Scale, Governance and Change in Zambezi Teak Forests

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Sustainable Development for Commodity and Community

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Dedicated to all the people of Mulobezi and south western Zambia

I keep six honest serving-men
(They taught me all I knew)
Their names are What and Why and When
And How and Where and Who.
I send them over land and sea,
I send them east and west;
But after they have worked for me,
I give them all a rest.

Rudyard Kipling

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Preface

The history of timber logging in south western Zambia in the twentieth century has a lot to teach us about sustainable forest management in the twenty first century. In 1918 a tramline was laid to transport Zambezi teak logs from Mapanda forest, 27 miles south east back to the mill in the frontier town of Livingstone. The rails were made of Zambezi Teak in the absence of steel and replaced the slow and expensive alternative of ox–wagon and river barge for transporting logs to the sawmill. By 1927 the wooden rails had been replaced with standard 3 feet 6 inch Cape gauge steel rails and the first bridge had been built across the Sinde river. By 1934 the line of rail had reached Mulobezi, 101 miles north west of Livingstone. This marked the start of industrial exploitation of the highly productive Zambezi Teak forests. Estimates from Zambesi [*sic*] Saw Mills records indicate that extraction was maintained at roughly 85,000 m^3 of round logs per year for 40 years. This exploitation set in place a chain of events that ultimately led to the destruction of these forests. A few small patches of virgin forest remain. This was not the intended outcome. The *Livingstone Mail* of 30th October 1924 carried an article on the proposed new steel railway line which indicated that anticipated traffic was around 200 tons of timber per day and that "due to cutting being confined to mature trees over 14ins diameter, which formed but a small percentage of the forest stand, this quantity should continue or increase for all time." When a group of investors recently attempted to revive the logging of Zambezi Teak in Mulobezi they struggled to maintain a harvest of 1000 m^3 per year and after four years the company collapsed.

The lessons to be learned are not simple and in simplifying them we risk missing out on an opportunity to learn how ecology and society interact to produce failure from the potential for success. Trees are a renewable resource, and although Zambezi Teak only increases in diameter by between 1 and 3 millimetres per year, the vast forests could have produced a sustainable harvest in perpetuity. So why didn't they? This book attempts to answer that question, but more importantly it attempts to address the complex methodological, philosophical and theoretical problems that surround the study of forests and natural resources and their interaction with society in a more general sense.

To illustrate this complexity we could try to answer the question about the decline of the Zambezi Teak forests by asking experts in certain disciplines to explain why this renewable resource was harvested to destruction. The forest manager will tell us that the harvest exceeded the annual increment and he or she would draw an analogy between capital and interest. Only the interest on the capital should be harvested or we risk incrementally drawing on our capital which, if we keep harvesting a fixed amount, will result in the forest becoming depleted. The ecologist will explain that young Zambezi Teak trees germinate readily but are vulnerable to fire and survived because fire was not able to penetrate mature Zambezi Teak forest. When logging opened the mature forests a thick undergrowth was able to grow and this supported hot fires which killed off young trees. South western Zambia has one of the highest incidences of wildfire in the world and therefore no regeneration takes place after logging unless fire is excluded for a few years. The anthropologist will tell you that Lozi and Nkoya people or their forebears have lived in the area for thousands of years. They harvest honey from Zambezi teak forests, and the alcoholic beverage they brew from honey plays an important part in their cultural life. Fire used to smoke bees from their nests is left burning over a wide area so that it clears the snakes and the long grass, making it easier and safer for the next expedition to harvest honey. The political scientist will identify the tension between chiefs and traditional institutions on the one hand and the state authorities on the other. The claims to authority by both parties over the same resource constitute one of the fundamental problems of natural resource governance in Zambia. The social scientist will point out the result of the state claiming tenure of all natural resources and their inability to police the claim. This has created a *de facto* open access commons where people try to harvest as much as they can so they don't lose out to others who are doing the same thing. All of these explanations are correct.

