

**Deterrence analysis of compliance with fishery regulations among artisanal
fishers in Sudan**

by

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Dedication

To my parents Awad and Jawahir and my sisters and brothers

Declaration

I declare that this thesis I hereby submit for the degree of PhD in Environmental Economics at the University of Pretoria is entirely my own work and has not been submitted anywhere else for the award of a degree or otherwise.

Parts of the thesis have been submitted for publication in Journals.

Any omissions or errors in thinking are entirely my own.

Signed:

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Date: 2012

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Degree: PhD Environmental Economics

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Abstract

This study analysed causes of the problem of over-fishing in the Jebel Aulia Reservoir (JAR) in Sudan and investigated reasons behind the failure of current management and policy regimes to promote sustainable management and exploitation of fishery in this reservoir. To achieve these objectives existing analytical frameworks and methodological approaches to study noncompliance with regulations have been adapted to allow two important extensions: (1) using frequency instead of intensity as a measure of violation rate and, (2) modifying the probability of detection to depend on time to account for frequency of violation. The adapted analytical models have then been empirically implemented to develop a typology of fishers according to violation rates and to analyse determinants of noncompliance and extent of violation with mesh size regulations among artisanal fishers in the JAR. This study represents the first research effort investigating causes and implications of illegal fishing and noncompliance with fishery regulations in Sudan in general and particularly in the JAR.

The study extended the two times dynamic deterrence model (DDM) to use frequency instead of intensity of noncompliance as a measure of violation rate. The method of comparative statics was employed to derive analytical results on the sensitivity of optimal violation to a number of key

factors of high relevance to compliance with regulations designed to protect against over-fishing. Analytical results obtained with this extended DDM confirmed the findings of earlier empirical studies employing alternative static and dynamic formulations and revealed interesting economic meanings of modelled relations. The study concludes that a number of factors related to market and institutional failures make frequency more suitable than intensity as a measure of violation in artisanal fisheries of developing countries.

Applications of DDM have so far been limited to the case of constant probability of detection, which assumes independence of the length of time to detection. One objective of this study was therefore to modify the DDM to allow for more flexible and broader specification by introducing two important variables to the supply of offences function, namely, evasion activity and enforcement efforts. One of the major modifications made by this study is modelling the probability of detection as a Cox proportional hazard model instead of the survival hazard used in the literature. The new modelling of probability of detection also makes the previous specification only one of the three versions of the new model, since the new model accommodates the situations of constant and inconstant probability of detection. The results of comparative statics analysis revealed important potential ways of extending the standard DDM to allow for optimal choice among critical trade-offs between evasion efforts and violation rates.

The study then applied the adapted DDM to empirically analyse and test specific hypotheses about artisanal fishers' compliance behaviour using data from a survey of artisanal fishers in the JAR area. Survey data was collected from a sample of 241 fishers from five landing sites at the study area. Factors that determine the probability of violation as well as the extent of violation were analysed employing an ordered Probit model and a count data model respectively, in two steps. The first step analysed the determinants of the choice to belong to one of the defined fishers' typologies. In the second step, a zero truncated negative binomial model was applied to analyse determinants of the extent and frequency of violation among violators only. Results of the empirical analyses suggest that fishers seem to care more about the size of the penalty than the presence of regulation enforcing agents as a deterrent, mainly due to corrupt options and effective evasion activities used by fishers. The study also suggests that better education of fishermen is necessary, as well as the provision of alternative income generating activities

especially during the fish reproduction season, access to credit for ownership of legal nets, and finally, effective regulation of the importation of illegal nets will be necessary to enhance compliance with mesh size regulations in Sudan. It is also necessary to promote community level organisation and awareness campaigns among fishers about the dangers for future fish stocks of eroding small fish quantities through the use of illegal nets and consequently endangering the social welfare of all.

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ACRONYMS AND ABBREVIATIONS

COXPH	Cox Proportional Hazard Function
CV	Chronic Violators
DDM	Dynamic Deterrence Model
FD	Fisheries Administration Department
FAO	Food and Agriculture Organization of the United Nations
HCENR	The Higher Council for Environment and Natural Resources
JAR	Jebel Aulia Reservoir
JAD	Jebel Aulia Dam
MAAWR	Ministry of Agriculture, Animal Wealth and Water Resources
MAARI	Ministry of Agriculture, Animal Resources and irrigation
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
NV	Non-Violators
OV	Occasional Violators
UNEP	United Nations Environmental Programme
VR	Violation Rate
SSA	Sub-Saharan Africa
WB	World Bank
WFP	World Food Programme
ZPM	Zero Poisson Model
ZTNBM	Zero Truncated Negative Binomial Model