1

Methodology for Forest Ecosystem Mediating Indicator – Case Mt. Kilimanjaro, Tanzania

John Eilif Hermansen
Department of Industrial Economics and Technology Management
Norwegian University of Science and Technology, NTNU, Trondheim
Norway

1. Introduction

Communication of ecological and environmental knowledge, values and concerns by means of indicators is widely accepted and adopted as a part of environmental management systems, results-oriented politics and international reporting, and benchmarking initiatives.

Application of an indicator system is a normative course of action supported by different professional perspectives and parochial interests, struggling for resource control and ownership, investigation of business opportunities, and political interests. Development and selection of indicator systems is a natural extension of questions of justice and equity regarding resources, and should accordingly be conducted in an open, transparent and consensus-based process in spirit of enlightenment and democratic traditions.

The purpose of this work is to elaborate on the asymmetrical relationship between local and indigenous people dependent on their traditional rights to tropical forest habitation and those global interests who would intervene in their traditional understanding and use of the forest resources. Forest dwellers and native forest service users in developing countries may expect a large gap between their life world and the global actors. A methodology for devising a forest ecosystem indicator system intended to balance the asymmetry and re-allocate some of the knowledge power about the forest resources back to the local community, is suggested.

A framework for mediating ecological indicators is evolved in order to keep elements of global versus local interests, nature versus society and epistemology versus ontology together in one system. This construct is referred to as the *Balanced Ecosystem Mediation Framework* (BEM-framework) (Hermansen, 2008, 2010).

The framework emerged during a case study of the catchment forest reserve at the southern slopes of Mt. Kilimanjaro. By using data from a plant ecological investigation of the forest (Hermansen et al., 2008b) an ideal typological indicator was developed to be used in the BEM-framework. The proposed indicator is generally referred to as the *Ecosystem Mediating Indicator (EMI)* and the *Forest Ecosystem Mediating Indicator (FEMI)* when applied on forest ecosystem services. Further, as an illustration of its application to the catchment forest reserve at Mt. Kilimanjaro, a special case is suggested called the *Catchment Forest Ecosystem Mediating Indicator (CFEMI)*.

CFEMI is meant to be an equitable, and ecologically acceptable, instrument for building up a reservoir of transferable knowledge. CFEMI is designed for communication and management of forest ecosystem values where there is a need for a significantly better quality communication process between the local level and global level of interests and concern.

A premise of the framework is that it should be possible to establish a negotiated understanding of tropical forest resources conveyed by a knowledge system that supports or at least evens out some of the asymmetric influence and power of the globalized community vis-à-vis the local community regarding communication of forest values.

The chapter begins with a discussion of forest management and indicators followed by a description of the Kilimanjaro case study from which the indicator and framework emerged. The framework is then described and discussed.

1.1 Local ecosystem resource governance and issues in forest management

The deterioration of tropical forests is increasing (FAO, 2007; MA, 2005; UNEP, 2007). The need for new initiatives for sustainable forest management has been raised by many authors and institutions (Studley, 2007; Van Bueren & Blom, 1996). There is a serious concern about insufficient means and instruments for a possible future sustainable use, management and governance of biodiversity and ecosystem resources (Newton & Kapos, 2002; Noss, 1990, 1999; TEEB, 2010).

Especially indigenous and poor communities are vulnerable to failed governance because of their heavy reliance on local, natural resources for subsistence and income (Lawrence, 2000; Vermeulen & Koziell, 2002; WRI, 2005). Indigenous people and communities are also on the defensive in order to protect and develop their historical rights, cultural heritage, ecosystem resources and land. UN Convention on Biodiversity (CBD) includes framework for monitoring and indicators, and new targets for biodiversity are added to the Millennium Development Goals in order to cover genetic variety, quantity of different taxon, geographic distribution and social interaction processes (CBD, 2006).

Studley (2007) states that virtually all aspects of diversity are in step decline due to the three interacting interdependent systems of indigenous knowledge, biodiversity and cultural diversity. All three are threatened with extinction. The list of threats includes rapid population growth, growth of international markets, westernised educational systems and mass media, environmental degradation, exogenous and imposed development processes, rapid modernisation, cultural homogenisation, lost language, globalisation, extreme environmentalism and eco-imperialism.

Vermeulen and Koziell (2002) give a review of biodiversity assessment and integration of global and local values including elaborating on the contrast

> *"between "global values" – the indirect values (environmental services) and non-use values (future options and intrinsic existence values) that accrue to all humanity – and "local values" held by the day-to-day managers of biological diversity, whose concerns often prioritise direct use of good that biodiversity provides. Assessments are based on values."*

Studley (2007) suggests a vision for realising the aspirations of indigenous people to ensure the enhancement of biological and cultural diversity which includes an endogenous approach dependent on building the capacity of forest development staff in acculturation, cross-cultural bridging, forest concept mapping and information technologies.

Wieler (2007) advises decision-makers that the development and implementation of an environmental monitoring system and adequate policy targets for improved environmental performance are crucial. She recommends an impact strategy that includes *relationship management* at the core to identify who are the people positioned to have influence on the changes that need to be made (Creech et al., 2006).

Especially in cases where many stakeholders and their interests pose a complex cultural and social relationship to the resources, the process to define targets for environmental improvement and performance can be difficult. The process involves negotiation and mediation between those involved. A tropical forest land where local people are directly dependent on forest resources is an example of such a case.

In order to increase the efficiency of environmental policy and management strong focus on performance is necessary and therein formulation of performance indicators. The purpose of this study is to present a deliberate and communication oriented multi-purpose forest resource indicator which may be equitable and understandable across cultural and societal borders, and also meet the requirements for *proximity- to-target* approach (Esty et al., 2006)).

1.2 Locally rooted proximity-to-target forest indicator

A wide variety of ecological indicators have been generated for the purpose of reflecting trends and needs for realising policy targets and improved nature management. The terms environmental and ecological indicators are often used as synonyms or in an arbitrary manner. Here, the notion ecological indicator is regarded as a subset under environmental indicator and use of the term ecological indicator applies directly to the ecological processes (Niemeijer & de Groot, 2006; Smeets & Wetering, 1999). Usually ecological or environmental indicators are part of a linear and hierarchical management system which includes monitoring, reporting and decision making. Van Bueren and Blom (1996) suggest a structure starting with determining goals, outlining principles and criteria with guidelines for action, which are measured and verified by indicators before they are compared with established norms and discussed. The hierarchy of the management system consists of the input (an object, capacity or intention, e.g. management plan), the process (the management process) and the output (performance and results).

The hierarchical model is systematic, logical and effective, but it is open in order to include the mediation and negotiation perspective that could increase the local people's participation and influence in local management. The model could be developed further to be more systemic and include feedback thereby reducing the asymmetry between global and local interests.