This book is about the Zambezi teak forests of south western Zambia but as Kipling's verse suggests, it is an attempt to answer a difficult question: how do we study such a complex system of interactions in order to produce a solution which ensures long term sustainable forest management? There is no simple answer. It is an exciting time to be working on problems of natural resource management because it appears that professionals from disparate fields are finally acknowledging the need to take a multidisciplinary approach to problems around natural resources. The new discipline of Sustainable

Development has been founded to accommodate this vision. Nevertheless the difficulties of successfully achieving this integration are far from being overcome. This requires a profound change in the views not only of academics, scientists and managers, but also of politicians, traditional leaders and civil servants. There is a need to change fundamental methodological, philosophical and theoretical approaches to how we study natural resources. Just as important is the need to communicate this knowledge to those responsible for making and implementing laws and governance. I hope this book will contribute to renewed interest in the Zambezi Teak forests and contribute to the changes which are needed to manage what remains of this once important resource.

Acknowledgements

My work on Zambezi Teak has its genesis in my first visit to Mulobezi in 2004. The Zambezi Sawmills railway, the history and the ecology of the Zambezi Teak forests fascinated me. The people of Mulobezi were a revelation. The generosity of HRH Chief Moomba over the years, the way he has welcomed me to Mulobezi and allowed me complete freedom of movement within his Chiefdom have allowed me to form the ideas which make up the bulk of this book. The genuine friendships I have in Mulobezi are a treasured outcome of my visits. I owe him, and the people of Mulobezi Game Management Area a great debt of gratitude.

The interaction I have had with HRH Senior Chief Inyambo Yeta and the Kuta at Mwandi has made a lasting impression on me. The serene and ordered conduct of affairs at the palace at Mwandi is a rare occurrence in a region so affected by turmoil over the last 100 years. As an example of leadership and local administration, I know of no better system than that which exists in Barotseland. I hope that it can be put to good use in managing the natural resources of the region in the future.

During the course of this work a number of people have been of assistance, and without them, a lot of this work would not have been possible.

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List of Acronyms

AF Agricultural Fields

AGB Above Ground Biomass

ANOVA Analysis of Variance

BAU Business-As-Usual

BRE Barotse Royal Establishment

BPF *Baikiaea plurijuga* forest

CAMPFIRE Communal Areas Management Programme for Indigenous Resources

CRB Community Resource Board

CBNRM Community-Based Natural Resource Management

CITES Convention on Trade in Endangered Species of Wild Flora and Fauna

COP Conference of Parties

CPR Common-Pool Resource

D Dambo

DBH Diameter at Breast Height

DBPF degraded *Baikiaea plurijuga* forest

ETM+ Enhanced Thematic Mapper

EKC Environmental Kuznets Curve

ENSO El Niño Southern Oscillation

FIRMS Fire Information for Resource Management System

F Fire Scars

FTT Forest Transition Theory

FAO Food and Agricultural Organisation

GDP Gross Domestic Product

GIS Geographic Information System

GLAS Geoscience Laser Altimeter System

GMA Game Management Area

GCM General Circulation Model

ICESat Ice, Cloud and land Elevation Satellite

IPCC Intergovernmental Panel on Climate Change

IAD Institutional Analysis and Development

IFRI International Forestry Resources and Institutions

JFM Joint Forest Management

JFMA Joint Forest Management Area

KIA Kappa Index of Agreement

KML Keyhole Markup Language

KW Kalahari Woodland

LiDAR Light Detection and Ranging

LIRDP Luangwa Integrated Rural Development Programme

MSS Multispectral Scanner

MODIS Moderate Resolution Imaging Spectroradiometer

MAUP Modifiable Areal Unit Problem

MRV Monitoring, Reporting and Verification

MW *Colophospermum mopane* Woodland

NDVI Normalized Difference Vegetation Index

NGO Non-Governmental Organisation

NTFP Non-Timber Forest Products

PRA Participatory Rural Appraisal

PFT Plant Functional Type

PTA Parent Teachers Association

RDC Rural District Council

REDD Reduced Emissions from Deforestation and forest Degradation

REDD+ Reduced Emissions from Deforestation and forest Degradation plus

SD Sustainable Development

SOM Self Organising Map

SFM Sustainable Forest Management

SRTM Shuttle Radar Topography Mission

TM Thematic Mapper

UNFCCC United Nations Framework Convention on Climate Change

UN-REDD United Nations-Reduced Emissions from Deforestation and forest Degradation

