups of the fishery can be classified as overfished. Most studies evaluating the status of Zanzibar's resources have been focusing on ecological surveys and fishermen's perception.

The stock assessment of the key target species of Chwaka Bay suggests that the exploitation rate of three out of the six target species exceeds recommended levels (E0.1). Despite high juvenile retention rates and length at first capture being below optimum length at first capture, fishing mortalities are highest for adults. Due to the nursery characteristics and the topography of the bay, juveniles might occur in higher

abundances and larger fish may concentrate further outside the bay area. Consequently, an increase in mesh size only seems economically viable, if the radius of the fishery was increased to capture larger specimens outside the shallow bay area.

The trophic model indicates that the Chwaka Bay ecosystem is comparatively mature. The bay is strongly bottom-up driven, with biomass concentrations around the first and second trophic level and a low overall fish biomass. The strongest impact on the ecosystem is exerted by dragnets and traps. Both gears potentially destabilize the ecosystem by reducing the biomass of top-down controlling species. Together with hand lines, dragnets and traps are the least selective fishing methods. In addition, traps exert the highest fishing pressure on 4 out of the 6 selected key species. While the dragnet fishery is the least profitable, it also provides the highest number of jobs for the community, as it is a labor-intensive fishing method.

Simulations of different use scenarios suggest that the elimination of dragnets would lead to the highest increase in overall fish biomass and profits for the fishermen remaining in the fishery. Nevertheless, this scenario would leave 58 % of fishermen without job and is, therefore, not feasible under the current lack of alternative livelihoods and the high dependency of the villagers on fisheries resources. The complete reallocation of dragnet fishermen is likewise not feasible, since current effort is already high, and a further increase will lead to strong biomass reductions of target species and losses in individual profits of fishermen. Without compromising individual profits (-20 %) and biomass structure of the ecosystem (-30 %), only a part of the dragnet fishermen can be reallocated, leaving 37 % of fisher without jobs.

In conclusion, the fishery of Chwaka Bay is fully exploited with some groups experiencing overfishing and does not provide scope for further expansion. Emperor fish together with similar vulnerable target resources such as groupers might be unsustainably harvested throughout the island. The lack of recognition for the capacity of dragnet boats to absorb surplus labour and their marginalization is likely hindering the development of feasible management plans aimed at regulating their use. In order to stop the use of dragnets on Zanzibar, management should focus on an effort control of this gear, while investing in the diversification of livelihoods.

Problems encountered

One of the central problems of the data collection system on Zanzibar is that information is only available in a highly aggregated form, namely overall catch in kg and price per target family per district. This information is only of limited informative value; neither analytical nor holistic methods can be applied. Very detailed information is in fact collected by the beach recorder: the catch in kg and price of each target family per gear, fishermen, boat and day. However, this information is stored in data sheets and is not made electronically available. Clearly, the limited personnel and technical capacities are the root cause of this situation. This highlights the need for a better financial support of the DMFR for the collection of data that can be used to evaluate and manage Zanzibar's fisheries. Furthermore, the complexity of the fishery, the chaotic situation at the landing sites and the limited manpower for data collection all make it very difficult to accurately sample and estimate information on overall catch of target families let alone precise information on fishing effort. Furthermore, catch information at family level likely masks the dynamics of important target species. I therefore propose to expand the data collection to include the easier collected length-frequency distribution data of some of the key target species.

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| <p>Aneeqe Javaid; Project:WP2.2. Modeling behavior of fishermen/ Temporal dilemma, time preferences and natural resource extraction</p> |
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Aims: to shed lights on two important issues related to the temporal dilemma with respect to natural resource extraction. The first investigates the impact of the temporal dilemma on resource users' extraction behavior, while the second focuses on understanding the relationship between their time preferences and their extraction behavior.

Objectives/research questions:

How does the temporal dilemma impact extraction rates?

How does the temporal dilemma impact the use of destructive extraction methods?

Do higher individual time preferences lead to higher extraction rates?

Do higher individual time preferences lead to greater usage of destructive extraction methods?

