

Farmers' adaptation to climate change: the case of Morogoro, Tanzania

DISSERTATION

**zur Erlangung des akademischen Grades
doctor rerum agriculturalarum (Dr. rer. agr.)**

eingereicht an der
Landwirtschaftlich-Gärtnerischen Fakultät
der Humboldt-Universität zu Berlin

von

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geboren am 20. Juni 1977 in Bielefeld

Präsident der Humboldt-Universität zu Berlin

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Tag der mündlichen Prüfung: 24. September 2012

Berliner Schriften zur Agrar- und Umweltökonomik

herausgegeben von
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Band 19

Till Benjamin Below

**Farmers' adaptation to climate change:
the case of Morogoro, Tanzania**

Shaker Verlag
Aachen 2012

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

Zugl.: Berlin, Humboldt-Univ., Diss., 2012

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Printed in Germany.

ISBN 978-3-8440-1486-0

ISSN 1618-8160

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen

Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: www.shaker.de • e-mail: info@shaker.de

Acknowledgments

Since a misty morning in September of 2008 this work has gone a long way in seeking to understand what is behind smallholder farmers' adaptation to climate change. The research process has been an intense and often very challenging experience. Without the support of many different people and institutions this dissertation would not have come to life. Therefore, I wish to thank all of them sincerely.

First and foremost I would like to thank my principal supervisor, Dieter Kirschke, for the opportunity to work on the PhD project under his position of Chair for Agricultural Policy at the Humboldt-Universität zu Berlin. Dieter Kirschke always encouraged me to critically question my own assumptions and he helped me greatly not to lose track of the “candies” that were more or less concealed in the research project. I also owe great thanks to my co-supervisor Christian Franke who guided me through the econometric analyses. I am very grateful for his patient, cordial and prompt responses to all my questions. I wish to thank Martin Qaim from the Georg-August-Universität Göttingen for agreeing to evaluate this dissertation. Furthermore, I would like to express my gratitude to Susanne Neubert and Wolfgang Bokelmann for being part of the defense committee.

While pursuing this research endeavor, I had the chance to work together with great colleagues at a number of different places and institutions. My special thanks go to all of my colleagues of the Chair for Agricultural Policy. I very much appreciate the good spirit and the inspiring working atmosphere at our division. Our PhD seminars were a stimulating and creative learning experience. In particular, I would like to thank Julia Schmid for the good company and her insightful comments during our long discussions. Without the great support of Kerstin Oertel the figures and the overall layout of this dissertation would not be the same, and I owe her my gratitude. Furthermore, I wish to thank Helga Meaini for her support with many administrative issues, as well as Astrid Häger and Kurt Jechlitschka for their helpful comments.

I started to work on the PhD project during a temporary assignment as research associate of the Leibniz-Centre for Agricultural Landscape Research (ZALF). The work was generously supported by a grant from the German Federal Ministry for Economic Cooperation and Development (BMZ) through the Advisory Service on Agricultural Research for Development (GIZ-BEAF). From my colleagues at ZALF I learned a great deal about interdisciplinary research and I received plenty of help in carrying out the fieldwork. Hence, I want to thank all my colleagues at ZALF very much. A special thanks goes to Stefan Sieber,

Karen Tscherning, Johannes Schuler, Peter Zander, Jans Bobert, Götz Uckert and Karin Stahl.

In Tanzania, I was fortunate to work and live at the Sokoine University of Agriculture. From the many people that helped me to realize the data collection I have to thank first of all Khamaldin Mutabazi. Without his thoughtful advice and practical support I would have not been able to collect the same quantity and quality of empirical data. I also owe much gratitude to Henry Mahoo and the members of the Soil Water Management Programme for inviting me to work with their institution and for sharing their great expertise on smallholder farmers' adaptation. Furthermore, I want to thank my five research assistants, Gilbert Msangi, Geoffrey Chiduo, Jackson Kajjage, Peter Rutaba, and Sewando Ponsian for their accurate work. I am also very grateful for the time that the farmers from both research sites devoted to answering our questions. Among the many more Tanzanian colleagues that helped me during research planning and fieldwork I would like to thank especially Joseph Hella, Catherine Kilasara, Caroline Kilembe, Joseph Mpagalile, Yonika Ngaga, and Stephen Nindi. Additionally, I would like to thank Tim Loos, Anja Fasse and Harry Hoffmann for the good company during fieldwork and beyond, as well as for the fruitful discussions about our PhD projects.