USGS United States Geological Survey

VAG Village Area Group

WBCSD World Business Council for Sustainable Development

WCRP World Climate Research Programme

WCED World Commission on Environment and Development

ZAWA Zambia Wildlife Authority

Chapter One
Forests, Climate Change and the Socio-ecological System

As humanity reaches a critical stage in the transition from an industrial society to a post-industrial information age, our relationship with nature presents human society with stark choices. Sound environmental stewardship will allow biological and cultural evolution of life on earth to continue, whilst further environmental degradation will have severe consequences for human survival and may ultimately result in extinction (Laszlo, 1994). The possibilities for research to make a contribution to the transition to a sustainable society are complex and the questions that must be answered are challenging to conventional research practice. Theoretical approaches to simultaneously maintaining sustainable ecosystems and achieving sustainable and equitable global development have provided the impetus for a postmodern "scientific revolution" over the last twenty years (Naveh, 2000). Attempts to understand the interaction of economic, ecological and social systems are central to a new holistic science, which recognises that the Total Human Ecosystem (*sensu* Naveh, 2000), cannot be understood by reducing it to its parts (Holling, 2001; Li, 2000). Complexity science acknowledges the influence of feedbacks in structuring non-linear relationships between factors which implies a strong role for the local context in mediating these interactions (Cilliers, 1998; Green & Sadedin, 2005; Larsen-Freeman, 1997; Liu et al., 2007; Walsh et al., 2008). The application of this new paradigm in a holistic synthesis of the problems of climate change and its multiple potential effects on environment and society is at the heart of this study of the Zambezi Teak forests of south western Zambia.

The demand for a holistic synthesis, in the spirit of this postmodern scientific movement, exposes traditional disciplinary approaches as insufficient for the task of anticipating the future outcomes of human economic and social activity on the environment (Stock & Burton, 2011). My approach to studying the decline of the Zambezi Teak forests has been to attempt a holistic synthesis of the problems surrounding Sustainable Forest Management (SFM) and Sustainable Development (SD) in the dry, deciduous forests of south western Zambia. Forests provide a focus for addressing one of the most important consequences of more than a century of industrial activity: the warming of the global climate system. The human causes for this are unequivocal (IPCC, 2013) and will result in a loss of 5% of GDP per year to the global economy unless action is taken to reduce the emission of CO_2 into the atmosphere (Stern, 2006). There are other potential costs that measures of GDP do not take into account. The emphasis on forests in the context of climate change is twofold:

1. To prevent the conversion of forested land to other land cover types to reduce the emissions from land cover change (Bonan, 2008)

2. Forests represent one of the most cost effective methods of sequestering carbon from the atmosphere (Stern, 2006).

In addition to the services that forests provide at a global scale, the dry deciduous forests of Africa supply local communities with a variety of essential Non Timber Forest Products (NTFPs) (Chikamai et al., 2009; Shackleton & Shackleton, 2004; Shackleton et al., 2011) and provide a range of ecosystem services (Marunda & Bouda, 2010). This global, regional and local demand for forests to sequester carbon, provide ecosystem services and supply the demands from local communities for forest products is a significant challenge for SFM. A collapse in rural livelihoods which are dependent on the harvesting of forest products during times of hardship, may result in social and political unrest as a result of a combination of forest destruction and climate change. The exact nature of what needs to be done to manage forests sustainably is complex, with multiple potential outcomes possible, and there is a need for solutions which are scale dependent, involve local communities in forest management and are effective at reducing emissions. This presents a significant challenge. If forests represent a cost effective way of ameliorating climate change as Stern (2006) suggests, they almost certainly do not represent a simple way of achieving this objective.

The challenge lies in the fragmented nature of the theory which informs the process of deforestation and sustainable development, the diversity of national and traditional governance arrangements for managing forests, the diversity of forest types, and the potential effects of climate change on forests around the world. A holistic synthesis of the many disciplines and theories which inform SFM is needed. The task is to connect functional social-ecological interrelationships which are spatially relevant and matched to an appropriate scale. I attempt such a synthesis in this study.