Summary of work conducted and main findings:

This dissertation sheds lights on two important questions related to temporal dilemma with respect to natural resource (fisheries) extraction:

How does the presence of temporal dilemma impact resource users' extraction behavior? (ii) What is the relationship between individual time preferences and resource extraction behavior? For both cases two different aspects of extraction behavior were considered: (i) effort level decision, and (ii) extraction method choice.

Chapter 2 looks at the impact of temporal dilemma on the distinct but inter-related problems of over-extraction and destructive extraction in natural resource use settings. Standard CPR experiments were employed without time delay (control groups) and CPR experiments with time delay (time treatment groups) in conservation earnings to investigate whether or not participants were likely to extract greater amount of resource in the presence of temporal dilemma. Results suggest that delaying the benefits of conservation – an experimental feature which brings the experiment closer to reality, as conservation benefits always occur with a time delay – mainly impacts participants' extraction decision by making them more likely to try out destructive extraction methods. It was found that the number of people, who do not opt for destructive extraction method even once during gear choice rounds, was significantly less in the time treatment groups as compared to control groups. On the other hand, we did not find evidence of difference in effort level between time treatment groups and control groups when participants could not chose their extraction method. Chapter 3 combines experimental methods and questionnaire data to understand the relationship between individual time preferences and natural resource (fisheries) extraction. Individual time preference was elicited with incentivized choice experiments and the resulting time preference was linked to extraction data from questionnaires and CPR experiment. Findings suggest that the relationship between time preferences and CPR extraction is not as straightforward as predicted by classical economic theory. In contrast to earlier studies, it was found that fishers' time preferences were positively correlated to their extraction rates. Our surprising findings can partly be explained by the disinvestment effect of time preferences and by fishers' cognitive abilities. Chapter 4 looks at the use of destructive fishing methods and its relationship to individual time preferences. Due to intertemporal nature of fisheries extraction activities, standard economic theory suggests that an individual's valuation of future income (individual time preferences) can play a major role in determining the gear used for extraction. Based on earlier theoretical work two ways were identified, in which individual time preferences can impact the adoption of destructive extraction (fishing) methods; (i) the conservation effect which posits that patient individuals are less likely to use destructive extraction methods since they are more likely to account for the loss of future income that is accompanied by using these methods, (ii) the disinvestment effect which argues that patient individuals are more likely to use (costly) destructive extraction methods since they have greater ability to invest in their extraction capabilities. An agent-based

model was used to understand the relationship between time preferences and adoption of destructive fishing gear. Our model suggests that the nature of destructive gear (i.e. whether it is a cost-saving gear or more costly gear) along with the level of social dilemma determines whether patient or impatient individuals are more likely to adopt such a gear. Additionally agent's beliefs regarding future resource condition and other agent's extraction level can have a major influence in some cases. Our results clarify the conditions under which conservation effect becomes more dominant as compared to the disinvestment effect and vice versa.

Maria Adam Nyangasa, Projekt WP2.3 - Access to Food and Nutritional Status of the Zanzibari Population (PhD Student from BIPS)

Aim: to examine potential impacts of environmental changes and globalization on food security and food choices and the implications for health and nutritional status of the Zanzibar population in Unguja Island.

Objectives/Research questions:

1) understand and assess interplay of households and community structures towards health outcomes in relation to nutrition and diseases; 2) analyze spatial clustering of community health outcomes (wasting, obesity or metabolic disorders) using GPS; 3) assess nutritional status and food consumption behaviors of all members of the household through anthropometric measurements and individual dietary diversity score; 4) investigate metabolic biomarkers in blood and urine to assess health and disease risks among the Zanzibari.