To incorporate both a systematic and a systemic forest management model it follows that a new approach to the construction of indicators is needed. Van Bueren & Blom (1996) outline very well the demand for quality in the work of designing sustainable forest indicators and they warn about incorrectly formulated criteria for management standards and indicators. However, an indicator for a forest management system that aims to increase local participation and equality regarding influence and control over local resources also must be easy to understand and use. The work for sustainable forest management rests on the assumption that local people understand how to protect the forest ecosystem services better than a scientifically constructed indicator, which fails to incorporate the knowledge of local people.

Hence, the study proposes an ecological communication model that enlarges the objectives and applications of ecological indicators. The proposed indicator framework has purposes beyond measuring ecological status, impacts or performance. The indicator should also be a tool for reflexive learning and communication including mediation and negotiation between stakeholders on the global and local scale, which includes nature itself represented by the sciences of ecology (Hermansen, 2006, 2010; Latour, 2004) as a stakeholder (Elkington, 1998).

First, ecology is addressed as a necessary knowledge system in an epistemological context for understanding the relationship and integration of natural resources to a globally recognized system, and second, the indigenous knowledge system is addressed in order to strengthen local motivation, control and proper management of community depending on a sustainable use of the ecosystem resources in an ontological context.
To make a distinction between the local context and interests and the global context and interests, two stakeholder groups, *locals* and *globals*, are introduced. The denotation of the rather new and little used term globals is not explained in dictionaries. Baumann (1998) and Strassberg (2003) refer to globals as people who are relatively free from territorial constraints, obligation, and the duty to contribute to the daily life of a community. Locals are geographically bound and they may bear the consequences of globalization. Bird and Stevens (2003) elaborate on the relationship between proximate locals and globals that may find it more difficult to work with each other because of issues of *trust*. This article attempts to enhance the understanding of locals and globals to include not only interests but also the context of the understanding of the forest ecosystem in order to make an ecosystem indicator which is ecologically founded and accepted (global perspective) and locally understood and equitable (local perspective).
Scientifically oriented assessments and validations as well as normatively oriented assessments and validations are integrated with local understanding of the forest as a source of necessary ecological goods and services to the local community. To increase the momentum of an indicator system it may be designed as a *proximity-to-target* performance indicator. The process of deciding the targets provides an opportunity for locals and globals to make reflections concerning targets, i.e. the ecological quality of the forest.

1.3 Case: Catchment forest reserve, Mt. Kilimanjaro, Tanzania

Mainland Tanzania has according to Blomley (2006) one of the most advanced community forestry jurisdictions in Africa, and Participatory Forest Management (PFM) has become the main strategy of the forest policy. He states that among the lessons learned is an increasing awareness of the importance of local forest users and managers and he espouses decentralized forest management schemes. The suggested indicator system is devised to support these efforts, and the results from an ecological study of the moist mountain forest plants at the southern slopes of Mt. Kilimanjaro are used as a case for the creation of the indicator (Hermansen et al., 2008).
The indicator is meant to be embedded in the social context of the governmental forest policy especially the Catchment Forest Project (CFP) (Hermansen et al., 1985; Katigula, 1992; Kashenge, 1995; MNRT, 1998, 2001, 2006). Creation of the indicator embeds an interpretation of possible interests and use of local ecosystem resources by the Chagga people and community (Akitanda, 1994, 2002; Bart et al., 2006; Misana, 1991, 2006; Newmark, 1991; Ngana, 2001, 2002; Soini, 2005; Stahl, 1964; Tagseth, 2006, 2008).
The Chagga people and community at the southern slopes of Kilimanjaro are included in this study as representatives for local stakeholders whose interests are then juxtaposed to the global interests. The interests of the Chagga people are presented here as an ideal typological position (space does not permit a serious and fair study of the relationship between the local community and ecosystem services). The indicators can be considered to be a measure of the interest conflicts between locals and globals, and also between ecology and people. The preparation and use of the indicator may then be a useful tool in a tool-box

for the "*keepers of the forest*" (Studley, 2007) promoting interaction between the indigenous knowledge system, biodiversity and cultural diversity.

2. Case study: Construction of the catchment forest ecosystem mediating indicator

The CFEMI is pilot scheme developed on site as a specific ecological mediating indicator. CFEMI is based on experience from an ecological investigation of the plant life in a tropical moist forest at Mt. Kilimanjaro (Hermansen et al., 2008). CFEMI is a composed indicator showing how far a certain site in a specific forest deviates from norms or targets, in this case sites at different altitudes in the forest belt between 1600 and 2700 m asl on the southern slopes of Mt. Kilimanjaro (Fig. 1). The targets represent a specific defined and assumed, optimal ecological state. It is essential to point out that the purpose of CFEMI is not to be universal, but instead to be a measure for strengthening the local actors's role in defining their forest resources and sustainable forest management in the context of the catchment forest. This means that CFEMI may be regarded as a quasi-indicator (Andersen & Fagerhaug, 2002) more concerned with local and situational reality and thereby of limited value for general utilization and comparability for benchmarking with other areas.

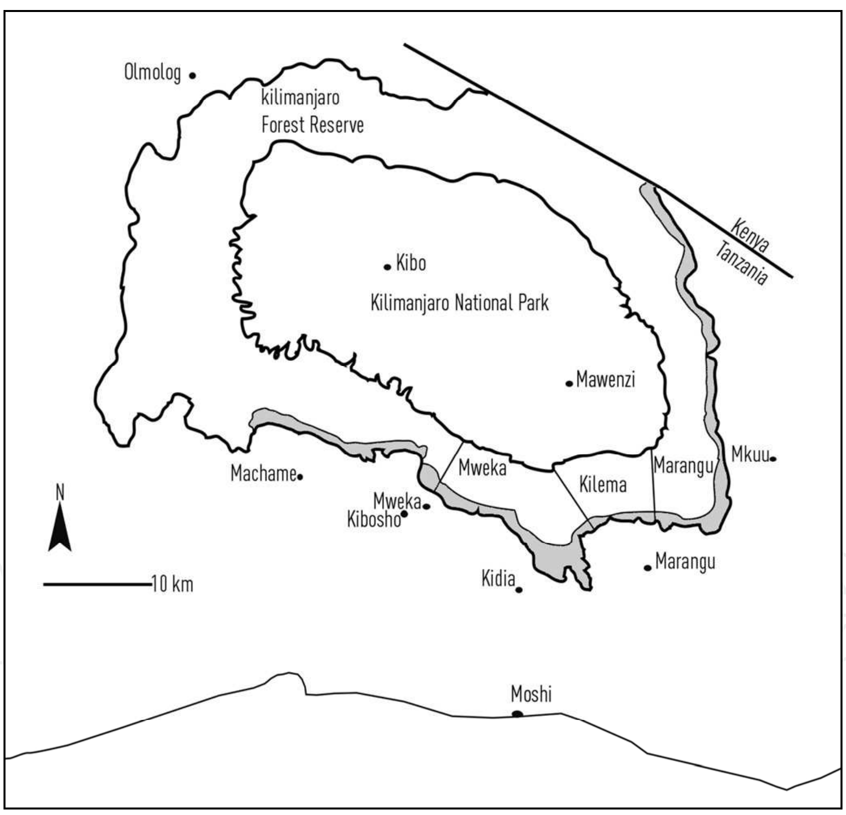

Fig. 1. Kilimanjaro Forest Reserve and the three transects Mweka, Kilema and Marangu. The upper forest border mainly follows the Kilimanjaro National Park border. The Half Mile Forestry Strip is shaded. (Modified from Newmark, 1991)

The procedure applied for constructing the indicator includes definition of system, goals, objectives, identifying relevant ecological factors and variables, outlining methods for measurement and data collection, negotiating the construction of the index and calculation of indicators, deciding on norms and target values, and finally the presentation of the proximity-to-target performance indicator.

