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Integration of Fishers' Perceptions on the Environment in a Multinomial Probit Model: The Green Economy in a Small-scale Fishery

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Abstract — The objectives of this study were to examine both the significance of fishers' perceptions regarding environmental role and degradation into their adoption of new preferences regarding environmental management and how these preferences themselves influence environmental perception. The study is based on data from 200 fishermen in the north-east of Madagascar. The paper analyses the effects of environmental variables and fishers' perception on the way how the fishers perceive environmental change in a multinomial probit model. This model is used to define the aggregate of fishers' bottom-up and top-down explanatory variables of increasing the climate change perception.

INTRODUCTION

A contemporary challenge in green economies is to characterize sustainable socio-ecological systems, coupling attributes of the environment and social organization. This persistent challenge is especially typical in tropical waters where global climate change effects are felt at the local-scale (McClanahan *et al*., 2008). Integrating these effects with local adaptation is becoming increasingly urgent in the management of tropical marine resources in the Western Indian Ocean (WIO) as they cause widespread environmental stress and coral bleaching.

Small Island Developing States (SIDS) are keenly aware of the importance of the marine environment and resources for their sustainable development and economic stability. Millions of people in the SIDS of the WIO are dependent on healthy oceans for their sustainable livelihood. However, these countries face the major issue of apparently conflicting objectives between long-term governance of the oceans and the short-term needs of local communities who make a living from fisheries resources. Thus, there is a need for integrated policy making that will address cross-cutting issues across several

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domains to connect the environmental, social and economic aspects of ocean governance (Cole, 2003).

The concept of a Green Economy seems to be appropriate for this purpose (UNEP, 2012). NGOs and international organisations are applying it to conservation issues and sustainable and equitable biodiversity use within the context of holistic and integrated development. Favourable public perceptions of conservation initiatives and a high awareness of environmental issues by local coastal communities are essential to ensure the success of such an initiative. In the case of Madagascar, a developing island state, evaluation of the perceptions of coastal communities and small-scale fishers of the changing global environment will be an important step on the road to a Green Economy (IOC/UNESCO, 2011). The main objective of this paper was thus to examine the relevant environmental parameters and adaptive attitudes of 200 traditional fishers to climate change on the north-east coast of Madagascar. We employed a multinomial probit model to do this, analysing fishers' perceptions of the environment, their awareness of climate change and preferred adaptive measures to this phenomenon.

BACKGROUND

A Green Economy (UNEP, 2012) balances natural resource values with social and economic values, taking into account any loss in value of ecosystem services due to environmental impacts. The implicit requirements for a comprehensive valuation of ecosystem services fitted in well with our objectives. A Green Economy provides a chance to "get the balance sheet right" by accounting for both the current and future values of ecosystem benefits to people (UNEP, 2012). The essence of a Green Economy is that it recognizes the sum of all ecosystem services, meeting UNESCO requirements for both top-down and bottom-up strategies (IOC/UNESCO, 2011).

The top-down approach is based on the principle that the use of resources may be regulated by a centralized government, exchanged using a system of private property, and/or managed through collaborative action, with a revaluation of externalities in natural capital (Roseta-Palma *et al*., 2010). Plummer and FitzGibbon (2004) suggested that, in the context of the commons, power is "the prerogative of an authority such as the state to deprive fishers of their freedom respecting harvesting practices and investments".

The bottom-up approach focuses on the idea that local communities have the ability or potential to control, influence and exercise authority within such situations (Poteete & Ostrom, 2008). Natural resource co-management is now visualized as a proactive method of ensuring a healthy, sustainable environment and economy (Ostrom, 2006; Cinner *et al*., 2009). In bottom-up approaches, an effective Green Economy thus requires an enabling environment. The creation of appropriate policies and effective institutions at all levels has proven key in supporting people-centred, sustainable development (Ostrom, 2006; Poteete & Ostrom, 2008; Cinner *et al*., 2012). Experience in sub-Saharan, small-scale fishing communities has further demonstrated how small-scale solutions can trigger new actions, empower people with self-owned initiatives, and provide the right framework to catalyse synergies in economic development with social inclusivity (Cinner *et al*., 2012).

Ecosystem services provided by a marine environment are of crucial importance for food security and poverty eradication in coastal nations, as well as many of the sectors that currently drive their economies. Marine ecosystems services include spawning grounds and nurseries for fisheries, biodiversity value, blue carbon opportunities, and opportunities for sustainable human activities such as ecotourism. The challenges for SIDS are to integrate these values into their development policy.