Summary of work conducted and main findings:

The study enrolled 235 households and 1314 participants (age 0-96years old) drawn from 80 randomly selected Shehias (local expression for "wards", the smallest administrative unit on Zanzibar) to give a representative picture of the study area. Two "household members' questionnaires" (all members under 2 years and all members above two years) and a "head of household questionnaire" were used to collect data on individual and household dietary information and related determinants respectively. Anthropometric measurements data was collected on all members of the household, blood pressure information was obtained only on members above 2 years of age. The study collected venous blood and morning urine samples from all participants in an overnight fasting status; blood sample was collected from members above 5 years of age and urine from all members of the household. Physical activity was measured objectively using accelerometer to a sub-sample of 95 children and adolescents between 3-16 years old. All measurements taken by trained fieldworkers following internationally accepted and published standardized procedures.

A feedback workshop was conducted in Zanzibar in February 2015 to present preliminary results of the study to participated Shehias and stakeholders. The workshop was attended by approximately 150 invitees who included more than 80 Shehias of the participated Shehias, about 15 stakeholders from Tanzania mainland and Zanzibar Island, press from local news papers and some of the external partners same as mentioned in the cooperation section above.

First results were presented during the 12th European Nutrition Conference FENS in Berlin September 2015 and during the 10th German Society for Epidemiology (DGEpi) conference Berlin October 2015, allowing a first insight into the prevalence of cardio-metabolic risk factors in this study population representative for Zanzibar.

Results showed that the prevalence of cardio-metabolic risk factors was generally lower in rural than in urban areas and lower for male than for female individuals.

Of 235 participated households, more than half 54.9%; where from rural area with an average household size of 6.7 persons per household. Majority of the households

were headed by men 62.1% with the highest percentage from rural areas 33.6%. The majority of the remaining households were headed by women who were either widow, single parents or in polygamous marriage; 25.1% of household heads are polygamous. The results further show that literacy and illiteracy rates were highest among head of households in the rural areas. Overall, more than three-quarter 82.2% of the household heads had attained some level of education.

More than half 52.9% of the respondents reported one regular income to ensure stability of household food supplies, with majority of the respondents being from urban area 30.7% with one source of income and about 6.1% reported with two or more sources of income. Primary sector (farmer, livestock, fishing, daily wages) was the main occupation group for the majority of the household heads 27.7%. The second most common activity was Tertiary sector (services and trade) which was reported by 19.6% of household heads. **Prevalence of Malnutrition:** The study investigated nutritional status of all participating members from age 0-96 years old. The prevalence of underweight, overweight and obese for both male and female was 36.5%, 13.1% and 8.2% respectively. The trend shows that as the population gets older the prevalence of underweight decreases; the prevalence was 30.1% for all children below 5 years, 22.8% for participants between 15-59 years and 2.7% for elderly participants. The overall prevalence of underweight was slightly higher in male (19.2%) than in female participants (17.3%). On the other hand, overweight and obesity increases with increasing age, with the highest prevalence among adults between 15-59 year olds with prevalence of 72.1% and 76.9% respectively. Majority of women adults of age 15-59 years were more obese 18.4% compared to male participants (4.4%). **Prevalence of Cardio-metabolic risk factors:** The prevalence of hypertension, high cholesterol, high LDL, and high insulin was significantly higher in women in urban areas compared to men except for high HbA1c levels which was significantly higher in women in rural areas. High TG levels and high albumin-to-creatinine ratio was low. High prevalence of particular risk factors was not restricted to the urban population. **Importance of scientific findings:** Data on nutrition and lifestyle factors and related determinants in association with health outcomes from epidemiological studies are scarce for entire family in sub-Saharan Africa. In assessing health and nutrition status of the participants, this study did not only determine the prevalence of malnutrition in the study population, but provides also quantitative data on food consumption, and gives an overview of individuals with intakes that are below or above the national average as well as the extents to which diets of different population groups vary from each other. The study also investigated determinants of malnutrition, e.g. household structure, household economic situation, infrastructures as well as availability and accessibility of healthy foods. Specific anthropometric indices of malnutrition measured using body composition (BIA) and other measurements of body size (hip, waist and arm circumference) will be available at a later stage to examine their relationship to social, dietary and biochemical and health data. Bio-samples (venous blood and urine) indices investigated dietary biomarkers, history of hypertension and new data on blood pressure and in a sub-sample of 104 children between 3-16 years; accelerometers were used to assess physical activity levels.

