Factors affecting Income Strategies among households in Tanzanian Coastal Villages: Implications for Development-conservation initiatives

J. K. Sesabo[a, b, c,*] , R. S. J. Tol [b, d, e]

[a] *International Max-Planck Research School for Maritime Affairs, Hamburg, Germany*

[b] *Research Unit Sustainability and Global Change, Hamburg University and Center for Marine and Atmospheric Science, Bundesstrasse 55, D-20146 Hamburg, Germany*

[c] *Department of Economics, Mzumbe University, Morogoro, Tanzania*

[d] *Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands*

[e] *Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, USA*

July 8, 2005

Working Paper FNU-70

Abstract

This paper applies Tobit models to investigate factors that explain households' decision-making on whether or not to participate in various activities, using household data collected from two Tanzanian coastal villages (Mlingotini and Nyamanzi). The results indicate that households' decision to participate in various activities is significantly influenced by asset endowments, households' structure, local institutions, and location- specific characteristics of both villages. In addition, these results reveal that fishing assets entitlements and access influence are the main determinants for variation in total household's income. Taken together, the findings show existence of households' heterogeneity in making choices among different activities, which should be considered by policymakers when designing conservation-development policies in coastal areas.

Keys words: coastal resources, households, assets, activities, Tanzania, conservation-development policies

1. Introduction

Coastal areas are abundant in natural resources that are important economically, socially and environmentally. Currently, about two thirds of the world population is living within 60 kilometers of the coastal shoreline [1]. Just like in other countries of the world, coastal areas of Tanzania comprise unique ecosystems upon which 25% of the country's population depends for survival and/or commercial purposes [2,3]. This implies that coastal resources utilization such as fishing is recognized to constitute a key element of local economy. Together with the coastal resources, the coastal population's welfare also depends on the availability of other employment opportunities**.** Therefore, sustainable management of coastal areas and their resource, and employment creation are critical to the livelihood of many Tanzanian coastal communities.

Despite the economic and social importance of coastal resources to the vast majority of people living along the coast, recent years have witnessed an increase of threats upon these resources. These threats are in the form of increased human pressure due to population growth and tourism (resulting in overexploitation of fisheries resources, cutting of mangroves for fuel and construction, destruction of coral reefs and sand mining), use of destructive fishing methods, destruction of habitats, and pollution [2, 4-5]. Overexploitation and destruction of coastal resources combined with conversion of coastal areas into land uses alter the magnitude, timing and quality of coastal waters that feed coastal resources. As a result it is becoming increasingly precarious for the coastal people to support themselves.

For about two decades there have been initiatives from international development agencies as well as governmental and non-governmental organizations. Some examples include the establishment of Mafia Island Marine Park, Menai Bay Conservation Area and Tanga Coastal Zone Conservation and Development Program. The main objectives of these initiatives were to promote sustainable use of coastal resources as well as improving livelihood of coastal households. The initiatives included a top-down state management approach, which was in the form of establishing Marine Protected Areas (MPAs) as well as a participatory approach popularly known as community-based conservation initiatives (see for example [2,6]). The latter approach was aimed at

promoting active involvement of local people in the management of coastal and other natural resources see for example [3].

Most of these initiatives have been unsuccessful due to the lack of understanding of social, economic, cultural, and environmental factors that influence the decision making process of rural households. Moreover, these development-conservation policies are supposed to benefit them [7-9]. Other important reasons for these disappointing results are: oversimplification of problems, lack of local institutional capacity to conduct projects, skepticism of donors and organizations about households' knowledge on coastal resources and their potential contribution to livelihood strategies, predetermined thinking pattern of policy makers (for example on how conservation of fishery resources can be achieved through combination of management to limit access and providing alternative incentives to current participants to leave fishery) and lack of interdisciplinary research approach. As a result, governmental and non-governmental organizations fail to develop appropriate and effective conservation-development policies.

In the face of increased threats upon coastal resources, together with lack of alternative employment opportunities, the position of policies for coastal resources management, poverty alleviation or livelihood improvement requires a particular attention regarding the appropriate balance between the roles of institutions and communities. Just like other rural areas, coastal households participate in multi-activity based livelihood strategies. They can alternatively or simultaneously fish, farm, collect firewood, harvest forest products or participate in self and wage employment activities. In this case development-conservation initiatives need to include local people when designing these initiatives. In particular, this implies that if coastal management policy makers wish to provide better and more adequate support to the rural development with the aim of raising fishing communities' welfare, it will be necessary to understand their surroundings and the contribution of different economic activities in their livelihood.

Although some research works have been done on coastal resources in the Tanzania coastal areas, see [6, 10-13], little attention has been given to explain how households choose activities and how heterogeneous their livelihood strategies are (using micro-economic concepts and tools). Of particular relevance to understanding household behavior are recent findings from studies among rural households that show that

households assets endowment plays a critical role in shaping households' activity participation decision, welfare outcome and resource conservation [14-18]. As a result, any initiatives geared towards improving conservation-development policies for coastal rural households must be based on the informed understanding of coastal rural households' behavior. Also, it should enable the government and non-governmental organizations to identify more effective approaches, which lead to a win- win[1] outcome.

This study links assets endowment and activity choice in order to shed light on activities participation decisions of coastal rural households in Tanzania using a case study of two villages as illustration. In this context, factors influencing household's activity choice and the level of income are studied with emphasis on the role of household endowments. The hypotheses are empirically tested using household survey data from two villages (Mlingotini and Nyamanzi). Results of the analysis have potential implication for policies related to conservation-development programs. The paper also contributes to the greater understanding of households' activities participation decision in coastal areas, so that in future policymakers can come up with better-informed strategies for sustainable coastal resource use and management.

This paper is organized as follows: In the next section the conceptual framework is presented. In the third section, the empirical approach is described. The forth section reports results and discussion and the fifth section concludes the paper by pointing out wider policy implications.

2. Conceptual framework

Several forces influence the households' decision to participate in different activities. Evidence adduced earlier suggests that the decision to participate in a certain activity is triggered by the rewards offered, risks associated with the activity and households' capacity, which is determined by the assets endowment [16,19-20] and this explains why not all households have the same opportunities to participate in different activities.

The conceptual framework for this study builds from the work of Reardon and Vosti ([21]), Dercon [14], Ellis [22] and Barret et al. [16]. Drawn from such frameworks are the

[1] The win-win outcome can be achieved through combination of management approaches that directly benefits households as well as the coastal environment.

indicators of households' endowments that determine the behavior of these households regarding activities participation. From Fig. 1, it is discernible that rural household activity participation is strongly influenced by *assets endowments.* Barret and Reardon [23] define asset as stocks that produce cast or in-kind returns. These assets are the bases for household ability to participate in activities to generate income (such as canoes for fishing or land for farming). Some of the livelihood literatures see for example Ellis [22] and Carney [24] proposes five–ways of classifying assets: physical capital (land, and productive tools), human capital (education status, skills and experience), social capital (networks and organizations), natural capital (common properties natural resources) and financial capital.

As depicted **Fig. 1** in the access to different types of assets is affected by *Household structure* comprising age of household members, size and the composition within the household [19,25]. The influence of households' structure is in the form of determination of work force available, absence or presence of a male head, consumption demand and preferences on investment patterns. The household members contribution to the household total income differs according to their age. Thus, different households might have different consumption and labor units. These differences may lead to diverse in labor allocation decisions and strategies to exploit the labor resource among different households. The diversity may include manipulation of households' own labor to meet their objectives. The household structure may not only determine resources availability and consumption patterns but also other activities that can be undertaken by households.

Furthermore, *facilitating factors*, which include factors such as market institutions, service provisions and political environment, also influence households' access to assets [26]. These factors are regarded as policy variables because they can be influenced by policy at various levels. The factors may affect the *assets endowment* and *household demographic structure,* which in turn influence the decision of the household to participate in a given activity and the level of income. On the other hand, the level of income also affects the household demographic structure through migration of household members and increase in fertility.

This framework highlights the role of households' assets in activity choice decision, controlling for demographic and facilitating factors in influencing decision among coastal rural households.

3. Methodology

3.1 Data sources

The study is based on a survey of rural coastal households that was conducted between January and March 2004. The questionnaire was administered in two (Bagamoyo and West) districts of Tanzania. In Bagamoyo district, data was collected from Mlingotini village located close to Bagamoyo district headquarters (12 km) and about 56 km north of the capital city Dar-es-salaam. In West district, data was collected in Nyamanzi village 16 km from Zanzibar Stone Town. Marine protected areas and open Forest area (know as Free economic zone) were proximate to Nyamanzi village. Most of the households in the area were reported to have originated as fishing village more than 30 years ago. Both villages lie within tropical humid climate of the coastal belt. They enjoy both short rains (October-November) and long (March-May) rains, which characterize the East African coast (**Fig. 2**).

The selection of the villages was purposeful rather than random. Based on the consultations with Institute of Marine Sciences in Zanzibar, such households were chosen to reflect the diversity of environmental condition and economic opportunities available to them were chosen for this study. Of a particular interest were the contrasts between the villages situated near protected areas and those without protected areas as well as villages located near or remoteness from the town market.