2.1 Management of the catchment forest

Forest reserves in Tanzania have for more than 100 years been under different forest and forestry administration and management regimes from the German colonial time to the prevailing Catchment Forestry Project (CFP) launched in 1977 and organizationally situated under the Forestry and Beekeeping Division of the Tanzanian Ministry of Natural Resources and Tourism (MNRT).

In 1941, under British colonial time, a buffer zone, *The Half Mile Forestry Strip* (HMFS), was established as a social forest zone under local management of the Chagga Council at Mt. Kilimajaro (Kivumbi & Newmark, 1991). The management worked very well the first 20 years, but after independence in 1961 the management became more centralised and the zone itself came under heavy pressure, overexploitation and encroachment from local people partly due to population growth and partly due to ineffective management. Most of the approximately 800 meter broad buffer zone along the eastern and southern part of Mt. Kilimanjaro appears even today as a seriously damaged forest far from its natural state.

Initially, the CFP did not manage the forest reserve well, and encroachment, deforestation and fragmentation of the catchment forests increased (Akitanda, 1994, 2002; Hermansen, 2008; Hermansen et al., 1985; Kashenge, 1995; Katigula, 1992; Lovett & Pocs, 1992; Mariki, 2000; Newmark, 1991; Sjaastad et al., 2003; William, 2003;). Lambrechts et al. (2002) has verified the status and the extent of encroachment of the forest by aerial survey.

New national forest polices over the last 15 years have as a goal to improve the effectiveness and promote local responsibility towards a sustainable forest management practise (MNRT, 1998, 2001, 2006) with the development of criteria and indicators for sustainable forest management in Tanzania (MNRT, 1999). Local participatory forestry (Blomley, 2006), forest management and democracy are all important issues and it not easy to find ways to transfer enough power and security to local communities and devise sustainable and effective local forest management (Wily, 2001). Global initiatives connected to fair trade strongly support the strengthening of local forest management (Macqueen, 2006).

The objectives of the CFP can be summarized to promote the utilization of the forest resources in a sustainable manner, and secure that the three key functions - production of forest goods, water generation and conservation of biodiversity of the forest - are maintained. The following interpretation of objectives forms the relationship between management purposes and ecological contents (Hermansen et al., 1985):

Water generation: Regulation and conservation of water resources and supply in the catchment area; reduction of run off and soil erosion, which is especially important in moist mountain areas.

Gene-pool conservation: Preventing extinction of rare and endemic plant and animal species in the diverse moist forest; it is essential to maintain biodiversity and keep the genetic potential for ecological and evolutionary purposes and for present and future utilisation of biological forest resources.

Production: Logging of indigenous tree species and supply of other forest products for local consumption and sale.

A number of recent studies describe, explain and discuss the forest ecosystem at Mt. Kilimanjaro, and the threats to and use of forest resources (Bart et al., 2006; Bjørndalen, 1992; Hemp, 1999, 2006a, 2006b, 2006c; Howell, 1994; Katigula, 1992; Lovett & Pocs, 1992; Lyaruu, 2002, Madoffe et al., 2005, 2006; Mariki, 2000; Misana, 1991, 2006; Misana et al., 2003; Ngana,

2001, 2002; Soini, 2005;). The arguments for understanding and supporting the conservation of plant biodiversity of the forest at Kilimanjaro are presented in many of the reference above, as well as many other articles, not referred. Burgess et al. (2007) analyse the biological importance of Eastern Arc Mountains.
Studies from Kilimanjaro and neighbouring mountain forests (eastern arc) have included inventories suitable for supporting monitoring of the forests ecosystem services and contain data which are suitable to some degree for performance indicators, but they are mainly dealing with distribution of tree species, density of trees and timber volume including regeneration (Hall, 1991; Huang et al., 2003; Jakko Pöyry, 1978; Madoffe et al., 2005, 2006; Malimbwi et al., 2001;). Water management of the Pangani river basin, which is a very important regional and national concern, is tightly connected to the management of the catchment forest at Mt. Kilimanjaro (Ngana, 2001, 2002; Røhr, 2003; Turpie et al., 2003). The river is feed from several tributaries from Kilimanjaro and other hills and mountains in the area.

2.2 Purpose and objectives of CFEMI

CFEMI offers a composite indicator of relevant ecological features that can be recognised as essential for catchment forest management; namely the conservation and protection of a specified forested area that serves local people with ecosystem services in a global perspective. Management means to keep and even enhance the forest quality within the area in order to improve water conservation and generation, to protect biodiversity and to serve local people with forest goods.
The overall goal of CFEMI is to contribute to a broad stakeholder-oriented approach (Elkington, 1998; Grimble, 1998; Grimble & Wellard, 1997) to the knowledge and understanding of the forest and to promote an ecologically and socially wise use of the goods and services of the forest, including contributions to:

- reasonable common understanding of status and changes of the ecological conditions in the forest between globals and locals,
- motivating, learning and increasing a management oriented behaviour towards the forest resources,
- meet the requirement for local participation; application of the indicator could vary (e.g. full employment of the concept and indicator system or limited employment mainly showing the large structures in the forest).

Classes of objectives encompass:

- protection of forest ecology quality
- secure ecosystem services from the forest for the local people
- materiality for mediation and negotiation between locals and globals
- increasing local influence, control and competence regarding local resources
- provide opportunities for interactive learning loops.

The act of creating the indicator encourages mediation of the ecological aspects into a logical structure from goals to corresponding objectives, practical variables, measurement procedure and collection of relevant data.

2.3 Ecological and environmental aspects

This section will explore the variety of ecosystem assessment alternatives from the very general to the specific. Ecosystem assessment alternatives are provided from many sources.