Due to high prevalence of hypertension among study participants, our partners in Zanzibar are collecting additional water samples in the participated Shehias to investigate the association between hypertension and the quality (potassium and sodium) of the water sample in those Shehias. Several studies have investigated the status of blood pressure with the quality of water intake and several have explained this problem to be common mostly in coastal areas. The simple explanation given is that the problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change induced sea-level rise. Our survey data are also a source for further investigations and analysis; and provide a valuable starting point for future interventions.

The spatial clustering of community health outcomes (underweight, overweight, hypertension or metabolic disorders) using land use data (e.g. tourism or industrial zone, soil types) as well as environmental characteristics (e.g. potassium and sodium in drinking water) will help to get insight into “high risk” or “low risk” areas on the island and may be the basis for the development of tailored interventions.

Challenges/Problems

The study was conducted according to plan. However, there was a delay of publication of results due to maternal-leave of the responsible PhD student Maria Adam Nyangasa between 11/2014-12/2015. According to her supervisor (Dr. A. Hebestreit) Mrs. Nyangasa can be expected to finish her doctoral thesis in the second half of 2018.

4. General results, Perspectives and possible follow-up activities

During the SUTAS final Symposium in Stone town (Zanzibar, September 2016) over 50 participants the SUTAS consortium (University of Bremen, Jacobs University, Bremen, University of Oldenburg, Institute for Epidemiology and Prevention Research (BIPS), Bremen, Senckenberg Research Institute and Natural Museum (SaM), Wilhelmshaven, Institute of Marine Sciences, Zanzibar (IMS), State University of Zanzibar (SUZA)) and further guest scientists from the region joint for three days to reflect on the SUTAS-project results and to discuss possible future avenues for research in the region. The main findings are summarized below:

Personnel involved in SUTAS: Six international SUTAS Doctoral.-Students (see above) plus about 40 additional researchers, comprising M.Sc. students, senior scientists and postdoctoral students, of which roughly half were from Germany and half from the region (Tanzania, Kenya, Ethiopia, Sudan).

Avenues for further research:

- Assemblage and mapping of data (with the basis of a GIS based multilayer data base) of all research that has been conducted on coral reefs, sea grasses and fisheries to obtain a complete picture of the present state of knowledge;
- Development of a fisheries monitoring programme together with the fisheries authority, which allows data optimization at lowest monitoring effort/costs, to assure that meaningful data are being collected for stock assessment and for the elaboration of adequate management measures;
- Assessment of the artisanal fishery for large pelagics in conjunction with the assessment of offshore stocks harvested by the West Indian Thuna commission to get a clear picture of stock status;
- Water quality is a cross cutting research theme for all research groups. Eutrophication, heavy metal contamination, microbial contamination through sewage effluents, all impact on the quality of coastal waters, directly affecting the health of near shore ecosystems (sea grasses, coral reefs) but also inland (drinking) water is greatly impacted. Salinization of drinking water in some areas of the island is already occurring and water quality in terms of Coli and other bacteria seems to be critical in some areas. Since demand for drinking water will greatly increase due to population growth and increased tourism, ways have to be found to assure the provision of clean drinking water in the future and to reduce contamination and pollution of coastal waters. Integrated research needs to contribute to solve this problem;
- Zanzibar, as an island Socio-ecosystem greatly driven by tourism development, is considered an ideal case study system to investigate and model system change over time as driven by local and global environmental and socio-

economic drivers. Since coral reef biodiversity and endemism is high as is the landscape beauty and its cultural heritage (Stone town), the value of this island for conservation is also high.