A random sampling strategy was employed to select some 250 households for interview. Structured interviews were conducted with each of the head of household. The questionnaire was designed to solicit information on households' demographic structure, income sources, sales of outputs, access to markets, problems inherent in coastal resources and attitude on management of coastal resources. Household income from agriculture, fishing, seaweed-farming, and other activities was estimated according to the reported production (for consumption or sale) at the prices that prevail in the market.

Fishing, transport and other assets were valued subjectively by respondent as equivalent to current resale value. In order to perform data analysis, missing values on incomplete sections of the questionnaires resulted in reduction of the sample from 250 to 217 households (Mlingotini=117 and Nyamanzi=100).

3.2 Data analysis and variables used

This study focuses on the total households' income as well as income by source, with particular interest as to why some households make more money from certain activities than do others. Many households did not participate in all activities and this made the income from agriculture, fishing and seaweed farming to include substantial number of zero values. This resulting a Tobit Model to be used because of a large fraction of the sample reported to have zero income from a given activity, since ignoring it would caused bias [27]. The model uses one set of variables to explain the decision to participate in a given activity and its income level.

Other methods require some variables to affect decision to participate in a given activity but not its income level. Thus, it is difficult to find any theoretical reasons for this. The main purpose of applying Tobit analysis in this context was to identify which of the variables were most significant in influencing the behaviour of coastal households in deciding which activities to undertake. We follow the approach used by Coomes et al. [18] by specifying total income from an activity (fishing, agriculture and seaweed farming) as an independent variable. However, in other studies the dependent variable was specified as a share of total household income arising from an activity [17,28]. The total activity income was used as broadly applicable proxy for activity participation. We refer activities to emphasize the focus of income generated by an activity (as proxy to yield) as opposed to its share on the total income. The share of income as a measure of activity can be misleading because it takes the proportional of income obtained from an activity and not the actual activity income. In addition, Ordinary Least Squares (OLS) was used to find out the determinants of the total income of the household**.** Similar models on the total household income have been widely used in the literature [17,29]. The models specifications are presented in the **Appendix 1**

In the current study, the dependent variables are defined in two ways: (1) a continuous income by source variable with three sources (fishing, agriculture and seaweed-farming (2) and a continuous total income variable. The income by source is measured in adult equivalent units after subtracting the production costs, whereby the total income was measured by taking the log of summation of all income obtained by household per adult equivalent, in a typical year[2]. The purpose was to adjust the discrepancy of combining dependants (predominantly consumers) and potential labor (predominantly producers) in order to make adjustment for potential labor supply within the households [30].

The conceptual framework built from the present study helped in identifying specific variables, in relation to the endowments, the presence of relevant institutions and the key livelihood strategies used by the studied households. The explanatory factors are organized into three groups:

(i) Household assets endowments;

(ii) Household structure; and

(iii) Facilitating factors.

The households' assets endowment variables used in the analysis were grouped into five categories namely physical capital, social capital, financial capital, human capital, and natural resources capital. To capture their effects, proxy variables were used in the estimation (**Table 2).** For the assets endowment, physical capital was captured by using the size of agricultural land per adult equivalent (LANDEQ) and the value of total assets per adult equivalent (ASSETEQ)[3]. Generally, access to physical capital is crucial to acquire wealth, which in turn influences the choice of activity to participate in. For instance, access to land may allow households to participate more in agricultural activities as opposed to fishing. Through increased income from farming, households are able to invest more in fishing and seaweed-farming. Conversely, increased access to land can also lead to a decrease in their participation in seaweed-farming and fishing. This is because the households decide to allocate more labor to farming. On the other hand, the higher value of total assets holding (ASSETEQ) increases the households' participation

[2] These scales were based on the work of Collier et al. [31] and they have been used virtually for every empirical study done in Tanzania (**Table 1**).

[3] This value excludes the value of land owned by the household

in many activities. These assertions imply that the access and availability of assets can relax the investment constraints, by investing in many activities despite the market imperfections (that may occur in credit and insurance markets). Results presented in **Table 2** shows that on average households owned 1.1 ha of farming land. This is due to the fact that about 52% of households owned less than 2.5 ha. Additionally, on average the total value of assets was 78.9 US$, where by fishing assets accounted for 56%, a clear case of demonstrating inequality in physical assets[4].

This study includes variables that indicate whether households possess fishing gears (FISHGEARS) and/or own a boat (OWNBOAT). Also, the dummy variable of the ratio of fishing assets to total assets value (FISHASR0) is included. It is hypothesized that access to fishing assets may increase participation in fishing while at the same time might reduce the rate of participation in farming and seaweed-farming. **Table 2** indicates that 86% and 31% of households in fishing activity own fishing gears and boats, respectively.

To capture the social capital variable, two dummy variables were used. The first variable reflects whether a household had a member who was involved in any association or informal group activities (PARTIC). This was measured as one if so and zero if not. Such organizations provide mechanism for mutual aid among members. These associations and groups are established to secure labor, skills as well as credit.[5] The second dummy variable focuses on whether a household shares fishing assets (SHREBT) or not. It takes a value of one if so and zero if not. These variables are included to capture the strength of influence of social networks on choosing which activity to participate in. Empirical studies showed that types of organizations including NGOs and community groups could determine the activities that rural households undertake [19, 32-33]. Therefore, this study anticipates that households' access to social networks should increase their participation rate to various activities. **Table 2** shows that 28% of the households participate in associations' activities or informal groups, while 58% reported sharing or renting a boat when accessing a fishing ground.

[4] In Tanzanian coastal areas, fishing assets such as boats act as an indicator of social status where households with fishing boats provide sharing and renting services to those who do not own a boat.
[5] It was observed that in Mlingotini village seaweed farmers' group members contribute about 0.09 US$ (1 US$ is equivalent to 1100 Tshs.) each to the group each time they sell their harvest. This money is loaned out on a rotation basis to members for liquidity provision when needed.

Financial capital is measured in terms of access to other income opportunities (OTHERY). This variable was measured in income per adult equivalent. The present study assumes that access to other income opportunities would foster higher participation rate in different activities through provision of income to finance investment in fishing, seaweed-farming and agricultural activities. On the other hand, availability of income from other activities may reduce the propensity to participate in fishing, seaweed-farming and agricultural through labor reallocation. The data shown in **Table 3** indicates that 94.9% of households participated in other activities and the average income was 264.1 US$ (**Table 2).**

The average age of adult members (ADULTAGE) and fishing experience (in years) (EXPF) of the head of household were included as proxy variables of human capital. The dummy variable of age of household head (HHAGE0) was also included (equals one if the household head is below 50 years and zero otherwise). The current study expects that both average age of adult members and experience in fishing would have a positive relationship with income emanating from different activities and fishing respectively. Also, the age of the head of household is expected to have a positive relationship with various activities. **Table 2** shows that on average adult members age was 36.2 years and 63% of the households' heads were younger than 50 years. On average, the heads of households participating in fishing activities had 17.8 years of experience in fishing.

The trend of fisheries resources (FISHTREND0) and the area used for seaweed farming (SWLAND in m^2) are included as a proxy of natural resource endowment. The trend of fish resources is a dummy variable, which captures the fish availability. This information was obtained by asking households how they perceived the availability of fish over the past five years (the value of one was assigned if fish stocks were reported to have decreased and zero otherwise). A negative fish trend is expected to have negative influence on households' decision to participate in fishing and a positive influence on the participation rate to other activities. The area available for seaweed is expected to have a positive relation on participation rate in seaweed-farming activity. **Table 2** indicates that on average households had 173 m^2 of seaweed area and 35.9% perceived availability of fish stock over past five years it has decreased.

The characteristics of households' composition such as gender of household (GENDER1), female-male ratio (FEMRAT) and size of households (HHSIZE/CWRAT) were included in the analysis. The gender variable measures the entrepreneurial motivation and managerial skills, while the female–male ratio and households' size represent the productive and consumptive units in the households. It is expected that female workers increase participation rate into seaweed farming and reduce the propensity to participate in fishing. And the reverse is true for male. The reason for this is that along Tanzanian coastal villages, fishing activity is male-dominated while women dominate seaweed-farming activity [34]. The relationship between the size of household via worker-consumption ratio can be either positive or negative. Availability of adult members implies higher propensity to participate in different activities as a result of their ability to supply more labour. Likewise, the more dependants are in the family, the lower the ability to participate in different activities due to lack of workforce. **Table 2** indicates that a typical household sample consisted of 4.4 members, which is also reflected in the statistics for coastal rural areas [35]. The on average female-male ratio was 0.52 whereas 84 % of households were headed by men, suggesting a male dominated scenario in the decision-making process.

Market access constraint and village dummies are included to capture the effect of facilitating factors with respect to institutions and location. Market access constraint dummies include credit market (CRDTCOT) and output market (OUTCOT). These dummies takes a value of one if the household reported having a market constraint and zero if otherwise. It is argued that lack of market access in rural areas is one of the causes of difference in transaction costs between households [16]. The location dummy variable (V2) has a value of one if the household reported to residing in Mlingotini village and zero if otherwise. Market constraint variables are expected to reduce household's participation in different activities. **Table 2** indicates that 53% and 43.8% of households reported to have problems in accessing credit and output markets, respectively. In contrast, some households staying a few kilometers from markets do not have access to urban market due to poor infrastructure and lack of transport assets. The scenario exemplified a case of institutional problem, which does not guarantee equitable access to market.