The first group of sources are various national forest policies including the CFP (MNRT, 1998, 2001, 2006; Sjaastad et al., 2003). The second group comprises strategies and efforts from international organisations. In addition to the authoritative bodies under the UN, such as FAO and others, the new initiatives connected to Millennium Ecosystem Assessment (MA 2005) are most relevant. The third group is connected to the globalization of environmental management standards including sustainable forest management under the International Tropical Timber Organization. A fourth group is NGOs and research institutes working with tropical forest politics, management and forestry. Examples include the Forest Stewardship Council (FSC), Rainforest Alliance, Social Accountability International (SAI) and The International Social and Environmental Accreditation Labelling (ISEAL).

Macqueen et al. (2006) outline the new historical opportunities for community ownership and management of forest to realize a better position for sustainable forestry due to the alliance with a new kind of globals connected to initiatives such as fair trade and others. The World Business Council for Sustainable Development (WBCSD) in alliance with IUCN has taken the initiative in recent years to meet the requirement and opportunities connected to Millennium Ecosystem Assessment (WBCSD & IUCN, 2006).

For CFEMI, the purpose and objectives of CFP are directly relevant, as are the linkages between *Ecosystem Services and Human Well-being* of Millennium Ecosystem Assessment and the conceptual framework between biodiversity, ecosystem services, human well-being and drivers of change especially relevant.

Based on CFP and the MA framework, the ecological parameters for CFEMI can be grouped into two main categories a) forest structure and b) forest biodiversity. These categories have been chosen because maintaining these two qualities will secure that most of the other important ecological factors including microorganism and fauna and the abiotic environment, will be covered. If forest structure and biodiversity are intact on a certain level, the forest will keep its resilience potential and a number of other ecological qualities which can provide ecosystem services for human well-being in a sustainable way (Table 1).

2.4 Selection of variables and primary indicators

The case of forest management at Mt. Kilimanjaro and the Chagga people as representative stakeholders for local interests is used here as an illustration of the conceptual and practical circumstances of the indicator scheme. CFEMI is proposed as a proximity-to-target indicator meant to work in the context of negotiation and mediation between globals and locals, while strengthening the local interests, influence, control and competence regarding sustainable forest management. The distinction between globals and locals are used to underline the actor perspective of the two paramount stakeholder groups of local society and international organisations, institutions and power structure. Both globals and locals are aggregates of other more specified stakeholders.

CFEMI should support the management goals for inter alia CFP and MA in a manner that strengthens the influence of local people and mediation between locals and globals. Table 2 gives an overview of criteria for selection of ecological features that could be relevant variables or primary indicators for CFEMI. Table 3 shows the complete list and description of the measured variables, units and levels of measurement.

Composition of variables is decided based on the criteria of what are relatively easily accessible. The variables cover important features for the ecosystem services connected to biodiversity and structure where the hypothesis is that the untouched forest has the potential to provide for the demanded ecosystem services such as production of forest goods (e.g. timber, fuel wood, fodder, medical plants), conservation of biodiversity, and water regulation and supply of water of good quality.

Ecological aspect	Management goals and ecosystem services
Forest structure	Maintain a natural-like structure of trees including age/size (basal area and height of trees) and canopy cover and restore areas where forest structure is damaged. **Main ecosystem services:** Constructs the forest room and constitutes the system for nutrient cycling, soil formation and primary production, form the overall habitat for all organisms, regulate local climate, retain, store and purify water and moisture and makes a optimal primary production possible **Benefit for locals:** Secure safe water for consumption and the furrow irrigation system produce timber, fuel wood, food, cash crops, fodder and many other bio products. Erosion control Income from tourism **Benefit for globals:** Timber, carbon storage, climate regulation. On regional level water to irrigation, hydropower, consumption and ecosystems via Pangani River basin water system is extremely import. Tourism especially eco-tourism
Biodiversity	Maintain natural level of biodiversity including diversity of trees. **Main ecosystem services:** Provider of genetic material for large number of organism necessary for keeping the evolutionary potential intact, and provision of large number of species **Benefit for locals:** Secure a wide variety of organisms to be utilized by the society where some already have known benefit for people and probably many other are undiscovered useful species which will be discovered in the future. Income from tourism **Benefit for globals:** Secure biodiversity resources for future generation. Medicines Ecosystem resilience Tourism and eco-tourism. Recreation

Table 1. Main ecological aspects, goals for management and ecosystem service of the catchment forest reserve at Mt. Kilimanjaro

2.5 Measurement and calculation

Table 3 shows measured and analyzed variables and Table 4 the total average value and derived target for the nine individual variables or indicators which constitute CFEMI. Identifying variables and methods for measurement, and deciding on targets require both quantitative and qualitative approach, and are depending on local conditions.

CFEMI is proximity-to-target indicator and the target is determined for each variable as a certain value higher than the total average value for each individual variable for each site (plot). All trees within each site of 1000 m^2 along the three transects (Mweka, Kilema and Marangu) are measured and the average value for each site is then calculated. These site specific average values are then accumulated to a total average value for all sites. However,

Criterion	Description
	ECOLOGICAL ASPECTS
1	Represent important forest physiognomy and biodiversity if trees on a plant are at an ecologically acceptable level
2	Directly associated to ecosystem services (Supporting, provisioning, regulating and cultural services)
	MEDIATION AND LEARNING ASPECTS
3	Easy or intuitively understandably by local people as a relevant description of forest services and goods
4	Support learning processes
5	Supporting learning processes and local participation in selection of indicators, measurement and calculation
6	Support management efforts
	TECHNICAL ASPECTS
7	Easy to measure and calculate
8	Does not hurt the ecosystem

Table 2. Criteria for the selection of variables

among the analyzed 54 sites there are 18 sites which are too affected by human impacts and encroachment that the sites cannot be regarded as be representative for closed forest or they contain mainly dense stands of *Erica* trees. These stands are omitted from the calculation of total average value and determination of targets, but these sites are of course included in the presentation of the CFEMI score for all sites (Table 5 and Fig. 2). Hermansen et al (2008) gives a detailed description of field work and results.

Some variables are measured by using numerical data (number of tree species and stems, basal area, tree height, crown width, crown width sum and crown depth), and average value is calculated. Cover of epiphytes is variables estimated by using ordinal (categorical) data (covering of climbers and covering of vascular, lichens and bryophytes), and the average value is calculated from the ordinal values.

The score for each site is calculated as the percentage of the average value for all the nine variables for a certain site compared with the target. Hermansen (2008) contains a complete list of calculated values of variables and score for all sites.

2.6 Results

The proximity-to-target score in percentage for the sites along the three altitudinal transects from lower to upper forest borders at the southern slopes of Mt. Kilimanjaro of Mweka, Kilema and Marangu, is shown in Fig. 2. Table 5 shows average values for the sites along each transect grouped into three zones: HMFS, central part and the upper part of the forest reserve.