- Health studies have shown that poor food accessibility, poor food consumption and food insecurity remain a key public health problem in many households in Unguja. Associations between wealth, food consumption and health differ regionally throughout Unguja island, the driving factors need to be further understood;
- Prevalence of overweight/obesity in adults (mainly women), hypertension and raised blood glucose are alarming, besides a high prevalence of under-weight in children under 14 years and there is a need for locally-tailored approaches to increase awareness of overweight/obesity as a risk factor for CVD and other chronic diseases;
- There is an urgent need for longitudinal studies in order to investigate true causality of associations a) between food consumption and food security and related determinants as well as b) between cardio-metabolic risk factors and health outcomes.

In the appendix The symposium programme is provided as is a presentation of the SUTAS Programme and its outcomes on the West Indian Ocean Conference of Marine Science (WIOMSA) in Daressalam in October 2017

Envisioned future for SUTAS?

- SUTAS shall continue beyond the time frame of the present funding period through its integration into the ZMT budget.
- PhD positions shall be announced through interdisciplinary research projects in core areas of ZMT.
- At present, core areas are the tropical West Indian and West African ocean coasts, the Eastern Pacific tropical South and Central America, the Brazilian coast and the Indonesian archipelago.
- SUTAS shall continue to offer basic scientific training (statistics and scientific communication) as well as disciplinary training in Focus areas of ZMT research, and shall conduct a summer school annually.
- A doctoral circle, comprised of all interest groups of ZMT, shall periodically review the program. Doctoral guidelines orient the student through the study period.

5. Possible economic use of Project results, of patents and collaborations with the industry

The research conducted within SUTAS was mainly focused on basic ecosystem research but has also dealt with assessments of fishery and aquaculture practices and their impacts on the ecosystem. Moreover, in project W1.2, antimicrobial and cytotoxic activities of secondary metabolites extracted from the most abundant sponges at the reef around Bawe were tested and experiments revealed that the most abundant sponges were remarkably well defended against co-occurring marine bacteria and in particular against potential pathogens. Moreover, the majority of the sponge extracts also displayed cytotoxic activities. It is well possible that future research on sponge metabolites could lead to pharmaceutical relevant substances. Results obtained in SUTAS may thus eventually open new avenues for collaborations with the productive sector of Zanzibar/Tanzania.

6. Contributions of collaboration partners within Germany and abroad that have contributed to the results of the SUTAS Project.

All partners of the SUTAS consortium have contributed to the project as planned. Both, the IMS (Institute for Marine Science) and the State University of Zanzibar (SUZA) have contributed to the health and nutrition research (WP2.3) and the ecological and fisheries research (WP1.1; WP1.2 and WP2.1 and WP2.2) respectively. The Universities of Bremen and Oldenburg, have contributed to the research of the WP1.1 and WP1.2 respectively. The Jacobs University and the Leibniz Institute for Epidemiology and Prevention Research (BIPS) have contributed to the WP2.2 and WP2.3, while the Senckenberg Research Institute and Natural Museum (SaM), helped with the WP1.2

7. Studies for qualifying purposes

The SUTAS program was meant to train 6 doctoral students in an interdisciplinary context and to provide a logistic basis for common fieldwork in a core region of ZMT research, for which the island of Zanzibar was selected. Until the day of writing this report, four of the six doctoral students have already completed their studies, two are still ongoing.

8. List of publications

In the following lines, a list of scientific products will be presented for each of the six doctoral projects. Since these were combined with other research activities of the SUTAS partners, the scientific products of those are also presented

Project: WP1.1. Seagrass-macroalgae competition/ Eutrophication of Sea grass meadows of West-Zanzibar