4. Results and discussion

4.1 Activities participation patterns and asset heterogeneity

The income generating activities pattern from households living around coastal areas vary between and within villages [6]. In our study, activities are divided into five major categories namely: agriculture activities (farming and livestock production[6]), fishing, seaweed-farming, wage employment (wages and salaries from non agricultural activities) and self-employment activities (for instance, various business, collection of shells, coir rope making, and stone collection). **Table 3** shows participation rates, earnings and income shares by sources for the households sampled. From this table, it is clear that participation in multiple activities was a common phenomenon among households in the area of the study, which is in line with other observations in rural Africa [16]. In rural Africa, markets for credits and insurance are missing or do not function well, hence participation in various activities act as a strategy for ex-ante risk mitigation (a way to cope with adverse shocks) and earnings for the cash needed to make investment [16]. It was observed that 92.6% of households participate in more than one activity. The estimated value of economic production among households in the sample for the period 2003/2004 is 198,037US$ or 912.6US$ per households (i.e. subsistence and market value).

This study found that majority (97%) of households participates in other activities (this include self-employment and wage employment), where agricultural activities account for 82 % of all households, followed by fishing activities with 57.1 %. However, very few households participate in seaweed-farming (37.7 %) activities. From these results it can be noted that the participation rate in various activities in Nyamanzi village is greater than in Mlingotini. The study further noted that although most households engage in farming, the overall contribution of agricultural activity to the total households' income is only 14 %. This could be attributed to low agricultural productivity due to decline in soil fertility [36-37], population growth [38], market failures [39], government and institutional failures [40]. Fishing income appears to be the most important source of income accounting for 52 % of total income for all households respectively. Similarly,

[6] Livestock production is not a traditional economic activity in coastal areas, since few people own livestock.

for those households participating in other activities, they earn on average about 28.9 % of their total income from these other activities.

Considerable sample heterogeneity in activity participation is evident between as well as within communities. **Table 3** indicates that high earning shares arise from fishing activity in both villages. The average share earnings derived from fishing in Nyamanzi village is higher than that of Mlingotini village.[7] These differences are statistically significant from each other at the 10% level (t=-1.74, p=0.08). The observed inter-village differences can be explained in terms of local endowments. Nyamanzi village is located near protected areas, this gives households opportunity to enjoy spillovers in terms of availability of fish and higher abundance. In addition, Nyamanzi households have access to the town market because of the presence of feeder roads.

Fig. 3 shows the variation in income sources and shares by size of agricultural land across households. This illustrates the importance of heterogeneity in household decision making process whether to participate in a given activity or not. The assets heterogeneity takes into account the physical assets holdings (i.e., size of agricultural land owned by household value of fishing assets). It is observed that agricultural income increases for larger agricultural holdings. This can be explained by economies of scale. However, the share of agricultural income to the total income is very small due to low productivity of agricultural crops in the study area. In contrast, the share of fishing income is large for those households who have fishing assets despite their fishing assets being of poor quality assets[8].

Fishing activity is more important for the landless households in the sample compared to the land-rich households because about 70% of their total income comes from fishing (**Fig. 3**). Our results indicate that landless households rely heavily on fishing activity, suggesting the importance of owning or leasing fishing assets and not land in their asset portfolios. Also, the result shows land-rich households (households with land above 5.5ha) earn more income from fishing than their land-poor counterparts. The observed differences are attributed to differential fishing assets. The mean fishing assets are

[7] The average earnings from fishing activities in Nyamanzi village is 623.5 US$ whereas in Mlingotini is 359.1 US$.

[8] 67% of the total households participating in fishing activities have less than 36.4 US$ of the total value of fishing assets.

significantly (t = -2.7963 p=0.0056) different between the land-rich households and the land-poor households. In other words, households holding larger agricultural land have higher mean value of fishing assets (341.7 US$) than land-poor households (100.5 US$). Another reason for observed difference in fishing income is that land rich households have no credit constraint because they use land title deeds as collateral to secure bank loans and part of their income arising from agricultural activities to finance investment in fishing activity (such as buying of fishing boats, gears, etc). This is consistent with the findings of Barret et al. [16], which showed that poor households are unable to participate in various activities because they cannot meet the investment requirements for entry into remunerative activities.

Additionally, **Fig. 3** shows that landless households earn a lower income from other activities than their land-rich counterparts. In most Sub Sahara African countries, land asset is regarded as a form of wealth. Consequently, land-less households compensate their lack of land by participating in activities that deal with the extraction of natural resources such as fisheries.

4.2 The determinants of participation in different economic activities

Estimation results from the Tobit model that measures participation in different activities are given in **Table 4.** These results indicate that factors shaping activity participation differ across the board of different activities.

Furthermore, it is obvious, physical assets are key determinants of how households choose to participate in various activities along the coastal areas. Moreover, households with large agricultural land (LANDEQ) tend to participate more in agricultural, seaweed farming and fishing activities. In effect, the higher the income from agriculture, the higher the participation rate in seaweed-farming and fishing activities. This implies that ownership of agricultural land can be treated, as sunk costs required for financing these activities. Thus, availability of liquidity assets can relax the households' capital constraints.

Another key physical asset that affects households' participation in various activities is the type of fishing asset and its endowment value. Households with low fish asset ratio (FISHASR0) are more likely to reduce their participation in fishing activity while at the

same time they increase their participation in seaweed-farming activity. This could be due to the fact that seaweed-farming activity acts as a source of income smoothing for households with low-value fishing assets. This argument suggests that fishing activity for those households with low quality fishing assets is a coping mechanism that enables them to alleviate hardship associated with poverty rather than a route out of poverty altogether. This study shows that access to fishing boats (BOATOWN) reduces households' participation in agricultural activities. Access to fishing boats give households the advantage of participating in fishing activity as opposed to agricultural activities. In addition to assets, higher endowment of total assets (ASSETEQ) increases participation in fishing activity. Clearly, fishing is not a domain of household with few and/or poor fishing assets. This is consistent with other findings based on income diversification in Africa [14,16], which shows how poor households are forced to diversify into low-return activities.

Effects of social variables are consistently important in all activities. Access of households to social networks[9] (PARTIC) increases participation of households to seaweed-farming and agricultural activities[10]. This concurs with different assertions that social capital and organizational capabilities act as better strategies for mutual support whenever households are faced with either inputs or outputs market imperfection [41]. Through group activities, households are able to enjoy economies of scale such as a decrease in transaction costs and improvement on their knowledge through sharing of information on technical issues relevant to a given activity. This is consistent with the findings of Grootaert [42], which demonstrated that membership in groups and associations provides benefits to individual households such as of access to credit and pooled savings.

Furthermore, interaction variable between fish assets sharing, and fishing as a primary activity (PRIMSHARE) appears to increase participation in fishing while at the same time it reduces participation in agricultural activities. Our findings suggest that sharing and renting of fishing assets reduce the transaction costs for those households with fishing as the primary source of income. This is through provision of fishing capital

[9] This implies the ability to access groups and/or associations activities.
[10] In the study area, households with agricultural, fishing and seaweed-farming activities normally work in groups and this enables them to access labor, financial supports and information regarding their activities

by ensuring access to markets and institutions where they are absent. This observation supports the argument advanced by Davis [20] that group strategies provide potential social capital to address credit and market access constraints. This is via improvement of access to service provision and overcoming entry barriers into new activities.

The results on financial capital show that availability of other income (OTHERY) increase the propensity to fish. This implies that access to other employment activities act as a source of income, which helps to finance fishing investments where most of insurance and credit markets are absent. In most African countries, it can be noted that other employment activities enable households to participate in various activities by providing them with a working capital. In this case other employment activities act as a substitute for credit or credit constraint. However, the marginal effect of additional income arising from other activities to participate in fishing activity is too small to explain the observed variation (**Table 4).** Also, the coefficients of these income sources are not significant, in influencing household's decision to participate in agricultural or seaweed-farming activities.

Linking human capital variables with activity participation, it can be seen in **Table 4** that participation in fishing and its level of income are significantly influenced by the age of household head (HHAGE0) and fishing experience (EXPF). This means that younger heads of households with experience tend to participate more in fishing activity. With respect to age of household head, the result supports the conjecture that fishing activities require fishermen to go further inside the ocean to exploit un-explored fishing grounds. Moreover, young fishermen have more energy to go far away than old fishermen. This is supported by descriptive statistics, which show that young male households are more likely to travel long distances to fetch fish (7.27 kms) as compared to their older counterparts, who undertake fishing in the proximate fish breeding grounds (5.7 km). The mean distance to fishing ground is statistically different between the older and younger heads of households ($t = -2.5$, $p = 0.014$). The estimated effect of age of heads of households support the life cycle hypothesis, where by older heads of households decrease the probability of participating in various income generating activities due to their low level of energy.

Also, participation in fishing activity increases with the increase in fishing experience. This underlines the importance of fishing experience with respect to knowledge of fishing fertile grounds and the efficient use of fishing equipments. This suggests that those young heads of households who have experience and energy to efficiently use fishing gears realize more fish catches and hence increase participation in fishing activity as opposed to older heads of households with more experience.

Table 4 illustrates that a decrease in fishing resources (FISHTREND0) decreases the propensity to fish. This is because under normal circumstances most of the households participating in fishing do so in the same grounds. A large seaweed area (SWLAND) increases seaweed farming.