To place the problem of SFM in such a context, this introduction outlines the background to the problem, the purpose of the study and its significance, and ends with the presentation of four research questions which address some of the problems associated with the SFM of dry deciduous forests in south western Zambia.

Forests and Sustainable Development

In a landmark publication the World Commission on Forests and SD suggested that forest decline not only undermines social stability and local cultural diversity, but threatens global economic security in ways which transcend national boundaries (Salim & Ullstein, 1999). Forest decline has effects on the environment, the economy and society. These effects interact, frequently compounding cause and effect and leading to feedback loops that are difficult to predict and which imperil the well-being of future generations. The interactions, their consequences and their amelioration are recurring themes throughout this study and are at the heart of sustainability science (Clark & Dickson, 2003).

Sustainable Forest Management (SFM) represents the integration that is needed between forestry practice and SD. The term SFM does not refer to a rigid set of aims and objectives and like SD, tends to have different interpretations which are dependent on one's opinion on conservation, economic development and politics. Traditionally, forests have been managed to sustain a flow of timber. Gifford Pinchot, the first head of the Forest Service in the United States and an influential figure in forestry and conservation, was clear in advocating 'wise use' as the primary purpose of a national forest (Pinchot, 1907). In Pinchot's view forests had a single purpose: they should be managed to supply timber in perpetuity in order to facilitate economic progress. Carbon, rather than timber, is potentially a new commodity for which forests are in demand, but this should not result in forest management policy falling into the trap of replacing timber with carbon in a Pinchot style, single objective management plan. The goals of SFM must be to integrate the principles of SD into the policies and practices of forest management so that in addition to supplying a commodity, forest resilience is sustained, livelihood requirements of local people are satisfied, tenure and access rights of local people are clear and secure and there is equitable sharing of forest revenue (Campbell et al., 2007; Wunder, 2006). There is increasing evidence that if these requirements are not satisfied, and if plans to manage forests for carbon sequestration encourage centralisation of forest governance in pursuit of carbon revenue, then the outcomes of the global programme of Reduced Emissions from Deforestation and forest Degradation plus (REDD+) are not guaranteed (Phelps et al., 2010b; Poudyal et al., 2013). Forest management policy in Zambia is not capable of delivering community benefits through REDD+ (Leventon et al., 2014). A significant problem which is not addressed is the widespread unsustainable charcoal production which supplies the urban poor with a source of heat and cooking fuel and the rural poor with a cash income (Kutsch et al., 2011). The current policy and practice of the Zambia Forestry Department do not constitute an attempt at SFM (Jones, 2007; Leventon et al., 2014; Whiteman, 2013).

More fundamental problems with implementing REDD+ are of equal concern for successful SFM. There are limitations to the current techniques for measuring land cover change and biomass; the scale of research and theory application are not matched to the scale of the problem; the lack of appropriate governance structures which include local Zambian communities in forest governance is a threat to forest survival; and the medium to long term threat which climate change itself poses for forest survival is seldom assessed. Forests and SFM need to adopt the principles of SD to be successfully implemented, but also have the potential to inform theories of SD through the testing and implementation of these theories.

A continuing theme in this study of tropical forest change is that it demands an interdisciplinary approach to produce a holistic synthesis of the ecological, social and institutional factors which determine land cover change. There is clear recognition that interdisciplinary research is necessary for identifying solutions to resource use problems (Janssen & Goldsworthy, 1996). The concept of sustainability is integrative and the emerging field of sustainability research is partly defined by its interdisciplinarity (Clark, 2007). Interdisciplinary research involves a triangulation of depth, breadth and synthesis (Klein, 1996). In this book I offer breadth in a review of the social-ecological system, depth in the chapters which present findings from empirical research, and some elements of synthesis.