- Hoeijmakers, D., Belshe, E.F., Rixen, T., Nehl, U., Mtolera, M., Teichberg, M. Nutrient effects on seagrasses in the heavily populated western-coast of Zanzibar. (In preparation)
- Hoeijmakers, D., Belshe, E.F., Rixen, T., Nehl, U., Mtolera, M., Teichberg, M. Seagrass response to *in situ* nutrient enrichment in a low and high-impacted site along the western-coast of Zanzibar. (In preparation)
- Belshe, E.F., Hoeijmakers, D., Herran, N., Mtolera, M., Teichberg, M. Seagrass community-level controls over organic carbon storage are constrained by geophysical attributes within meadows of Zanzibar, Tanzania. Submitted to BioGeoscience.
- Moreira-Saporiti, A., Hoeijmakers, D., Mtolera, M., Teichberg, M. Feeding behaviour of *Tripneustes gratilla* related to a seagrass overgrazing event in Zanzibar. (In preparation).
- Moreira-Saporiti, A., Hoeijmakers, D., Msuya, F., Teichberg, M. Seaweed farming and trampling affects differentially macroalgae, climax and ephemeral seagrass species. (In preparation).
- Arturo Saavedra Hortúa, D., Gonzales Viana, I., Teichberg, M. Enzymatic activity of *Cymodocea serrulata* (R.Brown), under varying concentrations and sources of nitrogen and phosphorous. In preparation.
- Moreira-Saporiti, A. (2016) Feeding behaviour of *Tripneustes gratilla* related to a seagrass overgrazing event in Zanzibar. ISATEC master thesis, University of Bremen.
- Arturo Saavedra Hortúa, D. (2016) Physiological response and nutrient uptake of tropical seagrass *Cymodocea serrulata* under varying nutrient conditions. ISATEC master thesis, University of Bremen.

- Gese, K. (to be completed 2018) Phenolic compounds concentration in seagrass leaves exposed to low and high nutrient concentrations in Zanzibar. University of Oldenburg

Project WP1.2: Coral derived organics matter cycling/ Chemical ecology of sponges

- Helber S.B., de Voogd N.J., Muhando C.A., Rohde S., Schupp P.J., 2016. Anti-predatory effects of organic extracts of 10 common reef sponges from Zanzibar. *Hydrobiologia* 790:247-258.
- Helber S.B., Hoeijmakers D.J.J., Muhando C.A., Rohde S., Schupp P.J., 2017. Sponge chemistry is one factor for increasing sponge on reefs in Zanzibar. *In prep* for PlosOne.
- Helber S.B., Steinert G., Yu-Chen W., Muhando C.A., Rohde S., Schupp P.J., 2017. Highly diverse microbial communities in sponges from Zanzibar. *In prep* for Scientific Reports.
- Viviana Esteban (2017) Recruitment of Scleractinian corals under a high abundance of corallimorpharians and after strong bleaching event in the region of Zanzibar, Tanzania (Master thesis, ISATEC)
- Katharina Schubert (2014) Analysing ecological effects of Corallimorpharia on reef ecosystems. (Master thesis, ISATEC)
- Kruse, M., Tayler, M. & Reuter, H. 2016. Lunar, diel, and tidal changes in fish assemblages in an East African marine reserve. *Regional Studies in Marine Science* 3: 49–57, doi:10.1016/j.rsma.2015.05.001
- Kubicek, A. & Reuter, H. 2016. Mechanics of multiple feedbacks in benthic coral reef communities, *Ecological Modelling* 329: 29-40. doi:10.1016/j.ecolmodel.2016.02.018. eingereicht
- Kubicek, A., Breckling, B., Hoegh-Guldberg, O. & Reuter, H. (subm.). Changing priorities in coral life histories - Trait-shifts in coral reef communities in reaction to climate change scenarios

Project WP1.3. Effect of Aquaculture on Carbonate builders/Calcium carbonate production and the response of calcifying organisms to natural and anthropogenic threats on the shallow platform of Zanzibar, Tanzania