Our results show that household composition affects participation in various activities. This based on the fact that the number of female workers (FEMRAT) positively influences the decision to participate in seaweed activity. This can be explained in that with a large number of total workers, the extra female effort is directed towards seaweed-farming activity. Other variables of household composition (GENDER1 and HHSIZE) are neither significant nor adequate in explaining the observed diversity of households in their participation in various activities.

Interestingly, results on the facilitating factors variable show that households with market constraints (MKTCOT) increase their participation in agricultural activities. This result contradicts our prior expectations. This can be explained by the fact that for most households, agricultural activity is not their main source of income. Households tend to increase their participation in agricultural activities when there are market constraints in other sectors such as fishing and seaweed-farming activities. The same variable is not significant in explaining the decision to participate as well as the level of income from fishing and seaweed-farming activities.

The location variable effect (V2) is significant and negative for the participation and income arising from fishing and seaweed activities. It was observed that households residing in Mlingotini village are more likely to reduce their participation in fishing and seaweed activities. This implies that they fish less and have less emanating income from fishing and seaweed-farming. Three reasons can explain this phenomenon:

- Mlingotini village lacks good feeder roads as compared to Nyamanzi village, which connect Bagamoyo and Dar-es-salaam main road, despite being only a few kilometers from this main road. This forces the fishermen to internally sell their fish as well as fishmongers/traders.
- Mlingotini village has no access to Marine Protected areas as opposed to Nyamanzi village. This means fishermen in Mlingotini usually compete for the same fishing grounds over the years. This increases the risk of overexploitation with adverse consequences of dwindling fish resources. On the other hand, protected areas surrounding Nyamanzi village allow households to access the fish resources during a certain period of a month only. For example, the management of Chumbe and Menai protected areas usually sets restrictions on the time when to undertake fishing. In this case, fishermen from the surrounding villages of protected areas benefit from increased fish resources. Additionally, fishermen take advantage of spillover effects from protected areas as they fish in their proximity. These include migration of fish from the protected areas to the surrounding fishing grounds.
- Households participating in seaweed farming have no market for their seaweed products and thus are forced to wait for a company from Zanzibar to buy their products. Also, the type of seaweed grown in Mlingotini gives low yields since it is not well adapted to local weather condition as opposed to the well-adapted type that is grown in Nyamanzi village.

The multiplicative interaction between agriculture and fishing dummies variables was also included to measure separate impact of fishing activity and agricultural activity. The result suggests that households participating in both fishing and agricultural activities are more likely to increase their participation in agricultural activity compared with their counterparts participating in other combination (e.g. agricultural and seaweed-farming). These findings imply fishing activity act as a source of income to finance agricultural activities. This result is in line with the observation that in Sub-Sahara Africa, non-agricultural sectors provide working capital to agricultural sector during the process of rural development [43]

4.3 The determinants of total household income

As discussed in the previous section, the level of predictors of households to participate in income generating activities differs from one activity to another. Consequently, it is important to analyze the determinants of total income at household level in order to understand the factors responsible for total income variation among households.

Results presented in **Table 5** indicate that entitlements to fishing assets such as possession and/or access to fishing gears, fishing boats and social capital are important determinants of total household income. Access to fishing assets like boats increases the income of household by approximately 87% while fishing gears increase income by 38%. Access to fishing assets through renting or sharing increases total income by 65%. This suggests that endowment and/or access to fishing assets is very important for those households living along the Tanzanian coastal areas. Even though most of artisanal fishermen possess fishing assets, they also have land, which allow them to participate in agriculture activity. Similar results have been observed for artisanal fishermen in Southeast Asia [44].

The fish resource trend affects the total income via a decrease in the amount of fish caught by fishermen. For those fishermen who reported a decrease in fish trend, their total income also decreased by 12%. Most of households indicated that compared to the previous 5 years, fish resources had decreased due to over-fishing. The decrease in fish resources was attributed to an increase in human population.

Pertaining to agricultural land ownership (LANDEQ), the results suggest that an additional increase of 1 hectare of agricultural land leads to about 65% increase in total household income. The quadratic term (LANDEQ2) variable, which captures the non-linearity between household total income and land assets, was significant at 1% level. This s that suggests total income increases initially and there after decreases as the size of land increases. The ownership of an area for seaweed-farming in the sea has a positive and significant effect on the households' total income, even though it accounted for a small proportion. From these results, it is obvious that agricultural activity is in most instances, the second most important economic activity for those households participating in fishing activity (recall section 4.1).

The life cycle of adult members of household (ADULTAGE) is significant and it negatively influences the level of total household income. This result contradicts our prior expectations. An increase in the average age of adult members by a unit leads to a reduction in the total income by 1%, though its effect is very small. This result shows the effect of age on income via the ability of adults to supply labor to various activities. As members become older, the ability to supply labor to various activities tend to decrease and this leads to a decrease in household total income.

5. Conclusions and Policy Implications

The study illustrates the heterogeneity of households as they choose which activity to undertake. The data suggest that households participate in agriculture (farming and livestock keeping), fishing, seaweed farming as well as self- and wage employment. From these activities, it is evident that fishing activity is the main source of income and its average contribution to the total household income is about 52%. Both qualitative and quantitative analyses suggest that participation in fishing, seaweed-farming and agricultural activities are correlated with the physical endowments of households including fishing assets and agricultural land, social capital (sharing and renting of fishing capital, membership to groups activities) and location (village dummy).

The empirical results indicate that the level of participation in fishing activity is positively correlated to the value of fishing assets owned by the household. However, this is sometimes reduced by the quality of fishing assets used. This is evidence of credit market imperfection, which forces poor households to reduce their participation in fishing activity because of lack of finance for their investments in fishing assets. The use of low quality fishing gears is a common threat to the fisheries resources in most parts of Tanzanian coastal areas[11]. In addition, ownership of fishing assets is confirmed as an important factor influencing the total per capita income.

The analysis also shows that land endowment increases the propensity to participate in agricultural, seaweed-farming and fishing activities. Furthermore, the result indicates the presence of linkage between agricultural activities and other activities (seaweed-farming and fishing). Access to land assets increases agricultural income,

[11] Most fishermen along the coast use poor fishing methods such as the use of undersized fishing gears, which cause degradation of the fish stock [45].

which is used as a source of working capital for fishing and seaweed-farming activity. This shows that rural coastal households engage in multiple activities for their livelihood, and one activity can be used a source of working capital to other activities. However, due to lack of complementary resources such as land, the landless households have a low rate of participation in fishing and seaweed-farming activities, hence low income arising from these activities. The study provides some evidence that landless households experience barriers in their attempt to participate in various activities due to lack of working capital.

Social capital variables in terms of networks (group or association activities, sharing of assets) positively influence the decision to participate in agricultural, fishing and seaweed-farming activities. This implies that through networks, households are able to overcome risks at the same time meeting their subsistence and investment requirements. Additionally, the location variable, which captures rural infrastructure, seems to be an important variable in determining household decision to participate in certain activities. The result indicates that households residing within an area with good infrastructure such as better roads are more likely to participate in many activities than their counterparts with poor roads. This supports the notion that households with superior access to markets are in a better position to overcome output market constraints and to sell more products arising from their activities. This observation points the importance of infrastructure in most of rural African countries in shaping the decision to participate in various activities.

The analysis suggests that

(i) Establishment of credit programs that are accessible to poor households and use of sustainable approaches are essential to minimize the inherently high cost of lending. The support for flexible loans that builds on existing informal and formal financing schemes can provide a means of appropriate capital investment in various activities such as fisheries development. Together with this development strategy, it is worthwhile to develop appropriate and affordable fishing techniques, more efficient processing and storage facilities. These initiatives are vital to ensure a win-win situation in coastal areas. Such initiatives can increase household capability to participate in various activities.

However, careful implementation is necessary to avoid over-harvesting of fisheries resources arising from access of credits.

(ii) Recognition of complementarities between incomes accrued from various activities in coastal villages is important in order to come up with effective conservation-development policies. For example, if fishing is the most lucrative activity, the increase in access to land for the landless households will raise income, which in turn may result in higher investments in fishing activities and therefore increase pressure on fishing resources. The creation of alternative employment opportunities and access to land can reduce pressure on fishing resources, if and only if, expected returns from alternative activities are greater than those from fishing activity.

(iii) A better understanding of social networks is essential, especially by examining how these networks are established and their working mechanisms. This could offer more insight and lead to their improvement.

(iv) Promotion of investments in rural infrastructure needs to be a key area so as to link rural areas better with the rest of the economy.

In general, the study suggests that villages and households are not homogenous entities that can be isolated and identified by a single objective or a common interest. Therefore, rural development and natural resources management policies (such as those geared to increasing rural income and job opportunities through consolidation of fragmented holdings, credits and extension services, improved transportation and markets, and protection of ecosystem) based on the assumption of homogeneity cannot guarantee to produce the desired positive outcome among villages in the same region or households within the same village. Differences in household decision-making process apply not only to assets, household composition, natural resource endowment, and institutions, but are also driven by their preferences, and interests. The priorities of households to participate in activities that exploit natural resources and their management is likely to differ because of their different capacities, and powers to defend their interests.