The HMFS shows, as expected, much lower values (average score: 60) compared with average score 99 for the central part and 92 for the upper part. Average scores for the complete transects are quite similar for Mweka (91) and Marangu (93) and lower for Kilema (80). It is the low values from HMFS (50) along the Kilema transect which draws that average down. In the Kilema transect about double as many sites were measured in the HMFS part of the transect as in the two other transects. Sites on low altitudes are over-exploited and well developed sites are situated on higher altitudes (Fig. 2).

Tree structure variables			Description	Units
A.	**Basic units**		Inventory units for identification, geo-referenced information and multivariate analysis	
	a.	Tree	Individual identified and measured tree or stem	
			o Running serial number	Idnr
			o Running serial number within plot	Number
	b.	Plot	Identified by transect and plot number	
B.	**Localization**			
	a.	Altitude	Altitude above sea level	m asl
	b.	Transect	Transect from lower to upper forest border	Nominal
	c.	Exposition	Indication of exposition in 400 grades	degrees
	d.	Slope	Indication of slopes in 400 grades	degrees
C.	**Stem**			
	a.	Tree number	Each tree (or stem on trees divided in 2 or several stems under 1 m) is identified by transect and running number with the plot	Number
	b.	Tree species	Each tree is identified	
	c.	Height	Estimated height	m
	d.	DBH	Measured diameter at breast height	m
	e.	Basal area	Calculated basal area	m^2
	f.	First branch	Height to lowest living branch	m
	g.	Shape	The shape of the trunk is assessed :	Nominal
			o Straight	0
			o Leaning	1
			o Bent	2
			o Crooked	3
	h.	Buttress	Each tree has been assessed if it has buttress or no	Yes or no
D.	**Canopy**			
	Crown area (total leaf area)		Estimation of the horizontal projection of the canopy of each tree. The area is calculated from estimation of the diameter of the crown along to axis through origo.	m^2
E.	**Epiphytes**			Ordinal
	a.	Climbers	Estimation of the cover of climbers and lianas on each tree:	
			No climbers or lianas observed	0
			Some few / thin climbers, shorter than 2 m	1
			Some more dense / thicker climbers, more 2 m long	2
			Climbers cover the stem and some thin lianas may occur.	3
			Large and large lianas	4
			The tree is heavily affected by thick lianas	5
	b.	Vascular epiphytes	Estimation of the cover of vascular epiphytes:	
			No or very few individuals observed.	0
			Less than 10 % of stem and branched cover	1
			Between 10 – 25 % of	2
			Dense mats of epiphytes may cover between 20 to 40 %	3
			Dense mats cover between 40 and 75 %. Some hanging mats.	4
			The tree is overgrown with dense and some hanging mats	5
	c.	Non-vascular epiphytes	Estimation of the cover of bryophytes and lichens	
			No or very few spots or individuals observed.	0
			Less than 10 % of stem and branched cover	1
			Between 10 – 25 % of	2
			Dense mats of epiphytes may cover between 20 to 40 %	3
			Dense mats cover between 40 and 75 %. Some hanging mats.	4
			The tree is overgrown with dense and some hanging mats	5

Table 3. Measured and analyzed variables

Ecological aspects	Category	Indicators / variables	Units	Notes	Average	Target
Forest structure	**Tree structure**	Number of stems	no	1	40.6	50
		Basal area	m²	2	6.0	7.5
		Tree height	m	3	19.2	24
	Leaf cover	Crown width	m²	4	67.2	84
		Crown width sum	m²	5	2416	3020
		Crown depth	m	6	11.8	14.7
Biodiversity and water conservation	**Epiphyte cover**	Covering of climbers	class	7	1.5	1.9
		Covering of vascular, lichens and bryophytes	class	7	2.3	2.9
Biodiversity	**Tree species**	Number of tree species	no	8	6.7	8.4

Data are based on the measurement and estimation of 1502 trees within 36 sites (plots) of 1000 m². The different targets are set close to the values for which are considered to be well developed stands (approximately 25 percentage above average values). All sites are within the forest reserve. Sites mainly containing more than 50 *Erica excelsa* trees and sites from Half Mile Forestry Strip are not included in calculation of average values and target values. Notes:

1. The number of trees per site varies between 2 and 89. Overall average number of stems is 41.
2. The sum of basal area per site varies between 0.1 and 13.2. The overall average is 6.0.
3. The tree height varies between 6 and 40 m. The overall average is 19.2 m.
4. The average crown width per site (the horizontal project of the crown for each tree) varies between from 10 to 170 m². The overall average is 67 m². The largest crown is 961 m².
5. The sum of crown width for all the trees within a site. The crowns are merged into each other and will therefore exceed 1000 m². The sum varies between 70 and 5450 m². The overall average is 2416 m²
6. The crown depth is the height between lowest living branch and top the tree and varies between 7.2 and 16.2 m as average for the different sites. The overall average is 11.8 m. The highest tree crown depth is 39 m
7. Epiphyte cover is estimated by a non-linear classification and the calculated average is the average class for the tree within the plot. Target is set to 25 % above average. Average above 3.0 implies that the average tree has a substantial cover of epiphytes and climbers, which may play an important role for water conservation and retention.
8. The number of species within the sites varies between 2 and 13. The average is 6.7.

Table 4. CFEMI variables, total average values and target values.

The most significant observation is the large range of score on the Kilema track from the lowest (30 percentage point) to the highest score (134 percentage point). Especially the sites in the HMFS are far from the target for an ideal forest composition and structure. However, this was expected and obvious from simple visual inspection of the area. The HMFS is allocated to a buffer zone. People in the adjacent home garden farm land can collect fuel wood and other goods in strip under certain rules. But for all transects, the cutting of trees degrades the forest considerably. Some sites would not be categorized as forest according to standard definition. The total area of HMFS is 8769 ha where about half of this land can be afforested (Kivumbi & Newmark, 1991) and where there is considerable potential for increasing the forest quality and hence the value of forest ecosystem services to the local people by better management. For all transects, the most well-developed and maintained sites are between 2000 to 2500 m asl as noted by the fact that many of these sites scored above 100. Based on these data, it is reasonable to conclude that the CFEMI demonstrates and represents the ecological quality of the different forest sites.