- Natalia N. HERRÁN, Gita R. NARAYAN, Claire REYMOND and Hildegard WESTPHAL: Calcium carbonate budget and coral reef structure along a distance gradient from Stone Town, Zanzibar – Submitted to *Frontiers in Marine Science* in June 2017.
- Natalia N. HERRÁN, André KLICPERA, André FREIWALD and Hildegard WESTPHAL: A moving partnership: New insights into semi-mobile solitary coraltubeworm association offshore Zanzibar (East Africa) – Submitted to *Invertebrate Biology* in February 2017
- Natalia N. HERRÁN, Silas MUKAKA and Hildegard WESTPHAL :How do fine-size particle dynamics in tropical shallow waters influence coral reef geomorphology? (in prep.):
- E. Fay BELSHE, Dieuwke HOEIJMAKERS, Natalia N. HERRÁN, Mirta TEICHBERG: Seagrass community-level controls over organic carbon storage are constrained by geophysical attributes within meadows of Zanzibar, Tanzania – Submitted to *Limnology and Oceanography* in May 2017
- Gita R. NARAYAN, Natalia N. HERRÁN, Claire REYMOND, Yohanna W. SHAGHUDE, Hildegard WESTPHAL: An assessment of the coastal water quality status off of Stone Town, Zanzibar, Tanzania – in preparation for

submission

Project WP2.1-Project: Modeling the multispecies fishery of Chwaka Bay, Zanzibar-Basis for Exploration of Use and Conservation Scenarios

- Rehren, J., Wolff, M., Jiddawi, N., in press. Fisheries assessment of Chwaka Bay (Zanzibar) – following a holistic approach. *J. Appl. Ichthyol.*
- Rehren, J., Wolff, M., Jiddawi, N., accepted with minor revisions. Holistic assessment of Chwaka Bay's multi-gear fishery – using a trophic modeling approach. *J. Marine Syst.*
- Rehren, J., Wolff, M., Jiddawi, N., in prep. State of the inshore fisheries in Zanzibar - Synopsis.
- Rehren, J., Wolff, M., Jiddawi, N., in prep. Ecosystemic and economic effects of different fisheries management scenarios in Chwaka Bay (Zanzibar): a modelling study using EwE.
- Mildenerger, T., 2015. Assessment of the Artisanal Tuna and Billfish Fisheries on Zanzibar. M.Sc thesis, University of Bremen.
- Del Solar Escardó, A., 2015. Diet composition and overlap of five commercial marine species of Chwaka Bay, Zanzibar, Tanzania. M.Sc thesis, University of Bremen.

Project WP2.2. Modeling behavior of fishermen/ Temporal dilemma, time preferences and natural resource extraction

- Javaid, A. 2016, Temporal dilemma, time preferences and natural resource extraction, PhD Thesis for the degree of PhD in Economics at Jacobs University Bremen.
- Javaid, A., Kulesz, M. M., Schlüter, A., Ghosh, A., & Jiddawi, N. S. (2016). Time Preferences and Natural Resource Extraction Behavior: An Experimental Study from Artisanal Fisheries in Zanzibar. *PloS one*, 11(12), e0168898.
- Javaid, A., Janssen, M.A., Reuter, H. and Schlüter, A., 2017. When Patience Leads to Destruction: The Curious Case of Individual Time Preferences and the Adoption of Destructive Fishing Gears. *Ecological Economics*, 142, pp.91-103.
- Javaid, A.: Temporal dilemma, natural resource extraction and the use of destructive extraction methods: experimental evidence from Zanzibar (in preparation)
- Javaid, A.: Behavioral determinants of destructive extraction method usage in Zanzibar fisheries (in preparation)
- Gehrig, S.; Hammerstein, P.; Schlüter, A.: Norms of cooperation, economic evolution and sustainability: an experimental study of two fishing villages in Zanzibar (in preparation)
- Gehrig, S.; Schlüter, A. Jidavi, N.: Human dimensions of heterogeneity in a small-scale fishery in Zanzibar and implications for governance, income and well-being (in preparation)
- Gehrig, S., 2016. Social-cultural Heterogeneity and Scarcity in an Artisanal Fishery: Economic Experiments in Chwaka Bay, Zanzibar, Tanzania, ISATEC Master Thesis, Bremen University.