In order to have good policies, there is a need for policy makers and conservationists to look beyond classical portrayals of rural households. This will improve their

knowledge regarding households' behavior in order to come up with a win- win situation. For instance, coastal resources conservationists (including those dealing with fisheries) should command a good knowledge on socio-economic aspects, geographical and demographic characteristics of households living along rural coastal areas. By taking into account the constraints and characteristics of these households, they could provide a basis for policy design on natural conservation and improvement of households' welfare in coastal areas. This implies that only the well-targeted and carefully designed policies will be effective and efficient in delivering intended incentives and programs to the right people in the right places with respect to the correct resources. This could be enhanced if policy makers in government and non-governmental organizations take time to gather information, so as to properly tailor in their approach when choosing initiatives for conservation and development issues. Most of the crucial information can be gathered by using methods that capture income activities available at local level as well as households' assets endowment, households' structure characteristics, natural resource base, infrastructure and the availability of institutions.

Along Tanzanian coastal areas, as in other rural areas, there are limited empirical studies shedding light on the behavior of rural households with respect to use of coastal resources, due to lack of data. In order to come up with more empirical and comparable studies, there is a need to collect more data from different coastal regions and ecosystems. Only with solid evidence at hand, policymakers and development planners can use the relationship between coastal resources and livelihoods of rural households, to formulate target efforts that will result in a win- win policy. However, the challenge lies in convincing governmental and non-governmental organizations, research bodies, and research funding agencies to invest in information gathering. This is necessary in order to build up a panel data on household behaviors regarding their strategies for livelihood and the natural resources available to them within the coastal as well as in other rural areas.

Acknowledgments

This work is funded by the International Max-Planck Research School for Maritime Affairs at the University of Hamburg and the Michael Otto Foundation for Environmental

Protection. Mzumbe University, Tanzania, is greatly acknowledged for providing funds for data collection, technical and scientific support. We wish to thank Dr. Shunula for his valuable comment on the study questionnaire. We are grateful to many people interviewed for their patience and assistance.

6. References.

[1] Small C, Nicholls RJ. A Global Analysis of Human Settlement in Coastal Zones. Journal of Coastal Research, 2003;19(3): 584–599.

[2] Francis J, Bryceson I. Tanzania Coastal and Marine Resources: Some Examples Illustrating Questions of Sustainable Use: In: Lessons learned-case studies in Sustainable Use, 2001. pp 76-102.

[3] Tanzania Coast Management Partnership (TCMP). Coastal Management Report no. 2002. Tanzania State of Coast Report: The National ICM Strategy and Prospects for Poverty Reduction, TCMP, 2003.

[4] Mohamed SM. Water Quality and Pollution: In: Ngusaru AS, editor. The Present State of Knowledge in Marine Science of Tanzania: Sythesis Report; Tanzania coastal Management Partnership and Science and Technology Working group, May 2000; 2000.

[5] Masalu DCP. Coastal Erosion and Its Social and Environmental Aspects in Tanzania: A Case Study in Illegal Sand Mining. Coastal Management 2002;30(4):347-359.

[6] Andersson J, Ngazi Z. Coastal Communities' Production choices, Risk Diversification, and Subsistence Behavior: Responses in Periods of Transition, A case studies from Tanzania. Ambio 1998;27(8):686-693.

[7] Gadgil M, Berkes F, Folke C. Indegenous knowledge for biodiversity conservation. Ambio 1993;22:151-156.

[8] Soto B, Munthali SM, Breen C. Perception Of the Forestry and Wildlife Policy by the Local Communities Living in Maputo Elephant Reserve, Mozambique. Biodiversity and Conservation 2001;10:1723-1738.

[9] Levine A. Local responses to marine conservation in Zanzibar, Tanzania. Breslauer Symposium on Natural resource Issues in Africa. Center for African Studies, University of California, Berkeley; 2004.

[10] Semesi AK. Coastal resources utilization and conservation issues in Bagamoyo, Tanzania. Ambio 1998;27(8):635-644.

[11] Tanzania Coast Management Partnership (TCMP). TCMP working document no. 5006. Socio-economic Assessment of Tanzania's Coastal Resources; 2000.

[12] Tietze U, Groenewold G, Marcoux A. Demographic Chance in coastal fishing communities and its implication for the coastal environment. FAO FisheriesTechnical Paper no. 403. Rome, 2000.

[13] Jiddawi NS, Öhman MC. Marine Fisheries in Tanzania. Ambio 2002;31(7):518-527.

[14] Dercon S. Wealth, risks and activity choice: cattle in western Tanzania. Journal of Development Economics 1998;55(1):1-42.

[15] Sherr SJ. A down Spiral? Research evidence on relationship between poverty and natural resource degradation. Food Policy 2000;25(4): 479-498.

[16] Barret CB, Reardon T, Webb P. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food Policy 2001;26:315-331.

[17] de Janvry A, Sadoulet E. Income Strategies Among Rural Households in Mexico: The Role of Off-farm activities. World Development 2001;29(3):467-480.

[18] Coomes OT, Barham BL, Takasaki Y. Targeting conservation-development initiatives in tropical forests: insights from analyses of rain forest use and economic reliance among Amazonian peasants. Ecological economics 2004;51: 47-64.

[19] Winters P, Davis B, Corral L. Assets, activities and income generation in rural Mexico; Factoring in social capital and public capital. Agricultural Economics 2001;27:139-156.

[20] Davis JR. The Rural Non-Farm Economy, livelihoods and their diversification: Issues and options. NRI Report No. 2753;2003.

[21] Reardon T, Vosti S. Links between rural poverty and the environment in developing countries: assets categories and investment poverty. World development 1995;23(9): 1495-1506.

[22] Ellis F. The determinants of rural livelihood diversification in developing countries. Journal of Agricultural Economics 2000;51(2):289-302.

[23] Barret CB, Reardon T. Asset, Activity, Income Diversification Among African Agriculturists: Some Practical Issues. Project report to the USAID BASIS CRSP; 2000.

[24] Carney D. Sustainable Livelihoods. Environment and Development. Putting Poor Rural People First. Discussion paper 240, IDS, Brighton; 1998.

[25] Walker RT, Perz S, Caldas M, Teixeira-Silva LG. Land-use and land-cover change in forest frontiers: the role of household life cycles. International Regional Science Review 2002;25(2):169-199.

[26] Reardon T, Delgado C, Matlon P. Determinants and effect of income diversification amongst farm households in Burkina Faso. The Journal of Development Studies 1992;28(2):264-296.

[27] Greene, W.H. Econometric Analysis. 5th edition, Prentice Hall, 2003.

[28] Fisher M. Household welfare and forest dependence in Southern Malawi. Environmental and Development Economics 2004;9:135-154.

[29] Corral L, Reardon T. Rural Nonfarm income in Nicaragua. World development 2001;29(3): 427-442.

[30] Chayanov AV. The Theory of Peasant Economy. Thorner D, Kerblay B, Smith REF, editors. Irwin, Illinois, American Economic Association; 1966.

[31] Collier P, Radwan S, Wangwe S.Labour and poverty in rural Tanzania: Ujamaa and rural development in the United Republic of Tanzania, Oxford: Clarendon Press, New York, Oxford University Press, 1986.

[32] Portes, A. Social Capital: Its origin and application in modern sociology. Annual Review of Sociology 1998;24(1):1-24.

[33] Bowles S, Gintis H. Social Capital and Community Governance. Economic Journal. 2002;112:419-439.

[34] van Ingen T, Kawau C, Wells S. Gender Equity in Coastal Zone Management: Experience from Tanga, Tanzania. Tanga Coastal Zone Conservation and Development Programme/IUCN Eastern Africa Regional Programme; 2002.

[35] Tanzania Population and Housing Census 2002; http://www.tanzania.go.tz.

[36] Benin S. Policies affecting land management, inputs use and productivity: land redistribution and tenure in the highlands of Amhara region. Paper presented at the conference on Policies for Sustainable Land Management in East African Highlands, UNECA, Addis Ababa, April 24-26 2002 (revised). IFPRI, Washington, D.C. Mimeo; 2003.

[37] Sanchez PA, Shepherd KD, Soule MJ, Place, FM, Burez RJ, Izac AN, Mokwunye AU, Kwesiga FR, Ndiritu CG, Woomer PL. Soil fertility in Africa: An investment in natural resource capital. In: Buresh RJ, Sanchez, P.A, Calhoum F, editors. Replenishing soil fertility in Africa. Madison, WI, USA: Soil Science Society of America; 1997.

[38] Cleaver KM, Schreiber GA. Reversing the spiral: The population, agriculture and environment nexus in Sub-Saharan Africa. Washington, D.C. The World Bank; 1994.

[39] Holden S, Binswanger HP. Small-farmer decision making, market imperfections, and natural resource management in developing countries. In Lutz E, editor. Agriculture and the Environment: Perspectives on Sustainable Development. A World Bank Symposium. The World Bank, Washington, D.C.; 1998.

[40] World Bank. Adjustment in Africa: reform, Results, and the Road Ahead, A World Bank Policy Research Report. The World Bank, Washington, D.C.; 1994.

[41] Fafchamps M, Minten B. Returns to Social Network Capital Among Traders. Oxford Economic Papers 2002;54:173-206.