The northern region of Madagascar is an international priority for marine conservation (Obura *et al*., 2012). It provides a critical habitat for numerous endangered species and is particularly vulnerable to climate change (Obura *et al*., 2011; Obura, 2012). The Malagasy government and conservation NGOs began to help local communities to acquire management rights to their local forests from the late 1990s.

This process has now been extended to the marine environment. Since the late 2000s, local coastal communities have been encouraged to gain rights over clearly-defined marine areas termed "Locally Managed Marine Areas" (LMMAs) and these have been divided into strict conservation and multiple resource use areas. The Malagasy government and marine conservation NGOs have further encouraged local communities to create associations to manage these marine areas for their biodiversity and sustainable resource use benefits. Local community associations have been made responsible for enforcement of the management rules in the LMMAs, granting of permits for activities in multiple resource use areas, and for the distribution of benefits from the LMMAs within their communities. Management rules in the strictly protected areas inside the LMMAs include the prohibition of the harvest of marine resources, mangrove trees and corals.

METHODS

Data were collected in December 2010 during Conservation International Rapid Assessments in 15 villages between Ambolobozokely and Vohemar on the extreme NE coast of Madagascar. Here, the coast of Madagascar is relatively isolated and unpopulated due to its remoteness. Each coastal village included approximately 20 households, mostly involved in fishing. 250 structured interviews with fishers were performed by three local research assistants fluent in spoken Malagasy following training. Respondents were selected opportunistically by walking through each community and neighbouring fields with local guides to ensure that only one individual per household, though not necessarily the head of the family, was interviewed. Men were preferentially interviewed as they are active in marine resource extraction. However, women were also interviewed if they engaged in marine harvesting. Of the 250 interviews, 200 interviews were complete, clear and error free and used in the following econometric analysis. There was a concern is that some responses were based on a desire to please the interviewers.

Respondents were questioned regarding the ecosystem services that the ocean provides them, to reflect their perceptions of the significance of the environment. Questions covered the role and importance of coral reefs, mangroves and seagrass beds for fishing. A question was asked for each ecosystem, as follows: "Do you think that [coral reefs] are important to support your fishing activities?" Responses were assessed as: "important", "unimportant" or "do not know"; the last responses were dropped from the analysis. Reference was made to marine resource-use laws and regulations and respondents were questioned about their knowledge of these matters. Subsequently, individuals were asked if they would like to engage in climate change adaptation measures or not. If yes, they were invited to choose which of the proposed measures were most appropriate.

Data from the survey were divided into two categories in line with the principles of a Green Economy:

Bottom-up variables

Bottom-up variables comprised individual fishers' details (gender, education, alternative livelihoods to fishing) and fishers' perceptions of the importance of the various ecosystems to their activities (coral reefs, mangroves and seagrass beds). These variables were compiled in standardised datasets that addressed some of the most pressing environmental challenges, such as the impact that local marine resource harvesting has on ecosystem services and how natural resources will respond to climate change. These variables are used in some socio-economic monitoring networks in the Western Indian Ocean region and could serve as data sources in a socio-economic data sharing system.

Top-down variables

Top-down variables comprised fishers' recommendations on adaptation measures to climate change, their awareness of and compliance with fisheries regulations, the enhancement of fisheries sustainability for future generations, and marine conservation. These are viewed as top-down variables with respect to climate change by several international organizations such as the Swedish International Development Agency.

Both categories of variables were combined within a "balance sheet" on climate change awareness, accounting for both the current and future value of the ecosystem benefits to fishers.

Theoretical model and empirical strategy

In this study, we wished to investigate what perceived causal effects climate change has on fishers' livelihoods. It was thus important to establish whether variation in these perceived effects influence marine resources status and fisheries productivity. We also needed to identify which measures would constitute appropriate actions to adapt to climate change in collaboration with the local fishers.

Fisher's responses were assumed to be normally distributed. The theoretical framework for analysis of their responses can be cast in a random utility model (Kalouptsidis *et al*., 2007; Holland & Sutinen, 1999; Hutton *et al*., 2004; Marchal *et al*., 2009). Descriptive techniques were used to define their perceptions of climate change as a utility function within a submodel which was based on a random utility model (Holland & Sutinen, 1999). However, the significance of variables that explain patterns in such results typically cannot be assessed using these methods.

In our case, we needed to assess the significance of the bottom-up and top-down factors in fishers' perceptions of climate change. Multinomial models are more appropriate for this purpose because these assess the effects of variables within multiple probabilities, while accommodating similarities between choice alternatives but decomposing similar patterns in perceptions into perceived similarities across choice alternatives and those attributable to sample heterogeneity.