Project WP2.3 - Access to Food and Nutritional Status of the Zanzibari Population (PhD Student from BIPS)
Scientific products

- M.A. Nyangasa, S. Kelm, M. Sheikh, A. Hebestreit. Design, Response Rates, and Population Characteristics of a Cross-Sectional Study in Zanzibar, Tanzania. *JMIR Res Protoc*, 2016. 5(4): p. e235.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5159612/>
- M.A. Nyangasa, C. Buck, S. Kelm, M. Sheikh, L.K. Brackmann, A. Hebestreit. Association between cardio-metabolic risk factors and body mass index, waist circumferences and body fat percent in a Zanzibari cross-sectional study. (Submitted in April 2017 to *PLOS One*)
- M.A. Nyangasa, C. Buck, S. Kelm, M. Sheikh, A. Hebestreit. Socio-economic and Demographic Correlates of Food Consumption Score and Food Insecurity Experience Scale in Zanzibari households. (Submitted in August 2017 to *Food Security*)
- L.K. Brackmann, C. Buck, M.A. Nyangasa, S. Kelm, M. Sheikh, A. Hebestreit. Anthropometric and biological predictors for hypertension in a cross-sectional study in Zanzibar, Tanzania. (Submitted in October 2017 to *Hypertension*)
- M.A. Nyangasa, C. Buck, S. Kelm, M. Sheikh, L.K. Brackmann, A. Hebestreit. Association between cytokines, Leptin and obesity indices in a Zanzibari population above 5 years. (in preparation)
- C. Wiessner, A. Hebestreit, M.A. Nyangasa, S. Kelm, M. Sheikh, C. Buck. Modeling the spatial variation of the association of access to food and food and nutrition insecurity in Zanzibar, Tanzania. An application of geographically weighted regression. (in preparation)
- C. Wiessner, A. Hebestreit, M.A. Nyangasa, S. Kelm, M. Sheikh, C. Buck. Modeling the spatial variation of the association between correlates of weight status and markers of under- and overweight in Zanzibar, Tanzania. An application of geographically weighted regression. (in preparation)
- “Prevalence of hypertension among the Zanzibari population and the association with potassium and sodium in drinking water” (Kim Brackmann, M.Sc Thesis, UB)
- “Modeling the spatial variation of the association of socio-economic factors and dietary habits on health indicators in Zanzibar, Tanzania. An application of geographically weighted regression” (Christian Wiessner, M.Sc Thesis, UB)
- “Association between characteristics of socio-economic status on Zanzibar with household food diversity and individual HbA1c levels” (Nassor Nassor, Zanzibar State University)
- “Association between characteristics of land use on Zanzibar with household food diversity and individual insulin levels” (Rukia Ali Omar, Zanzibar State University)

9. Measures to save and provide access to - SUTAS data

ZMT holds a database for all research projects and for data derived from thesis (M.Sc. and Ph.D.) studies. This database contains raw and metadata (site coordinates, date, name of data collector, description of data type) for the respective studies and also provides a description of the methods used for their collection. While this database is being further developed, metadata are to become accessible for larger Meta analysis studies. All scientists and students involved in - and associated to the SUTAS programme were requested to contribute their research data to the database.

10. List of Press releases- and Mediareports

- Neue Graduiertenschule SUTAS startet 2013 mit integrierter Forschung in Sansibar, 2012, PM
- ZMT-Doktorandin mit YOUMARES Posterpreis ausgezeichnet, 2014, Webnews
- SUTAS Graduiertenschule: "Wir haben viel erreicht in Forschung und Ausbildung." 2016, Webnews
- Erster Alumni Workshop des ZMT in Ostafrika, 2016, Webnews
- Expeditionsblog: Stone Town, Sansibar, 18. - 23.9.16
- Expeditionsblog: Sansibar, 15.9.16 - 15.10.16
- Expeditionsblog: SUTAS Symposium, Sansibar, 19.9.16 - 23.9.16
- Expeditionsblog: Sansibar, 8.3.15 - 9.4.15
- Expeditionsblog: Sansibar, 23.8.14 – 8.11.14
- Expeditionsblog: Sansibar, 31.12.13 - 31.5.14
- Expeditionsblog: Sansibar, 10.2.13 – 16.2.13

s.auch:

<http://www.leibniz-zmt.de/de/search-zmt-homepage.html?q=SUTAS>