Back in Germany, some good friends and dear colleagues gave me additional advice on conceptual questions, problems of data analysis, life, the universe, and everything. Christoph Müller, Jawoo Koo, and Philip Thornton provided results of biophysical modeling for the research area. Martin Gemeinholzer prepared a map of the Morogoro region. Jessica Welker helped me to write better English. Silke Hüttel, Alwin Keil and Mario Basto helped to solve problems of econometric data analysis. Theo Rauch gave valuable comments on the concept and results of the study. Henrike Rieken, Tom Kutter, Jan Witte, Jan Puchstein, Sascha Reeb, and Hannah Bohle made my life more fun and they were always polite enough to listen to my stories about farmers and econometrics.

Moreover, I wish to thank my mother Irene, my father Lutz and my brother Michael for supporting and encouraging me in many ways to complete this PhD research. Finally, I want to thank Eefje Aarnoudse who accompanied me during the ups and downs of this long endeavor. Eefje helped me to grasp farmers' perspectives during some weeks of my fieldwork in Morogoro, to understand complex hydrological processes when I visited her in Wageningen, and to improve the English of the manuscript back in Berlin. I am deeply thankful for her great compassion and her constant support.

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List of abbreviations

AATF	African Agricultural Technology Foundation
BEAF	Beratungsgruppe Entwicklungsorientierte Agrarforschung (Advisory Service on Agricultural Research for Development, GIZ)
BMZ	Bundesministerium Für Wirtschaftliche Zusammenarbeit (German Federal Ministry for Economic Development Cooperation)
CGE	Computable General Equilibrium
CSIRO (GCM)	GCM developed by the Commonwealth Scientific and Industrial Research Organisation (Australia)
DALDO	District Agricultural and Livestock Development Officer (Tanzania)
DSSAT	Decision Support System for Agrotechnology Transfer
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus group discussion
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit, GmbH (German Society for International Cooperation, Ltd.)
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
LDC	Least Developed Country
LPJml	Lund-Potsdam-Jena managed Land Dynamic Global Vegetation and Water Balance Model
m.a.s.l.	Meters above sea level
MAFC	Ministry of Agriculture, Food and Cooperatives (Tanzania)
NAPA	National Adaptation Programme of Action
NBS	National Bureau of Statistics (Tanzania)
NCAR (GCM)	GCM developed by the National Center for Atmospheric Research (USA)
OECD	Organisation for Economic Co-operation and Development
REPOA	Research on Poverty Alleviation (NGO, Tanzania)
RRA	Rapid rural appraisal

RWH	Rainwater harvesting
SRES	Special Report on Emission Scenarios (IPCC)
SUA	Sokoine University of Agriculture
TNBC	Tanzania National Business Council
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania

Summary

Sub-Saharan smallholder farmers are expected to be severely affected by climate change. A better understanding of processes that shape smallholder farmers' vulnerabilities and adaptation in the face of climate change is critical to develop well-targeted adaptation policies. The implications of climate change for smallholder farmers are currently assessed with two main approaches, top-down impact assessments and bottom-up adaptation studies. Top-down approaches use process-based models that are often associated with high uncertainty and may in turn lead to misinformed adaptation action. Bottom-up assessments draw on farmers' existing implicit and explicit knowledge about the response to climatic stimuli and the conceptual thinking on socio-ecological vulnerability. Bottom-up assessments could significantly reduce the uncertainty resulting from coarse climate projections but they are constrained by lack of empirical evidence.

The existing conceptual literature on socio-ecological vulnerability is mostly argumentative and not sufficiently substantiated by models or empirical findings. In particular, there exists a lack of conclusive scientific evidence on the determinants driving smallholder farmers' adaptation to climate change based on methodological approaches and sample sizes that allow for rigorous statistical analyses.

Against this background, the objectives of this study are (1) to develop and evaluate a site-specific, bottom-up and forward-looking method for exploring smallholder farmers' adaptation to climate change with a mixed-method approach and a large sample size; and (2) to empirically assess smallholder farmers' adaptation and its determinants in a case study. While processes of farmers' adaptation to climatic stimuli are clearly bound to spatial and temporal conditions, this study assumes that there exist underlying generic drivers of individual adaptation behavior and that farmers' historic adaptation to climate variability and change is an acceptable second-best option to analyze their response to future climate change.