[42] Grootaert C. Social Capital, Household Welfare and Poverty in Indonesia. The World Bank, Washington D.C.; 1999.

[43] Mwabua G, Thorbeckeb E. Rural Development, Growth and Poverty in Africa. Journal of African Economies 2004;13 (Supplement 1): 16-65.

[44] Bailey C, Pomeroy C. Resource dependency and community stability in coastal fishing communities of Southeast Asia. Society and Natural Resources 1996;9:191-199.

[45] Mohamed SM, Muhando C, Machano H. Assessment of Coral Reef Degradation in Tanzania; Results of Coral Reef Monitoring 1999-2002. In: Linden O, Sauter D, Wilhelmsson D, Obura D, editors. Coral Reef Degradation Indian Ocean; 2002.

Appendix 1

Based on the conceptual framework, the activity income equation is defined as:

$$y_i^* = X_i'\beta' + \varepsilon_i'$$

For a Tobit model, a dependent variable, say activity income, can take a value of zero or positive values as follows:

$y_i = y_i^*$ if $X_i'\beta' + \varepsilon_i' > 0$ and $y_i = 0$ if $X_i'\beta' + \varepsilon_i' \leq 0$

Where y_i^* is a partial latent dependent variable that capture the *i*th household propensity to earn income from a certain source, X_i is a matrix of variables such as household asset endowments, household structure, institutions and location characteristics, which describe the potential benefits of participating in various activities, β' is a parameter vector to be estimated, ε' is a random disturbance term. The model assumes that $\varepsilon_i \sim N(o, \sigma^2)$.

Using maximum likelihood estimation, the log-likelihood function for this Tobit model is expressed as follows:

$$\ln L = \sum_{y_i>0} -1/2[\ln(2\pi) + \ln\sigma^2 + \frac{(y_i - \beta' X)^2}{\sigma^2}] + \sum_{y_i=0} \ln[1 - \Phi(\frac{\beta' X}{\sigma})]$$

Where, Φ is the cdf of the standard normal distribution function. Here the first part of the likelihood function is essentially the classical regression model for the non-zero observations, while the second half represents the probabilities for the censored observations. The maximum likelihood estimator has the desirable properties of being both consistent and asymptotically efficient [27]**.**

In addition, the Ordinary Least Square (OLS), which represents the total income equation, is defined as follows:

$$\ln Y_i = \beta_0 + \beta_i \sum X_i + \varepsilon_i$$

Where, Y_i is the total income of the household i in logarithm form, X is the set of explanatory variables and β_0 and β_i are the coefficients to be, ε_i is an error term**.**

Table 1

Adult Equivalence scales: Index of calorific requirements by Age and Gender

Age group (years)	Male	Female
0-2	0.4	0.4
3-4	0.48	0.48
5-6	0.56	0.56
7-8	0.64	0.64
9-10	0.76	0.76
11-12	0.80	0.88
13-14	1	1
15-18	1.2	1
19-59	1	0.88
over 60	0.88	0.72

Source: Collier et al., 1986

Table 2

Descriptive variables

Variables description	Variables	Mean	Standard deviation
Physical Capital			
Size of agricultural land per adult equivalent (Ha)	LANDEQ	1.1	1.34
Land square	LANDEQ2	2.96	7.89
Fish asset ratio (1 if the ratio of fish Asset in total assets value is below 40%)[a]	FISHASR0	35%	NA
Boat dummy (1 if own a boat and 0 otherwise)[a]	OWNBOAT	31%	NA
Fishing gears (1 if own a gears and 0 otherwise)[a]	FISHGEARS	86%	NA
Value of fishing assets	FISHASEQ	43.9	145.2
Value of total assets in US$	ASSETEQ	78.9	225.3
Social Capital			
Membership in associations (1 if member and 0 otherwise)	PARTIC	28%	NA
Sharing fishing assets (1 if share and 0 otherwise)[a]	SHREBT	58%	NA
Financial Capital			
Other income in US$	OTHERY	264.1	312.4
Human capital			
Average age of adult members (years)	ADULTAGE	36.2	9.18
Age of household head dummy (1 if is below 50 years and 0 otherwise)	HHAGE0	63%	NA
Fishing experience (years)[a]	EXPF	17.86	12.85
Natural resources			
Fish trend (1 if decreasing and 0 Otherwise)	FISHTREND0	35.9%	NA
Area of seaweed farming (in squared meters)	SWLAND	173	558.8
Household's composition/structure			
Gender of Household Head (1 if male and 0 Otherwise)	GENDER1	84%	NA
Female/male ratio	FEMRAT	0.52	0.25
The size of Household (Consumption-worker ratio)	HHSIZE(CWRAT)	4.36 (1.16)	2.08(0.24)
Facilitating factors			
Credit market constraint (1 if constrained and 0 Otherwise)	CRDTCOT	53%	NA
Output market constraint1 if constrained and 0 Otherwise)	MKTCOT	43.8%	NA
Village (1 if residing in Mlingotini and 0 otherwise	V2	53.9%	NA

[a] Take into account only for the household participating in fishing.

Table 3

Activities participation rates, shares in total household income in two villages

Activity	Nyamanzi	Mlingotini	Both Village
Agriculture			
Participation rate	88%	76%	82%
Mean income (s.d) in US$	115.6(209.0)	138.5(228.5)	127.9(219.5)
Income share (range)	11.4%(0-51%)	16.8(0-100%)	14%(0-100%)
Fishing			
Participation rate	64%	51%	57.10%
Mean income (s.d) in US$	623.5 (1429)	359.2(749.6)	481(1120.3)
Income share (range)	61.4%(0-100%)	43.6%(0-100%)	52.6%(0-100)
Seaweed farming			
Participation rate	50%	27%	37.70%
Mean income (s.d) in US$	32.1(46.9)	46.1(109.5)	39.6(86.6)
Income share (range)	3.1%(0-88.5%)	5.6%(0-100%)	4.3%(0-100%)
Other activities			
Participation rate	97%	93.20%	94.90%
Mean income (s.d) in US$	244.8 (274)	280.6(312.4)	264.1(312.4)
Income share (range)	24%(0-100%)	34.1%(0-83%)	28.9%(0-100%)
Mean income in US$	1015.9(1589)	824.4(1218.2)	912.6(1401.2)
Observations	100	117	217

Table 4

Tobit estimates for Participation in different activities (Agricultural, Fishing and Seaweed -farming)

Variable	Estimated coefficient	Standard error	t-statistics	Marginal effects
Fishing activity				
Constant	-608.6	329.2	-1.85*	-
Landeq	130.4	74.8	1.74*	0.05
Fishasr0	-837.4	204.2	-4.10***	-0.3
Expf	28.9	8.3	3.47***	0.01
Hhage0	536.5	221.1	2.43**	0.19
Primshare	772.6	222.1	3.48***	0.28
Othery	0.6247	0.3193	1.96**	0.0002
Fishtrend0	-930.5	263.3	-3.53***	-0.34
asseteq	2.24	0.3705	6.06***	0.0008
V2	-400.3	213.1	-1.88*	-0.14
Observations	N=124			
Agricultural activity				
Constant	-73	10.7	-6.83***	-
Landeq	141.6	4.8	29.26***	0.48
Primshare	-106.8	17.8	-6.0***	-0.37
Ownboat	-41.4	18.2	-2.28**	-0.14
Agrifish	26.1	3	8.82***	0.09
Mktcot	24.3	11.3	2.15**	0.08
partic	24.7	12.7	1.95**	0.08
Observations	N=178			
Seaweed Farming Activity				
Constant	-196.4	58.1	-3.38***	-
cwrat	55.1	35.6	1.55	0.21
landeq	14	7.1	1.96**	0.05
Fishasr0	48.1	18.5	2.60***	0.18
femrat	84.7	36.6	2.32**	0.32
swland	0.15	0.01	11.38***	0.0006
partic	34.7	18.8	1.85*	0.13
V2	-44.8	18.3	-2.44**	-0.17
Observations	N=82			

Note: Single, double and triple asterisks (*) denote significance at the 10 , 5 and 1 percent level, respectively.

Table 5

Regression model of total household income

Variable	Estimated coefficient	Robust standard error	t-statistics
constant	5.4	0.25	21.56***
Landeq	0.65	0.1	6.86***
Landeq2	-0.05	0.02	-3.23***
Swland	0.0002	0	4.57***
Fishtrend0	-0.12	0.11	-1.23
Shrebt	0.65	0.17	3.79***
Adultage	-0.01	0.01	-2.02**
Fishgears	0.38	0.16	2.29**
ownbt	0.87	0.23	3.83***
R2 n=217	0.68		
F-statistics (p-value)	48.97(0.0000)		

Cook –Wesberg for heteroscedacity chi2 (1)=0.66 pvalue 0.4164.
Mean VIF =3.0.
Ramsey reset Test F(3, 205)=0.368 p-value 0.5652.
Note: Single, double and triple asterisks (*) denote significance at the 10 , 5 and 1 percent level, respectively.