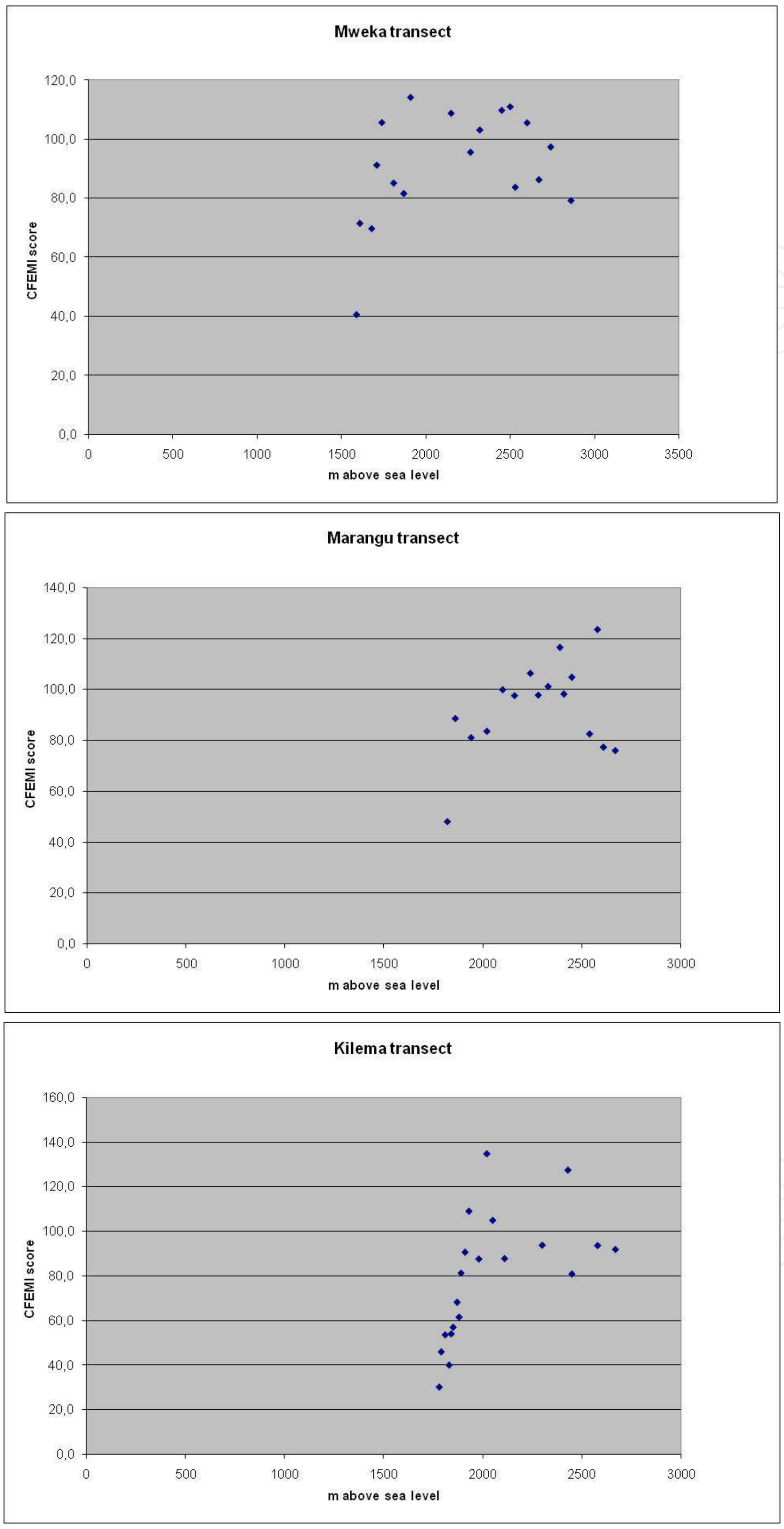

Fig. 2. CFEMI score in percentage for the sites along the altitudinal transect Mweka, Kilema and Marangu, Mt Kilimanjaro. The Half Mile Forestry Strip (HMFS) is between 1590 m asl and 1749 for Mweka, 1780 and 1880 for Kilema and 1820 and 2000 for Marunga.

	Mweka		Kilema		Marangu		Average	
HMFS	68	(4)	50	(7)	72	(3)	60	(14)
Central part	101	(8)	96	(11)	101	(9)	99	(28)
Upper part	94	(6)	93	(2)	90	(4)	92	(12)
Average	91	(18)	80	(20)	93	(16)	87	(54)

Table 5. Average CFEMI score group for the three distinct altitudinal zones of the forest along the three transects Mweka, Kilema and Marangu at the southern slopes of Mt. Kilimanjaro. Number of sites is shown within parenthesis.

3. Framework for mediating balanced ecosystem indicators

The methodology for development of EMI, FEMI and CFEMI is basically built on systems thinking and elements from systems engineering and used as tool for connecting different subsystems, such as stakeholder interests, forest ecology and management together into the larger system where the indicators are meant to work. An essential part of the methodology is the construction of the communication model Balanced Ecosystem Mediation (BEM) framework.

3.1 Construction of the BEM framework

The construction of the indicator is built on a pre-understanding of communication as an instrument for mediation and negotiation of knowledge and interests, and that these processes are integrated and accepted as fundamental for further development of the context where FEMI will contribute.

Technically, most environmental indicator systems are designed within an open system concept which includes conceptual, normative and operational elements. The notion of a system often encompasses "*a combination of interacting elements organised to achieve one or more stated purposes*" (Haskins, 2006), and could be an assemblage of elements constituting a *natural system*, a *man-made system*, an *organizational system* or a *conceptual knowledge system*.

An ecological indicator system aiming to be a management tool can be defined within all these four classes of systems and merged into an overall communication system where the indicator and the different circumstances around the indicator become elements in the system. The challenge is to design and understand how the interaction across the boundary interfaces between the elements, the subsystem and eventually the environment outside the system boundary, influence and bring the system into being. Systems thinking is an underlying concept used to assist in combining the ecological and social elements in the development of FEMI such that the indicator moves closer to a management and stakeholder approach.

Van Bueren and Blom (1996) advanced the "*Hierarchical Framework for the Formulation of Sustainable Forest Management Standards. Principles, Criteria, Indicators*" (PCI) on behalf of Tropenbos Foundation which challenges many of the aspects relevant for the FEMI indicator system. They suggest top-down oriented hierarchal framework for a forest management system with consistent standards based on the formulation of principles, criteria and indicators for sustainable forest management. In the context of development of FEMI, the PCI system appears to be an expert-oriented initiative that belongs to the sphere of influence and interests of the globals.

In order to create a structure involving the locals and strengthening their interests while supporting dialogue and continuous learning, the PCI framework has been modified. The proposed structure allocates the indicator system a more interactive role, and enlarges the system to a construct that shows an ideal typological symmetric mediation between the locals versus globals, ecology versus nature (resources or ecosystem services), and society versus culture (Hermansen, 2008). The framework is called the *Balanced Ecosystems Mediation (BEM)* Framework (Fig. 3).

The transecting lines S and V in Figure 6 represent the ideal symmetric or balanced case based on scientific and normative criteria and arguments. The vertical lines a, b, and c illustrate different constellations where the position, influence and control by the locals is more or less reduced or lost to the globals. The line **a** shows the situation where the locals are incapacitated and have lost most control over their ecosystem resources; line **b** represents the situation where the locals have managed to participate in forest management; and line **c**, the situation where the locals have substantial influence and control over local ecosystem services.