In order to fulfill the research objectives, quantitative and qualitative data were collected at the household and the village level. Morogoro Region, located in central-eastern Tanzania, was selected as the case study area because of its documented vulnerability to climate change and because results of this area were expected to be interesting in a broader perspective. Based on a critical review of literature from social science and development economics, a climate change response framework was developed and variables hypothesized to influence farmers' adaptation were identified. Furthermore, an index-based approach to measure farmers' adaptedness was developed, the activity-based adaptation index (AAI).

The data was analyzed using factor analysis, multiple linear regression, descriptive statistical methods and qualitative content analysis. The econometric analysis was undertaken in two steps, first a multiple linear regression analysis with original predictor variables was conducted, which was followed by the combination of a factor analysis with a regression analysis based on latent variables. The empirical results are discussed in the context of theoretical concepts of adaptation and the sustainable livelihood approach.

The results of this study indicate that farmers' adaptation to climate change is determined by four factors, namely the production potential of the area, the availability of productive inputs, the socio-economic status of the household, and farmers' social and financial capital. Both, the factor analysis and the regression analysis with original variables reveal a similar structure of these determinants, highlighting the stability of the results. Furthermore, this study identified 33 practices potentially suitable for adaptation to climate change and currently used among Morogoro's smallholder farmers. From a methodological perspective it was found important to involve stakeholders with local knowledge in the assessment because successful agricultural adaptation requires information about site-specific capacities and constraints.

This study has two major conclusions. First, the mixed-method bottom-up approach of this study is a promising way to capture the complexity of adaptation processes, and to address a number of shortcomings of previous assessments. The approach circumvents the uncertainties associated with top-down impact assessments by introducing farmers' knowledge into the analysis. Additionally, it reduces the risk of wrongly specified weights of traditional index studies by using indicating variables that are relatively easy to assess for local stakeholders. Second, the determinants of farmers' adaptation identified in this study add empirical foundation to the mostly argumentative existing literature. While none of the determinants themselves are completely new, the specific contribution of this study is to confirm the influence with a quantitative approach and a rigorous econometric analysis.

Zusammenfassung

Es wird erwartet, dass Kleinbauern in weiten Teilen Subsahara-Afrikas gravierend durch den Klimawandel beeinträchtigt werden. Für die Entwicklung zielgerichteter Politiken zur Anpassung an diese Beeinträchtigungen ist ein verbessertes Verständnis von Wirkungszusammenhängen kleinbäuerlicher Vulnerabilität und Anpassung notwendig. Die Implikationen des Klimawandels für Kleinbauern werden derzeit hauptsächlich mit Top-down und Bottom-up Ansätzen untersucht. Top-down Ansätze beruhen auf prozessbasierten, biophysikalischen Modellen, die häufig mit großen Unsicherheiten behaftet sind. Es besteht die Gefahr, dass diese Unsicherheiten zu falschen Schlussfolgerungen für Anpassungspolitiken führen. Bottom-up Ansätze gehen aus von dem expliziten und impliziten Wissen der Landwirte über den Umgang mit klimatischen Stressoren sowie von Konzepten der sozial-ökologischen Vulnerabilität. Bottom-up Ansätze können einen wichtigen Beitrag zur Verringerung der bestehenden Wissenslücken leisten, die mit den unsicheren Klimaprojektionen einhergehen. Allerdings sind diese Ansätze bisher nur mangelhaft empirisch fundiert.

Die bestehende konzeptionelle Literatur über sozial-ökologische Vulnerabilität hat vielfach rein argumentativen Charakter, und sie ist nicht hinreichend durch Modelle oder empirische Belege fundiert. Insbesondere mangelt es an Studien zu den Determinanten kleinbäuerlicher Anpassung auf der Grundlage von methodischen Ansätzen und Stichprobenumfängen, die fundierte quantitative Auswertungen ermöglichen.

Vor diesem Hintergrund verfolgt die vorliegende Arbeit zwei Oberziele: (1) Die Entwicklung und Erprobung einer ortsspezifischen, vorwärts gerichteten Bottom-up Methode zur Analyse kleinbäuerlicher Anpassung an den Klimawandel, mit einer kombinierten quantitativ-qualitativen Forschungsmethodik und einem großen Stichprobenumfang. (2) Die empirische Analyse der Determinanten kleinbäuerlicher Anpassung im Rahmen einer Fallstudie. Prozesse kleinbäuerlicher Anpassung sind analytisch schwer zu fassen, da sie zeitabhängig sind und von jeweils spezifischen räumlichen Bedingungen geprägt werden. Diese Studie geht demgegenüber von der Existenz grundlegender allgemeiner Determinanten kleinbäuerlicher Anpassung aus. Außerdem wird angenommen, dass die Untersuchung der historischen Anpassung von Kleinbauern an Klimavariabilität und -wandel eine geeignete zweitbeste Strategie zur Analyse ihrer Reaktionsfähigkeit in Bezug auf künftige Klimaveränderungen darstellt.