We thus utilised the multinomial probit model (MNP; Duch *et al*., 2010). According to Hutton *et al*. (2004), MNP estimates are more accurate than those derived from multinomial logit (MNL) as they do not assume independence of irrelevant alternatives (IIA). In our case, the multinomial probit (MNP) model was used to analyse respondents' decisions, providing error correlations with the estimated coefficients.

According to the literature, variations in perceptions on climate change can be correlated with fishers' experience (Aphunu, A., & Nwabeze, G. O., 2013). In the analysis, the interviewees were thus divided into three categories: "junior fishers" with 1-10 years of experience, "experienced fishers" with 10-20 years of experience, and "senior fishers" with 20 years or more experience. A probit model of fishers' perception may be expressed as:

$$I_i=W_i+u_i$$

where I_i is a binary variable with a value of 1 if the fishers considered variables important in climate change, or 0 if not. W_i is a vector of other variables that affect climate change perception, and u_i is a vector of error terms.

As our objective was to evaluate the effect of each variable on perceptions of variation in climate change, we needed to estimate the marginal effect (dP/dW) of bottom-up variables W_j and top-down variables W_i on fishers' perceptions of climate change (P) and find which factors mostly affect variation in climate change perception and to what degree.

Since we obtained a predicted value I_i of fisher's perceptions from the first probit model, a definitive MNP model which calculates the marginal effects on P generated by a change in the variables W_i and W_j, compared to its average value, can be written as:

$$dP_{ij}/dW_{ij} = P_{ij}=\alpha+\delta_{1j}\, w_j+\delta_{2i}\, w_i+\gamma\bar{I}_i+\varepsilon_{ij}$$

where:

P_{ij} is the variation in fishers' perceptions of climate change, faced with variations in the variables w_j, a vector of bottom-up variables (gender, education, alternative livelihoods, importance of coral reefs in general, importance of coral reefs for fisheries, importance of mangroves for fisheries, importance of seagrass for fisheries);

w_i is a vector of top-down variables (awareness of national law on marine resources, law enforcement and compliance; enhanced sustainability of coral reefs, the ocean and fisheries for the next generation; enhanced capacity to adapt to climate change);

α is a constant in the mode and $\bar{I}_i$ the predicted perception;

δ_{1j}, δ_{2j} and γ are the parameters, and ε_{ij} the error term.

The interpretation of this multinomial probit model of dP_{ij}/dW_{ij} is as follows: positive signs indicate higher perceptions of climate change, as the value of the associated variables increases, while negative signs suggest the reverse.

Commercially available software is used to estimate the parameters in this model, simultaneously using full information maximum likelihood methods (we used STATA 10 SE, a product of Econometric Software, Inc.).

RESULTS and DISCUSSION

The results of the multinomial probit model (MNP) are presented in Table 1. Eight choice options were included within the model for bottom-up variables and seven for top-down variables. The greater the positive value, the more effect there was in a given choice.

A pseudo-R2 is commonly used to assess the predictive power in a discrete choice model such as the MNP. A pseudo-R2 of between 0.40 and 0.50 (Table 1) is indicative of relatively high explanatory power in such a discrete choice model. Many of the variables in the MNP were correlated to some degree. We ran a variety of restricted models, leaving out different explanatory variables to see if a smaller set would still provide the same predictive power and eliminate problems of multi-colinearity.

Table 1. Fishers' perceptions of top-down and bottom-up variables relative to climate change.

	Junior fishers (< 10 years of activity)		**Experienced Fishers (10< X <20 years of activity)**		**Senior Fishers (> 20 years of activity)**	
	dP/dW	S.E.	dP/dW	S.E.	dP/dW	S.E.
Bottom-up variables (wj)						
Fisher-specific variables						
Gender	0.001	0.009	0.011	0.012	-0.001	0.006
Education	0.019	0.034	0.024	0.021	0.020	0.023
Alternative livelihood activities	0.377	0.528	0.138	0.321	0.149	0.302
Fisher perceptions						
The value of coral reefs	0.082	0.190	0.118	0.116	0.043	0.108
Importance of coral reefs for fisheries	0.012	0.461	0.032	0.172	-0.018	0.164
Importance of mangroves for fisheries	-0.057	0.192	0.024	0.164	0.124	0.186
importance of seagrass for fisheries	-0.240	0.362	0.053	0.190	0.074	0.081
Top-down variables (wi)						
Adaptive measures						
Awareness of national law on marine resources	-0.055	0.197	-0.012	0.224	-0.055	0.048
Law enforcement	0.187	0.254	-0.029	0.140	-0.031	0.127
Compliance by others	0.038	0.236	0.015	0.149	-0.052	0.128
Enhanced sustainability of coral reefs	-0.086	0.239	-0.077	0.115	0.030	0.137
Enhanced sustainability of fisheries for the next generation	-0.296	0.564	0.034	0.260	-0.099	0.268
Enhanced sustainability of ocean	0.043	0.308	-0.110	0.142	-0.017	0.106
Enhanced capacity to adapt to climate change	-0.089	0.181	-0.053	0.149	0.098	0.276
Pseudo R2	**0.45**		**0.40**		**0.50**	