Fig. 1. Conceptual framework (adapted from Reardon and Vosti, 1995)

Fig. 2. Map of the study area

Fig.3. The income shares by size of agricultural land

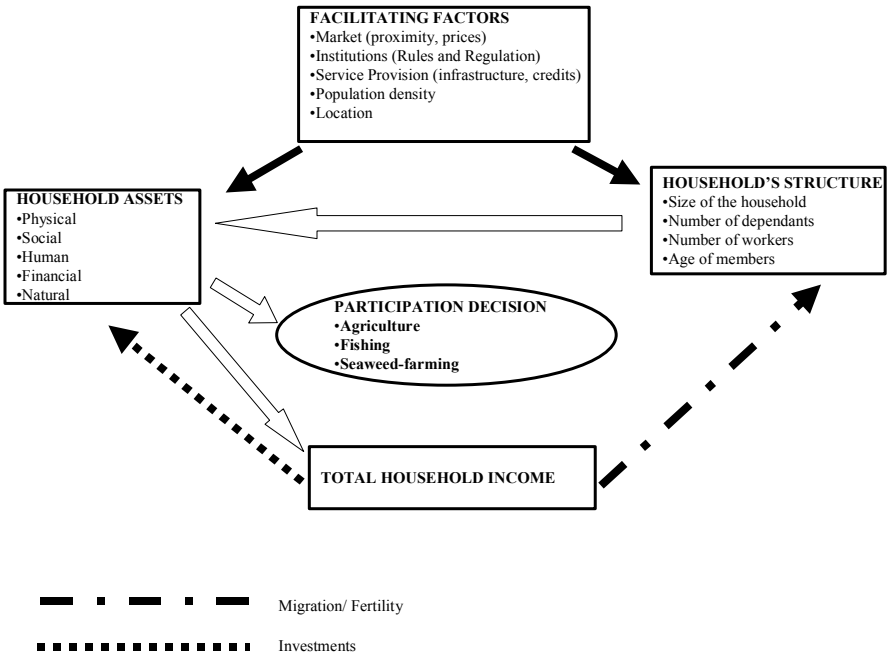
FACILITATING FACTORS
•Market (proximity, prices)
•Institutions (Rules and Regulation)
•Service Provision (infrastructure, credits)
•Population density
•Location
HOUSEHOLD ASSETS
•Physical
•Social
•Human
•Financial
•Natural
HOUSEHOLD'S STRUCTURE
•Size of the household
•Number of dependants
•Number of workers
•Age of members
PARTICIPATION DECISION
•Agriculture
•Fishing
•Seaweed-farming
TOTAL HOUSEHOLD INCOME
Migration/ Fertility
Investments

Fig. 1


UGANDA
KENYA
Bukoba
Nairobi
Musoma
RWA.
Mwanza
BUR.
Moshi
Arusha
Shinyanga
Study Area
Kigoma
Singida
Tabora
Tanga
5°
TANZANIA
Dodoma
Zanzibar
Bagamoyo
Indian
Morogoro
Dar es Salaam
Sumbawanga
Iringa
Ocean
Mbeya
Lindi
10°
Mtwara
ZAMBIA
Songea
MLW.
MOZAMBIQUE
0 100 200 mi

Fig. 2

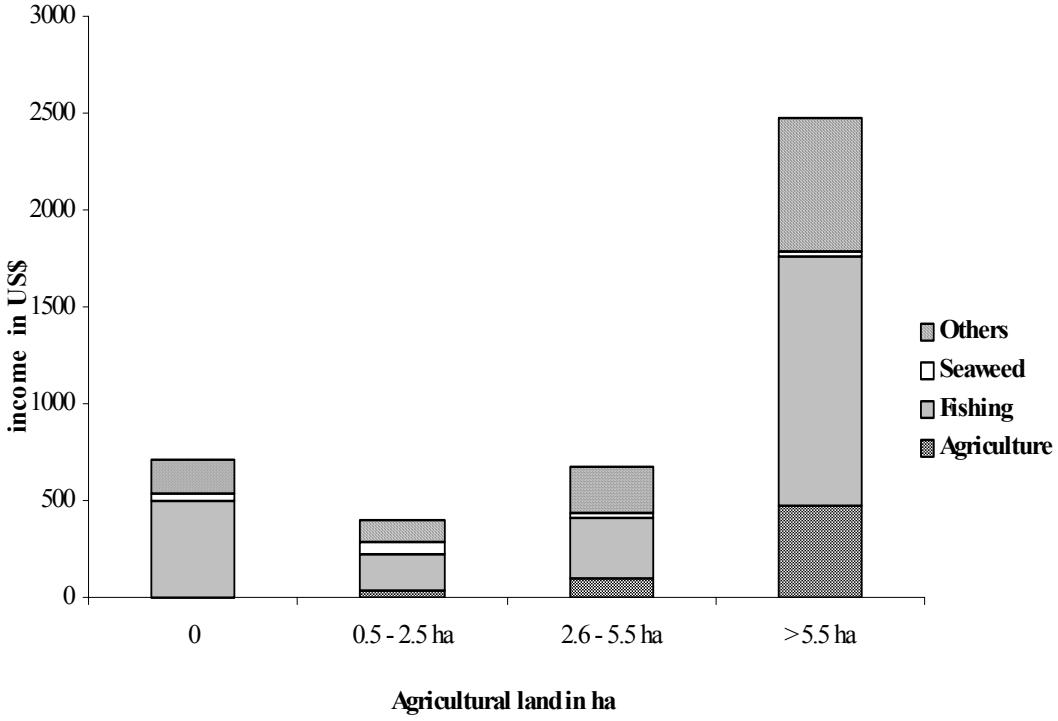
3000
2500
2000
1500
1000
500
0
income in US$
Others
Seaweed
Fishing
Agriculture
0
0.5 - 2.5 ha
2.6 - 5.5 ha
>5.5 ha
Agricultural land in ha
Mean Fishing assets 88.6$US 105.4$US 102.4 $US 341.7 $ US

Fig. 3

Working Papers

Research Unit Sustainability and Global Change

Hamburg University and Centre for Marine and Atmospheric Science

Sesabo, J.K. and R.S.J. Tol (2005), *Factor affecting Income Strategies among households in Tanzanian Coastal Villages: Implication for Development-Conservation Initiatives,* **FNU-70** (Submitted)

Fisher, B.S., G. Jakeman, H.M. Pant, M. Schwoon. and R.S.J. Tol (2005), *CHIMP: A Simple Population Model for Use in Integrated Assessment of Global Environmental Change*, **FNU-69** (submitted)

Rehdanz, K. and R.S.J. Tol (2005), *A No Cap But Trade Proposal for Greenhouse Gas Emission Reduction Targets for Brazil, China and India*, **FNU-68** (submitted)

Zhou, Y. and R.S.J. Tol (2005), *Water Use in China's Domestic, Industrial and Agricultural Sectors: An Empirical Analysis*, **FNU-67** (submitted)

Rehdanz, K. (2005), *Determinants of residential space heating demand in Germany*, **FNU-66** (submitted)

Ronneberger, K., R.S.J. Tol and U.A. Schneider (2005), *KLUM: A simple model of global agricultural land use as a coupling tool of economy and vegetation,* **FNU-65** (submitted)

Tol, R.S.J. (2005), *The Benefits of Greenhouse Gas Emission Reduction: An Application of* FUND, **FNU-64** (submitted)

Röckmann, C., M.A. St.John, F.W. Köster, F.W. and R.S.J. Tol (2005), *Testing the implications of a marine reserve on the population dynamics of Eastern Baltic cod under varying environmental conditions,* **FNU-63** (submitted)

Letsoalo, A., J. Blignaut, T. de Wet, M. de Wit, S. Hess, R.S.J. Tol and J. van Heerden (2005), *Triple Dividends of Water Consumption Charges in South Africa*, **FNU-62** (submitted)

Zandersen, M., Termansen, M., Jensen,F.S. (2005), *Benefit Transfer over Time of Ecosystem Values: the Case of Forest Recreation,* **FNU-61** (submitted)

Rehdanz, K., Jung, M., Tol, R.S.J. and Wetzel, P. (2005), *Ocean Carbon Sinks and International Climate Policy*, **FNU-60** (submitted)

Schwoon, M. (2005), *Simulating The Adoption of Fuel Cell Vehicles*, **FNU-59** (submitted)

Bigano, A., J.M. Hamilton and R.S.J. Tol (2005), *The Impact of Climate Change on Domestic and International Tourism: A Simulation Study*, **FNU-58** (submitted)

Bosello, F., R. Roson and R.S.J. Tol (2004), *Economy-wide estimates of the implications of climate change: Human health*, **FNU-57** (submitted, *Ecological Economics*)

Hamilton, J.M. and M.A. Lau (2004) *The role of climate information in tourist destination choice decision-making,* **FNU-56** (forthcoming, Gössling, S. and C.M. Hall (eds.), Tourism and Global Environmental Change. London: Routledge)

Bigano, A., J.M. Hamilton and R.S.J. Tol (2004), *The impact of climate on holiday destination choice*, **FNU-55** (submitted, *Climatic Change*)

Bigano, A., J.M. Hamilton, M. Lau, R.S.J. Tol and Y. Zhou (2004), *A global database of domestic and international tourist numbers at national and subnational level*, **FNU-54** (submitted)

Susandi, A. and R.S.J. Tol (2004), *Impact of international emission reduction on energy and forestry sector of Indonesia*, **FNU-53** (submitted)