Um die Forschungsziele zu erreichen, wurden quantitative und qualitative Daten auf Haushalts- und Dorfebene erhoben. Als Untersuchungsgebiet wurde die Region Morogoro im Osten Tansanias ausgewählt. Zum einen wegen ihrer dokumentierten Klimavulnerabilität und zum anderen, weil erwartet wurde, dass

die Ergebnisse aus dieser Region auch für andere Gebiete relevant sind. Ausgehend von einer kritischen Analyse bestehender sozialwissenschaftlicher und entwicklungsökonomischer Studien zu dem Thema wurde ein Analyserahmen für die Untersuchung der Klimaanpassung von Kleinbauern entwickelt. Darüber hinaus wurden potentielle Einflussvariablen für die Klimaanpassung der Kleinbauern identifiziert sowie ein indexbasierter Ansatz zur Messung der Anpasstheit von Kleinbauern entwickelt, der Activity Based Adaptation-Index (AAI). Die Daten wurden mit den Verfahren der Faktorenanalyse, der multiplen linearen Regression sowie einer qualitativen Inhaltsanalyse ausgewertet. Die ökonometrische Auswertung erfolgte in zwei Stufen. Zunächst wurde eine Regressionsanalyse mit Originalvariablen durchgeführt. Daran anschließend wurde eine Faktorenanalyse in Kombination mit weiteren Regressionen durchgeführt. Die empirischen Ergebnisse werden vor dem Hintergrund theoretischer Konzepte von Anpassung und dem Sustainable Livelihood Approach diskutiert.

Die Ergebnisse dieser Studie zeigen, dass die Anpassung der untersuchten Kleinbauern an den Klimawandel durch vier Faktoren bedingt ist. Hierbei handelt es sich um das ortsspezifische Produktionspotential, die Verfügbarkeit von Inputs, den sozio-ökonomischen Status des Haushaltes sowie sein soziales und ökonomisches Kapital. Die Ergebnisse der Faktorenanalyse und der Regressionsanalyse mit Originalvariablen deuten auf eine sehr ähnliche Strukturierung des Wirkungszusammenhanges hin, was die Stabilität der Ergebnisse zeigt. Ein weiteres Ergebnis dieser Arbeit besteht in der Identifikation von 33 Maßnahmen, die potentiell zur Klimaanpassung von Kleinbauern beitragen können und bereits von einigen Landwirten im Untersuchungsgebiet praktiziert werden. In methodischer Hinsicht weisen die Ergebnisse auf die große Bedeutung hin, die einer Beteiligung von Stakeholdern mit lokalem Wissen an Anpassungsstudien zukommt. Die Integration von lokalem Wissen ermöglicht eine bessere Berücksichtigung von ortsspezifischen Kapazitäten und Hemmnissen landwirtschaftlicher Anpassung.

Aus dieser Studie können zwei übergeordnete Schlussfolgerungen gezogen werden. Erstens ist der hier gewählte Bottom-up Ansatz mit einer Kombination von quantitativen und qualitativen Untersuchungsmethoden ein vielversprechender Weg, die Komplexität von Anpassungsprozessen analytisch zu erfassen und Defizite traditioneller Verfahren zu überwinden. Das gewählte Verfahren umgeht die Unsicherheiten von Top-down Ansätzen, indem das Wissen der Landwirte in die Analyse einbezogen wird. Darüber hinaus reduziert das Verfahren das Risiko falsch gewichteter Indexkomponenten, indem Indikatorvariablen gewählt werden, die relativ einfach von lokalen Stakeholdern gewichtet werden können. Zweitens sind die hier identifizierten Determinanten kleinbäuerlicher Anpassung ein wichtiger Beitrag zur empirischen Fundierung der existierenden

vorwiegend argumentativ ausgerichteten Anpassungsstudien. Während keine der Determinanten selbst vollständig neu ist, liegt der spezifische Beitrag der Arbeit in der genauen Überprüfung ihres jeweiligen Einflusses mit einer methodisch anspruchsvollen, ökonometrischen Analyse.