Climate Change

Concerns about global climate change have reached unprecedented levels, and there is increased confidence that these changes are due to human activity (IPCC, 2013). There is evidence that forests can attenuate global warming through carbon sequestration and that in doing so tropical forests perform an environmental service worth hundreds of billions of dollars (Canadell & Raupach, 2008). Approximately 70%-80% of the forested area of Africa is covered by dry, deciduous forests (Murphy & Lugo, 1986). The Above Ground Biomass (AGB) of these forests is low relative to moist, tropical evergreen forests (Timberlake et al., 2010), but because the area they occupy is large, they represent huge potential as a carbon sink provided the correct management strategies are adopted (Marunda & Bouda, 2010). Indications are that the below ground biomass of these forests also comprises a significant carbon pool, the extent of which has not been adequately investigated. More than half of Africa's population live in the area where these forests occur, and their livelihoods depend largely on the natural resources which the forests produce (Chidumayo & Gumbo, 2010). Poor forest management practices are widespread with the consequence that most deforestation in Africa is taking place in dry forests (Brink & Eva, 2009).

Desanker & Justice (2001) highlighted the lack of case studies of land use change in Africa at the local level. Their focus on the potential which free Landsat data represents for developing detailed land use change models in Africa is a challenge partly taken up in this study. Documenting land use change is an important input to regional and global climate modelling and will contribute towards better predictive ability of these models (Willis et al., 2013).

Drivers of Land Cover Change

The fastest land cover change to occur since the evolution of humans is happening in tropical forests (Achard & Blasco, 1990). Changes in forest cover in dry ecosystems of Africa between 1990 and 2000, showed that the Zambezian region accounted for 84% of total deforested area (Bodart et al., 2013). Figures for deforestation rates in Zambia vary widely. Between 298,000 ha per annum and 444,800 ha per annum were lost between 1996 and 2006 (Stringer et al., 2012) depending on the method used to measure deforestation. The Food and Agricultural Organisation (FAO) estimates the rate of forest loss in Zambia between 1990 and 2010 to be about 0.33% per annum which is a figure of roughly 167,000 ha per annum (FAO, 2010). A large part of the discrepancy results from how different authors take into account forest degradation, which is a far bigger problem than deforestation (Kutsch et al., 2011). Regardless of the accuracy of the estimates, Zambia has one of the highest rates of deforestation in the world.

Globally, clearance of land for agriculture is one of the major drivers of deforestation in tropical forests (Babigumira et al., 2014). Traditional agricultural practice in Zambia employs the *chitemene* system of shifting cultivation, which involves cutting, stacking and burning trees where a field is to be sited (Trapnell & Clothier, 1937). The ash contains nutrients and supports crops on the leached, nutrient poor soils for two to three years (Holden, 2001). This is the system currently in use in the study area. Prior to the introduction of colonial agricultural influences, the *chitemene* system constrained population growth because the overall productivity of the system was low (Holden, 2001). Hein et al. (2008) indicate that the *chitemene* system is sustainable in Miombo woodlands in Zambia with a population density of about four persons per square kilometre. Outside of the main villages of Sesheke, Sichili and Mulobezi, population density in the study area is estimated to be about four to five persons per square kilometre (Republic of Zambia Central Statistical Office, 2011). There is a history of commercial logging in the Zambezi Teak forests, which has had an impact on the forests by opening them and making them vulnerable to fire (Huckabay, 1986b; Martin, 1940). The long history of commercial timber exploitation in the Zambezi Teak forests provides an opportunity to document changes in land cover. The presence of rural subsistence farmers provides an opportunity to examine the human influences on land cover change. The close proximity of Kalahari Woodland, Zambezi Teak Forest and Mopane Woodland in a landscape which experiences broadly similar climatic conditions, provides an opportunity to compare the influence of different drivers of deforestation in different forest and woodland types. The adaptations of tree species to these climatic conditions, such as variation in leaf phenology, provide an opportunity to speculate on the potential influence of climate change on different forests and woodlands.