If *V* is moving upwards the ecological interests and concerns increase with stronger emphasis on protection and conservation, and if *V* is moving downwards, society utilize more of the ecosystem services with an increased ecological unsustainability impact and possibly a strong attenuation of the ecological resilience capacity.

The BEM framework should be regarded as an open system where the borders between the elements and subsystem are interfaces where mediation and negotiation can occur between the stakeholders involved. Both mediation and negotiation can take many forms depending on the question discussed or stakeholders (and subgroup of stakeholders) participating in the discourse.

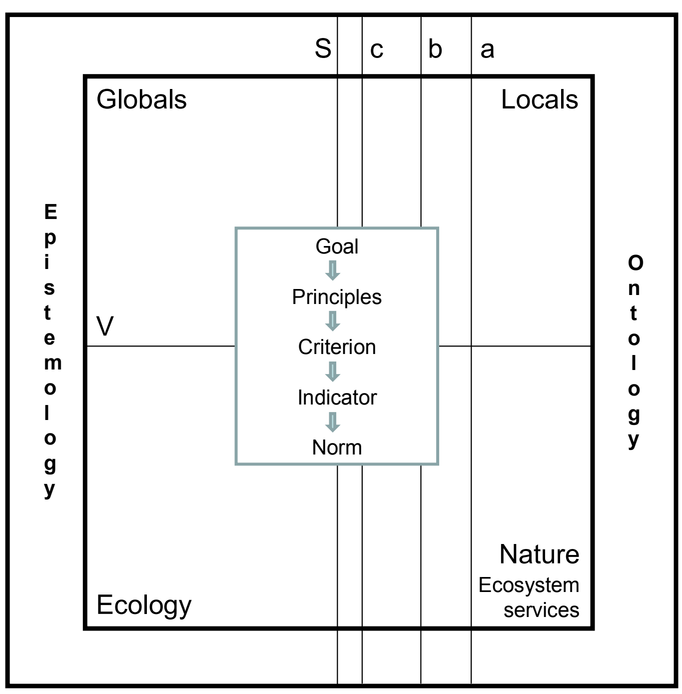

Fig. 3. The construct of the Balanced Ecosystem Mediation (BEM) Framework with the two knowledge regimes ontological and epistemological. S and V are representing the ideal typological symmetry (or balance) regarding mediation and negotiation for globals versus locals stakeholders and society versus nature (as stakeholders) respectively (Hermansen, 2010.

The corresponding influence of how the understanding of ecology (scientific) and nature, and the epistemological and ontological approach, are also illustrated in Fig. 3, and derives from the case study work in which the *indicator* was designated to be the core element in the forest management system in order to strengthen the position of the locals. The BEM framework is built on a nature versus culture model presented by Hermansen (2006, 2010).
FEMI is the general and theoretical model for the indicator, while CFEMI is intended to be a specific and practical indicator reflecting the complexity of the relationship between the catchment forest ecosystem and local society.

3.2 Terms and theoretical perspectives of the communication model

The structure of the communication process based on BEM framework can be illustrated as shown in Table 6. The two knowledge regimes (empirical and methodological), which are two different ways of acquiring and constructing knowledge, are paired with the accepted viewpoints of both globals and locals about ecological issues. A normative standpoint is taken by insisting on the right of local people to understand and participate in a discursive reflection on the content and value of the indicator system. The appurtenance interests of the globals comprise the ecological area regarding empirical knowledge acquired by an epistemological methodological approach, and the appurtenance interests of the local comprise the ontological way of experience of nature and natural resources and later ecological knowledge acquired by scientific work.

	Appurtenance of ecological knowledge	
Knowledge acquisition	**The globals**	**The locals**
Experience /empirical	The ecological accepted (relevant)	The ontological regime
Scientific work/methodological	The epistemological regime	The social accepted (relevant)

Table 6. Structure of knowledge regimes and appurtenance for globals and locals for the Forest Ecosystem Mediating Indicator (FEMI) concept.

3.3 Goal and objectives of forest ecosystem mediating indicators

Objectives and practical use of the indicator are intended not only to be a measure for communication, but also for mediation and negotiation process in itself and the further understanding of forest ecosystem and management of the forest resources. The indicators are part of the process and the overall objective can be specified by separate regimes and roles into the following regimes/roles as shown in Table 6. However, goals must be stated and the context of mediation by means of indicators must be set. The paramount goal is to contribute to democratized and enlightened mediation of ecosystem knowledge, services and values between nature and society, and strengthen the locals' position in the locals versus globals relationship, and hopefully secure the wise and sustainable use of the forest. Table 7 shows the relationship between the main features of the ecological mediation.
The integrated mediation by means of indicators is dynamic and process oriented interchange and can conveniently be divided into different phases (Table 8). These phases also give an indication of the learning cycle of the activities.
Mediation is not only an end-of-project activity, but an integral part of project development. Suitable settings for mediation can be established prior to inventory (as part of planning), part of field work (inventory), part of management and part of a continuing learning and negotiation process. In a dialogue, stakeholder's interests are also maintained, represented

here by local and global interests with accompanying impacts. Negotiated goals and aspects are the result of the process, integrating the consensuses of ecological content, definition of ecological service and values, and suggesting a political/management ecological regime that embraces the negotiated knowledge regime. Through genuine communicative mediation an equitable and symmetric communication process may then emerge.

Paramount objective	Democratized	Enlightened
Ecosystem knowledge	Mediation of scientific results	Mediation of scientific methods
Ecosystem services and values	Mediation of local resources	Mediation of scientific values/understanding

Table 7. Paramount goal and mediation of ecology

Mediation phases	Local interests and impact	Global interests and impact	Negotiated goals or aspects
Pre process understanding	Identify local concern and needs	Identify global concerns	Agree on concerns
Interpretation of positions	Identify local human resources	Identify scientific knowledge	Combining human resources
Designing phases	Defining need of ecological services:	Defining biodiversity and climate issues	Defining a complete description of values and resilience capacity
Pre-inventory	Practical training	Communicating support	--------
Part of inventory	Identifying and deciding	Be accepted as partner	Agree on working methods
Part of management	Control	Protect global ecological concern	Agree on management system
Part of continuously learning and negotiation process	Full access as respected partner	Move from global arrogance to universal partnership	Common interests of using communication opportunities of FEMI

Table 8. Typology of the different interests through the different mediation phases

3.4 Using FEMI to bring momentum to local management

MA (2005) is an initiative for handling the ecosystem resources under the vision of a globalized world and offers a framework both regarding ecosystem and geographic scaling. It further elaborates the relationship between the ecosystem and the human needs for ecosystem services that contribute to well-being and poverty reduction in the form of security, basic material for a good life and good social relations. This in turn necessitates requirements for freedom and choice of action. Status and quality of the forest on the global and regional scale will often be assessed in coarse categories such as area cover by forest, degree of deforestation, estimates of economic value of logs, stakeholder values etc. Application of the MA concept can easily result in a change of resource control and management away from already weak local participants to international bodies and business. FEMI is meant to adjust the management attitude in MA to facilitate a stronger local participation.