Hamilton, J.M. and R.S.J. Tol (2004), *The Impact of Climate Change on Tourism and Recreation*, **FNU-52** (forthcoming, Schlesinger et al. (eds.), Cambridge University Press)

Schneider, U.A. (2004), *Land Use Decision Modelling with Soil Status Dependent Emission Rates*, **FNU-51** (submitted)

Link, P.M., U.A. Schneider and R.S.J. Tol (2004), *Economic impacts of changes in fish population dynamics: the role of the fishermen's harvesting strategies*, **FNU-50** (submitted)

Berritella, M., A. Bigano, R. Roson and R.S.J. Tol (2004), *A General Equilibrium Analysis of Climate Change Impacts on Tourism*, **FNU-49** (submitted, *Tourism Management*)

Tol, R.S.J. (2004), *The Double Trade-Off between Adaptation and Mitigation for Sea Level Rise: An Application of* FUND, **FNU-48** (submitted, *Mitigation and Adaptation Strategies for Global Change*)

Erdil, Erkan and Yetkiner, I. Hakan (2004), *A Panel Data Approach for Income-Health Causality,* **FNU-47**

Tol, R.S.J. (2004), *Multi-Gas Emission Reduction for Climate Change Policy: An Application of* FUND, **FNU-46** (forthcoming, *Energy Journal*)

Tol, R.S.J. (2004), *Exchange Rates and Climate Change: An Application of* FUND*,* **FNU-45** (submitted, *Climatic Change*)

Gaitan, B., Tol, R.S.J, and Yetkiner, I. Hakan (2004), *The Hotelling's Rule Revisited in a Dynamic General Equilibrium Model*, **FNU-44** (submitted)

Rehdanz, K. and Tol, R.S.J (2004), *On Multi-Period Allocation of Tradable Emission Permits*, **FNU-43** (submitted)

Link, P.M. and Tol, R.S.J. (2004), *Possible Economic Impacts of a Shutdown of the Thermohaline Circulation: An Application of* FUND, **FNU-42** (*Portuguese Economic Journal*, **3**, 99-114)

Zhou, Y. and Tol, R.S.J. (2004), *Evaluating the costs of desalination and water transport,* **FNU-41** (forthcoming, *Water Resources Research*)

Lau, M. (2004), *Küstenzonenmanagement in der Volksrepublik China und Anpassungsstrategien an den Meeresspiegelanstieg,***FNU-40** (submitted, *Coastline Reports*)

Rehdanz, K. and Maddison, D. (2004), *The Amenity Value of Climate to German Households*, **FNU-39** (submitted)

Bosello, F., Lazzarin, M., Roson, R. and Tol, R.S.J. (2004), *Economy-wide Estimates of the Implications of Climate Change: Sea Level Rise*, **FNU-38** (submitted, *Environmental and Resource Economics*)

Schwoon, M. and Tol, R.S.J. (2004), *Optimal CO_2-abatement with socio-economic inertia and induced technological change*, **FNU-37** (submitted, *Energy Journal*)

Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2004), *The Effects of Climate Change on International Tourism,* **FNU-36** (forthcoming, *Climate Research*)

Hansen, O. and R.S.J. Tol (2003), *A Refined Inglehart Index of Materialism and Postmaterialism*, **FNU-35** (submitted)

Heinzow, T. and R.S.J. Tol (2003), *Prediction of Crop Yields across four Climate Zones in Germany: An Artificial Neural Network Approach,* **FNU-34** (submitted, *Climate Research*)

Tol, R.S.J. (2003), *Adaptation and Mitigation: Trade-offs in Substance and Methods,* **FNU-33** (submitted, *Environmental Science and Policy*)

Tol, R.S.J. and T. Heinzow (2003), *Estimates of the External and Sustainability Costs of Climate Change*, **FNU-32** (submitted)

Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2003), *Climate change and international tourism: a simulation study,* **FNU-31** (forthcoming, *Global Environmental Change*)

Link, P.M. and R.S.J. Tol (2003), *Economic impacts of changes in population dynamics of fish on the fisheries in the Barents Sea*, **FNU-30** (submitted)

Link, P.M. (2003), *Auswirkungen populationsdynamischer Veränderungen in Fischbeständen auf die Fischereiwirtschaft in der Barentssee*, **FNU-29** (*Essener Geographische Arbeiten*, **35**, 179-202)

Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – An Assessment of Structural Impacts on Decision-making Processes*, **FNU-28** (submitted)

Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – A Unique Approach?*, **FNU-27** (*China Environment Series,* Issue 6, pp. 120-124; http://www.wilsoncenter.org/topics/pubs/7-commentaries.pdf)

Roson, R. and R.S.J. Tol (2003), *An Integrated Assessment Model of Economy-Energy-Climate – The Model Wiagem: A Comment*, **FNU-26** (forthcoming, *Integrated Assessment*)

Yetkiner, I.H. (2003), *Is There An Indispensable Role For Government During Recovery From An Earthquake? A Theoretical Elaboration*, **FNU-25**

Yetkiner, I.H. (2003), *A Short Note On The Solution Procedure Of Barro And Sala-i-Martin for Restoring Constancy Conditions*, **FNU-24**

Schneider, U.A. and B.A. McCarl (2003), *Measuring Abatement Potentials When Multiple Change is Present: The Case of Greenhouse Gas Mitigation in U.S. Agriculture and Forestry*, **FNU-23** (submitted)

Zhou, Y. and Tol, R.S.J. (2003), *The Implications of Desalination to Water Resources in China - an Economic Perspective*, **FNU-22** (*Desalination*, **163** (4), 225-240)

Yetkiner, I.H., de Vaal, A., and van Zon, A. (2003), *The Cyclical Advancement of Drastic Technologies*, **FNU-21**

Rehdanz, K. and Maddison, D. (2003) *Climate and Happiness*, **FNU-20** (*Ecological Economics,* **52** 111-125)

Tol, R.S.J., (2003), *The Marginal Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties*, **FNU-19** (*Energy Policy,* **33** (16), 2064-2074).

Lee, H.C., B.A. McCarl, U.A. Schneider, and C.C. Chen (2003), *Leakage and Comparative Advantage Implications of Agricultural Participation in Greenhouse Gas Emission Mitigation*, **FNU-18** (submitted).

Schneider, U.A. and B.A. McCarl (2003), *Implications of a Carbon Based Energy Tax for U.S. Agriculture*, **FNU-17** (submitted).

Tol, R.S.J. (2002), *Climate, Development, and Malaria: An Application of* FUND, **FNU-16** (forthcoming, *Climatic Change*).

Hamilton, J.M. (2003), *Climate and the Destination Choice of German Tourists,* **FNU-15** (revised and submitted).

Tol, R.S.J. (2002), *Technology Protocols for Climate Change: An Application of* FUND, **FNU-14** (forthcoming, *Climate Policy*).

Rehdanz, K (2002), *Hedonic Pricing of Climate Change Impacts to Households in Great Britain*, **FNU-13** (forthcoming, *Climatic Change*).

Tol, R.S.J. (2002), *Emission Abatement Versus Development As Strategies To Reduce Vulnerability To Climate Change: An Application Of* FUND, **FNU-12** (forthcoming, *Environment and Development Economics*).

Rehdanz, K. and Tol, R.S.J. (2002), *On National and International Trade in Greenhouse Gas Emission Permits*, **FNU-11** (forthcoming, *Ecological Economics*).

Fankhauser, S. and Tol, R.S.J. (2001), *On Climate Change and Growth*, **FNU-10** (*Resource and Energy Economics*, **27**, 1-17).

Tol, R.S.J.and Verheyen, R. (2001), *Liability and Compensation for Climate Change Damages – A Legal and Economic Assessment*, **FNU-9** (*Energy Policy*, **32** (9), 1109-1130).

Yohe, G. and R.S.J. Tol (2001), *Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity*, **FNU-8** (*Global Environmental Change*, **12** (1), 25-40).

Kemfert, C., W. Lise and R.S.J. Tol (2001), *Games of Climate Change with International Trade*, **FNU-7** (*Environmental and Resource Economics*, **28**, 209-232).

Tol, R.S.J., W. Lise, B. Morel and B.C.C. van der Zwaan (2001), *Technology Development and Diffusion and Incentives to Abate Greenhouse Gas Emissions*, **FNU-6** (submitted, *International Environmental Agreements*).

Kemfert, C. and R.S.J. Tol (2001), *Equity, International Trade and Climate Policy*, **FNU-5** (*International Environmental Agreements*, **2**, 23-48).

Tol, R.S.J., Downing T.E., Fankhauser S., Richels R.G. and Smith J.B. (2001), *Progress in Estimating the Marginal Costs of Greenhouse Gas Emissions*, **FNU-4**. (*Pollution Atmosphérique – Numéro Spécial: Combien Vaut l'Air Propre?*, 155-179).

Tol, R.S.J. (2000), *How Large is the Uncertainty about Climate Change?*, **FNU-3** (*Climatic Change*, **56** (3), 265-289).

Tol, R.S.J., S. Fankhauser, R.G. Richels and J.B. Smith (2000), *How Much Damage Will Climate Change Do? Recent Estimates*, **FNU-2** (*World Economics,* **1** (4), 179-206)

Lise, W. and R.S.J. Tol (2000), *Impact of Climate on Tourism Demand*, **FNU-1** (*Climatic Change*, **55** (4), 429-449).