The historical record of Zambezi Teak forest distribution, exploitation, management and tenure provides a unique opportunity to examine the relationship between forests and SD. In addition, the diversity of forest types in close proximity in the area, and the different drivers of deforestation to which they are vulnerable, represent a unique situation with respect to the narrative of deforestation in other areas of Zambia, and of dry, tropical African forests in general. The distinctive spatial and historical features of the area provide an opportunity to examine how different drivers of deforestation affect different forest types and this has important implications for the implementation of REDD+, SFM and SD. Many of the suggested causes of deforestation (and environmental degradation in general) confuse proximate with ultimate causes (Geist & Lambin, 2002; Paul, 1989) and solutions to the problem cannot be found if the causal basis of deforestation is not clearly established. South western Zambia provides a unique opportunity to examine different proximate causes of land use change such as commercial logging, expansion of rural agriculture, increased incidence of fire and commercial charcoal production.

REDD+ and the Social-Ecological System

The role which forests play in sequestering CO_2 received international focus in 2009 when the United Nations-Reduced Emissions from Deforestation and forest Degradation (UN-REDD) programme was launched to ensure that REDD+ was incorporated in any future agreements under United Nations Framework Convention on Climate Change (UNFCCC) negotiations (Phelps et al., 2010a). The proposal to make payments to forested countries on the basis of the successful reduction of carbon loss from forests is currently under a trial phase in Zambia and eight other countries (www.un-redd.org) (Stringer et al., 2012). The scale of a global REDD+ programme is immense and the potential implications for forest communities are profound (Angelsen, 2008a). The implementation of REDD+ presupposes the existence of the technical and human capacity for Monitoring, Reporting and Verification (MRV) and the implementation of governance structures which encourage land use practices that foster the sequestration of carbon (Phelps et al., 2010a). The commodification of carbon and the demands this introduces with respect to forest management policy will need to be carefully managed to ensure that REDD+ is enacted using the principles of SFM and achieves the objectives of SD (Karsenty et al., 2014).

A key component of climate negotiations, and the reason for the inclusion of REDD+ in a binding agreement, is to address issues of climate equity (Karsenty et al., 2014). Not only are the poorest at most risk with respect to climate change, but the mechanisms to ameliorate climate change via REDD+ will also have a direct effect on their lives (Morgan & Waskow, 2014). Forests are a source of food, medicine, building materials, and agricultural land and are of spiritual and cultural significance to millions of people in the tropics (Chikamai et al., 2009; Makonda & Gillah, 2007; Shackleton et al., 2011). This demands a case study of how local social institutions which regulate how people use forests will be affected by the implementation of the largest global programme of payment for ecosystem services which has ever been proposed.

Figure 1.1 indicates how the different theories included in the theoretical framework inform the research presented in the relevant chapters. Concept mapping is a general method for developing and structuring research which aims to display ideas and the interrelationships between them in a graphical format called a concept map (Novak, 1990; Trochim, 1989). The approach taken to the research in this study has been called a "landscape approach" and some of the recommendations of Sayer (2009) are applicable to this work (see Page 94). The term covers a wide variety of approaches in the literature and could equally be called an "ecosystem approach", although issues of scale make it possible that a landscape could be envisaged as a subset of an ecosystem. Nevertheless one of the requirements for a landscape approach is the combination of positivist and constructivist approaches to research without excessive philosophical introspection regarding ontology (Sayer, 2009). The concept of a landscape as a multifunctional entity (Naveh, 2001) demands the selection of an interdisciplinary framework for conducting the research.

Scale, Governance and Change

Scale

Scale mismatches are at the heart of many natural resource management problems (Cumming et al., 2006) and include mismatches of ecological, social and economic factors that determine successful natural resource utilisation. Inadequate considerations of scale are often the source of problems associated with analytical methodology, and both economic theory and political discourse commit the error of applying theory to inappropriate scales, leading to unnecessary disputes in the implementation of REDD+. The south central region of Africa is a diverse ecological and cultural landscape (Figure 4.8). History, socio-cultural practices and details of geomorphology and ecology are unique to a particular location and are all factors which influence the outcome of SD (Becker & Ostrom, 1995; Clark, 2007; Fiksel, 2006; Naveh, 2000; White, 2013). At the continental scale most of south western Zambia is mapped as undifferentiated woodlands and miombo woodland (Timberlake et al., 2010; White, 1983). This obscures the immense diversity in the ecological characteristics of these woodlands and forests, one of which is variation in leaf phenology which varies between sites and between species (pers. obs.). The history of the study area is unique in Zambia, and there are