Assessments of the ecological status and trends require a set of indicator systems. *The Driving force–Pressure–State–Impact–Response* (DPSIR) framework (Smeets & Wetering, 1999) is often used. However, Niemeijer and de Groot (2008) argue that moving the framework for environmental indicators from causal chains to causal networks could be a better tool for management decisions and they suggest an enhanced DPSIR-system that could be appropriate. FEMI can be considered as local status indicator, but based on the proximity-to-target concept for principle design of construction, the indicator is working as a performance indicator where performance (status) is compared with a defined ideal typical well developed, natural and healthy forest (the target).

Hence, the intention of FEMI is to enlarge the framework for an ecological forest indicator to include ecological integration and the potential for a larger understanding and dynamic involvement among stakeholders.

3.5 Proximity-to-target performance indicator

To measure ecological and management oriented policy categories, such as for example the wise and sustainable use of forest resources, requires a set of different measurable indicators and data. Some are easily measurable with instruments and metrics, and others by judgement, often value laden along a scale. Performance indicators on social level usually refer to different kinds of reference conditions and values, such as national or international policy targets. Especially demanding, both technically and politically, is the implementation of sustainability performance indicators. Often they are very vague and difficult to follow up and address with responsible authorities or actors. European Environmental Agency (EEA, 2007) has defined the usefulness of a proximity-to-target approach:

> *"… concept of environmental performance evaluation is being developed for use in an environmental management system to quantify, understand and track the relevant environmental aspects of a system. The basic idea is to identify indicators (environmental, operational and management) which can be measured and tracked to facilitate continuous improvements. Performance indicators compare actual conditions with a specific set of reference conditions. They measure the 'distance(s)' between the current environmental situation and the desired situation (target): 'distance to target' assessment."*

Proximity-to-target indicators are a type of environmental performance indicator designed for ranking, benchmarking and monitoring action towards well defined and measurable objectives. The proposed CFEMI is an extension of the concepts and principles from both the macro (societal) and micro (corporate) levels including mimicry of the proximate-to-target indicator from '*Pilot 2006 EPI Environmental Performance Index*' launched by Esty et al. (2006).

3.6 Reliability of measurements

To make high quality, representative measurements of forest variables, is a challenge. West (2004) gives an account of *accuracy* as the difference between a measurement or estimate of something and its true values, *bias* as the difference between the average of a set of repeated measurements or estimates of something and its true value, and *precision* as the variation in a set of repeated measurements or estimates of something.

Because much of the measurement phase of the field work is dependent on assessment of the values for the different variables, the indicator is vulnerable to the skills and experience of the observers. Within a close collaborating group of local foresters the observations can be sufficiently accurate, but comparing the results between different forests and assessment teams, the assessment could vary significantly.

4. Discussion

The scientific judgement on the feasibility of BEM framework and FEMI will depend on expectations, and many demurs and critics discussed can be raised. Concepts for ecological integrity which incorporates information from the multiple dimensions of ecosystems are, however, expected to be a useful tool for ecosystem managers and decision makers. The mediation framework and indicator are devised both to expose ecological integrity, and to be instrumental for the mediation between nature and society, and between locals and globals. This implies that the ultimate results of the application of the indicator is connected to the process of continuing improvement of genuine understanding between the globals and locals, and the continuing improvement of the management of the forest in order to secure ecosystem services for the local people as first priority and for the globals as second.

Working out the indicator system and then executing the implementation both contribute to the momentum of the learning loops and to the factual learning about the very easy accessible features of the forest ecosystem and corresponding ecosystem services.

Both selection of ecological phenomena, variables, field methods and measurements, and composition and calculation of the composed indicator are critical issues. To achieve a sufficient accuracy is difficult for many of the variables especially those depending on estimation of heights and cover. The success of the indicator will depend on how the balance of purpose, accuracy and selection of possible variables are compared with the momentum for increased local participation, increased consciousness and ecological knowledge, and increased motivation for interactive cooperation for finding wise solutions.

Local participation of sustainable management of a tropical forest requires that the knowledge about ecological status and the ecosystem services that the forest can provide, can be communicated in way that support enlightenment, democratic management processes and are environmentally sound. Hence, whole process of development and implementation using ecological indicators should be scientifically and ecologically proper (the global perspective) and locally understandable and fair (the local perspective). The case study shows that it is possible to carry out field inventory programs that encompass variables that cover main ecosystem services especially valuable for local and regional utilization, by using simple measurable ecological variables. However, many of the measured variables depend on estimations of measured values and the measurement could then be less reliable for calculation of the indicator.

The connection to the real social conditions at the slopes at Mt. Kilimanjaro in this case is rather weak due to the fact that detailed investigation of the relationship between society and ecosystems is not done. Assessing and making decisions about ecosystem resources is a normative and political action, and a challenge for an indicator system is then to make the normative dimension visible and an object for deliberative processes. To meet the requirement for local participation the indicator system has to move from a hard ecological approach with only measurable indicators to a practical and soft ecological approach and use an open, conceptual and learning oriented systems engineering approach. This movement from a hard system towards a soft system allows greater application of assessment, judgement and estimation.

5. Conclusion

The study has demonstrated and elaborated on the use of ecological indicators to support a balanced and mediating management concept in order to increase the influence of local

interests on vital and ecological valuable forest resources, and to encourage knowledge insertion to achieve a proactive approach to sustainable forest management contributing to enlightenment and democratizing of ecological resource management.
Further work should explore how to develop and connect such initiatives deeper into a learning process and as a genuine measure for mediation, negotiation and decision making.

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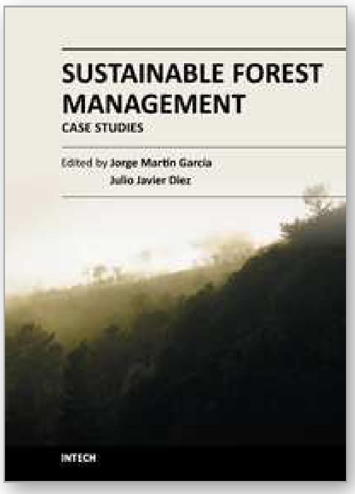

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The concept of forest sustainability dates from centuries ago, although the understanding of sustainable forest management (SFM) as an instrument that harmonizes ecological and socio-economic concerns is relatively new. The change in perspective occurred at the beginning of the 1990s in response to an increased awareness of the deterioration of the environment, in particular of the alarming loss of forest resources. The book collects original case studies from 12 different countries in four continents (Africa, America, Asia and Europe). These studies represent a wide variation of experiences from developing and developed countries, and should clarify the current status of SFM worldwide and the problems associated with its implementation.