Significance of variables in fishers' perceptions of climate change

Among the bottom-up variables, gender and education were not correlated with or considered relevant to climate change. However, alternative livelihoods were considered the most relevant individual specific factor in the face of climate change, particularly by junior (0.377) and experienced fishers (0.138). Coral reefs, which represented a positive externality to the community, were mostly considered relevant by experienced (0.118) and junior fishers (0.082). However, coral reefs were not equally relevant to all fishers, and were even considered in a negative light by some senior fishers. Mangroves were considered particularly relevant to fisheries in the face of climate change by senior fishers (0.124), but negatively so by junior fishers. Seagrass was considered irrelevant to fisheries and viewed negatively so by junior fishers.

With regard to the top-down variables, senior fishers were convinced that enhancing their capacity to adapt to climate change was of fundamental importance (0.098); they assigned low coefficients to all remaining measures, showing their scepticism regarding other actions in the face of climate change.

The enhancement of ocean sustainability via the creation of marine protected areas was relevant to junior fishers (0.043) but viewed negatively by the others.

Law enforcement was considered the most relevant measure (0.187) to ameliorate the effects of climate change by junior fishers, while enhancing the sustainability of fisheries for future generations was considered more important by experienced fishers (0.034). Awareness of national law on marine resources was considered irrelevant by all fishers.

DISCUSSION

Our results on top-down variables were in accordance with Cinner *et al*. (2012), who elaborated on the need for a long-term investment in environmental governance within community management strategies because of social barriers or taboos (Cinner, 2007). The best way to adapt to environmental changes and adopt a Green Economy would be through Locally Managed Marine Areas (LMMAs), representing a community-based adaptive strategy, established in the SIDS to support the survival of local communities and protect marine resources from climate change (Cinner *et al*., 2009). In Madagascar, there have been concerted efforts by NGOs to promote community-based coastal conservation which have coincided with national policies to promote decentralized natural resource management, in particular within co- and community-managed protected areas.

According to Andriamalala and Gardner (2010), LMMAs in Madagascar incorporate temporary and permanent reserves that protect reefs and mangrove forests, and are managed through taboos or traditional village law which govern resource use, and have been legalized by the state. The LMMA concept seems to be consistent with fishers' opinions in NE Madagascar. Effectively, senior fishers argued that methods based on their traditional knowledge would enhance both biodiversity conservation and their cultural and spiritual values. Moreover, the junior and senior fishers favoured actions leading to sustainability in their marine resources.

Madagascar's marine environment is critically important to the food security and revenue of its population, over half of whom live within 100 km of the coast (WRI, 2003). Many coastal communities have such close cultural ties to a seafaring way of life that they have no viable alternatives to subsistence fishing (Cinner *et al*., 2009). Dependence on diminishing marine resources deepens their poverty trap, further degrading the natural capital upon which they depend. This drives fishers to adopt increasingly destructive practices to maintain landings, in turn further weakening the resilience of the ecosystems and the biodiversity that underpins their food security and livelihoods.

Madagascar's fragile marine resources are thus facing unprecedented threats from climate change, habitat destruction and overfishing. Green Economy initiatives, developed especially within an ecologically robust national network of marine protected areas, will present the only viable means of safeguarding the resilience of Madagascar's remaining healthy ecosystems; our multinomial probit model revealed that this was the main concern of senior fishers. Inexperienced fishers, on the other hand, preferred solutions that would involve the revival of traditional knowledge but using modern tools.

An LMMA network approach to environmental management should include representation by communities, government agencies, non-governmental organizations, educational institutions and businesses. Through such an integrated approach, LMMAs may alleviate dependency on marine and coastal resources and lead to the development of a Green Economy. Capacity development to accomplish these ends could take place within SIDS-SIDS partnerships, involving the sharing and consolidation of uniquely developed approaches to coastal management. The material covered could include LMMA networks, the transmission of local and indigenous knowledge on customary environmental management, and community participation in scientific coastal monitoring, management and decision-making.

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